

- downstream of DCDB cables.
- ii) Cables between 220V DCDB and Sub DBs at various elevations
- iii) Incomer cables for DG board, emergency board, DC lighting board etc.
- iv) 220V DC - incomer cable for protection and control purpose to HV switchgear shall be minimum 10 sq.mm copper and for LV switchgear minimum size shall be 6 sq. mm copper.

8.05.13 The fire survival power & control cables shall be used for the following important auxiliaries/areas:

- a. DC emergency lube oil pump.
- b. Turbine lube oil pump/barring gear.
- c. Jacking oil pump.
- d. Scanner air fan.
- e. Incoming & outgoing cables for DC lighting distribution board.
- f. Fire /smoke detection system.
- g. DC seal oil pump.
- h. DC emergency lighting cables for Main Plant Building.
- i. Batteries to charger and DC distribution board.
- j. Emergency turbine trip by push button in control room.
- k. Boiler turbine: Generator inter-trip which includes the interconnecting cables between
 - 1. Boiler master fuel trip and turbine trip relays
 - 2. Generator trip relays and turbine trip relays
 - 3. Generator trip relays and 400kV circuit breaker
 - 4. Generator trip relays and generator field breaker.
 - 5. Generator trip relays and UAT breaker.
- l. Other requirements as per latest CEA guidelines.

8.06.00 Cable Accessories

8.06.01 Termination and Straight Through Joint Kits

- a) Cable trays shall be well away from hot steam pipelines and shall not be immediately above or below the steam pipes.
- b) Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements.
- c) The materials required for termination and straight through joints shall be supplied in kit form. The kit shall include all insulating and sealing materials apart from consumable items and installation instruction.
- d) The termination kits shall be suitable for termination of the cables to indoor switchgear or to a weatherproof cable box of an indoor/outdoor mounted transformer/motor. The termination kits shall preferably be as of the following types.

- i) PUSH ON' type for LT cables.

CHAPTER 23 : LT POWER CABLES**1.00.00 SCOPE OF SUPPLY**

The LT Power cables shall be supplied, installed and commissioned in accordance with the following specification.

Other cables including special cables if any which are necessary as per proven engineering practice for satisfactory & trouble free operation of the entire cable system of the power plant shall also be within the scope of supply. These shall include all such cables for electrical integral with mechanical equipment systems and subsystems.

2.00.00 CODES & STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS: codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:1554 (Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanized steel wires, formed wires and tapes for armouring of cables.
IS : 4905	Methods for random sampling.
IS : 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part - I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to and including 1100V.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEC-754 (Part-I)	Test on gases evolved during combustion of electric cables.
IEEE-383	Standard for type test of Class IE Electric Cables.
IEC -60332	Tests on Electric cables under fire conditions. Part-3 : Tests on bunched wires or cables (category -B)
SS-4241475 classF3	Swedish Chimney test
NES-715-1	Temperature index

3.00.00 DESIGN CRITERIA

3.01.00 The cables will be used for connection of power circuits of the system. Actual cable sizes will be selected by the Contractor. Number of different sizes selected will be kept to a minimum for optimization.



- 3.02.00 Cables shall be generally laid on ladder type cable trays or drawn, through rigid Steel pipe conduits. For interplant connection cables shall be routed along overhead cable bridge.
- 3.03.00 For continuous operation at specified rating, maximum conductor temperature shall be limited to the permissible value as per relevant standard and/or this specification whichever is more stringent.
- 3.04.00 The insulation and sheath materials shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.
- 3.05.00 Armouring shall be single round wire of galvanized steel for multicore cables and aluminum for single core cable for power. For Fire survival power cable, Single core cables to be used in A.C. system, the armouring over inner sheath shall consist of single layer of round copper wire, for multi-core cables to be used in A.C. system and single/two core cables in D.C. System, the armouring over inner sheath shall consist of single layer of round galvanized steel wire.
- 3.06.00 The inner and outer sheath shall have flame retardant low smoke (FRLSH) characteristics or fire survival characteristics as the case may be, and shall meet the requirements of additional tests specified for the purpose.
- 3.07.00 Core identification for multicore cable shall be provided by colour coding.
- 3.08.00 Cables shall be so designed and manufactured that no damage occurs during handling, transit, storage, installation under any operative conditions which they may be subjected to.
- 3.09.00 Minimum value of volume resistivity for XLPE insulation shall be 1.0×10^{14} ohms-cm at 27 deg C and 1.0×10^{12} ohms-cm at 90 deg C.
- 3.10.00 Maximum continuous operating temperature shall be 90 deg C under normal operation and 250 deg C under short circuit condition. The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath of black colour as per IS: 5831.

4.00.00 SPECIFIC REQUIREMENTS / CONSTRUCTIONAL REQUIREMENTS

4.01.00 1.1KV Aluminium Conductor Power Cables

1100 volt, 90 Deg.C rating, heavy duty power cables with stranded aluminium conductor, extruded XLPE insulation, extruded HRPVC,FR-LSH inner sheath, aluminium round wire armour for single core cables and galvanized steel strip /wire armour for three (3) core cables, and extruded HRPVC, FR-LSH overall sheath.

Cables shall be manufactured in conformity to IS-7098 part 1 - 1988, amended up to date and bearing ISI mark.

4.01.01 Conductor

Aluminium conductor used in power cables shall have tensile strength of more than 100N/sq.mm. Conductors shall be stranded.



