

FEWA-PL-SS-E-0057 REV.0

**TECHNICAL SPECIFICATION
132KV CABLES, OPTIC FIBRE CABLES AND THEIR
ACCESSORIES**

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calculations and information to verify that cable sizes and method of installation are satisfactory.

The Contractor shall carry out at his own expense moisture content, water table level, and soil thermal resistivity tests along the 132kV cable routes and such other tests as he may consider necessary, sufficiently in advance before manufacture of any cable, to satisfy himself that the conditions on site and his proposed arrangement of cables and method of installation are such that the maximum current carrying capacity can be maintained. If the Contractor considers that the conditions and the proximity to other power cables, spacings and method of installation are likely to reduce the maximum current carrying capacity below the declared value he shall immediately notify the Engineer as to what the maximum current carrying capacity would be under these conditions and shall not proceed with the work on that portion of the route affected until the Engineer has given his permission.

The Engineer may instruct the Contractor to increase the section of the conductors or to take other means to ensure that the maximum current carrying capacity is maintained over the whole of the route.

Technical schedules in volume 3 shall be completed for each of the cables offered.

1.4. Calculations and Measurements

The cables and their accessories shall be constructed to meet the requirements when operating with full load or at any load factor. The Contractor shall submit at least the following calculations and records:

1. report of own site measurements of the actual soil electrical resistivity along each cable route
2. report of own site measurements of the actual soil thermal resistivity in accordance with IEEE 60442
3. report of own site measurements of moisture content and water table.
4. calculation results of the continuous current rating (as indicated in the offer) of the proposed cables and their accessories and short circuit capacity of the metallic sheath/armour in accordance with system design requirements.
5. calculation of zero sequence impedance and positive/negative sequence impedance of the power cables
6. calculation of induced voltages on pilot/telephone cables installed in parallel with the power
7. calculation of earthing wire cross sections.
8. report of density, grain size distribution, cement/sand ratio and thermal characteristics of proposed bedding and backfilling material of power cables
9. report of own site measurements of the actual zero sequence impedance and positive/negative sequence impedance of the power cable.

1.5. Voltage Marking and Identification

The colouring of outer sheaths shall be black unless otherwise specified by the Engineer and shall be embossed continuously along the length of the cable in English as follows to the approval of the Engineer.

The letters and figures shall be raised and shall consist of upright block characters arranged along two or more lines approximately equally spaced around the circumference of the cable. The maximum height of the characters shall be 13 mm and the minimum size 15 % of the approximate overall diameter of the cable or 3 mm whichever is the greater. The space between the end of one set of embossed characters and the beginning of the next shall be not greater than 150 mm.

- Nominal voltage
- Property of FEWA
- Size and type of cable
- Year of Manufacture
- Manufacturer's name and country

For example for 33kV cable :

CABLE 33000 VOLTS, PROPERTY OF FEWA, 1 CORE, 500 MM² COPPER, XLPE, 2002, "MANUFACTURER'S NAME" Country of Manufacturer..

1.6. Sealing, Drumming and Packing

Immediately after the Works Tests both ends of every length of metal-sheathed cable shall be sealed by means of a metal cap fitting over the end and plumbed to the sheath. Other cables shall be sealed by enclosing the ends in approved caps, tight fitting and adequately secured to prevent ingress of moisture.

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

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

Each drum shall have a distinguishing number, either printed or neatly chiselled on the outside of one flange.

Contract No., particulars of the cable, i.e. type, voltage, conductor size, number of cores, finish, length, gross and net weights, shall be clearly shown on one flange of the drum. In addition, the words "Running End" shall be marked on the flange and the direction for rolling shall be indicated by an arrow. The method of drum marking shall be to the Engineer's approval.

All cables and accessories shall be carefully packed for transport and storage on site in such a manner that they are fully protected against all climatic conditions, particular attention

being paid to the possibility of deterioration during transport to the Site by sea or overland and to the conditions prevailing on the Site.

Wooden drums shall be suitably constructed to avoid trouble due to shrinkage, rot and attack by insects.

1.7. Cable Lengths

Where applicable, cables shall be supplied in maximum drum lengths bearing in mind the transport limitations in gaining access to the Site. No drum shall contain more than one length. Cables shall be installed in maximum possible lengths and straight through jointing between shorter lengths will not be permitted without the prior written authority of the Engineer.

