SPECIFICATION NO. 15

SMALL WIRING

CONTENTS

1 GENERAL CONDITIONS

1.1 Scope

This specification describes the requirements with which the manufacturer shall comply in order to supply 600 V multi-core control cable, copper conductor, flexible metallic sheath, non fuel base material insulated and non toxic, low smoke, halogen free (LSOH) material jacketed

1.2 Reference Standards

All equipment required within the scope of works shall conform as a basic requirement with the latest edition of the following standards:

IEC 60068	:	Environmental testing
IEC 60947-7-1	:	Low voltage switchgear and controlgear – Part 7-1 : Ancillary equipment -Terminal blocks for copper conductors.
NEMA WC5/ICEAS-61-402	:	Thermoplastic-insulated wire and cable for the transmission and distribution of electrical energy
ASTM B3	:	Standard specification for soft or annealed copper wire
TIS 838	:	Standard for control cables

The latest edition of each standard shall mean the edition available on the date of signing the Contract.

1.3 Principal Requirements

1.3.1 Service Conditions

Cable insulating material shall be suitable for installation in wet and dry locations.

1.3.2 Site and Service Conditions

The equipment shall be capable of operating at its full ratings under site and service conditions as mentioned below.

The switchgear room has no air conditioning system.

Seismic activity:	None
Maximum wind speed:	(≈100 km/h)
Maximum recorded rainfall:	250 mm/day
Number of days with thunderstorm:	100 days/year
Average rainfall:	20 mm/day
Mean maximum annual relative humidity:	94%

Mean minimum annual relative humidity:	79%
Minimum daily relative humidity:	17%
Maximum temperature of surfaces exposed to sunbeam:	80°C
Mean minimum daily temperature:	24°C
Maximum ambient temperature:	40°C(1)
Minimum ambient temperature:	11°C
Maximum ambient temperature in trench for Control cables	65°C

(1) according to IEC 60694 over 40oC will be possible under special requirement.

1.3.3 Design Requirements

The maximum continuous current-carrying capacity of each individual cable type and cross-section used shall be determined, taking into account Site conditions. The resulting load reduction factors are subject to the approval by the Authority.

The conductor cross-section of each cable shall be adequate to carry the fault currents determined by the relevant short-circuit protection device when operating under the specified load conditions, without deterioration of the dielectric properties. Calculation including the short-circuit calculations, shall form part of the documents to be supplied by the Contractor.

2 600 V CONTROL CABLE AND 600 V SWITCHBOARD WIRE

2.1 Control Cable

2.1.1 Construction

The general construction of the control cable shall be suitable for installation in wet and dry locations and shall be furnished with the characteristics described herein. The control cable shall meet the following specific requirements.

2.1.1.1 Conductors The conductor shall be of soft or annealed uncoated copper wire and shall conform to ASTM B3. Concentric-stranded conductor shall conform to Table 2.

2.1.1.2 Insulation The insulation shall be polyvinyl chloride suitable for use on a copper conductor with a maximum operating temperature not less than 75 ºC

The insulation thickness shall not be less than 1.14 mm (0.045 in).

The insulation shall conform to Part 3 of ICEA Pub. No. S-61-402.

2.1.1.3 Fillers. Fillers shall be used in the interstice of the multi conductor, cable where necessary to give the complete cable a substantially circular cross section.

2.1.1.4 Wrapping. The cable shall be helically wrapped over the filler and copper shielding with 0.0254 mm (0.001 in) thickness non-hygroscopic mylar or polyester tape.

2.1.1.5 Inner Jacket. Inner jacket shall be polyvinyl chloride or polyethylene of at least 1.14 mm(0.045 in) thickness and shall be applied over the wrapping

2.1.1.6 Shielding. The shielding shall be annealed copper tape of suitable width and shall be helically applied over the inner jacket with a minimum 10% lap.

The annealed copper tape shall be at least 0.1 mm (0.004 in) thickness and substantially free from burrs.

2.1.1.7 Jacket. The jacket shall be of a black polyvinyl chloride jacket over the wrapping and shall comply in all respects with Part 4 of ICEA Pub. No. S-61-402.

2.1.1.8 Circuit Identification. The assembly of conductors in cable composed of 12 conductors or less shall be in accordance with the combinations given in the Table 1. When more than one color is required, the base and tracer color coding shall conform to method 1, Part 5 of ICEA Pub. No. S-61-402.

