SECTION 7.5

TECHNICAL SPECIFICATION

PART 5 - POWER AND AUXILIARY CABLES

NATIONAL ELECTRICITY CORPORATION (NEC)

REPUBLIC OF SUDAN

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5 POWER AND AUXILIARY CABLES

5.1 GENERAL

The routes for the cables have selected on preliminary bases and if required lengths of cables are indicated, it describes the approximate length of the cable route and not the total length of any kind of required cables.

The Tenderer is requested to check the actual cable length and to offer those quantities which are, according to his estimations, necessary to perform the work properly. Variations regarding the required length of any cables are not acceptable, as far as the Contractor has not been informed in writing by Employer/ Engineer that cable route shall be extended.

The Employer will neither furnish manpower assistance for transport, laying and erection, nor equipment assistance, or other material. All incidental costs hereto shall be included in the Contract Price.

All cables shall be designed in accordance with the latest issues of IEC Publications and other standards as may be approved by the Employer/ Engineer.

The Contractor is bound to measure and record the thermal resistivity of the backfilling material after reinstatement every 200 m run, or as directed by the Engineer.

Any measure shall be taken to obtain best uniform thermal resistivity all along the cable routes, and to advise the Employer on the actual current carrying capacity he is recommending for operation under site conditions. This shall be done by means of a detailed study immediately after the respective circuit has been laid.

All cables shall be selected to withstand without distress any short circuit currents as indicated in Article 7.1 above.

The cables may be exposed to the direct rays of the sun at the terminations of gantries, of the transformers etc. They shall be capable of withstanding such

exposure continuously without any detrimental effect on insulation, sheathing or covering. However installation of sun sheds may be required at particular locations.

All cables and their accessories to be supplied shall have insulation levels able to withstand any voltage surges which are normally expected to occur in the power system in which the cable is to be employed, due to switching operations, sudden load variations, faults, etc.

The cables and their accessories shall be constructed to fulfill the requirements when operating with full load or at any load factor. Special reference is made to the climatic conditions described under Article 7.1. For laying of power cables, the Contractor shall submit at least the following calculations and records:

- Calculation results of the continuous current rating (as indicated in the offer) of the proposed cables and their accessories
- Calculation results of permissible overload current of the power cables, starting from 50, 75 and 100 % of the above mentioned continuous permissible transmission capacity of 1, 2, 3, 4 and 5 hours
- Calculation of short circuit carrying capacity under short circuit conditions (1 sec)
- Report of own site measurements of the actual soil thermal resistivity and prevailing ground temperature along the route before cable laying
- Report of density, grain size distribution, and thermal characteristics of proposed bedding and backfilling material of power cables
- The reduction factor of permissible transmission capacity applied for the site conditions as result of the chosen bedding and backfilling material of the power cables and including all crossing and parallel running power cables
- Calculation of induced voltages on pilot/telephone cables installed in parallel with the power cables

- Calculation of induced voltages and currents in the power cable sheaths at full load and at short circuit
- Calculation of earthing wire cross sections

5.2 INCIDENTAL CHARGES AND ERECTION

The Contractor shall lay and assemble all specified cables completely and shall, pursuant to a final site test, hand them over in working order. The incidental charges and erection work shall, in particular, besides all other necessary work and charges as covered by the Tender Documents, include:

- Survey of the cable routes which are selected by the Employer/ Engineer, and survey of the soil thermal resistivity to be expected along the cable routes, selection of delivery cable lengths and all necessary fittings
- Supervision of excavation and, if necessary, shuttering and dewatering of the cable trenches, as well as the preparation of the cable ducts and supporting structures for installation of the cables
- Cable laying, including bedding into the ground, or laying in ducts and rooms, fastening on racks, cable brackets or supporting structures, cable ducts including cable racks, as well as cable-supporting structures and sealing ends and joint supports
- Supervision of procurement and filling-in of cable bedding and backfilling material which shall have a maximum thermal resistivity of 120 cm°C/W under operation conditions and shall be chemically neutral. In case the thermal resistivity exceeds 120 cm°C/W, even under completely dried out conditions, the Contractor shall submit an alternative proposal to cope with the thermal design of the bedding and backfilling material
- Measurement of the thermal resistivity of the backfilling material along the cable route
- Supervision of procurement and laying of concrete slabs, supervision of procurement and laying of cable ducts at road crossings

