SECTION – 2.02

POWER AND CONTROL CABLES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of power and control cables.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

a) 1.9/3.3 kV grade XLPE insulated armoured FRLS power cables between PCS to Inverter Duty Transformers
b) Cables for 11 kV Unearthed System**,** XLPE insulated, armoured, FRLS power cables shall be provided for the 11 kV unearthed system, including but not limited to the following systems:

- IDT to BESS yard Switchgear.
- BESS yard switchgear to MCR switchgear.
- MCR switchgear to 70 MVA transformer (Cable Box–1C).
- 70 MVA transformer cable box to Load Break Switch Panel
- Load Break Switch Panel to Neutral grounding system.
- Auxiliary transformers system.

c) Bidder shall refer conceptual SLD for minimum sizing requirements and number of runs. However same shall be finalized during detail engineering.
d) 1.1 kV grade XLPE insulated armoured FRLS cables
e) 1.1 kV grade PVC insulated armoured FRLS control cables
f) Earthing Wires
g) Shielded cables
h) Auxiliary cables

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and / or supplemented by this specification.

IS: 3975	Mild steel wires formed wires and tapes for armouring of cables.
IS: 5831	PVC insulation and sheath of electric cables.
IS: 7098 Part-I	Cross-linked polyethylene insulated PVC sheathed cables
IS: 7098 Part-II	Cross-linked polyethylene insulated PVC sheathed cables
IS: 8130	Conductors for insulated electric cables and flexible cords.

IS: 10418	Drums for electric cables.
IS: 10810	Methods of tests for cables.
IS: 3961	Recommended current ratings for cables
IEC: 60502-2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV).
IS:398	Aluminium Alloy Conductors.
IEC 60331, BS 6387, SS 299	Fire Resistance Test
IEC 60332, BS 4066, IEEE 383	Flame Retardant Test
IEC 61034, BS 7622, EN 50268	Smoke Emission Test
IEC 60754, BS 6425	Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content
ASTM D 2863	Oxygen Index Test.
IEC:332	Test on electric cables under fire conditions.
Indian Electricity Act and rules framed there-under.	
Regulations laid by CEA of India.	
Regulations laid by the office of the Chief Electrical Inspector to Government (CEIG).	

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Power cables shall be provided for the following systems:

- 11 kV unearthed system
- 415 V earthed system
- 230 V earthed system
- 110 V DC unearthed system
- 48 V DC earthed system
- 24 V DC earthed system

4.2.0 Power cables shall be sized to satisfy the following Criteria:

- Short circuit withstand capacity for applicable fault current and duration.
- Full load current carrying capacity under installation conditions considering Site ambient temperature& site installation (Grouping) conditions based on Manufacturer's recommendation.
- Permissible voltage drop limits under steady state/transient state as applicable. Voltage drop shall be limited to 3% for AC circuits and 1% for DC circuits.

4.3.0 Cables shall be armoured (except earthing cables/wires) type only.

4.4.0 Power cables shall be XLPE insulated. Control cables shall be PVC / XLPE insulated.

4.5.0 PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90 °C and short circuit conductor temperature of 250 °C.

4.6.0 Cables for 11 kV system shall be rated for 11/11 kV unearthed grade. Cables for 415/230 V AC shall be rated for 1.1 kV grade.

4.7.0 For 3 Phase, 4 Wire power system, Neutral conductor size shall be of same size as the phase conductors' size. Half neutral shall not be acceptable.

4.8.0 To minimize the damage that can be caused by a fire, conductors installed in electrical cable tray systems shall have jackets which have non-propagating, self-extinguishing flame retardant, low smoke (FRLS) characteristics. Outer sheath shall be of PVC black in colour. These cables shall meet the following test requirements.

