Annex VII: MV, LV Power Cables

Contents

1 General requirements

The scope of delivery shall include design, supply, install and put in operation the middle voltage (MV) for the purpose of interconnection power plant busbars, Isolating transformers and substation busbars, as well as the low voltage (LV) power cable providing supply from the power plant auxiliaries to the substation equipment.
The MV cable shall operate voltage 13.8 kV and must be capable of carrying 1250 A nominal current.
The LV cable shall operate 0.480 kV and must be capable carrying at minimum 800 A nominal current.
The MV cable shall be utilized for:

- Two connections from the power stations PS1 and PS2 to the substation busbars through the isolating transformers, which accounts to 450 m distance approximately.
- Interconnection between the PS1 and PS2 busbars, which accounts to 250 m approximately
- Connection from the substation switchgear to the first pole or underground channel for the Feeders 1,2,3, which is estimated at a total of 300 m.

The LV cable must provide a connection from the 480 V buses of PS1 and PS2 auxiliary transformers to the substation AC distribution system. The approximate length of the cables is 150 m and 300 m respectively.

It should be noted that the above distances for MV and LV cable are considered as the route length, which allows the Bidder to present its technical and commercial proposals in a completed form. However, the Bidder must clarify the exact length during the project design phase and recalculate the total cost of the cable according to the unit prices presented by him in the proposal.

For more information refer to **Attachment 1 MV/LV Cable**.

The project implementation should include, but not limited to, provision of the following accessories and auxiliary materials:

- all necessary number plates for cable identification (numbering code will be defined later).
- all necessary mounting materials
- all necessary fire protection materials for sealing of the cable openings in the substation and power station buildings, as well in the outdoor cable trenches
- all necessary protective tubes for the cable routing of non-plasticized polyvinyl chloride
- all necessary material for the burial
- all necessary mounting and clamping materials etc.
- all necessary cable sealing ends, slip-on cable sleeves, including clamping materials
- all necessary sealed couplings
- all necessary cable glands

2 Requirements for Cable Routing and Tracing

Single-core middle voltage cables insulated with extruded cross-linked polyethylene must be laid in the separate cable trench or with other middle voltage cables with maximum separation and free access for maintenance. Cables must be laid without a trench backfill.

On vertical cable risers, walls and ceilings cables must be fastened with corrosion resistant cable clamps (e.g., clamps with cable couplings).

Vertical cable risers located near passages or in electrical areas which are subject to possible mechanical damage, should be protected with an appropriate metal plate up to 1 meter above the ground.

Upon completion of the laying of the cable all the holes in ceilings, floors and walls provided for cable tracing must be sealed with a fire-resistant material. The same applies for boards and switchgear cabinets, penetrations between cable channels in the vertical riser, etc.

If cables are no longer supported in cable trays or risers, the power cables must be laid in PVC tubes, external UPVC tubes and should be used at an air temperature over 60 °C inside a galvanized steel pipe.

Surface mounted flexible pipes must be fixed every 1.5 m.

Control and communication cables must be laid at a sufficient distance from these power cables so as to eliminate interference, and to prevent incorrect transmission of signals. The minimum distances power, measurement and control cables must be 300mm.

Laying the cables outside of the building is preferable to install on cable bridges that need to be ventilated naturally.

If the cables are laid in the ground a sand layer should be filled in the trench after excavation. Cables should be placed on the sand separately from each other according to the voltage system. Cables should be laid at a minimum depth of 0.8 m. The trench should be covered with a concrete slab in order to withstand the load of vehicles.

In places where the cable must pass under roads cable ducts with openings of a suitable diameter should be provided for.

It is necessary to provide for the marking of cable routes using a warning tape.

During the laying of cables in cable trays, risers, cable channels, etc., as well as the choice of the cable size, attention should be paid to the availability of an adequate ventilation, as well as to the elimination of the possibility of cables overheating or deformation.