1.8. Quantities

The equipment layout drawings attached to the tender are provided for information only, and it is therefore the Contractor's responsibility to establish the exact quantities of cables and accessories required to complete the whole of the works as described elsewhere in the Specification.

2. SURPLUS CABLE

All surplus cut lengths of cables shall be handed over to the FEWA Central Store.

Brass, lead, copper or other approved sealing caps of the correct size shall be installed for all spare cut lengths of cable exceeding 30 metres in length to enable them to be properly stored for future maintenance purposes. The Contractor shall be responsible for the immediate sealing of such cut lengths and the cost thereof shall be deemed to be included in the Contract Price.

The cable surplus pieces handed over to FEWA store shall be properly protected from mechanical damages and packed with the radius not less than specified for the particular type of the cable. All the excess cables are to be listed drum wise and returned to FEWA Stores/Sharjah. The statement of surplus cables with stores acknowledgement shall be submitted along with final invoice.

The surplus cut lengths shorter than 100 m shall be contractor's property. The contractor shall clean the completed cable route and remove all cable and other material surplus preferably the same day but not later than the next day after particular work completion.

3. 132 KV XLPE CABLE AND ACCESSORIES

3.1. Conductor

The conductor shall comprise stranded, soft annealed, electrolytic copper wires, round and compacted with standardised conductivity, in accordance with IEC 60228 and shall be protected against water penetration in the longitudinal axis.

3.2. Insulation and Screens

The conductor shall be covered with three layers i.e. the conductor screen the insulation and the insulation screen. All three layers shall be mutually compatible and shall, in the same

manufacturing process, be continuously extruded and completely dry cured by a common head (simultaneously). For cooling after vulcanisation, preference is given to dry cooling. The insulation shall be of highly pure XLPE. To reduce the methane content of XLPE a heat treatment after curing shall be carried out.

To restrict the longitudinal passage of water, semi conducting water swellable tapes shall be provided beneath the lead sheath.

3.3. Lead Alloy Sheath

The lead shall be new and of approved origin and purity and shall be alloyed in ½C or copper/tellurium.

The sheathing shall be of uniform thickness and homogeneous construction, reasonably close fitting, seamless and free from porosity or defects and remain stable in service.

The composition of the sheathing and its thickness shall be suitable for resisting fatigue due to vibration, have good creep ductility and the construction shall be capable of withstanding the external and internal mechanical stresses likely to be encountered during manufacture, testing, transport, installation and service without puncture, fracture, or stress cracking.

The sheath shall be bedded on tapes providing electrical continuity between screen and sheath and designed to absorb thermal expansion. The insulation shall prevent longitudinal water penetration in the event of cable damage.

3.4. Over sheath

The outer covering shall be preferably high density polyethylene, termite-resistant, vermin-proof, resin-bonded graphite coated, and suitably prepared against decomposition under the prevailing service conditions at site.

4. BONDING & EARTHING OF HIGH VOLTAGE CABLES

For connection of sheaths of single core 132 kV cable, cross bonding system is to be adopted.

The conductors and sheaths of single-core 132kV power cable connections shall be transposed at each joint pit location.

Details of cross-bonding systems of single-core 132kV cable circuits and design of the relative individual accessories shall be subject to the approval of the Authority/ Engineer. Insulated flanges at each joint are required. Full load sheath voltages at unearthed locations shall be limited to 65 Volts. Bonding shall have provisions for periodic sheath integrity tests.

The maximum induced voltage at the cable sheaths at load current shall not be higher than 65 Volts during the normal operation conditions and 2.5 kV if a one phase to ground fault occurs in the network.

The standard delivery drum length shall include a suitable tolerance for achievement of the most effective bonding, and the pertinent calculation shall be submitted with the cable route as approved by the authorities concerned.

For cross bonding systems, cable sheaths shall be directly earthed through link boxes at every third joint bay. At the intermediate joints the sheaths shall be earthed through voltage limiters to limit steep-fronted transient over voltages to a value which can be safely withstood by the sheath insulation, (i.e. in addition to the cable over sheath this includes external joint insulation, terminal base insulation, joint and sheath sectionalising insulation - if any - as well as the insulation of the bonding leads and link boxes appropriate to cross-bonded or single point bonded systems). The voltage limiters shall be of non-linear type.