4.01.02 Insulation

Cross linked polyethylene (XLPE) of natural colour, extruded over screened conductor. This shall be conforming to IS: 7098 Part-1 (1988).

4.01.03 Inner Sheath

The laid up insulated cores of twin and multicore power cables shall be provided with an inner sheath of extruded HRPVC, FRLSH compound conforming to Type ST2 of IS:5831. Single core power cables need not be provided with any inner sheath.

4.01.04 Armour

For single core armoured cables, armouring shall be of aluminium wires/formed wires.

For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia of cable under armour	Size and Type of armour
Upto 13mm	1.4mm dia GS wire.
Above 13 & upto 25mm	0.8mm thick GS formed wire/1.6mm dia GS wire.
Above 25 & upto 40mm	0.8mm thick GS formed wire/2.0mm dia GS wire.
Above 40 & upto 55mm	1.4mm thick GS formed wire/2.5mm dia GS wire.
Above 55 & upto 70mm	1.4mm thick GS formed wire/3.15mm dia GS wire.
Above 70mm	1.4mm thick GS formed wire/4.0mm dia GS wire.

The aluminium used for armouring shall be of H4 grade as per IS:8130 with maximum resistivity of 0.028264 ohm mm² per metre at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.

The gap between armour wires / formed wires shall not exceed one armour wire/ formed wire space and there shall be no cross over / over-riding of armour wires / formed wires. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wires / formed wires.

4.01.05 Overall Sheath

Outer sheath shall be of PVC as per IS:5831 & black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following properties.

- (a) Oxygen index of min. 29 (as per IS 10810 Part-58).
- (b) Acid gas emission of max. 20% (as per IEC-754-1).
- (c) Smoke density rating shall not be more than 60% (as per ASTM-D-2843).

4.02.00

1.1KV Grade Copper Conductor Fire Survival Power Cables

1100 volt grade, 90 Deg.C rating, Power cables with stranded Copper conductor, heat resistance elastomeric insulation generally conforming to Type IE-2 of IS:6380-1984, extruded Halogen free or very low Halogen elastomeric inner sheath, generally conforming to Type SE-3 of IS-6380-1984, round wire/strip armour and extruded outer sheath of elastomeric material generally conforming to Type SE-3 of IS:6380-1984.

The cables shall be generally manufactured in conformity to IS-9968 Part-1/1988.

The cables shall be rated for 3 hours fire rating.

4.02.01

Conductor

Conductor shall be of stranded construction, consisting of high conductivity annealed plain copper wires conforming to Class-II of IS 8130. A suitable heat barrier tape, preferably glass mica tape shall be provided over the conductor.

4.02.02

Insulation

Cores of the cable shall be identified by colouring of insulation. Following colour scheme shall be adopted.

- 1 core - Red, Black, Yellow or Blue
- 2 core - Red & Black
- 3 core - Red, Yellow & Blue
- 4 core - Red, Yellow, Blue & Black

4.02.03

Laying up of cores (For multi core cables only)

The core shall be suitably identified in accordance with IS: 9968 (Part-I).

The suitable fire retardant material fillers shall be used for filling in the interstices.

Two layers of plain glass fiber binder tape shall be applied over the laid up cores.

4.02.04

Inner Sheath

An inner sheath of extruded special low smoke and very low halogen content (acid gas generation shall be less than 2% by weight) elastomeric (HOFR) compound of black colour conforming to Type SE-3 of IS-6380/1984, amended up to date, shall be provided over the laid up cores. This shall be provided even for single core cables after providing two layers of plain glass fiber tape over the insulation.

4.02.05 **Armour**

For Single core cables to be used in A.C system, the armouring over inner sheath shall consist of single layer of round copper wire.

For multi-core cables to be used in A.C. system and single/two core cables in D.C. System, the armouring over inner sheath shall consist of single layer of round galvanized steel wire.

4.02.06 **Outer Sheath**

The extruded outer sheath shall be of special low smoke and very low Halogen content (Acid gas generation shall be less than 2% by weight) elastomeric HOFR compound comprising of synthetic rubber and shall generally conform to the type SE-3 of IS: 6380 latest revision.

Minimum value of 'Tensile Strength' and 'Percentage elongation rate rupture' shall be 8 Newton/Sq. mm and 250% respectively.

The colour of outer sheath shall be black or any other colour agreed mutually between Owner and Supplier.

4.03.00 **Flexible Trailing Cables**

4.03.01 1100 V Grade flexible trailing cable shall be tinned copper of Class – 5 of IS – 8130, heat resistant electrometric compound based on EPR insulation, inner sheath of heat resistant electrometric compound PCP sheath, nylon cord reinforcement and heat resistant, oil resistant and flame retardant heavy duty electrometric compound FRLS CSP outer sheath.

5.00.00 **CABLE SELECTION & SIZING**

5.01.00 LT Power cables shall be sized based on the considerations mentioned in chapter 1.

5.02.00 Derating Factors

Derating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

- a) Variation in ambient temperature for cables laid in air
- b) Grouping of cables
- c) Variation in ground temperature and soil resistivity for buried cables.

5.03.00 Cable lengths shall be considered in such a way that straight through cable joints are avoided.

6.00.00 GENERAL REQUIREMENTS**6.01.00 Drum Length & tolerance**

6.01.01 Cable shall be supplied in wooden drums. The standard single length of each drum shall be minimum 500 metres for large size of cable minimum 1000 metre for smaller size of cables.