- Provision of auxiliary erection structures such as tarpaulins, free-standing structures, etc.
- Supply of all material necessary for jointing, terminating and fixing the cables to the switchgear (and transformers/ reactors, if any), as well as cable trays, clamps, grounding material and all further tools and accessories required for proper installation
- Assembly ready for use, including assembly for the connection of joints and sealing ends, including cast resin cones, cable oil for joints and terminations, as well as making the electrical connections

5.3 SEALING AND DRUMMING

Immediately after tests at the Contractor's premises, both ends of every length of cable shall be sealed with a metal cap (with pulling eye for power cables) which shall be plumbed to the sheath.

All cables and conductors shall have the inner ends brought out and suitably fixed to the drum to avoid any damage during handling or pulling operations.

The cables shall be rolled on strong wooden or steel drums provided with suitable wooden battens to protect the cables from damage. They shall also be suitable for storage in the open air without additional protection by casing or shutters for a period of at least two years.

The drums shall be marked in English to indicate the direction of rolling, and also as stipulated in the Special Conditions of Contract, Shipping Marks, plus the following:

SIZE AND TYPE OF CABLE, VOLTAGE, CABLE LENGTH

For all spare cut lengths of cable which are to be delivered to the Employer's stock, approved sealing caps of correct sizes shall be supplied and properly mounted immediately after the respective cable length is cut.

5.4 STANDARDS

The cables with cross-linked polyethylene insulation shall satisfy IEC 60502 and equivalent standards, even if it does not apply to polyethylene-insulated cables exclusively.

Should a manufacturer e.g. present a standard especially for cross-linked, polyethylene-insulated cables, which is nationally approved, then he may base his offer on such standard, and shall submit copies of this standard together with his Proposal, including lists and explanations of where these standards deviate from the below mentioned standards.

Each offer shall generally comply at least with the latest issues of the following:

IEC 60028	International standard of resistance for copper
IEC 60060	High voltage test techniques
IEC 60071	Insulation co-ordination
IEC 60093	Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials
IEC 60183	Guide to the selection of high voltage cables
IEC 60228	Conductors of insulated cables
IEC 60229	Tests on cable over-sheaths, which have a special protective function and are applied by extrusion
IEC 60230	Impulse tests on cables and their accessories
IEC 60287	Calculation of the continuous current rating of cables (100 % load factor)
IEC 60330	Methods of test for PVC insulation and sheath of electric cables
IEC 60332-1	Tests on electric cables under fire conditions
IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV - 30 kV

General Specifications

IEC 60811	Common test methods for insulating and sheathing materials of electric cables
IEC 60853	Calculation of the cyclic and emergency current ratings of cables
IEC 60949	Calculation of thermally permissible short circuit currents, taking into account non-adiabatic heating effects
IEC 60986	Guide to the short circuit temperature limits of electric cables with a rated voltage from 1.8/ 3 (3.6) kV to 18/ 30 (36) kV
VDE 0207	Insulating and sheathing compounds for cables and flexible cords
VDE 0209	Specification for insulating coverings and sheaths of thermo-plastic material for insulated cables and flexible cords
VDE 0271	PVC-insulated cables with nominal voltages up to and including 6/10 kV
VDE 0278	Power cable accessories with nominal voltages U up to 30 kV (Um up to 36 kV); Requirements and test methods
VDE 0472	Testing of insulated cables, wires and flexible cords; General
VDE 0816	External cables for telecommunication systems
VDE 0845	VDE Specification for protection of telecommunication installations from over voltages
IEC 60793	Optical fibres generic specification: general and measuring methods, mechanical properties, transmission and optical characteristics, environmental characteristics
IEC 60794	Optical fibre cables general specification, product specification and telecommunication cables
ITU-T G652	Characteristics of a single mode optical fibre cable
ITU-T G653	Characteristics of a dispersion shifted single mode optical fibre cable

ITU-T 653 Characteristics of a 1550 nm wavelength loss minimized single mode optical fibre cable

5.5 TESTS

All cables proposed by the Tenderer shall be type tested. The type test certificate shall be included in the Tender or submitted at signature of Contract at the latest.