The bond connection shall be able to carry the normal sheath current as well as the maximum fault current without undue heating. The completed bonding system shall be subject to a test in the presence of the Authority/Engineer. The cables used for cross-bonding leads shall be of a concentric design with an inner insulation of PE and an outer insulation of PVC.

Earthing at each joint location shall comprise tinned copper wires or copper weld earth rods and insulated copper earth connections of not less than 150 mm² copper cross section, all supplied and installed by the Contractor with waterproof cast iron or stainless steel link boxes at each joint and cross-bonding location. Link boxes shall be housed in reinforced underground concrete pits designed for easy access and link disconnection to facilitate periodic serving tests.

After all earth cable connections to link boxes are made, the link boxes are to be filled with suitable compound upto earth cable top level so as to prevent moisture/ water entry through cores of earth cables.

Lids of concrete pits shall have two strong recessed handles, which shall move freely and not project after the lid is placed in position. They shall be designed for heavy traffic loading but as light weight as possible.

The size of copper earth connections shall be adequate to carry the full expected fault current for the cable system.

All steelwork not subject to the full fault current shall be earthed with not less than 95 mm² insulated copper conductor or equivalent bare copper earth tape.

The individual ground resistance at each earthing point shall not exceed 5.0 Ohm. Where necessary, additional earth rods shall be provided to obtain this value.

Insulated links placed in suitable boxes shall be included for easy disconnection at indoor terminations to facilitate periodic cable anti-corrosion protection tests. Weatherproof link boxes mounted on support structures shall be provided at outdoor terminations.

5. JOINTS & END TERMINATIONS

Joints and terminations shall have provisions for carrying out periodic sheath integrity tests on the cable.

5.1. Joints

The conductors shall be spliced by means of compression ferrules or welding or equivalent, the intended method (e.g. Cadweld process) to be intimated with the Tender Proposal.

The conductor screen shall be jointed with a semi-conductive plastic layer, wrapped with semi-conductive bonding tape.

The Tenderer shall explain in detail his proposed method of insulation jointing. The joints shall meet the cross bonding requirements specified in relevant clauses.

The insulation screen shall be linked with a semi-conductive plastic layer.

The metallic sheath shall be connected by means of copper or lead tape, copper braid, tinned annealed copper wire, copper wire netting tape, etc. Perfect bonding shall be ensured wherever connections/joints are made.

The joint shall be protected by a copper or lead tube and protective glass fibre box casing, filled with water-proof compound, or a combination of corrosion proofing tapes having waterproofing/electrical properties to satisfy D.C. serving tests.

Any alternative jointing method shall be equivalent in performance to the method specified, the Tenderer shall submit information to demonstrate the performance and experience of this method.

Jointing shall take place under environmentally clean conditions.

The cable joints shall be accommodated in reinforced concrete pits with reinforced concrete covers. The design and the dimensions of the joint pits shall be subject to the concurrence of the cable and joint manufacturers and approval of the Authority/Engineer.

A complete and detailed list of tools and equipment required for jointing the proposed cables shall be submitted with the Tender.

5.2. Outdoor Sealing Ends

For outdoor sealing ends, porcelain insulators shall be provided, designed with a creepage distance for 50 mm/kV based on rated line to line voltage to cater for the extraordinary pollution at the site area. The shape of the sheds of the insulator shall cater for the marine and desert pollution. The insulators shall be of self-cleaning, open profile type, they shall have smooth surface with no under-rips. No drip edge is permitted.

Arcing horns with reduced gap for insulation co-ordination shall be provided.

All terminations shall be made by using stress control cones. They 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 shall have the same thermal expansion coefficient as the cable. The sealing ends shall be filled with high viscosity polyisobutylene, silicone oil, or equivalent and suitable expansion device shall be provided.

Sealing ends mounted on support insulators and supported on hot-dip galvanised steel structures shall be complete with sun shielding and provision for accommodating an earth disconnecting link box.

These structures shall be designed to allow simple installation of down-droppers to the terminations.

The arrangement of the terminations, the supporting structures, including the cable fastening, shall be subject to the approval of the Authority/Engineer. A complete and detailed list of tools and equipment required for terminating the cables shall be submitted by the Contractor.

For proposal of alternative methods which shall be equivalent in performance to the method specified, the Contractor shall submit information necessary to demonstrate the performance and experience of the method.