6.01.02 1.1KV Copper Fire Survival Power cables shall be supplied in wooden drums. Each drum shall be minimum 500 metres single length of cable.

Allowable tolerance on individual drum length is (+)5%.

6.02.00 Non-standard length

Bidder will be required to obtain Owner's approval before packing the non standard length of cables on drums. Non-standard lengths shall not be less than half of the standard packing length in any case.

6.03.00 Cable identification

Cable identification shall be provided by embossing on every meter on the outer sheath the following:

- a) UPRVUNL
- b) Manufacturer's name or trademark
- c) Voltage grade
- d) Year of manufacture
- e) Type of insulation and sheath, e.g. XLPE /HRPVC FRLS,IE2/SE3 F.S. as applicable.
- f) No. of core and size of cables.
- g) Sequential length marking at an interval of 1m through out the length of the cable.
- h) ISI mark
- i) Type of improved fire performance, e.g. FR/FR-LSH/FS.

7.00.00 PACKING

7.01.00 Cables shall be supplied in non-returnable drums. The drums shall be of heavy construction as per relevant IS. All wooden parts shall be manufactured from seasoned wood. All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. Wooden drums shall be treated by immersing in copper nitrate solution

7.02.00 Cable shall be wound and packed on drums in such a manner that it will be properly sealed and firmly secured to the drum. The ends of each length shall be sealed before shipment. Heat shrinkable cable seals shall be used for this purpose

7.03.00 A label shall be securely attached to each end of the reel indicating the length, type, voltage grade, conductor size and number of core of the cable. A tag containing the same information shall be attached to the leading end of the cable inside. An arrow and necessary instructions shall be marked on the

drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on cable drums

7.04.00 The cable drums should carry the following details in printed form (non returnable):

- a) UPRVUNL & Manufacturer's name or trade make
- b) Type of cable & voltage grade
- c) Year of manufacture
- d) Type of insulation / sheath e.g. XLPE /HRPVC FRLS,IE2/SE3 F.S. as applicable.
- e) No. of core and size of cables
- f) Cable code
- g) Length of cable on drum
- h) Direction of rotation, by arrow
- i) Approx. gross mass.
- j) ISI mark
- i) IS/IEC number

8.00.00 TESTING PROCEDURE

8.01.00 TESTS DURING MANUFACTURE:-

During the manufacture of cables, manufacturer's standard tests shall be performed and record / test report shall be made available to purchaser's representative during inspection / testing.

8.02.00 TYPE ROUTINE & ACCEPTANCE TESTS:-

After completion of manufacture of cables, type, routine and acceptance tests shall be performed strictly as per relevant IS & other applicable standards amended upto date.

Routine tests shall be carried out on 100% drums.

8.03.00 TYPE TESTS :-

8.03.01 The type test as per applicable standards and as given below shall be conducted on one drum selected on random basis out of every 10 drums or less of each type and size of cable. Size shall mean area of cross section in sq.mm read in conjunction with the number of cores. Type shall mean type of insulation, sheath, volt grade FRLS/FS etc. In case, facilities of any of the type tests are not available at the works of the supplier, then such type tests shall be carried out by the supplier at independent recognized Govt. approved laboratory at the cost of supplier.

1. Tensile test (for aluminium) as per IS:8130
2. Wrapping test (for aluminium) as per IS:8130

Note:- In the case of compacted circular & shaped conductors these tests shall be carried out before compacting/shaping for ensuring use of H2 grade aluminium.

3. Conductor Resistance test as per IS:8130.

4. Test for armour wire/strip as per IS:3975
- 5) Test for thickness of XLPE Insulation and HRPVC,FR-LSH sheath :-
Requirements and methods of tests for the thickness of insulation, inner sheath and outer sheath shall be as per IS: 7098 (Part-2).
- 6) Tensile strength and elongation test for insulation & sheath :-
This test shall be carried out as per IS:7098 Part-2 for XLPE cable.
- 7) Ageing test for insulation and sheath:-
The method of test shall be as per the relevant IS standard. The period of test shall be 168 hours (7 days). At the end of the ageing period, the tensile strength and elongation test shall be carried out as per Sr.No.(6) above. The value obtained must not differ from the corresponding values obtained before ageing by more than + or - 25% in case of XLPE compound.
- 8) Loss of mass test for HRPVC, FR-LSH sheath :-
This test shall be carried out as per IS 583/1984 012 IEC 540 & IEC 502, on cables of all voltage grades. The maximum permissible loss of mass is 2 mg/sq.cm for PVC.
- 9) Shrinkage test for XLPE insulation & HRPVC FR-LSH sheath:-
This shall be carried out as per IS:5831 – 1984 for sheathed and as per IS 7098 (Part 2) 1985 for XLPE insulation.
- 10) Hot deformation test for HRPVC,FR-LSH sheath :-
This shall be carried out as per IS:5831 / 1984.
- 11) Cold Impact test for HRPVC,FR-LSH sheath :-
This shall be carried out as per IS:5831.
- 12) Heat shock test for HRPVC,FR-LSH sheath :-
This test shall be carried out as per IS 5831 / 1984 and IEC 540 and IEC 502 & sheath shall pass the requirements of this test.
- 13) Thermal stability test for HRPVC,FR-LSH sheath :-
This test shall be carried out on cables as per IS 5831 / 1984 and IEC 540 and cables shall pass the minimum requirements of 80 minutes for sheath.
- 14) Hot set test for XLPE Insulation :-
This test shall be carried out as per IS:7098 Part-1 and Part-2 and cable shall pass the requirements given therein.