2.1.1.9 Spare Conductors. The minimum number of spare conductors in each control cable shall be as follows:

Conductor Number in Cable	Minimum Number of Spare Conductors
2	NIL
3	NIL
4	NIL
5	NIL
9	2
12	2

2.2 Switchboard Wire

2.2.1 Construction

The Switchboard wire shall be suitable for installation in dry location especially for wiring used within the control switchboard or other substation equipment control cabinets.

2.2.1.1 Conductors. The conductor shall be soft drawn or annealed tin-coated copper wire and shall conform to ASTM B3. Concentric-stranded conductor shall conform to Table 3.

2.2.1.2 Insulation The insulation shall be polyvinyl chloride suitable for use on a copper conductor with a maximum temperature not less than 75 ºC. The insulation thickness shall not be less than 1.14 mm (0.045 in) The insulation shall conform to Part 3 of ICEA Pub No. S-61-402.

Table 1 : Colors Sequence for Control Cables

Conductor Number	Background or Base Color	Tracer Color
1	Black	-
2	White	-
3	Red	-

Conductor Number	Background or Base Color	Tracer Color
4	Green	-
5	Orange	-
6	Blue	-
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White

Table 2 : Stranded Conductor for Control Cables

Conductor Size (sq.mm)	No of Strands	Nominal Strand Diameter (mm)	Approximate Overall Diameter (mm)
1.5	7	0.50	1.50
2.5	7	0.67	2.01
4	7	0.85	2.55
6	7	1.04	3.12

Table 3 : Switchboard Wire

Conductor Size (sq. mm.)	No of Strands	Nominal Strand Diameter (mm)	Approximate Overall Diameter (mm)
1.5	30	0.25	4.2
2.5	50	0.25	4.7
4.0	56	0.30	5.3
6.0	84	0.30	5.9

2.3 Conductors Sizes

All switchboard wires used within the control and protective relay boards or other control cabinet shall be tinned, stranded copper switchboard wire and shall meet the requirement of ICEA Pub. No. S-61-402.

2.3.1 Conductor Sizes for Control Cable

Each control cable conductor minimum sizes used for power supply and control circuits shall be as follows:

2.3.1.1	Secondary current transformer circuits	4	sq.mm. (for CT_{sec} 1A)
2.3.1.2	Secondary voltage transformer circuit	2.5	sq.mm.
2.3.1.3	Substation equipment D-C or A-C Control circuits	4	sq.mm.
2.3.1.4	Status and alarm circuit	1.5	sq.mm.
2.3.1.5	Power supply circuit	4	sq.mm.

The voltage drop at the load for 2.3.1.5 shall not be more than 3%.

2.3.2 Conductor sizes for Switchboard and Equipment Control Cabinet Wiring

Wiring used within the switchboards, and other equipment control cabinets shall have minimum sizes as follows:

2.3.2.1	Secondary current transformer circuits	4	sq.mm. (for CT_{sec} 1A)
2.3.2.2	Secondary voltage transformer circuits	2.5	sq.mm.
2.3.2.3	Substation equipment D-C or A-C control circuits	2.5	sq.mm.
2.3.2.4	Status and alarm circuits	1.5	sq.mm.
2.3.2.5	Power supply circuits	4	sq.mm.

Calculation of secondary current circuits for Clauses 2.3.1.1 and 2.3.2.1 shall be submitted to the Authority for approval. The Authority shall review the calculation, if a larger size of control cable and switchboard wire are required for the proper functions of the protection, then the Contractor shall carry out to change the size of the control cable and switchboard wire without extra charge to the Authority.

2.4 Metallic Shield

Metallic shield shall be made of copper tape for control cables.

As Metal Sheath Cables are installed, non magnetic metallic glands which effective earth the armour, are recommended for all cable entries. All joints in cables should be made in such a way as to prevent entry of vermins as well as to maintain the fire circuit integrity. The manufacturer shall have a tested joint system with test reports indicating compliance. Termination by crimping is recommended.

Metal shields of the control cables shall be grounded at both ends of each cable. Each end of the cable shield shall be welded to an insulated 600V, PVC, copper ground conductor with 6 sq.mm size and this conductor shall then be attached to the ground bus by a terminal lug provided inside of the equipment cabinets, instrument transformer junction boxes, and the switchboards.

Provision for sealing at each end of the cable shall be provided including wrapping over the connection of the shield and the insulated ground conductor by the PVC insulating tape.