All cable ends should be prepared in accordance with relevant conditions of the manufacturer and connected to existing terminal strips with clamps, terminal screws, fixtures, terminals, etc.

Necessary cable end terminations, open and ventilated cable ends, where there is no end sealing, should be attached to the corresponding supporting structures.

3 General Requirements for Cable Laying

Unless specified otherwise, the following applies:

Three single-core cables of compacted round copper conductor with cross-linked polyethylene insulation must be used as middle voltage cables.

Power cable and communication cables must be placed in the electrical duct bank. Bidder must submit design for owner engineer's approval.

For outdoor straight-through cable joints and end terminations porcelain insulators must be provided for.

Cables must be suitable for installation indoors, in the sunlight (direct or indirect), in channels, on trays, in earth and water. Cables must be sunlight, oil, seawater resistant, and be immune to damages by bacteria, insects and rodents.

Outer shells must be made of non-combustible or fire-resistant material.

All the cables must have identification code at both ends using numbered markings with a corresponding coding system. Cores must be numbered or identified by color codes.

Cables must be laid so as to enable easy replacement or repair.

Within the territory of the Power Plant and Substation cables must be installed in the PVC conduits buried in the ground. Existing cable trays or reinforced concrete cable ducts being fit to use, also can be used upon the Customer’s consent.

Exceptions must be approved by the Customer’s.

4 Middle Voltage Power Cables

Middle voltage cables must comprise three single-core cables of compacted round copper conductor with cross-linked polyethylene insulation with semiconducting swellable tapes under and above the metal shield.

The conductor shield must be extruded and consist of a semiconducting cross-linked polyethylene layer. The insulation shield must be extruded and consist of a semiconducting cross-linked polyethylene layer.

The conductor should have a circular cross section.

The metal shield should consist of copper wires and two copper tapes.

The insulation of a middle-voltage cable must be of an extruded cross-linked polyethylene (XLPE), forming a wound dielectric around the conductor.

Longitudinal and radial hydraulic sealing of the conductor and the metal shield must be provided.

The outer protective sheath consists of a copolymer aluminum amalgam and an extruded high density polyethylene block. Mechanical and physical features of the outer protective sheath must conform to the characteristics described in IEC recommendations.

Middle voltage power cables must be designed for the thermal characteristics and short-circuit of electrical systems, with regard to the minimum short circuit duration of 0.5 s unless specified otherwise.

5 Low Voltage Power Cables

LV cables must have a protective shield, comprise twisted, single- or three-core cables with insulation preferably of extruded cross-linked polyethylene. The cable must be sealed with a red, not fading, outer PVC sheath. Three-core cables must have conductors with individual protective shields.

LV Cables must be manufactured considering thermal and short circuit properties of electrical systems.

Cables must be sealed and connected to a metal clad external switchgear or end termination must be installed in housings of the cabling, mounted on power transformers.

In case of failure of air conditioning systems in switchgear rooms the external and internal conditions will be the same. Therefore, cable end terminations, which correspond to the maximum site conditions, should be used.

6 Current Carrying Capacity of Power Cables

Cable current carrying capacities for specific site conditions shall be determined based on standard cable rated characteristics as provided in the relevant standards or the SUPPLIER's declared current ratings and then apply the appropriate derating factors to account for the ambient and installation conditions when compared to the reference installation conditions applicable to the selected standard current carrying capacity.

In sizing cables, the maximum sustained nameplate rating of the equipment shall be taken.
General requirements for the MV cable:

- Rated voltage: 13.8 kV, 3-phase system
- Nominal current flowing through the power station busbar: 1250 A
- Cable must be able to carry in normal operating mode: 20 MVA

General Requirements for the LV power cable:

- Rated voltage: 480 V, 3-phase
- Nominal current: 800 A

Cable current carrying capacities shall be expressed in amperes with an ambient air

temperature of 35°C and a copper conductor temperature of 90°C in line with the applicable copper conductor and insulating material requirements.