- 15) Test for bleeding and blooming of Pigments for HRPVC,FR-LSH Sheath :-
This shall be carried out as per IS:5831 / 1984.
- 16) Fire Resistance Test
This test is compulsory and shall comply with the relevant clause of applicable IS.
- 17) Partial Discharge Test for XLPE Cables :-
The partial discharge test for XLPE insulation shall be carried out as per IS:7098 (Part-II).
- 18) Bending Test for XLPE Cables :-
The test method and test requirement shall be as per IS:7098 (Part-II). On completion of this test, the sample shall be subjected to partial discharge measurement and comply with the requirements given in above sub-clause 17.
- 19) Insulation Resistance / Volume resistivity -
As per IS 7098 Part-2 / 1985.
- 20) Dielectric Power Factor Test
As per IS 7098 Part-2 / 1985.
- 21) Heating cycle test for XLPE Cables :-
This test shall be as per IS:7098 (Part-II)
- 22) High Voltage Test
This test shall be performed as per the relevant Indian Standard 7098 Part 2 / 1985.
- 23) Test for Rodent & Termite Repulsion Property of Sheath :-
A few chipping of the PVC compound is slowly ignited on a porcelain dish or cubicle in a muffle furnace at about 60 degree C. The resulting ignited ash is boiled with a little ammonium acetate solution (10%). Place a drop of aqueous sodium sulphide solution on a thick filter paper and allow to soak. Touch the spot with a drop of above extract. A black spot indicates the presence of lead, the anti-termite and rodent compound.
- 24) Impulse Withstand Test
As per IS – 7098 (2) (amended upto date).
- 25) Water Absorption Test
As per IS 7098 Part-2 / 1985.

8.03.02 The normal sequence of the electrical tests shall be as per Clause 16.1.1 of IEC-502/1978 and / or as per IS 7098 Part – 2 / 1985 . All the tests listed herein shall be applied successively to the same sample.

8.03.03 The inner and outer sheath of the XLPE insulated cable shall be subjected to all the tests applicable for PVC sheath as per IS 5831 / 1984.

8.04.00 SPECIAL TESTS ON HRPVC 'FR-LSH' MATERIAL

All the sizes of XLPE power cables of the 'FRLS' HRPVC sheathed type shall pass following special test requirements. Inner sheath wherever applicable shall also be of the 'FR-LSH' type 'HRPVC' to meet these special tests.

i) Oxygen/Temperature Index test on sheath material :-

This test shall be carried out as per American National Std. A STM-D-2863/77.

The minimum oxygen index shall be 29 at room temperature.

For determination of the temp.index, the oxygen index test shall be carried out at different temperature upto 250°C. However, the test shall be carried out by extra-polation method beyond temperature at which the material of sheath may start deformation. The minimum temp. index (i.e. the temperature at which the oxygen index is minimum 21) shall be 250°C generally as per BICC Hand Book Chapter-6.

ii) Acid gas emission test on sheath material :-

This test shall be carried out as per IEC Std. 754-1. The maximum acid gas emission shall be less than 20 by weight.

iii) Smoke density test on sheath material :-

This test shall be carried out as per American National Standard ASTM-D-2843/1977 and also as per UITP method (3M cube test on finished cable sample). The ASTM test method is compulsory. For passing this test, the requirement of light transmission shall be minimum 40% after the test.

iv) Flammability test on finished cable sample :-

This test shall be carried out as per the following method :

Swedish Std.SS:424-14-75 Class-F3. This test known as Swedish Chimney test is compulsory.

IEEE std. 383-1974 – This test known as the vertical tray flame propagation test shall be conducted if insisted by purchaser.

IEC Std: 332-1. – The cable should meet the requirement of all the above standards.

9.00.00 ROUTINE TESTS :

The following tests shall be carried out as Routine tests on each and every drum length of cable, as per IS 7098 (Part 2) / 1985.

- High Voltage Test
- Conductor Resistance Test
- Partial discharge test (for screened cables) – on full drum length.

10.00.00 ACCEPTANCE TEST :

The following test shall be carried out as Acceptance Test in the presence of UPRVUNL Inspecting Engineer on samples taken from the delivery lot. One drum out of every 10 number of drums or less shall be selected at random sampling basis in each lot for the Acceptance Tests which shall be carried out at manufacturer's/supplier's cost.

1. High Voltage Test
2. Conductor Resistance Test
3. Tensile / wrapping test.
4. Partial discharge test (In screened cables).
5. Insulation Resistance/Volume resistivity test
6. Measurement of thickness of insulation and sheath and other dimensions
7. Tensile strength & elongation at break for insulation & sheath.
8. Hot set test on XLPE insulation
9. Flammability test as per Swedish standard SS:424-15-75 Class-F-3 (Swedish Chimney test)
10. Acid gas generation test as per IEC-754-1.
11. Smoke density test as per ASTM-D-2843/1977
12. Oxygen index test as per ASTM-D 2863/1977
13. Temp. index test as per ASTM-2863/77

11.00.00 TEST WITNESS

Tests shall be performed in presence of Owner/Owner's representative. The Contractor shall give atleast fifteen (15) days advance notice of the date on which the tests are to be carried out.