5.3. SF6 Sealing Ends

Sealing ends suitable for installation under SF6 gas pressure of the GIS or transformer cable chambers shall have non-porous moulded housings designed to prevent the transfer of SF6 gas or sealing end oil. Top and bottom fittings shall comply with IEC 60859 and their latest amendments. The terminations for GIS shall be either plug in type or conventional SF6 type and as required and applicable at site.

Cable insulation termination shall be constructed generally in line with that for outdoor sealing ends.

The cable contractor shall co-ordinate cable and cable sealing end fixing arrangement with the substation contractor in order to avoid any harmful mechanical interaction between the cable and the GIS. This arrangement shall be subject to approval by the Engineer.

The copper sealing end base plumbed to the cable sheath shall be insulated from the GIS or transformer chamber and protected against voltage flashover during switching operations by short circuit disconnecting links or sheath voltage limiters spaced around the sealing end base. Provision for earthing the base shall be provided. The cable contractor will be responsible for arranging the de-gassing and re-gassing of sealing end chambers for testing purposes including the provision of any adaptors, gas and replacement O rings and seals to complete the works.

6. OPTICAL FIBRE CABLES

6.1. Type of Cable/Fibre

The Optical Fibre cable details are furnished so as to choose the suitable splicing kits and distribution frames.

The optical fibre cable shall have 16 fibres of single-mode type, suitable for transmitting light signals.

The fibre shall be made of ultra pure fused silica glass suitable for operation at 1,300 and 1,550 nm wave lengths. The design shall be as per recommendations and specifications made by International Committees/Organisations such as ITU-T(G. 651 and G.652) and IEC 60793 and 60794, and all updated versions of both.

It shall provide very low dispersion values for the entire wave length range from 1,300 to 1,550 nm (so called dispersion flattened or dispersion compensated fibres). The Tenderer shall submit along with his Tender Proposal supporting documents comparing test conditions and measurement results.

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.

6.2. 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.

6.2.1 Buffer Tube

Two fibres loose buffer tube type shall be provided. The buffer must hold its shape, be tough, not susceptible to ageing 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.

6.2.2 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.

6.2.3 The Cable Core

The buffer tubes with the fillers - if any - shall be stranded 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.

6.2.4 Inner Sheath

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

6.2.5 Aramide Layer (strength Member)

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

6.2.6 Intermediate Sheath

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

6.2.7 Armouring

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

6.2.8 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

6.2.9 Colour Coding of the Fibre/Buffer Tube

The colour coding shall be in compliance with the international standard, IEC 304.

6.2.10 Marking

The outer sheath of the fibre cable shall have the following marking, repeated every 1.00 m
OPTICAL FIBRE CABLE - 16 FIBRES
PROPERTY OF FEWA,
"Year of Manufacturing, Manufacturer" Country of Manufacturer.

6.2.11 Installation Practice

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.

6.2.12 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 (< 0.1dB).

The non-permanent connectors are located at the route ends only. These connectors shall have a minimum attenuation and shall comply with the latest technology.

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. Fusion splicing shall be adopted. Average optical loss shall not exceed 0.08 dB per splice. No single splice shall exceed 0.1dB.

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, adaptor core, outer sleeve, auxiliary heat shrinkable sleeve, self-bonding tape, etc.

6.2.13 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 ferrule type of connectors suitable for withstanding high voltage hazards. The marshalling cabinets shall be insect-proof and water-tight with protection degree of IP55W (weather proof) made of hot-dip galvanised steel or aluminium and shall be designed such as to form an extremely rigid structure. The doors shall be of hinged construction with self-locking arrangement. The marshalling cabinets shall be suitable for wall mounting or for erection on steel structures.

6.2.14 Termination of the Fibres

The sheath and any armouring 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. The number of splice slots shall not be less than 20.

6.2.15 Tests on Optical Fibre Cables - At Factory

Following factory tests shall be undertaken :

i) TYPE TESTS

- Tensile Strength
- Crush Test
- Stress Vs Strain Test
- Compression response
- Twist Characteristic
- Bend response
- Short Circuit Test
- Heat Cycling Test

ii) SAMPLE TEST (To be done on one drum from a batch)

- Dimension

- Cut Off Wavelength
- iii) ROUTINE TEST (To be done each drum before delivery to FEWA)
 - TDR Scan (Trace to be retained for future reference, inclusion in the final test report)
 - Attenuation (Trace to be retained for future reference, inclusion in the final test report)