- Oxygen index of minimum 29 when tested as per IS 10810 Part-58
- Temperature index of minimum 250°C when tested as per IS 10810 Part-64
- Acid gas emission of maximum 20% when tested as per IS 10810 Part-59 Average light transmission of 40% minimum when tested as per IS 10810 Part-63 (average smoke density is maximum 60%)
- Flame test requirements as per IS 10810 Parts-53 and 62
- Flame retardant test requirements as per IS 10810 Part-61

4.9.0 For power cables, copper conductor shall be used for current rating of up to 16 A. For higher current rating, conductor can be aluminium/copper. Minimum size of copper conductor shall be 2.5 sq. mm and aluminium conductor shall be 6 sq. mm.

4.10.0 Conductor of control cables shall have plain annealed copper. The minimum size of control cable shall be of 1.5 sq.mm. For CT circuit minimum size shall be 2.5 sq.mm copper. Control cables shall have 20% spare cores.

4.11.0 Current transformers lead shall be checked for the lead burden vis-a-vis the current transformer VA capacity and knee point voltage. Minimum 2.5 sq.mm copper cables shall be used for connection of CT to load. In case 2.5 sq.mm size impose unacceptably high burden on CTs, 4 sq.mm copper shall be used. Voltage transformer leads shall be checked for voltage drop which shall be limited to within 1% for all cases other than tariff metering. For tariff metering the voltage drop shall be limited to 0.2%. In case the voltage drop with 2.5 sq.mm copper conductor exceeds this value; higher conductor sizes shall be used.

4.12.0 For instrument transformers used for tariff metering purpose, lead wires from instrument transformer secondary terminal box shall be directly terminated to metering panel No intermediate junction boxes shall be allowed in lead cables.

4.13.0 Power cables shall carry the full load current of the circuit continuously under site conditions considering the various derating factors like thermal resistivity of soil, ambient air/ground temperature, grouping, method of laying, etc.

4.14.0 Design ambient air temperature and ground temperature shall be considered at 50°C and 40°C respectively for cable sizing.

4.15.0 Power cables shall be sized to withstand the fault current of the circuit for the fault clearing time indicated below:

- All power cables: 1 second.

4.16.0 For 11 kV cables, screen of each core shall be sized to withstand system earth fault current for 1 second.

4.17.0 Signal cables shall be used for control and instrument circuits that require shielding to avoid induced currents and voltages.

4.18.0 Control cables shall have annealed copper conductor with minimum size of 1.5mm^2.

4.19.0 Signal cables shall have annealed copper conductor with minimum size of 0.5mm^2.

4.20.0 At least two (2) cores shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be four (4) for control cables of 10C or higher size. In each signal cable, two (2) pairs conductors shall be provided as spare.

4.21.0 While preparing cable schedules for control / protection purpose following shall be ensured:

- Separate cables shall be used for AC and DC circuits
- For different cores of CT and VT, separate cables shall be used
- Two separate cables shall be used from each relay panel, each 11 KV board etc. for main & redundant control supply.

While preparing schedule of power cables following shall be ensured:

4.22.0 11KV cable to be laid between BESS yard & MCR.

4.23.0 Method of curing for XLPE insulation shall be gas curing.

4.24.0 Conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied with XLPE insulation in one operation through triple extrusion.

4.25.0 For armoured cables, armouring shall be of aluminium for single core cables. For multicore armoured cables, armouring shall be of galvanised steel.

4.26.0 All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added into the PVC compound of the outer sheath. The sheath shall be resistant to water, UV radiation, fungus, etc.

4.27.0 Multi-core cable color coding shall be as follows:

- Red, yellow, blue for three core cable
- Red, yellow, blue, black for four core cable
- Red, yellow, blue, black and gray for five core cables
- Outer sheath shall be of black in colour.
- For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.

4.28.0 Three core 11/11 kV unearthed grade, cables shall constitute the following:

- Circular stranded and compacted aluminium conductor
- Extruded semi conducting compound as conductor screen
- Extruded XLPE insulation
- Extruded semi conducting compound as insulation screen
- Copper tape as metallic screen for each core
- Extruded PVC inner sheath
- Galvanized steel formed wire/strip
- Extruded FRLS PVC outer sheath
- Core identification shall be color coded (R,Y,B)
- Min Bending Radius: 20D (min.)