12.00.00 TEST CERTIFICATES

Certified reports of all the tests carried out at the works shall be furnished for approval of the Owner/Purchaser.

Test reports shall be completed with all details and shall also contain IS/IEC specified limit values, wherever applicable, to facilitate review.

The cables shall be dispatched from works only after receipt of Owner/Purchaser's written approval of the test reports.

13.00.00 SITE TESTS

The contractor shall carry out the following commissioning tests and checks after installation at site. In addition the contractor shall carry out all other checks and tests as recommended by the manufacturers.

1. Check for physical damage

2. Ensure that gland plates of single core power cables are of non-magnetic material.
3. Bimetallic lugs are used when connections are made between different materials (i.e. Copper & Aluminum)
4. Meggar test between each case and armour 1 sheath.
- 5.** Continuity check
6. Check connections.
7. Armour of single core cables should be earthed at one end only for multi core cables they are earthed at both ends.
8. Check for provision of correct cable tags, core ferrules, and tightness of connections.

CHAPTER 24 : LT CONTROL CABLES**1.00.00 SCOPE OF SUPPLY**

The cables shall be supplied, installed and commissioned in accordance with the following specification.

2.00.00 CODES & STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS: codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:1554 (Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
IS:3961	Recommended current ratings for cables.
IS:8130	Conductors for insulated electric cables and flexible cords.
IS:5831	PVC insulation and sheath of electric cables.
IS:2982	Copper conductor in insulated cables and cords.
IS:3975	Mild steel wires, strips and tapes for armouring cables
IS:5609	Specification for low frequency wirers and cables with PVC insulation and PVC Sheath.
IS:6380	Spec. of elastomeric insulation of sheath of electric cables.
IS:434(I and II)	Specification for rubber insulation cables
IEC:540	The methods for insulations and sheaths of electric cables and cords (elastomeric and thermoplastic compounds).
IEC:230	Impulse tests on cables and their accessories.
IEC:287	Calculations of the continuous current rating of cables(100% load factor).
IEC:288	Nominal cross-sectional area and composition of conductor of insulated cables.
NEMA-WC-5	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
IEEE:383	Standard for type test for class IE electric cables, filled splices and connections for nuclear power generation stations.
IEC: 332-1	Test on electric cables under fire conditions.

ASTM-D-2843	Standard test method for density of smoke from burning/decomposition of plastics
ASTM-D-2863	Test for determination of Oxygen Index.
IEC-754-I	Test method for acid gas generation.
IEC-331	Fire resisting characteristics of electric cables.
SVENSK Standard	SS- 4241475 Class F3

3.00.00 DESIGN CRITERIA

- 3.01.00 The cables will be used for connecting control circuits.
- 3.02.00 Cables shall be generally laid on overhead cable trays/cable trays in cable trenches or drawn through rigid Steel pipe conduits. For interplant connection cables routed along overhead cable bridge.
- 3.03.00 Perforated type cable trays to be used for control cables. Only in cable risers ladder type cable trays can be used for control cables.
- 3.04.00 For continuous operation at specified rating, maximum conductor temperature shall be limited to the permissible value as per relevant standard and/or this specification whichever is more stringent.
- 3.05.00 The insulation and sheath materials shall be resistant to oil acid and alkali and shall be tough enough to withstand mechanical stresses during handling.
- 3.06.00 The inner and outer sheath shall have flame retardant low smoke (FRLSH) characteristics or fire survival characteristics as the case may be, and shall meet the requirements of additional tests specified for the purpose.
- 3.07.00 The cables shall be designed and manufactured in accordance with the best engineering practice and shall be such as has been proven to be suited for the intended purpose.
- 3.08.00 Minimum value of volume resistivity for PVC insulation shall be 3.5×10^{14} ohms-cm at 27°C room temp. and 3.5×10^{11} ohms-cm at 85°C.

For fire survival control cable, the armouring over inner sheath shall consist of single layer of wire/round galvanized steel wire as per IS 975 amended upto date.

4.00.00 SPECIFIC REQUIREMENTS / CONSTRUCTIONAL REQUIREMENTS**4.01.00 1100 V Copper Conductor HRPVC FRLS Control Cables**

1100 Volt grade, 85 deg C rating, control cables with stranded copper conductors, HRPVC Insulation, extruded HRPVC, FRLS Inner sheath, round wire/strip armour as specified elsewhere in the specification and extruded HRPVC, FRLS overall sheath. The cables shall be suitable for use in 1100V non-effectively earthed system. Control cable shall generally conform to IS 1554 latest and have ISI mark. Armour shall be GS.



4.01.01 Conductor

Conductor shall be stranded, high conductivity annealed, plain (untinned) copper conductor having 7 strands for 0.67 sq.mm control cables. Conductor shall be generally conforming to Class-II of IS 8130.

4.01.02 Insulation

The conductors shall be insulated with HRPVC compound conforming generally to type-C of IS:5831/1984 amended up to date ,except for the following special properties / parameters, necessary at normal operation and at 85⁰c maximum permissible conductor temperature. The maximum value of volume resistivity of insulation shall be 3.5×10^{14} ohms-cm at 27°C and 3.5×10^{11} ohms-cm at 85 °C.

4.01.03 Inner Sheath

The laid up insulated cores of twin and multicore control cables shall be provided with an inner sheath of extruded HRPVC, FRLSH compound conforming to Type ST2 of IS:5831/1984 amended up to date.