As Factory Acceptance Tests, only routine and sample tests according to IEC Standards shall be carried out on all types of cables to be supplied under this project.

The Contractor shall fabricate the cable lengths necessary for the tests, over and above those within the Scope of Supply, and shall furnish them for the tests free of charge.

The Employer/ Engineer is entitled hereby to specify in detail from which part of the total Scope the samples for testing shall be taken.

Before energising a cable circuit, including all accessories, tests shall be performed on the complete installation.

For the pressure tests of high voltage power cables at site shall be performed with AC voltage only. The Contractor shall make available a suitable AC cable testing set.

All necessary preparations (e.g. removal of V.T., degassing, filling with SF6 gas, etc.) at the remote end Substations will be carried out by the Employer's personnel free of charge to the Contractor.

5.5.1 Tests for MV-XLPE Cables

- Routine cable tests according to IEC 60502.
    - In addition, the following shall be performed:
        - Conductor resistance test (IEC 60228)
        - Capacitance test

- Insulation resistance test
- Test on corrosion - resistant covering (IEC 60229)

- Tests after installation including all accessories:
  - According to IEC 60502
  - In addition, the following shall be performed:
    - DC conductor resistance test (IEC 60228)
    - Capacitance test
    - Insulation resistance test

5.5.2 Tests for LV and Control Cables

Sample Tests shall be performed, comprising as a minimum the following tests:

5.5.3 Tests for Optical Fibre Cables

Tests of the optical fibre cable shall be performed according to relevant latest issues of ITU-T and IEC recommendations valid at time of awarding the Contract.

Sample tests shall be performed and shall comprise at least

Test item	Test passing criteria
1. Dimensional tests:	
Diameter of core	To be checked against manufacturer proposal & approved document
Diameter of cladding	-do-
Diameter of primary coating	-do-
Diameter of buffer	-do-
Non - circularity	See Tech. Data Sheet
Concentricity errors	-do-
Length of cable/fibre	To be checked against Manufacturer proposal and approved document

Thickness of insulation	See Tech. Data Sheet
Thickness of sheath	-do-
Overall dimension	To be checked against Manufacturer proposal

2. Transmission and optical characteristics:

cable Cut-off wave length	See Tech. Data Sheets

Routine tests shall be performed, comprising at least:

Test item	Test passing criteria
1. Transmission and optical characteristics:	
Attenuation versus wave length	See Tech. Data Sheets
at wavelengths of 1270, 1300 and 1550 nm	(at 1300 & 1550 nm)
2. Environmental characteristics:	
Sheath defects, voltage test on the outer sheath with 10 kV DC/ 1 min between steel tape and graphite coating.	No break down
3. Electrical characteristics:	
Dielectric strength	No break down
Insulation resistance of outer	Ref. to IEC standards
Sheath	for the given insulation thickness

Site tests shall be performed

Comprising at least the following tests and the Contractor shall propose further tests to verify the soundness of

the installation works performed:

Attenuation measurements	See Tech. Data Sheets (at 1300 & 1550 nm)
HV test for outer sheath (10 kV/ 1 min between steel tape and ground)	No break down
Back scatter measurement	No abnormality at joints

5.6 MEDIUM VOLTAGE XLPE CABLES

5.6.1 Cable Construction

The conductors shall be made of round, stranded, soft annealed, electrolytic copper wires, and the cable shall be proof against water penetration in longitudinal axis. The conductors shall be screened by extruded semi-conductive XLPE. This in turn shall be covered by the XLPE insulation, the thickness of which shall be clearly indicated in the Technical Data Sheets. Another semi-conductive screen shall cover the insulation, followed by a copper shielding of adequate thickness to meet the earth fault current specified in Section 7.1 above.

Phase identification shall be provided on the screen by colour code red, yellow and blue.

The outer covering shall be preferably high density polyethylene, termite-resistant, vermin-proof, and suitable for the prevailing service conditions at site.

The cable structure is described to the full extent in Section 8.5,Technical Data Sheets (if applicable).

