

VOLUME-2
PART- I
Section-22
Power, Control and
Instrumentation Cables

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22. Power, Control and Instrumentation Cables

22.1 Intent of Specifications

The intent of these specifications is to define the scope of work under this section which covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, storage at site, erection, acceptance testing, commissioning, performance testing, handing over to Purchaser Limited and guarantee for trouble free operation of Power, control and Instrumentation cables, cable trays and all accessories for Keyi Hydro Electric Project, Arunachal Pradesh as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

It is not the intention to specify the minute details/smallest items to deliver a functional system or to define the standard manufacturing practice but to outline the performance, constructional, operational and guaranteed requirements. It is the responsibility of the contractor to ensure these requirements.

22.2 Scope of Supply

22.2.1 Material

- 12 kV XLPE power cable (High voltage cable)
- 1100 volt XLPE grade power cable (Low voltage cable)
- Control cables
- Instrumentation cables
- Galvanized cable trays of steel and perforated type, cable terminals, termination kits, cable lugs, cable glands, cable junction boxes and all other accessories.

22.2.2 Cable routing and support systems

- One set of cable support system including cable trays / hangers, fixtures, hardware etc. for supporting all the cables along the entire length of cable,
- Spare parts shall be discussed separately.
- Special Tools and instruments, if applicable

22.2.3 Services

- Transportation and delivery to site including all logistics and proper site storage and preservation as per manufacturer's recommendation.
- Site installation and commissioning
- Field / touch-up painting including all painting materials

- Performance and field acceptance testing as per the relevant clause of this section and submission of report
- Training of Purchaser's personnel including operation and maintenance staff
- All the technical documentation including preparation and submission of O & M manuals

22.3 Specific Parameters and Layout Conditions

22.3.1 Layout and General Arrangement

1. The 12 kV XLPE power cables shall be required to interconnect the following equipment:
 - Two (2) nos. Generator phase end terminals to 11 kV panels with 11 kV circuit breakers through multi run cables per phase
 - Two nos. Generator neutral end terminals to Neutral Grounding cubicle through multi-run cables per phase
 - 11 kV panels to and from
 - Two (2) nos. 15 MVA, 11/132 kV GTs,
 - Two (2) nos. 500 KVA, 11/0.433kV station auxiliary transformers (SATs),
2. 415V/240V AC and 110V DC cables shall be required to connect / interconnect the following in powerhouse complex, switchyard and other areas in the vicinity of powerhouse
 - Different auxiliary service boards,
 - Various distribution boards to local control cubicles/ equipment.
3. Control, instrumentation, coaxial and communication cables shall include all cables required for the installation of the complete instrumentation, control, protection and communication systems in the powerhouse complex, switchyard and other areas near powerhouse
4. Power, control cables at intake areas for the equipment supplied by the EM contractor.

22.4 Design considerations

The number of cores and sizes of the cables required for various circuits shall be worked out during detailed engineering.

However, minimum sizes for the following cable conductors shall be taken as:

- 1.5 mm² copper for control cable conductor,
- 1.5 mm² copper for annunciation and RTD cable conductor,
- 5 core x 4 mm² copper for connection between CT junction boxes and panels with one core remaining spare
- 5 core x 2.5 mm² copper for connection between PT junction boxes and panels with one core remaining spare

The cables covered by this specification shall be supplied in one length or in standard lengths as approved by the Purchaser.

All 11 kV XLPE cables shall be single core, unearthed, Al. conductor un-armoured. The cables shall be laid in cable trenches / cable trays.

Normally all LV cables will be un-armoured and will be laid on cable trays. However, any cable laid directly (without cable tray/pipe etc.) either underground or overhead shall be of armoured type. The armouring shall always be earthed at one end to ensure that it cannot become live if a fault develops within the cable.

For single core armoured cables, armouring shall be of aluminium wires. For multi-core armoured cables, armouring shall be of galvanized steel

All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady State and transient operating conditions as specified elsewhere in this specification.