2.5 Cable and Wire Markings.

The following information shall be printed on the surface of the cable and wires:

2.5.1 Name of manufacturer

2.5.2 Size of cables and wires and number of conductors

2.5.3 Type of insulation

2.5.4 Voltage classification

2.5.5 Date of manufacturer

2.6 Cable Ends

An end cap shall be provided on the cable end to which special attention shall be paid to prevent penetration of moisture during transportation.

2.7 Packing

All cables and wires shall be packed on reels. The reels shall be nonreturnable and shall be included in the prices of the cables and wires offered. The length of the cable and wire to be packed on each reel shall be as indicated below:

Control cables : 500 m + 0.5%

Switchboard wires : 100, 150 or 200 m + 0.5%

The following information shall be displayed :

- Name of manufacturer
- Size and number of conductors
- Type of insulation and voltage classification
- Length of cable
- Reel number and other suitable indentification for reel and reel size.
- Date of manufacture
- Total weight

3. TERMINATION AND LABELING

For all terminations of wires and cables the insulation shall be neatly stripped without nicking the strands of the conductors.

Each cable end shall be equipped with compression cable lug. Cable lugs for power cables shall be of adequate size.

Cable shall be firmly fixed on metallic supports.

Brass cable gland shall be used.

Cable glands or clamps shall be fitted in all cases to prevent stresses on conductors or terminals. It is important that the sealing compound and sleeving used in terminations is selected to suit the service conditions under which the cable is to operate.

No terminations will be accepted, if the insulation readings, 24 hours after making off, is less than 100 megohm using a standard 500 V or 1,000 V “Megger” (cables only).

Some slack cable in a loop or other suitable form is to be provided in a convenient place in the runs, where required.

Designation of each end of cable conductor or switchboard wire shall be marked with destination terminal name.

Each terminal shall carry a letter or number marking. Terminals shall be numbered on the terminal block in chronological order, from left to right and from bottom to top.

Dividers shall be provided to separate incomings. In addition, provision of a side marking shall allow identification of the cable arriving from the outside. Terminal covers with dividers shall be fitted onto power terminal blocks.

The wiring shall be arranged so as to avoid masking the distinctive markings of functional elements.

Wiring drawings for control and relay panels shall show wire and cable terminations for external wiring.

The ends of each cable core and all secondary panel wiring shall be fitted with white ferrules marked by printed black numbers, with the identification being the same as for the relevant terminals. Both ends of each cable shall be marked with terminal destination, including cubicle name, equipment name and pin number.

. In case different terminal boards are arranged close to each other, the numbers on the ferrules shall contain the terminal board denomination and the terminal number. The ferrules shall be fitted in such a way, that they cannot become detached when the wire is removed from the terminal. All internal wiring shall enter the terminal block from one side only.

The moisture and oil-resisting insulation material shall have a gloss finish.

All wiring used within the equipment control cabinets switchboards, and interposing relay cabinets shall meet the requirements of this Specification.

4. INSTALLATION

4.1 General requirements

The Contractor shall perform all relevant design and dimensioning of the complete cable systems and prepare the cable installation drawings with cable routing, connection diagrams and cable lists, details, etc.

All secondary wiring shall be arranged and protected to prevent damage it by arcing or by mechanical effects.

Power supplies for all control circuits of switchboard mounted devices, all control cabinet mounted devices, VT secondary circuits, and any other individual control circuits shall each be protected and provided with a miniature circuit breaker connected to isolate the devices from power supplies in the tripped or open position. The miniature circuit breakers shall be located within the switchboards or cabinets. Engraves nameplates shall be installed beside each set of the miniature circuit breaker for identification.

Each miniature circuit breaker shall be equipped with two electrically separated normally closed contacts: one for initiating the annunciator on the switchboard panel and the other shall be wired to the CSCS for alarm.

Wiring shall be neatly run, bundled or in rigid PVC wire-ways filled to not more than 70%.

Different functions of service, such as VT and CT circuits, tripping and annunciation shall not be routed in the same cable.

Control cables and high voltage power cables shall not use the same route.

Low voltage power cables and control cables shall be adequately spaced.

The installation of wiring shall take into account stresses due to vibration and the proximity of elements dissipating heat.

The Contractor shall ensure that all cabinets of the same type are wired in an identical manner.

All necessary precautions shall be taken to minimize inductive and capacitive coupling between different types of circuit.