A distinctive marking, including the following details, shall be embossed continually along with the whole outer covering:

- Manufacturer's name and/ or trade mark
- Year of manufacture
- Nominal voltage

- Marks one meter apart showing the cable length

The Tenderer must prove by calculation that the core screens are adequate to meet the systems highest short circuit current.

Jointing of cables in runs will not be accepted except if not explicitly approved by the Employer/ Engineer.

Single core cables shall be laid in three-foil formation.

5.6.2 Sealing Ends

MV sealing ends for power cables of appropriated size and type are required for connection of metal-clad switchgears, GIS, transformers and overhead lines. The terminations shall be suitable as necessary for use on switchgear, transformer cable boxes designed for either compound filling or air clearance (without compound) and overhead line termination.

Design of cable sealing ends has to be closely co-ordinated with the supplier of the equipment, the cable has to be connected to, and the manufacturer of the cable.

The system cyclic loading and fault condition shall in no way affect the termination. The supplier shall provide evidence with his offer that the terminations have been tested in a recognised laboratory. The details of test and method shall also be submitted.

The manufacturer shall supply evidence of experience indicating places where his products are being used.

The terminations shall be supplied complete with lugs, tubes, tapes, copper braids, lead wire and other necessary accessories. The exact dimensions of existing cable boxes (if any) will be given to the successful Tenderer upon his request. The termination shall not be impaired by the effects of humidity and/or atmosphere containing salt-laden sand.

All kind of MV cables shall be properly glanded on the gland plate of the equipment to be connected. The screen of the cable shall be earthed separately to allow disconnection for test purposes.

Outdoor Terminations

Outdoor terminations shall be suitable for termination of power cables on towers for connection of OHL and in air insulated cable boxes of transformers.

The termination shall be made by using stress control cones. The sealing end shall consist of prefabricated epoxy, silicone rubber, ethylene-propylene rubber or ethylene-propylene-terpolymer rubber and joined to the cable afterwards or of stress control cones moulded in one piece together with the cable insulation or made of crepe paper (elastic paper method) or of self-vulcanising insulation tapes. The stress control cone material should have the same thermal expansion coefficient as the cable.

The creepage distance of outer stress relive cone with alternating fins shall be as per requirements stated in section 7.1 above. The termination shall be supplied complete with fixing brackets, bushings, etc.

Glands and gland plates for the cables shall be made from non-magnetic material.

Indoor Terminations

Indoor terminations shall be used for connection of conventional air insulated indoor switchgear and try-type transformers installed indoors. The sealing ends shall be of the same type as described above, however without alternating fins.

For connection of SF6 type indoor switchgears, plug in sealing ends shall be used.

The sealing ends for three core cables shall permit crossing of cable cores without damage to the insulation, and all spacing shall be designed under consideration of the climatic conditions prevailing at site.

5.7 LOW VOLTAGE POWER CABLES, CONTROL - AND OPTICAL FIBRE CABLES

5.7.1 Low Voltage Power Cables

The low voltage cables shall be installed in accordance with IEC 60227 and further IEC or VDE Standards.

In selecting the number of cables as well as the cable cross sections, due regard shall be paid to the appropriate derating factors in relation to the climatic conditions at site. All cables and wires shall continuously carry their rated currents under the worst temperature conditions, which prevail in summer, and shall also withstand maximum fault currents without damage or deterioration. The max. permissible voltage drop for all auxiliary power supply and control cable circuits shall be less than 5%.

The Tenderer shall determine the exact lengths according to his arrangements, and shall provide an ample margin for cuttings for the total required quantity.

All LV power cables to be supplied shall be connected to the relevant station equipment in an approved manner, including all necessary wiring. Their spare cores shall be terminated and marked for future extensions. The cores shall be connected to terminals as such that crossovers are avoided.

The low voltage cables shall have the following characteristics:

- Rated Voltage nominal AC distribution voltage (three phase/ five wire system)
- Insulation extruded black flame retardant PVC, with particular measures against decomposition in the climate at site, or alternatively XLPE

Power cables above 50 mm^2 shall be XLPE insulated.