Power cables shall be chosen taking into account the following factors:

- System Fault level.
- Maximum time for fault clearance (i.e., operating time of the backup protection relays plus the time of operation of the circuit breakers).
- Full load current of the circuit.
- Short circuit current and duration (for breaker protected cables).
- Installation conditions.
- Voltage drop under normal running condition shall not be more than 5%.
- Voltage drop at motor terminals during starting shall not be more than 10%.
- The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.

22.5 Rating and Functional Characteristics

The type and rating of cables shall be as detailed below:

Particulars		Power Cables		Control cables	Instrumentation cables
		11kV	LT		
a)	Applicable standard	IS: 7098/IEC (Part-II)	IS: 7098 (Part-I)/ IS: 1554/IEC:60502	IS: 1554/IEC	IS: 1554/IEC
b)	Voltage grade	12/12kV	1.1 kV	1.1 kV	1.1 kV

c)	Whether earthed or unearthed grade	Unearthed grade			
d)	Conductor				
i)	Material	Stranded Copper/ Aluminium	1) Stranded Copper for cables below 10 sqmm & all cables used in DC system. 2) Stranded Copper for cables used in governor, MIV, excitations. 3) All other cables above and including 10 sqmm shall be stranded Aluminium.	Stranded plain annealed copper	Stranded plain annealed copper
ii)	Size	As required, based on design criteria		As per standard. Minimum 1.5 sqmm.	Minimum 1.5 sqmm.
iii)	Shape	Circular/sector shaped Circular only for 11 kV cables	Circular/sector shaped.	Circular/sector shaped.	Circular/sector shaped.
e)	Cores	Single cores as per requirement	Single or three or three and a half cores as per requirement	Multi cores	Multi cores
f)	Main Insulation				
i)	Material	Extruded XLPE	Extruded XLPE	Extruded PVC	Extruded PVC
ii)	Continuous withstand temperature (deg. C)	90	90	70	70

iii)	Shot circuit withstand temperature (deg. C)	250	250	160	160
iv)	Colour identification	As per relevant standards			
g)	Inner Sheath	All armoured and multi core unarmoured cables shall have distinct extruded inner sheath.			
i)	Materials	XLPE	PVC	PVC	PVC
ii)	Colour	Black	Black	Black	Black
h)	Conductor screen material	Extruded semi-conductor compound with a layer of non-magnetic metallic tape.	NA	NA	Aluminium Mylar tape of minimum thickness of 0.075mm with 20% overlapping to give 100% coverage. An ATC drain wire of 0.5 mm ² shall be provided below Al-Mylar tape.
i)	Armouring				
i)		Armoured	Cables buried directly in ground, cables laid in outdoor pothead yard, interconnection between outdoor pothead yard & powerhouse & all outdoor areas shall be armoured. All other cables shall be unarmoured.		
ii)	Materials	Aluminium wire for single core cable and GS wire/flat for multi core cables as per relevant IS/IEC. Minimum Coverage of 90%.		GS wire/flat as per relevant IS. Min. coverage of 90%.	
iii)	Breaking load of joint	95% of normal armour		95% of normal armour	

j)	Outer sheath	All power & control cable shall have extruded outer sheath			
i)	Material (Polyethylene based halogen free material not acceptable)	PVC	PVC	PVC	PVC
ii)	Colour	Black	Black	Grey	Grey
iii)	Marking	Cable size & voltage grade (by embossing) Word “FRLS” @ 5m (by embossing) Sequential marking @ 1m.		Cable size & voltage grade (by embossing) Word “FRLS” @ 5m (by embossing) Sequential marking @ 1m.	
k)	FRLS Properties on outer sheaths	Oxygen Index : Min. 29 (As per ASTMD 2863) Acid gas generation : Max. 20% (As per IEC754-I) Smoke density rating: 60% (As per ASTMD 2843) Temperature Index : Min. 250 degree C (As per ASTM D 2863)			
l)	Flammability test on all types of cables	As per Swedish chimney test F3 as per SEN 4241475 As per IEC 332 Part-3 (Category B)			
m)	Minimum no. of spare cores	Nil	Nil	2C/4C: Nil 5C: 1 7C-10C: 2 14C-19C: 4 20C and above: 20%	