4.29.0 Multicore 1.1 kV earthed grade cables shall constitute the following:

- Circular / shaped, stranded aluminium conductor (compacted for >10 sq.mm)
- Extruded XLPE insulation
- Extruded PVC inner sheath

- Galvanized steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.30.0 Single core 1.1 kV earthed grade cables shall constitute the following:

- Circular stranded and compacted aluminium conductor
- Extruded XLPE insulation
- Hard drawn aluminium wire armour
- Extruded FRLS PVC outer sheath

4.31.0 Single core 1.1 kV unsheathed cables with flexible conductors (for Earthing purpose) shall constitute the following as per IS 694 / 2010 or, latest:

- Multi stranded annealed bare copper conductor
- Un-armoured
- Extruded FR PVC insulation
- Colour: Green
- Packing:100m Coils packed individually in boxes and collectively in corrugated outer box

4.32.0 Multicore 1.1 kV earthed grade control cables shall constitute the following as per IS:1554-1 / 7098-1:

- Multi stranded annealed copper conductor
- Extruded PVC / XLPE insulation
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.33.0 Multi pair 1.1 kV earthed grade, overall screened signal cables shall constitute the following as per BS EN 50288-7:

- Multi stranded annealed copper conductor
- Extruded PVC insulation
- Twisted pair
- Overall polyester taped, Al-mylar screened with ATC drain wire
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.34.0 Multi pair 1.1 kV earthed grade, individual and overall screened signal cables shall constitute the following as per BS EN 50288-7:

- Multi stranded annealed copper conductor
- Extruded PVC insulation
- Twisted pair
- Individual polyester taped, Al-mylar screened with ATC drain wire
- Overall polyester taped, Al-mylar screened with ATC drain wire
- Extruded PVC inner sheath
- Galvanized steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.35.0 Signal Cable Minimum Specification (Conductor size, numbers of pairs shall be as finalized during detailed engineering) as per IS: 1554 (Part-I)/1998 & BS 5308:

- Overall Sheath
  a) Type : Extruded FRLS PVC Compound Type ST2 as per IS 5831
  b) Sheath Thickness: 1.5 mm(min.)
  c) Colour : Blue/Black/Gary

- Inner Sheath
  a) Type : PVC Compound Type ST1 as per IS 5831

b) Colour: Black
c) Thickness :1.0mm(min.)

- Armoured
  a) Type : GI Flat Strip / GI wire
  b) Armour Overall Diameter : shall be as per OEM

- Overall & Individual Pair shield and drain wires
  a) Shield : Aluminium backed myler/polyester tape with 25% overlap and thickness 0.075mm
  b) Drain wire : 0.5 mm^2 multistrand, tinned annealed copper conductor

- Pair Identification:
  Each twisted pair must have either different colour combination or, Pair No. for better identification
- Conductor
  a) Conductor Metal : Annealed Tinned Copper as per IS 8130
  b) Mutual Twist : More than 10 Twist per meter for pair

- Delivery Length: 1000 MTRS + 5% (Continuous without any joint)
- Conductor Resistance: 40 OHM/KM AT 20 °C
- Insulation Resistance : 5000 MEGA OHM/KM AT 20 °C
- Min Bending Radius: 12D (min.)
- Test Voltage AC: 1.5 kV AC between cores and 1 kV AC between cores and shield for 1 minute.

4.36.0 Flexibility Class for (as per IS 8130) shall be:
Solid conductors: Class 1
Stranded conductors: Class 2
Flexible conductors: Class 5

4.37.0 Single core multi run cables shall be laid as mentioned in clause 8.8 in Section-3 of IS 1255.

4.38.0 No Joints shall be permitted in any of the cables. Cable end termination kit & jointing kit (if unavoidable) shall be of approved make & shall be installed by OEM certified jointer.

4.39.0 **Cable drums**

Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with waterproof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails to eliminate ingress of water during transportation, storage, and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

All the cables shall be in bidder scope, which includes the additional cable requirement and the cables utilised for testing purpose. No additional cost shall be provided by the employer for additional cable requirement. Cable joints shall be avoided.