Cables for lighting and socket installation up to 20 kVA three-phase load shall have cores for the phases, and two cores of adequate size for the separate

neutral (N) and protective earth (PE) in addition. Higher rated loads shall separately be connected to the station earthing system.

All appropriate cable racks, pipes, supporting structures, cable terminals, ferrules, and auxiliary equipment as necessary for proper installation, connection and operation shall be included to the satisfaction of the Employer/ Engineer.

The colour coding for three-phase cable shall be red, yellow and blue for the phases, black for the neutral and yellow/ green for the protection earth.

Single-phase cables shall be coded red, neutral black and protection earth yellow/ green.

5.7.2 Control Cables

Multicore control cables shall be sheathed with extruded black flame retardant PVC compound and shall have standard cross section copper cores as given below. The outer covering shall be preferably high density polyethylene, termite-resistant, vermin-proof, and suitable for the prevailing service conditions at site.

The individual solid copper conductors shall be distinguishable by permanently and durably white number markings on the black insulation material. The marking shall resist abrasion and shall be applied at least every 20 cm length of each core. It shall be ensured that no numbers can be mistaken, i.e. 6 and 9 must be distinguished by underlining.

Colour coded system may also be considered, subject to final approval of the Employer/ Engineer.

The conductors shall comprise clean, smooth, soft annealed, electrolytic copper wires with standardised conductivity. The surfaces of individual wires shall be smooth and clean before the insulation is applied.

Cables for telephone and data links shall be of the twisted pair of wire type with an appropriated screen. The screen shall be connected to earth.

The copper tapes of the screened pairs as well as of the common screen shall be lapped with a rather long lay, the second one covering the butt space of the first

layer. The armoring tapes, on the other hand, shall be lapped with a short lay, the second one covering the butt space of the first layer.

All control cables to be supplied shall be connected to the relevant station equipment in an approved manner, including all necessary wiring. Their spare cores shall be terminated and marked for future extensions. Multi-core cables shall be connected to terminals as such that crossovers are avoided.

The cable structure is described to the full extent in Section 8.2, Technical Data Sheets.

A distinctive marking, including the following details, shall be embossed continually along with the whole outer covering:

- Manufacturer's name and/ or trade mark
- Year of manufacture
- Marks one meter apart showing the cable length

5.7.3 Optical Fibre Cable

Cable Design

a) Type of Cable/ Fibre

The optical fibre cable shall have fibres of the single-mode type, suitable for transmitting light signals.

The fibre shall be made of ultra pure fused silica glass suitable for operation at 1300 and 1550 nm wave lengths. The design shall be generally as per recommendations and specifications made by International Committees/ Organizations such as ITU-T and IEC, and all updated versions of both for single mode fibre.

It shall provide low dispersion values for the entire possible wave length range above the cut off wave length of the cabled fibre, which should not be more than 1270 nm.

The Tenderer shall submit along with his Tender Proposal supporting documents comparing test conditions and measurement results especially at 1300 and 1550 nm.

A coating over the cladding shall be provided to protect the fibre from external influences. This coating shall be made in such a way that it is very easy to perform stripping at Site thermally or mechanically.

Further technical details shall be as stated in these Specifications in Section IV, part 2, Technical Data Sheets.

b) The Cable Construction

The optical fibre cables shall be designed to suit both, laying in ducts/ PVC pipes and direct burying in the ground. The fibres shall be laid loose in buffer tubes filled with compound.

1. Buffer Tube

Single/ Multi-fibre loose buffer tube type shall be provided. The buffer must hold its shape, be tough, not susceptible to aging and be very flexible, so that it can be handled without noticeable stressing of the optical fibres.

The buffer tube shall be composed of an inner layer with very low friction coefficient and an outer layer to shield the fibre against mechanical influences. The design of the loose buffer shall be in such a way that the elongation of the cable under normal operating conditions does not result in attenuation increases beyond the limits specified by the above mentioned standards.

Technical requirements of single/ multi-fibre loose buffer are shown in Section IV, part 2. The technical characteristics of the buffer shall follow DIN VDE 0888 in connection with dimensions, colour codings and temperature range.