22.6 Performance Guarantee

The power, control and instrumentation cables along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

22.7 Design and Construction

22.7.1 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Standards	Description
IEC 61537	Cable tray systems and cable ladder systems for cable management
IEC 60331	Tests for electric cables under fire conditions
IEC 60332	Test on electric and optical fibre cables under fire conditions
IS 1554	Specification for PVC insulated (heavy duty) Electric cables
IS 7098 (Part I & II)	Specification for cross linked polyethylene insulated PVC sheathed cables for working voltage up to 33 kV
IS 1255	Code of practice for installation and maintenance of power cables up to and including 33kV rating
IS 5831	PVC insulation and sheath of electric cables
IS 10810	Methods of test for cables
IEC 60754	Test on gases evolved during combustion of electric cables
ASTM-D-2843	Standard test method for density of smoke from burning or decomposition of plastics
IS 10810 Part-58	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics
IS 3961 Part II	Recommended current ratings for cables

22.7.2 Power Cables

22.7.2.1 12 kV system

XLPE cables for 12 kV system shall be of suitable size, single core, heavy duty, unearthed, stranded, Aluminium conductor and shall be provided with semi-conducting conductor shield, XLPE insulation , semi-conducting insulation shield, copper tapped metallic shield if applicable and PVC outer sheath conforming IS: 7098 (Part - II).

The semi-conducting conductor shield shall ensure perfectly smooth profile and avoid stress concentration. The conductor shield shall be extruded in the same operation as the insulation.

The insulation shall be extruded type and manufacturing process shall ensure that insulation is free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method shall give very smooth interface between semi-conducting conductor shield and insulation.

A non-magnetic semi-conducting insulation shield shall be applied over insulation to confine electrical field to the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion process.

A copper tape/wire metallic shield shall be put over non-metallic insulation shield.

An extruded PVC outer sheath shall be applied over metallic shield with suitable additives to prevent attack by rodents and termites.

XLPE insulation shall be suitable for continuous conductor temperature of 90 deg C and short circuit conductor temperature of 250 deg C.

The cables shall be subjected to type, routine and acceptance tests as per applicable standard.

22.7.2.2 1100 volts grade

All single core and multi core cables shall be XLPE insulated. The cables for low voltage A.C. & D.C. system shall conform to IS: 7098 (Part I). These cables shall be 1100 volts grade, heavy duty, aluminium conductor as specified, heat resistant XLPE insulated, colour coded laid up, unarmoured/armoured, inner & outer extruded PVC sheath. The outer sheath shall be of specially formulated PVC compound having oxygen index, smoke density, acid gas and flame propagation properties as applicable for standards for FRLS cables. All the materials used for conductor and insulation shall be new and of requisite quality. Necessary tests during the manufacture shall be conducted to establish conformity with standards.

22.7.3 Control and instrumentation cables

All control & instrumentation cables shall be Fire Retardant Low Smoke type (FRLS).

All the control cables shall be copper conductor, HR-PVC insulated, PVC sheathed, unarmoured, 1100 volts grade. All the material used for conductor and insulation shall be new and of requisite quality. The conductor shall be of high conductivity Annealed single conductor copper.

The instrumentations cables in addition to meeting the requirements of control cables shall be provided with electrostatic shielding by aluminium tape and screening by annealed tinned copper wire.

22.8 Colour scheme and identification

To facilitate easy identification of phases a colour scheme of red, yellow and blue for phases and black for neutral shall be adopted for power cables. Multi-core control cables shall be colour coded for identification of cores as per IS: 1554 1988 / IEC.