De-rating factors must be considered while establishing the current carrying capacity of a cable. The actual values of various de-rating factors must be considered in accordance with the correction factors indicated in IEC 60364-5-52.
Current carrying ratings for cables must be estimated according to the relevant IEC regulations. Along with current capacity the following calculations must be provided:

- Short Circuit Withstand Capacity of Cables
- Calculation Of Voltage Drop in Cable

Under normal conditions, the maximum voltage drop must not exceed 2.5%.
The bidder must submit the design and detailed calculations of the current carrying capacity of each section for the approval of the owner engineer.

The following site conditions are to be used for design purposes:

CHARACTERISTIC	VALUE
Ambient Temperatures	35°C summer day time (Max) 25°C winter night time (Min)
Mean Daily Solar Exposure	5 kWh/m^2/day
Precipitation	Mean annual rainfall in excess of 3000mm
Humidity	Average relative humidity 80%
Mean Barometric pressure	1009 hPa
Atmospheric Classifications	Environments as defined in AS/NZS 2312-2014. Category C5-M: Very High Marine
Design Wind Speed	48 m/s

7 Cable Connections and Cable Terminations

For the connection of cable pressed cable lugs must be provided.

End terminations must be designed so that to prevent clamping of cable cores. Bimetallic clamps must be provided in case of connecting wires of different materials.

All necessary cable terminations must have plastic insulation. Branch sleeves must not be used.

Cable connections used must be made of fireproof plastic.

8 Cable Supporting Structures

The scope of delivery and installation of cable supporting structures include the following items:

- All necessary cable trays and risers.
- All necessary mounting materials and small items like plugs, bolts, etc.
- All necessary plastic caps to cover suspensions.

Design requirements

In general, hot dip galvanized finished cable trays, cable risers, suspension, bolts, clamps and all mounting materials with anticorrosive finishing must be used. If trays and risers cannot be used in certain areas, such areas must be fitted with cable brackets. They must be made of corrosion-resistant, hot-dip galvanized steel angle sections.

Steel angle sections must be carefully selected according to size and type.

In case of on-site cutting of angle sections to the size, prior to mounting, the open surface of the cut must be properly treated to prevent corrosion. The minimum requirement for this treatment is the application of an anticorrosive layer with zinc coating.

T-shaped branches, bends and other elements of cable trays must consist of prefabricated elements, in order to avoid crushing cables in these transition points.

Cables laid in the trays must be carefully placed and arranged. All tracing of cable trays, carried out outside of the buildings and not protected against the sun, should be covered with canopies made of materials specified for the equipment of cable trays.

Trays and risers must be installed so as to provide an 800 mm wide and 2200 mm high emergency exit in available passages for the personnel.

The distance between individual cable trays and risers should be large enough to avoid mutual interference between power cables, measuring and control cables, as well as between the cables of the communication system.

For the above cables separate cable trays and cable risers must be provided. Trays and risers should be designated with a number code and clearly visible colors every 10 meters for their recognition:

- AC power cables above 1000V: Red
- AC power cables less than 1000V: Black

For security purposes, plastic covers must be installed on lower parts of suspensions and all other open parts along the passages and emergency exits.

For indoor installations hot-dip galvanized materials with an average coating thickness corresponding to ASTM 386 must be used.

On all outdoor sites, as well as in partially covered buildings, the hot-galvanized material must be provided with an additional coating.

Cable trays must be designed so as to provide 15% spare space in all trays upon commissioning and acceptance.

Fasteners for cable trays and risers must be corrosion-resistant or at least hot galvanized. Rods, stairs and risers must be installed with corresponding bearing brackets attached to anchor beams or fixed to walls and ceilings by pins or bolts.

Welded joints to steel structures and welding of hot galvanized component parts over the cable trace must not be used.

Upon completion of cabling, cable trays deviation should not exceed 2.5 mm per 1.5 m (the distance indicated between two suspension brackets).