4.01.04 Armouring

For cables up to and inclusive 7 cores, galvanized round steel wire armour shall be provided. However, for control cables above 7 cores, galvanized steel strip armour shall be provided.

The armouring wire/strip shall generally conforming to IS: 3975 amended up to date.

For multicore armoured cables, the armouring shall be of galvanised steel as follows:

Calculated nominal dia of cable under armour**Size and Type of armour**

Upto 13mm

1.4mm dia GS wire.

Above 13 & upto 25mm

0.8mm thick GS formed wire/1.6mm dia GS wire.

Above 25 & upto 40mm

0.8mm thick GS formed wire/2.0mm dia GS wire.

Above 40 & upto 55mm

1.4mm thick GS formed wire/2.5mm dia GS wire.

Above 55 & upto 70mm

1.4mm thick GS formed wire/3.15mm dia GS wire.

Above 70mm

1.4mm thick GS formed wire/4.0mm dia GS wire.

4.01.05 Overall Sheath

A tough overall sheath of extruded HRPVC, FRLSH Compound conforming to type ST2 of IS: 5831/1984 shall be provided over armour. The colour of outer sheath shall be black or any other natural colour (with prior approval of the owner).

4.02.00 1100 V Copper Conductor Fire Survival Control Cables**4.02.01 Conductor**

Conductor shall be of stranded construction, consisting of high conductivity annealed tinned copper conductors conforming to IS 8130/1984 amended up to date.

A suitable heat barrier tape, preferably glass mica tape shall be provided over the conductor.

4.02.02 Insulation

The conductor insulation shall consist of heat resisting elastomeric material EPR (Ethylene Propylene rubber) and shall conform to Type IE-2 of IS:6380/1984 amended up to date.

4.02.03. Laying Up Of Cores (For Multi Core Cables Only)

The core shall be suitably identified in accordance with IS: 9968 (Part-I).

The suitable fire retardant material fillers shall be used for filling in the interstices.

Two layers of plain glass fiber binder tape shall be applied over the laid up cores.

4.02.04. Inner Sheath

An inner sheath of extruded special low smoke and very low halogen content (acid gas generation shall be less than 2% by weight) elastomeric (HOFR) compound of black colour or any other natural colour with prior approval from Owner conforming to Type SE-3 of IS-6380/1984, amended up to date, shall be provided over the laid up cores.

4.02.05. Armour

The armouring over inner sheath shall consist of single layer of wire/round galvanized steel wire as per IS 3975 amended up to date.

4.02.06. Outer Sheath

The outer sheath shall be of special low smoke and very low Halogen content (Acid gas generation shall be less than 2% by weight) elastomeric HOFR compound comprising of synthetic rubber and shall generally conform to the type SE-3 of IS:6380 latest revision.

The colour of outer sheath shall be black or any other natural colour agreed mutually between Owner.

5.00.00 GENERAL REQUIREMENTS**5.01.00 Drum Length & Tolerance**

The cable shall be supplied in wooden drums. Each drum shall be minimum 500 meters single length of cable. For above cable drums, allowable tolerance on individual drum length is +/- 5%.

1.1KV Copper Fire Survival control cables shall be supplied in wooden drums. Each drum shall be minimum 500 metres single length of cable. Allowable tolerance on individual drum length is $\pm 5\%$.

5.02.00 Non-standard length

Bidder will be required to obtain Owner's approval before packing the non standard length of cables on drums. Non-standard lengths shall not be less than half of the standard packing length in any case.

5.03.00 Cable identification

Cable identification shall be provided by embossing on every meter on the outer sheath the following:

- a) UPRVUNL
- b) Manufacturer's name or trademark
- c) Voltage grade
- d) Year of manufacture
- e) Type of insulation and sheath, e.g. HR85 for HR PVC/ FRLS, IE2/SE3/FS as applicable.
- f) No. of core and size of cables.
- g) Sequential length marking at an interval of 1m through out the length of the cable.
- h) ISI mark

Reference standard

Type of improved fire performance eg. FR/FR-LSH-FS

6.00.00 PACKING

6.01.00 Cables shall be supplied in non-returnable drums. The drums shall be of heavy construction as per relevant IS. All wooden parts shall be manufactured from seasoned wood. All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage.

6.02.00 Cable shall be wound and packed on drums in such a manner that it will be properly sealed and firmly secured to the drum. The ends of each length shall be sealed before shipment.

6.03.00 A label shall be securely attached to each end of the reel indicating the length, type, voltage grade, conductor size and number of core of the cable. A tag containing the same information shall be attached to the leading end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers shall be indicated on cable drums.

6.04.00 The cable drums should carry the following details in printed form (non returnable):

- a) UPRVUNL & Manufacturer's name or trade make
- b) Type of cable & voltage grade
- c) Year of manufacture
- d) Type of insulation / sheath e.g. HR85 for HRPVC/ FRLS, IE2/SE3/FS. as applicable.
- e) No. of core and size of cables.

- f) Cable code.
- g) Single length of cable on drum
- h) Direction of rotation, by arrow
- i) Approx. gross mass.
- j) ISI mark.

7.00.00 Testing Procedure**7.01.00 1100 V Copper Conductor HR PVC FRLS Control Cables****7.01.01 TYPE TESTS**

The type test as per applicable standards as given below shall be conducted on one drum selected on random basis out of every 10 drums or less of each type and size of cable (In presence of UPRVUNL representative). In case, facilities of any of the type tests are not available at the works of the supplier, then such type tests shall be carried out by the supplier at independent recognized Govt. approved laboratory at the cost of supplier.