Special precaution shall be taken to ensure, that no magnetic circuit is formed around single-core cables laid in single or trefoil formation, or around any cable liable to carry unbalanced currents.

The wiring shall be laid in ridged plastic ducts with slotted lateral openings. The conductors placed in the ducts shall have sufficient extra length. The fill factor for ducts shall not exceed 70%. The plastic material shall be sturdy and shall allow the ducts to withstand the impact resistance tests on apparatus with a reinforced enclosure. Burning of the plastic material through exposure to flame shall not spread beyond the combustion zone once the flame has been removed.

Splices or tee connections shall not be permitted in control wiring or instrument leads. Terminal blocks shall be used for all terminations

The cut end of cables shall be treated to prevent seepage of water into the cable. When unreeling cable from the cable drums, special care shall be taken to prevent damage to the cables. When moving the cover of the drum, care shall be taken to prevent damage to the cable sheath.

The Contractor shall provide all necessary materials for installation of the cables, such as grounding lead wires, compression type terminals, metal fitting, bolts and nuts including cable identification and felt packing to be inserted between cables and cleats.

Cables installed on cable racks, shall be firmly fixed to the cable rack at suitable intervals by plastic cable ties or equivalent.

All cables shall be provided with cable support.

During installation, care shall be taken not to damage the outer sheath of all wires and cable. Cables damaged during installation shall be repaired or replaced to PEA satisfaction at no additional charge.

4.2 Connections

In low voltage equipment, there are many connections, and faults caused by them play a major part in declining reliability of equipment. For each wire no intermediate connection is allowed between terminal blocks or equipments. It shall therefore be necessary to guarantee reliability of components used and to take care in their installation.

- Crimping

  This type of connection shall be made with specially designed equipment for the type of crimping required.

  Crimping of two conductors in the same cable lug or in the same terminal end shall be prohibited.

- Connection by Coiled Wire (Wire Wrapping).

  This connection technique requires use of a special tool and shall be implemented following good trade practice (*choice of post, device, etc.*)

- Screw-Type Connection

  The design of the various elements shall guarantee against any accidental unscrewing.

  The tightening of conductors shall guarantee a low contact resistance and secure attachment of the conductor, without damaging it.

- Clip Connection

  The quality of this type of connection depends largely on the quality of the components used; the Contractor shall indicate their characteristics.

- Connection by Connectors

  The connectors installed in humid premises or outdoors shall have the following characteristics:

  - quality and protection of electrical contacts for low currents (gold on nickel),
  - watertight against dripping from whatever direction,
  - withstand to 100% environment (relative humidity),
  - corrosion resistant material ("Marine" bronze).

  The connection of connectors shall be carried out by qualified personnel.

The guarantee of effective watertightness of the cable-connector assembly shall require the installation on each cable of a heat-shrinking cap, with epoxy resin injection in the hollow parts.

Each end of conductor of control cable and switchboard wire shall be provided with ring-tongue terminal lug to avoid CT open-circuited due to a loose screw.

4.3 Terminal-Terminal Blocks

All electrical connections from equipment to the outside shall be via terminal blocks. These terminal blocks shall be positioned vertically on both sides of the frame and in the lower part of cubicles or accessories.

The terminals shall be installed on metal "support plates" which serve as both the mount and the securing device of the assembly.

Each bank of terminals shall be blocked off at the each end by a fixed stop.

Terminals with clamping screws in direct contact with the conductor are not acceptable.

Terminal for CT circuit shall be of the short-link type.

Terminals blocks shall be grouped by category:

X1 - For annuciator circuit

X2 - For indicator circuit

X3 - For control and auxiliary relay circuit

X4 - For VT circuit

X5 - For DC auxiliary supply

X6 - For CSCS circuit

X7 - For AC auxiliary supply

X8 - For Capacitor bank

X9 - For CT circuit

For each category, terminal blocks shall be provided with 20% spare terminals.

Insulating barriers shall be provided using separators to avoid any short-circuits. Terminals shall be sized according to the conductors to be connected (8 mm pitch terminals with 4 mm test cells or 6 mm pitch terminals with 2 mm test cells).

Each terminal shall carry a printed letter or number marking. Terminals shall be numbered on the terminal block in chronological order, from left to right and from bottom to top.

Dividers shall be provided to separate incomings. In addition, provision of a side marking shall allow identification of the cable arriving from the outside. Terminal covers with dividers shall be fitted onto power terminal blocks.