The cables in drum shall be of continuous length without any joints. Packing and marking on each cable drums shall be as per IS 7098 Part-I & II

4.40.0 **Cable identification system**

a) In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed/printed on the outer sheath at an interval of one (1) meter throughout the length of cables.

- Owner: GIPCL
- BIS mark
- Manufacturer's name and or trade mark.
- Year of manufacture
- Cable code
- Type of cable and voltage class.
- Nominal cross section area of conductor and no. of cores.
- Progressive sequential length making.

b) Cables shall be marked as having FRLS outer sheath at every five (5) meters.
c) The embossing/printing shall be progressive, automatic, in line and marking shall be legible and indelible.

d) Multi-core cable color coding shall be as follows:

- Red, yellow and blue for three core cables
- Outer sheath shall be of black in colour.
- For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.
- For multi pair cables, each pair shall be coloured and numbered.

5.0.0 **TESTS**

Cables offered shall be type tested and proven type. Routine tests shall be carried out on 100% drums. Acceptance tests shall be carried out on no. of drums selected on random basis in the lot as per IS 7098 Part-I (Appendix-A) & Part-II (Annexure-D), of each type and size of cable of each lot. EPC contractor / Cable manufacturer shall provide the Type Test & Special Test reports as per Cl. No. 12.2 of IEC-62067. 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. Type test reports shall be latest and validity of type test reports shall be as per CEA guidelines.

The tests mentioned below are indicative. The cables shall be tested for any other tests mentioned in relevant IS including the latest amendments.

5.1.0 **Type Test**

a) Tests on conductor (as per IS 8130)

i) Annealing Test (for copper if any)
ii) Tensile test (for aluminium)
iii) Wrapping test (for aluminium)
iv) Resistance test

b) Tests for armour wires/strips (as per IS 3975)
c) Tests for thickness of insulation and sheath
d) Physical tests for insulation

i) Tensile strength and elongation at break
ii) Ageing in air oven

iii) Shrinkage test
iv) Hot test
v) Water absorption (gravimetric)

e) Physical test for outer sheath

i) Tensile strength and elongation at break
ii) Ageing in air oven
iii) Shrinkage test
iv) Hot deformation
v) Heat shock test
vi) Loss of mass test in air oven
vii) Thermal heat stability test (as per IS : 5831)
viii) Bleeding and blooming test

f) Anti-termite and anti-rodent test (on outer sheath).
g) Partial discharge test
h) Bending test
i) Insulation resistance (volume resistivity) test
j) Dielectric power factor test
i) As a function of voltage
ii) As a function of temperature

k) Heating cycle test
l) Impulse withstand test
m) High voltage test
n) Flammability test
o) Cold impact test

5.2.0 **Acceptance Test**

a) Annealing test (for copper)
b) Tensile test (for aluminium)
c) Wrapping test (for aluminium)
d) Conductor resistance test
e) Test for thickness of insulation and sheath
f) Hot set test for insulation
g) Tensile strength and elongation at break test for insulation and outer sheath
h) Partial discharge test (for screened cables)
i) High voltage test
j) Insulation resistance (volume resistivity) test
k) Tan Delta for MV / HV power cables.

5.3.0 **Routine Test**

a) Conductor resistance test
b) Partial discharge test
c) High voltage test

5.4.0 **Special Test**

a) Oxygen index test as per IS 10810 Part-58
b) Temperature index test as per IS 10810 Part-64
c) Acid gas generation test as per IS 10810 Part-59
d) Smoke generation test as per IS 10810 Part-63
e) Flammability tests as per IS 10810 Parts-53 and 62
f) Flame retardant test as per IS 10810 Part-61

5.5.0 **Site Test**

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a) Insulation resistance test
b) Tan Delta for MV / HV Power Cables.
c) High voltage test

All cables before laying shall be tested in cable drum at site. After laying of cables it shall again be tested to check for any damage of cable during laying.

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Cable sizing calculation
- General arrangement drawings
- Technical data sheet
- Test reports
- Catalogues
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan
- Conformity Certificates to be submitted (from NABL accredited lab)
- Short circuit withstands calculation of metallic screen and conductor.