6.2.16 Tests on Optical Fibre Cables -At Site (after installation)

Following tests are performed :

- i) Splice Tests for every joint (Attenuation & Backscatter)
- ii) Link Tests for every section (TDR scan, Dispersion)

6.3. Test Reports

All of the test results shall be clearly annotated with date/time; item identification; test equipment type and serial number; switch settings; screen axis names and dimensions and the marking of all points of special interest with comments. Detailed analysis and summary sections shall be included and the whole compiled into a single volume for presentation within one month of the overall link acceptance. The test results shall comply in all respect with the requirement as set out in the specification and data stated in technical particulars and guaranteed data and with standards ASTM-B415 and B416, ITUT (CCITT) G651 and G654, IEC 60793-1 and 60794-1, IEC-60068-2-14, IEC-2-52. Method and procedure of test shall be guided by the standard as above or such other standard as may be provided.

7. INSTALLATION OF CABLES AND ACCESSORIES

7.1. General

The 132 kV cables and their accessories shall be installed, tested and commissioned by the cable and accessories manufacturer's own staff, with local skilled and unskilled labourers employed only for excavation, installation of troughs, cable bedding, cable laying, backfilling and for civil work, which shall be adequately supervised by the Contractor's personnel.

The optic fibre cables shall be installed and tested by the Contractor's staff subject to written evidence approved by the Engineer that each member of staff engaged in the installation, supervision, jointing, termination and testing work has adequate qualification/work experience for such kind of cables. No member of staff employed on the installation work shall be changed without the prior written approval of the Authority/Engineer.

Excavation, installation of troughs, cable bedding, cable laying, backfilling operations or civil works shall not be sublet to a Subcontractor without the written approval of the Authority/Engineer.

The installation and handling of the cables shall be undertaken at all times by staff supplied with all the necessary plant, equipment and tools. The arrangement of the cables and all methods of laying shall be approved by the Engineer and shall be planned to provide an orderly formation, free from unnecessary bends and crossing, which will permit the removal of any one cable without undue disturbance to adjacent cables.

Every precaution shall be taken to ensure that cables and accessories are not installed in a manner or under conditions likely to cause electrolytic or other corrosive action or damage to, or be detrimental to the performance of the cables during operation.

Where required by the Engineer, all combustible outer coverings of cables installed within buildings shall be removed and if required the cables shall be protected against fire in an approved manner. Cables passing through floors shall be installed in the manner specified and where required shall be sealed into bushes employing fire resisting material to minimise the risk of spreading fire. 132kV cables, to be laid in trenches and basement are to applied with fire retardant coating, acceptable to 132kV cable manufacturer and approved by FEWA

The cables shall be laid along the routes and in the locations as finally approved. The Authority shall have the right to alter the cable routes and locations, where considered necessary, to avoid obstructions, or to suit finalised reserves allocated by Town Planning Authorities, for instance at the locations of future stations, or others.

The Authority/Engineer will, as far as possible, supply drawings showing the cable routes provided, and the locations of proposed circuits. In order to assist the Contractor, he may also furnish records of existing power cables, the accuracy of which, however, cannot be guaranteed.

Before starting work on site, the Contractor shall be fully responsible for obtaining the exact approved routes and locations from local authorities. He shall furthermore obey all relevant rules as applied by the Traffic Department with reference to traffic signs, diversions, etc. during the performance of his work.

The Contractor shall be responsible for obtaining from the engaged authorities any latest and correct information and details regarding the final levels, road centre lines, reserves for cables and other services and any other work in connection with his work.

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, over and above the damage penalty.

All arrangements of cables between the junction points and in the stations, the methods of laying and installation, and all arrangements bonding wires, link boxes, thermo-element boxes, etc. shall be subject to the approval of the Authority/ Engineer.

Installation radii shall be as large as possible, and the minimum shall be in accordance with the manufacturer's value for each type of the cable.

7.2. Excavation of Trenches

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 for dewatering, 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.

This refers also to green areas, where the Contractor is obliged to check with the authorities concerned if reinstatement may become necessary. All relevant costs (if any) shall be included in the Contract Price.

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

The excavation in city/town area with a lot of existing underground installations shall be carried out by hand only. The excavation in open areas can be carried out with the excavation machines in which case the contractor is obliged to obtain written proof from local authorities that there are no existing underground services on the parts of the route intended to be excavated by machines. However, such proof does not relieve the contractor from being responsible for damage of any services which may be not shown in the NOC drawings.