9 Applicable Standards

For cables and component parts the following rules and regulations should apply:

- IEC 60038 IEC standard voltages
- IEC 60050 International Electro Technical Vocabulary
- IEC 60183 Guide to the selection of middle-voltage cables,
- General Requirements and national regulations, respectively.
- IEC 60228 Conductors of insulated cables.
- IEC 60287 Section 1-1 Electric cables - Calculation of the current rating.
- IEC 60811 Common test methods for insulating and sheathing materials of electric cables.
- IEC 60853 Calculation of the cyclic and emergency current rating of cables.
- IEC 60885 Electrical test methods for electric cables
    - Section 2. Partial discharge measurement
    - Section 3. Partial discharge measurements on lengths of extruded power cables.
- IEC 60949 Calculation of thermally permissible short-circuit currents.
- CE 55/44 CE marking and declaration of conformity
- IEC-60502-1 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). Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV).

- 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). Part 2: Cables for rated voltages from 6 kV (Um =7,2 kV) up to 30 kV (Um = 36 kV).
- IEC-60909 Short-circuit currents in three-phase A.C. systems
- IEC-60986 Short-circuit temperature limits of electric cables with rated voltages from 6 kV (Um =7.2 kV) up to 30 kV (Um = 36 kV)

10 Inspections and Tests

The following inspections and tests must be carried out if otherwise is not provided for by these technical requirements (if necessary), in accordance with agreed standards and test program.

Checks before starting erection

- Check of the completeness of delivery
- Check of rated data according to the technical requirements

a) Power cables – check and tests on completion – after laying tests

Upon completion of cable laying the following tests must be carried out:

- visual examination of equipment for damages.
- visual check of correctness and accuracy of installation.
- checking of critical minimum operating distances.
- checking of bolts tightening.
- verification of completion of works on grounding connections.
- conductor resistance check and phased shutdown test.
- capacitance measurement.
- verification of the installation of plates with instructions and safety signs.
- outer shell DC voltage test.
- main insulation AC voltage test.
- direct and zero sequence impedance measurements.
- contact resistance connection check and connection test.

b) Cable with fittings, joints and clamps

The electrical resistance of clamps, joints and terminal fitting of each type must be accurately measured by the Contractor in the presence of the Employer/Employer's Representative.

If the joint consists of several parts fastened together by bolts (e.g., end clamp by a bolt on the jumper terminal), the resistance must be measured in the assembly.

The resistance of each of these fasteners must not exceed 75% of the resistance of the equivalent length of conductor, as measured adjacent to component parts, the existing bandwidth should at least be equal to that of the wire.

The Contractor must provide the appropriate equipment (e.g., digital micro ohmmeter) for the purposes of the above tests and must submit to the Employer/Employer's representative all information on the proposed instruments. Respective clamps must be supplied to connect cable conductors to the measuring instruments for samples testing to ensure proper surface contact.

c) Checking of the final installation

Not later than 90 days before the installation is completed, the Contractor must prepare and submit for approval all the documents related to the installation.

The documents on the verification of the installation must include check tables for all single-core cables, connections, cable lugs (end terminations) and tables of the cables metal shields.

After the installation of the entire cable, its final inspection must be carried out. The final inspection of the installation should be performed by the Contractor with the participation of the Employer's representatives or the Employer himself.

The results of the final inspection of the installation must be registered in the control specifications, including deficiencies that should be corrected. All this must be signed by the parties performing the verification. Deficiencies should be corrected prior to the energizing in accordance with the requirements of the Employer.

f) Tests on completion

At least 90 days before the completion of the cable installation, the Contractor must submit a schedule of the energizing.

Before the energizing of the cable, a visual examination must be carried out and the defects which may affect the safety of the cable and personnel should be immediately eliminated.

The cable line of the relevant substation should carry full operating voltage prior to the preparation for further tests which may be required by the Employer/Employer's representatives, and must be carried out by the Contractor, who will have to provide the necessary labor, transport, and other assistance as may be necessary, at no extra charge.