- 1) Tensile test (for Aluminium) as per IS:8130
- 2) Wrapping test(for Aluminium) as per IS:8130
- 3) Persulphate test (on tinned copper wire) as per IS: 8130.
- 4) Test for armour wire/strip as per IS:3975

5) Test For Thickness Of Insulation And Sheath

Requirements and methods of tests for the thickness of insulation, inner sheath and outer sheath shall be as per IS: 1554 (Part-I) and IS: 5831/1984.

6) Tensile Strength And Elongation Test For Insulation & Sheath

This test shall be carried out as per IS: 5831 for PVC cable.

7) Ageing Test For Insulation And Sheath

This test shall be carried out as per IS: 5831/1984.

8) Loss Of Mass Test For HRPVC,FRISH Sheath

This test shall be carried out as per IS: 5831/1984.

9) Shrinkage Test For Xlpe Insulation & HRPVC,FRISH Sheath

This test shall be carried out as per IS: 5831/1984.

10) Hot Deformation Test For HRPVC,FRISH & Sheath

This shall be carried out as per IS: 5831 / 1984.

i) Cold Bend Test For HRPVC Insulation

This test shall be carried out as per IS: 5831/1984.

12) Cold Impact Test For HRPVC,FRISH Sheath

This test shall be carried out as per IS: 5831/1984.

13) Heat Shock Test For HRPVC Insulation , FRISH Sheath

This test shall be carried out as per IS: 5831/1984 and IEC-540 and IEC-502 and PVC Insulation & sheath shall pass the requirements of this test.

14) Thermal Stability Test For HRPVC Insulation ,FRISH Sheath

This test shall be carried out on cable of all voltage grades as per IS 5831 / 1984 and IEC 540 and cables shall pass the minimum requirements of 100 minutes for insulation and 80 minutes for sheath.

15) Test For Bleeding And Blooming Of Pigments For HRPVC,FRLSH Sheath

This shall be carried out as per IS: 5831 / 1984.

16) Fire Resistance Test

This test is compulsory for all cables and shall comply with the relevant clause of applicable IS.

17) Measurement of Insulation Resistance (Volume Resistivity) For HRPVC Cables

This shall be carried out as per IS: 5831 / 1984 but the values of volume resistivity of HRPVC insulated cables shall be not less than the values given below:

Min. Vol. Resistivity at 27°C temp.3.5 x 10¹⁴ ohm-cm.

Min. Vol. Resistivity at 85°C temp.3.5 x 10¹¹ ohm-cm.

18) High Voltage Test

This test shall be performed as per the relevant Indian Standard 1554.

19) Test For Rodent & Termite Repulsion Property Of Sheath

"A few chipping of the PVC compound is slowly ignited on a porcelain dish or cubicle in a muffle furnace at about 60 degree C. The resulting ignited ash is boiled with a little ammonium acetate solution (10%). Place a drop of aqueous sodium sulphide solution on a thick filter paper and allow to soak. Touch the spot with a drop of above extract. A black spot indicates the presence of lead, the anti-termite and rodent compound."

Or any other chemical method for detecting the presence of lead.

7.01.02 The normal sequence of the electrical tests shall be as per clauses 16.1.1 of IEC-502/1978. All the tests listed herein shall be applied successively to the same sample.

7.01.03 Special Tests On HRPVC 'FRLSH' Material

All the sizes of 1.1 KV Grade HRPVC insulated, HRPVC Control cables of the FRLSH sheathed type shall pass these special test requirements. Inner sheath wherever applicable shall also be of the 'FRLSH' type 'HRPVC' to meet these special tests.

i) Oxygen/Temperature Index Test On Sheath Material

This test shall be carried out as per American National Std. ASTM-D-2863/77. The minimum oxygen index shall be 29 at room temperature.

For determination of the temp index, the oxygen index test shall be carried out at different temperature upto 250°C. However, the test shall be carried out by extrapolation method beyond temperature at which the material of sheath may start deformation. The minimum temp. index (i.e. the temperature at which the oxygen index is minimum 21) shall be 250°C generally as per BICC Hand Book Chapter-6.

ii) Acid Gas Emission Test On Sheath Material

This test shall be carried out as per IEC Std. 754-1. The maximum acid gas emission shall be less than 20% by weight.

iii) Smoke Density Test On Sheath Material

This test shall be carried out as per American National Standard ASTM-D-2843/1977 and also as per UITP method (3M cube test on finished cable sample). **The ASTM test method is compulsory.** For passing this test, the requirement of light transmission shall be minimum 40% after the test (Corresponding to 60 % smoke density).

iv) Flammability Test On Finished Cable Sample

This test shall be carried out as per the following method :

Swedish Std.SS:424-14-75 Class-F3. (This test known as Swedish Chimney test is compulsory).

IEEE std. 383-1974 – This test known as the vertical tray flame propagation test shall be conducted if insisted by purchaser.

IEC Std: 332-1. – The cable should meet the requirement of all the above standards.

7.01.04 Routine Tests

The following tests shall be carried out as Routine tests on each and every drum length of cable, as per IS: 1554 / IS: 8130/1984.

- High Voltage Test.
- Conductor Resistance Test.