All the cables shall carry manufacturer data in a permanent, legible manner at an interval of at least three (3) meter run. The manufacturer's data shall include the name, cable size, and voltage rating together with any other information. Permanent sequential marking to indicate length of the cable shall be embossed at every meter.

22.9 Accessories

22.9.1 Jointing Boxes/Jointing Kits

No joints in the newly laid cable are permitted. Straight through joints in the run of old power cables, wherever unavoidable, may be made through joint boxes provided the design of the jointing boxes ensures that the actual insulation strength between phases and to earth is greater than that of the associated new cable and eliminates any possibility of moisture entering the joint or the compound surrounding the joint. Provision shall exist for binding the sheaths of the two cables being joined solidly by approved means to ensure the electrical continuity of the sheath from one end of the cable run to other. Full details of the Jointing Boxes and of the Joints including dimensions shall be given.

The Jointing Boxes shall comply in all aspects with the provision of the latest issue of relevant standards.

22.9.2 Termination kit

The termination kits required for 12 kV XLPE cables terminations shall be heat shrinkable type. Any other latest type having proven performance in the field can also be accepted subject to approval of Engineer.

The Contractor shall supply all hardware consumables such as plumbing metal, sealing compound, tapes and other materials required for the making of these terminal connections of various sizes of cables and should leave at least 5% of these items for future use by the Purchaser.

22.9.3 Cable lugs

The Contractor shall ensure that no bimetallic action takes place, between the conductor of the cable and the cable-connecting lug by filling the lugs with suitable compound. The lugs shall be of standard quality conforming IEC / IS and of make approved by the Engineer.

22.9.4 Cable glands

The cable glands shall be made of brass duly electro tinned in order to avoid corrosion and oxidation of the surface. Glands shall provide neat, tight, dust and vermin proof termination. Gland shall be provided with rubber ring to hold the cables firmly when check-nut is slightly tightened. Gland shall be complete with suitable washers etc.

22.9.5 Compression type terminals for control wiring

These terminals are required for copper conductor of control wiring. They shall be crimped to the conductor while other end will provide flat surface for better connections. The connectors shall be made of Copper electro tinned.

22.9.6 Aluminium strip

Aluminium strip of adequate size for making tags for labels shall be supplied.

22.10 Cable trays and support structure

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized after fabrication as per relevant IS.

Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be minimum 3 mm .

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of minimum thickness 2 mm and shall be hot dip galvanized after fabrication as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.

22.11 Support System for Cable Trays

The erection of support system for cable trays is not included in the scope of cable supplier.

22.12 Fire Proofing

Cables passing through different fire zones shall be provided with fireproof barriers with the same fire rating as the penetrated walls or partitions.

22.13 Cable junction boxes

Junction box shall be constructed of sheet steel of thickness not less than two (2) mm. Ample wiring space shall be provided at the sides, and back of the enclosure for incoming and outgoing circuits.

Removable plates with gaskets shall be fitted at the top and bottom of the box to provide the entry for conduit or cable. The door shall be provided with suitable gasket and fitted with a lock type handle. The door shall be hung on hinges having brass bodies and stainless steel pins.

Each cable junction box shall be provided with terminals of adequate rating on the terminal strip of suitable thickness.

22.14 Inspection and Tests

The tenderer shall submit with the tender, copies of test certificates for the type tests as stipulated in IS: 7098, IS: 1554 (Part - I) and relevant IEC, carried out either in the manufacturer's works or any approved Laboratory. The test reports must not be older than 5 years in respect of all sizes of cables.

The purchaser may at his discretion get the cables tested for any/all type/special tests. The tenderer shall therefore indicate charges if extra, for carrying out type/special tests.

Before despatch, sample pieces of the cable shall be subjected to all types of routine, acceptance and FRLS tests at the manufacturer's works as stipulated in IS : 7098, IS : 1554 (Part - I)/IEC in the presence of purchaser or his representative. The tenderers must clearly indicate the details of testing equipment and other testing facilities available in their works. Offers from tenders with inadequate testing facilities shall not be considered.