2. Buffer Tube Filling Compound

The buffer tube shall be filled with a slightly thixotropic and chemically neutral compound. This is to prevent water from entering the buffer and running through it which may affect the fibre and result in attenuation increases. This compound shall not corrode the fibre or cause it to swell. It also shall not drip out at the

temperature range of: -10°C to + 70°C and shall be easy to wipe and wash off without leaving residue that would make it difficult to connect the fibres.

The compound shall not contain highly inflammable materials. The compound must have a composition such that it is not detrimental to the properties of other cable elements and shall have relatively low thermal coefficient.

3. The Cable Core

The buffer tubes with the fillers, if any, shall be stran-ded around a GRP (glass-reinforced plastic) central member. The GRP member shall serve both, as a support (buckling protection against kinking) and as a strain relief member.

The stranding shall be in such a way, that the bending radius will be as low as possible and the optical fibres having a well defined free space within which strain, buckling, pressure and bending stresses will have no influence on the transmission characteristics.

The stranded buffer tubes/ fillers around the GRP member with the moisture resistant compound in the empty interstices among them are wrapped by the core covering which consists of at least one layer non-hygroscopic tape, applied helically or longitudinally with an overlap.

4. Inner Sheath

A PE sheath layer shall be extruded above the core covering with a thickness of not less than 1.5 mm.

5. Aramide Layer (Strength Member)

An aramide yarns layer is laid above the PE inner sheath layer to serve mainly as strength member.

6. Intermediate Sheath

The intermediate sheath shall consist of high density polyethylene compound (black) with a thickness of not less than 1.0 mm.

7. Armoring

The armoring shall consist of a corrugated steel tape applied longitudinally with an overlap. The tape thickness shall not be less than 0.18 mm.

8. Outer Sheath

The outer sheath (HDPE) layer shall be covered by a semi-conductive layer. The thickness of the outer sheath shall not be less than 1.8 mm.

a) Colour Coding of the Fibre/ Buffer Tube

The colour coding shall be in compliance with DIN VDE 0888.

b) Marking

The outer sheath of the fibre cable shall have the following marking, repeated every 1.00 m:

- OFC (**O**ptical **F**ibre **C**able)
- Manufacturer's Name
- Year of manufacturing
- length of cable (running meter)

Installation Practice

a) General

A great care shall be paid when laying the optical fibre cable either directly buried in the ground or into PVC conduits.

The recommended method is to lay by hand into PVC conduits in such a way to have the maximum possible continuous length to minimise the number of joints. In case of laying in ducts, separate ducts shall be used for each optical fibre cable.

b) Splicing/ Non-Permanent Joints/ Straight Joints

Splicing of the optical fibre cable either along the route or at the terminals shall be carried out in such a way to have minimum losses (< 0.05 dB).

The non-permanent connectors are located at the route ends only. These connectors shall have a minimum attenuation (losses of connector and bulkhead together with the pigtail splice loss shall not be more than 0.3 dB) and shall comply with the latest technology at the time of the Contract Agreement's date.

Straight joints shall be made and buried in the ground at suitable locations and in such a way as to match the soil conditions at Site, subject to the approval of Employer/ Engineer.

c) Distribution/ Termination Boxes

The optical fibre cables shall be terminated at easily accessible terminal blocks inside distribution/ termination boxes. The fibres shall be terminated in low loss, as stated under b) above, screw-on type of connectors suitable for withstanding high voltage hazards.

The Termination boxes shall be insect-proof and water-tight with protection degree of IP55W (weather proof), made of hot-dip galvanised and suitably painted steel and shall be designed such as to form an extremely rigid structure. The doors shall be of hinged construction with self-locking arrangement. The termination boxes shall be suitable for wall mounting or for erection on steel structures. They shall be installed inside the telecommunication rooms.

The design of the termination box shall consider an OFC/ approach cable entry and outlets for patch cords (corresponding to the number of fibres) with the required cable gland(s). The same number of pig tails shall be supplied and spliced to the main OFC or to the approach cable and terminated by a female low loss connector.