7.01.05 Acceptance Test

The following test shall be carried out as Acceptance Test in the presence of Owner's Inspecting Engineer on samples taken from the delivery lot. One drum out of every 10 number of drums or less shall be selected at random sampling basis for the Acceptance Tests.

1. Tensile / wrapping test.
2. High Voltage Test.
3. Conductor Resistance Test
4. Insulation Resistance/Volume resistivity test.
5. Measurement of thickness of insulation and sheath and other dimensions.
6. Tensile strength & elongation at break for insulation & sheath.
7. Flammability test as per Swedish standard SS: 424-15-75 Class-F-3 (Swedish Chimney test).
8. Acid gas generation test as per IEC-754-1.
9. Smoke density test as per ASTM-D-2843/1977.
10. Oxygen index test as per ASTM-D 2863/1977.
11. Temp. index test as per ASTM-2863/77

7.02.00 **1100 V Copper Conductor Fire Survival Control Cables**

7.02.01 **Type Tests**

The type test as per applicable standards as given below shall be conducted on one drum selected on random basis out of every 10 drums or less of each type and size of cable (In presence of UPRVUNL representative). In case, facilities of any of the type tests are not available at the works of the supplier, then such type tests shall be carried out by the supplier at independent recognized Govt. approved laboratory at the cost of supplier.

S No.	Name of Tests	Governing Standard	Special Requirements as per Purchaser's Specification
1	Annealing test (for copper)	IS:8130/1984	--
2	Persulphate test (for tinned copper)	IS:8130/1984	--
3	Conductor Resistance test	IS:8130/1984	--
4	Test for armour wires	IS:8130/1984	--
5	Test for measurement of DC Resistance of armour	---	--
6	Test for Thickness of insulation and sheath and other dimensions	IS:9968(i)	--
7	Tensile strength & elongation at break for insulation	IS:6380/1984	--
8	Tensile strength and elongation for sheath	IS:6380/1984	--
9	Ageing test for insulation		
	Air over	IS:6380/1984	--
	Air-Bomb		
	O ₂ - bomb	IS:6380/1984	--
10	Oil Resistance Test for sheath	IS:6380/1984	--
11	Water absorption test for Insulation (Elect.)	IS:6380/1984	--
12	Hot set test for insulation	IS:6380/1984	--



S No.	Name of Tests	Governing Standard	Special Requirements as per Purchaser's Specification
13	Measurement of Insulation Resistance constant (K-value)	IS:6380/1984	--
14	High Voltage Test		
	i) Water immersion test	IS:9968(I)	--
	ii) Spark Test		
15	Oxygen index test on inner & outer sheath material	ASTM-D-2863/77	MIN-29
16	Temp. index test on inner & outer sheath material	ATM-D-2863/77 IEC-331	Min 350°C
17	Acid gas emission test on inner & outer sheath material	IEC-754-1	Acid gas generation shall be less than 2% by weight.
18	Smoke density test on inner & outer sheath	ASTMD—2843/77 IEC-331	Max. smoke density in percentage light absorption shall not exceed 20%.
19	Flammability test on finished cable sample as per following method	IS:8130/1984	--
	i) 3 Hour Fire Survival test	IEC-331	--
	ii) Swedish Chimney Test	SS-424-14-75 75 9 (Class F3)	---
	iii) Vertical tray flame propagation test	IEEE383/74	---
	iv) Single Vertical cable fire Resistance Test	IEC-332-1	--

7.02.02 **Routine Tests**

The following test shall be carried out as Routine Tests on each and every delivery length of cable.

1. High Voltage Test - IS: 9968 (I)
2. Conductor Resistance test - IS: 8130/1984

7.02.03 **Acceptance Tests**

Following tests shall be carried out as acceptance tests in the presence of Owner's Inspecting Engineer on samples taken from the delivery lot. One drum out of every 10 drums or less shall be selected on random sampling basis.

1. Annealing Test - IS 9968 (I)
2. High Voltage test - IS 9968 (I)
(Water immersion Test)
3. Conductor resistance test - IS8130/1984
4. Insulation Resistance Test - IS6380/1984
- Measurements of thickness of Insulation and sheath and other dimensions - IS:9968(I)
6. Tensile strength & elongation at - IS 6380/1984



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- Break for sheath
7. Tensile strength and elongation at break of sheath - IS 6380/1984 --As per GTP
 8. Oxygen index test on inner & outer Sheath material at room temperature ASTM-D-2863/77 Min. 29
 9. Temp. index test on inner & outer sheath material degC IEC-331 ASTM-D-2863/77 Min 350
 10. Acid gas emission test on inner & generation outer sheath material shall be less than 2% IEC-754-1 Acid gas
 11. Smoke density test on inner & outer density sheath material percentage light ASTM-D-2863/77 Max smoke in
Absorption shall not exceed 20%.
 - Flammability test on finished cable Sample as per following method
 - i) 3 Hour fire Survival Test IEC -331
 - ii) Swedish Chimney Test SS-424-14-75 Class-F3)

9.00.00 SITE TESTS

The contractor shall carry out the following commissioning tests and checks after installation at site. In addition the contractor shall carry out all other checks and tests as recommended by the manufacturers.

1. Check for physical damage
2. Bimetallic lugs are used when connections are made between different materials (i.e. Copper & Aluminum)
3. Continuity check
4. Check connections.
5. Check for provision of correct cable tags, core ferrules, and tightness of connections.