The following FRLS tests are to be conducted:

- HCL gas evolution test (IEC - 60754.1)
- Oxygen Index (ASTM-D-2863)
- Temperature Index (ASTM-D-2863)
- Smoke density test (ASTM-D-2863)
- Flammability test (IEC-60332.1)

- Swedish Chimney test (SS-4241425)
- Ladder test (IEEE383)

Copies of manufacturer's test certificates shall be submitted to the purchaser as soon as the tests are completed. The purchaser reserves to himself the right of having, at his expense, any inspection or tests of a reasonable nature carried out at the contractor's premises or at site, in addition to the aforesaid tests and the tests included in the contract, to satisfy himself that materials comply with the requirements of the specifications. The cost of samples required for such tests shall be borne by the contractor. All test reports shall be got approved from the purchaser before despatch of material by the contractor.

22.15 Drawings, Documents and Design Calculations

22.15.1 Design memorandum

The Contractor shall submit to Purchaser a design memorandum prepared in accordance to "Section 1-General Technical Specifications of the proposed equipment /system fulfilling the contract specification/requirement for approval prior to submission of drawings and documents. The design memorandum shall include the design philosophy, methodology, system description, input parameters for design, standards and codes, design & selection criteria, equipment data, material specification, major technical features, basic arrangement / layout etc.

22.15.2 Drawings and documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in "General Technical Specification (GTS)".

These drawings and documents shall include at least the following:

- Dimensional and constructional details of each size of cable
- Cable catalogue of HV voltage XLPE cables
- Cable catalogue of LV voltage PVC cables
- Cable catalogue of LV voltage XLPE cables
- Dimensional and constructional details of each type of cable accessories
- Dimensional and constructional details of cable trays of each type and size
- Catalogue of cable trays

22.15.3 Design calculation

The Contractor shall submit the design calculation in accordance with "General Technical Specification (GTS)" covering at least the following, for review / acceptance.

- Calculation for fault level and short circuit calculation for selecting the cable size,

22.16 Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.8 “packing and transportation”, clause 1.9 “site installation and erection” & clause 1.10 “site inspection & tests” of “Section 1 - General Technical specification”

22.16.1 Construction methodology

22.16.1.1 Fixing of supports

The embedment in powerhouse and switchyard for fixing cable racks and cable trays are not included in the scope of cable contractor but furnishing of relevant drawings for providing embedment are included in the scope of contractor

22.16.2 Special tools

The Contractor shall propose the list of special tools including their make and detailed specification as recommended by manufacturer(s), to be accepted by the Purchaser.

22.17 Quality Assurance and Testing

The bidder shall submit the quality assurance plan along with bid for approval of the purchaser. The Contractor shall follow the quality assurance and testing requirements as per quality assurance plan approved by the purchaser.

22.18 Guaranteed and Technical Particulars

Guaranteed and Technical Particulars as called for in Vol. VI shall be furnished along with the bid. Bids lacking in this may be considered unresponsive. Particulars subject to guarantees shall be clearly marked.

22.19 Completeness of Equipment

All fittings and accessories of the Power and Control Cables and associated auxiliary and ancillary equipment that may not have been specifically mentioned in these specifications but are usually necessary for completion of above equipment, shall be deemed to be covered by the specification and shall be indicated and furnished by the contractor without any extra charges to the purchaser.

22.20 Deviation from Specifications

While the purchaser does not bind himself to accept any deviation, due consideration will be given to any special devices or equipment put forward by the supplier with a view to increase the efficiency of the equipment and minimize the maintenance cost of the equipment as a whole.

Should the supplier wish to depart from these specifications, he shall submit a complete and itemized list of such deviations, together with full particulars of the reasons for the deviations in a separate schedule with special reference to clause and paragraph nos. of this specification. Unless this is done

and the purchaser's concurrence in respect of such deviations is obtained in writing, the equipment offered shall be deemed to comply in every respect with these specifications.