The connectors shall be fixed inside the termination box on connector holder which shall allow easy access to each of the connectors. The Patch cord cable's length shall be 10m and shall be provided with suitable male connector in order to form screw-on type. The loss of connector bulkhead and pig tail splice shall not be more than 0.3 dB.

d) Termination of the Fibres

The sheath and any armoring shall be stripped and then affixed to the termination box. Finally, the buffer fibres are affixed in special fibre splice trays (plastic or metal) and stripped with sufficient extra length.

The fibres are stored on these trays and spliced to the departing fibres or to the pigtails. Pigtails then shall be terminated by the female connectors. The number of splice slots shall equal to the number of fibres plus 20%.

e) Joints

The optical fibre joints shall be straight, embedded in reinforced nylon/ glass fibre sleeves. The joints shall be complete with cable clamps, inner split sleeve, protecting sheet, fibre guide, adapter core, outer sleeve, auxiliary heat shrinkable sleeve, self-bonding tape, etc.

5.8 CABLE INSTALLATION

5.8.1 Cables Laid Directly in the Ground

The cables shall be laid along the routes and in the locations as finally approved. The Employer shall have the right to alter the cable routes and locations, where considered necessary.

The Contractor shall take all necessary precautions to prevent damage to existing services and electric cables, and he shall be liable for any costs for repairing damage caused in the execution of the contractual work and shall pay the damage penalties according to the local laws and regulations.

Installation radii shall be as large as possible, and the minimum shall be 25 D along the route, and 15 D adjacent to joints and terminations (D being the overall diameter of the cable).

Before submitting his Proposal, the Tenderer shall satisfy himself concerning the nature of the ground likely to be encountered during operations. The Tenderer shall include in his prices excavation of ground of any nature and all types of soil likely to be met with and shall quote uniform flat rates. No claims for extras on any account whatsoever shall be accepted. No increase in price for excavation in

sand dunes, hard ground or rock, pumping water well point systems, cutting and reinstatement of any asphalt surfaces or any other cause shall be granted.

The exact location of each trench and pit shall be subject to the approval of the Employer/ Engineer.

Where trenches pass from a footpath to a roadway or at other positions where a change of level is necessary, the bottom of the trench shall rise and fall gradually.

The Contractor shall take all precautions necessary to prevent damage to the road or ground surface due to a slip or breaking away from the side walls of the trench.

Whenever trenches run parallel to existing services, cables, etc., the Contractor shall maintain a distance of at least 0.5 m between the existing services, cables, etc. and the edge of the new trench. The Contractor shall cross existing services with the utmost care and shall ensure that the cables are adequately protected. He shall obtain approval of the Employer/ Engineer concerning the method of crossing existing services in advance.

Each cable circuit, comprising the power cable(s) and the associated pilot/telephone- and optical fibre-cables, if any, shall be laid at the minimum depth below the road level given by the Engineer; the levels and relative particulars being ascertained by the Contractor from the authorities concerned. The Tenderer shall satisfy himself concerning the levels before submitting his Proposal.

As stipulated above, the depth of the cable trench shall be 1.3 m, but in some areas, the existing level may be more or less than the value below the road level, etc. thus the Contractor shall backfill 1.1 m soil upon the uppermost cable as a minimum in any case, subject to the Engineer's approval.

On the other hand, in cases where the existing ground level is higher than the expected final ground level, cables shall be laid to a depth as measured from the a/ m final ground level.

General Specifications

After the trench has been excavated to the necessary depth, a minimum of 0.15 m of approved material shall be placed to form a smooth bedding before the cables are laid.

Pullingin of cables shall not commence until the Employer/ Engineer has inspected and approved the depth of the trench.

After the cables have been laid and provided that their spacing has been approved by the Employer/ Engineer, they shall be covered up to the concrete tiles with an additional layer of approved bedding material (e.g. natural and properly riddled sand, or weak mix concrete, where the measured natural soil resistivity exceeds the value of 120 °C.cm/W) well compacted over and around the cables.

Cables shall be laid directly from the drums into the trenches and special rollers placed at close intervals (maximum 2 meters) shall be employed for supporting the cables while pulling and laying them. Rollers used during the laying of cables shall have no sharp projecting parts likely to damage the cables.

Until all the cables in the trench have been covered with their protection tiles as described below, no sharp tools such as spades, pick-axes or fencing stakes shall be used in the trench or shall be placed in such a position that they may fall into the trench.