4.4 Test Boxes

4.4.1 Verification of Measuring and Protection Devices.

Test block boxes shall be used to verify the essential circuits of protection and metering devices, since they facilitate inspection operations without affecting the safety of the assembly. They shall allow simultaneous measurement of currents and voltages feeding these protection systems and shall cancel all functions, except alarms and indications, during tests.

Protection systems mounted in cubicles shall always be fitted with these boxes to facilitate their testing using suitable testing sets.

These boxes shall always admit a current of 30 A, withstanding over-currents from major faults - over-currents which are fully transmitted by current reducers.

Depending on the complexity of the diagrams or the verifications to be performed, the terminal boxes may correspond either to each set of instrument transformers, or to a measurement unit or specific protection unit.

The various circuits may be tested in operation.

4.4.2 Voltage and Current Test

Boxes used for testing shall be closed by a cover, allowing continuity of the circuits.

These boxes shall not break the circuits when the cover is removed. For CT circuit, short circuit facilities shall be provided.

These boxes shall be flush mounted.

The maximum acceptable intensity shall always be 30 A. The dielectric strength testing voltage shall be 2000 V - 50Hz.

The various elements comprising these boxes shall be protected from environmental factors, in compliance with IEC publication number 60068.

Sockets shall include an orientation pin to avoid any connection errors.

The various position and combination of these pins shall be proposed by the Contractor.

By-pass of the "voltage" circuits on the terminal block shall be possible.

Screw-type connection shall be used.

"Current" circuits shall always be connected using round centrally drilled cable lugs.

4.4.3 Associated Testing Equipment.

The Contractor providing the elements fitted with test boxes shall also provide equipment for testing the circuits.

Connection sockets with leads shall be provided.

4.4.4 Installation.

All the test boxes installed shall be of the same type.

5. CABLE LAYING

The Contractor shall select the most suitable cable routes and raceways, ensuring a minimum of interference with other installations.

Routing shall be as short as possible, and shall pass through reserved areas free of any components, screws and bolts; in the proximity of removable or adjustable elements, wires shall be effectively protected.

As appropriate for the various locations the cables shall be installed in cable ducts, raceways, conduit – or tray systems, cable trenches, etc., or laid directly in the ground.

Cables running inside buildings or concrete trenches shall be laid on trays. The trays shall be of adequate strength and size to carry the specified number of cables, provide 25% spare capacity. The design of such trays shall include a safety factor to avoid permanent distortion, when supporting erection staff during cable installation. The trays shall be of suitable aluminium alloys or hot-dip galvanized steel standard materials.

Cable trays shall normally be of the ladder-type consisting of bars with rungs, evenly spaced (maximum 300 mm) according to requirements. Perforated, covered metal trays shall be used in highly polluted or otherwise endangered surroundings. All trays shall be rigidly fixed on supporting steel structures, masonry or galvanized racks. Cable trays arranged one above the other shall be at least 200 mm apart in case of power cables and 150 mm in case of control cables.

Earthing cable of the same size the one used for grounding grid shall be laid along cable tray and fixed as shown on corresponding drawing.

Cables laid on trays or racks shall be properly fixed or clamped. Supports and racks shall be arranged to facilitate removal or replacement of cables.

Cables branched from general raceways and directed to the relevant equipment shall be suitably protected, where required, over their entire lengths by e.g. galvanized steel conduits sealed at their ends against ingress of water. Conduits shall be fixed on steel structures, brickwork or be embedded in concrete floors or walls according to field requirements.

Conduits embedded in concrete or block-work shall be of a suitably rigid PVC-type. Cables laid outdoors, across roads in concrete or foundations shall run in hard PVC plastic pipes buried in ground at a depth of not less than 600 mm or embedded in concrete foundations at suitable depth.

The cross-sectional area of such ducts shall be utilized to 50% only. Pipe ducts shall terminate in concrete draw pits before entering buildings. Draw-pits shall be provided where required to facilitate cable installation.

Cables on brick walls or similar civil structures can be installed in conduits (galvanized steel conduits within the reach of persons or erection/maintenance devices, PVC conduits in other areas) or in pre-fabricated installation channels made of galvanized sheet metal or plastic.

Unarmored cables shall be properly protected against mechanical damage, where leaving ducts or covered trenches and the like.

Fire-partitions shall be provided where cables are passing through different fire zones or where entering cubicles and panels.

Pulling, fixing and terminating of cables shall be strictly in accordance with the manufacturer's instructions, using the recommended tools and appliances.