Protective concrete tiles shall be carefully centred over the cables.

After the cables have been laid and covered, the required tests after installation shall be performed.

Cable markers of an approved type shall be provided along each route of buried cables, to be erected after the reinstatement has been carried out.

Markers shall be installed at all joint positions, at all places where the route changes the direction, and on straight routes at distances not exceeding 30 meters. The location of the markers shall be approved by the Engineer.

In general, the cables shall be accompanied by minimum 0.3 m yellow warning tape, marked in minimum 30 mm high black letters, indicating "DANGER HIGH VOLTAGE CABLE"; to be approved by the Employer/ Engineer.

The Contractor shall provide the ducts for road crossings including one spare circuit in the required positions. Except where the Contractor considers that a larger size is necessary, ducts shall consist of 0.15 m minimum internal diameter PVC pipes with a minimum wall thickness of 5.3 mm as per BS 3405 set in a surround of not less than 2 x 0.15 m thick concrete.

The ducts shall be laid on lean concrete foundations previously prepared upon compacted subsoil, then carefully connected and aligned, and consolidated with concrete to be suitably vibrated. The ends of the ducts shall protrude to a distance of 1.0 m beyond the curbstones.

5.8.2 Cable in Concrete Trenches

All concrete trenches/ troughs and covers shall be provided and shall be subject to the approval of the Employer/ Engineer. Concrete trenches of an approved size and layout with pre-cast concrete covers may be cast in sidu or constructed out of pre-cast trench pieces. All concrete trenches shall be cast or placed on lean concrete.

All power cables installed in reinforced concrete trenches/ troughs shall be supported by means of suitable spacers. For cable movements the snaked laying of cables is required. The cables shall be laid in a regular snaked form in the horizontal or vertical planes and they shall be secured at regular intervals by clamps or straps. The distance between the fixing points and the straps must take into account electrodynamic stresses under short circuit conditions.

All cables shall run in a neat and orderly manner and the crossing of cables within the trench/ trough shall be avoided as far as possible. Cables of different voltages and purpose shall be kept separate. Separation may be achieved by an adequate space between the cable, laying of cables on different cable trays or in different cable trenches.

On completion of the cable laying all concrete trenches supplied under this Contract shall be inspected, and the Contractor shall be responsible for the replacement of any broken parts at no additional cost.

5.8.3 Cables Supported on Racks or Trays

The Contractor shall supply all racks, trays and supporting steelwork for the cables supplied and installed under this Contract.

All cables shall be run with particular regard to neatness of appearance. Multiple runs shall be marshalled so that cables entering or leaving the run do so in an orderly and logical manner.

When cables are laid on cable racks (which shall be provided with holes to improve ventilation), except otherwise accepted, not more than one circuit shall be placed on one cable rack and shall be laid in snaked form. Cable racks arranged one above the other shall be at least 0.3 m apart.

Non-magnetic clamps must be used for this purpose, to brace the cables against dynamic impulse forces during short-circuits.

The spacing of cable-supporting steelwork shall be to the approval of the Employer/ Engineer.

Wherever cables and accessories are installed and exposed to direct solar radiation, sun shields of approved material and design shall be applied and installed.

Movable footbridges shall be provided in order to enable the Contractor's and any maintenance personnel to step over the cables; number and design shall be subject to approval.

For the cable basement of substations the Contractor shall prepare the arrangement and layout for all cables including all future cables in order that crossings are avoided and sufficient space for future connections is provided. This work shall be co-ordinated with the relevant substation contractors and the design shall be subject to the approval of the Employer/ Engineer.

General Specifications

All iron parts such as footbridges, cable-supporting structures, etc. shall be corrosion protected as described hereinafter and shall be properly grounded. This is also valid for all nuts and bolts unless they are of stainless steel.

Consideration of Induced Voltage

For, the protection/ telephone cables laid in power cable trenches or in the vicinity of such power cables have to be protected against damage by induced high voltages occurring in case of asymmetrical power cable operation, e.g. during short circuits.

Thus the Tenderer must prove by calculation on the induced voltages whether the sheaths and insulations of the offered cables are sufficient for the given network configuration.