The Contractor shall arrange that not more than two adjacent sections of excavated trench shall be open at any time.

The trenches shall be located exactly within the approved reservation, the sides shall be straight and free from any sharp material/edges likely to injure the cable or accessories, the bottom shall be firm and of smooth contour and shall be free from any sharp materials/pebbles, etc. likely to damage the cables. Trenches shall be timbered or otherwise secured where necessary so as to avoid subsidence and damage. Whenever trench excavations are completed, immediately troughs are to be installed.

Where trenches pass from a footway 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.

The Contractor shall deal with and dispose of water so as to prevent any risk of the cables and other materials which are to be laid in the trenches being detrimentally affected. He shall provide all pumps, well points and appliances required, and shall carry out all necessary pumping and bailing. The Contract Price shall allow for all such equipment and operations.

The Contractor shall be responsible for public safety and hence shall provide picket fences and ropes along the routes of open trenches, as well as danger notices, barriers and red warning lights during the hours of darkness. A watchman shall be provided for every span of open trench during the night and non working hours.

Unless otherwise agreed, provision shall be made during excavation for reasonable access of persons and vehicles to property or places adjacent to the route. This provision shall be maintained until interim restoration has been completed.

Excavation in paved side-walks shall be carried out with special care. When removing paving slabs, the Contractor shall take the necessary precautions to avoid breakage. All slabs removed during performance of the work shall be re-established or replaced.

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 Authority/Engineer concerning the method of crossing existing services in advance.

Where sand dunes exist in the cable routes as finally approved, they shall be cleared to the normal ground level. Where the existing ground level is much higher than the final future ground level, cables shall be laid to a depth measured from the final future ground level. The amount of additional excavation shall be included in the Contract Price.

Wherever cables pass through wadis, which are subject to flooding by rainwater or underground water, special RCC trenches shall be constructed for laying of the cable. The Contractor shall show RCC trenches in the cable route drawings where cables pass through such wadis.

7.3. Excavated Material

The materials excavated from each trench shall be placed so as to avoid nuisance or damage to adjacent ditches, drains, fences, gateways and other property or things. Excavated material shall be stacked so as to avoid undue interference with traffic. Where, owing to traffic or for reasons of safety or other considerations, this is not permissible, the excavated material shall be removed from the Site and returned for refilling the trench on completion of laying; surplus material shall be disposed of by and at the cost of the Contractor in accordance with the local municipality regulation.

7.4. Methods of Laying

Cables between buildings or as otherwise indicated by the Authority/Engineer in schedules or drawings shall be laid inside the troughs in formed trenches. Cables shall be laid inside the troughs over sand bedding and sand filling after cables are laid. Thermal Resistivity of bedding and filling sand shall be 1.2 Cm/W and compacted to 90% after wetting. Cables shall also be drawn into pipes or ducts or laid in formed trenches or troughs or on racks or supported in trays or cleats as required by the Engineer. Where cables are laid in formed trenches the installation shall include for the removal and replacement of the trench covers and for the provision of temporary protective covers on the trenches where they cross access ways.

Where three single-core cables are laid direct in the ground or in formed trenches or supported in cleats or racks and form one three-phase circuit, they shall be laid spaced apart or in flat or triangular formation touching depending on the rating and permissible standing voltage unless otherwise agreed, the apex of the triangle being upmost. In order to maintain the triangular formation on the three cables they shall be tied together with rotproof straps when buried or secured by non-ferrous binders or cleats when installed in concrete trenches and basements. The binders shall be subject to approval by the Engineer. The binders shall be spaced at intervals not exceeding 1,200 mm. Where transposition is required the relative position of the three cables shall be changed at joint positions.

For each cable adequate length of cable shall be kept as loop near all joints/at appropriate places for jointing purposes in case of future damages.

Rates for cable installation and laying shall be respective of the manner and method of installation as mentioned in BOQ and corresponding drawings (e.g. ordinary trench, thrust boring, road/pavements cutting, waadi crossing etc.)

7.5. Cables Laid Direct in the Ground

Each cable circuit comprising three single-core power cables and the associated optical fibre-cables shall be laid at the minimum depth below the road level given in the typical trench cross section drawings, 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.

In general, the depth of the cable trench from the existing ground level shall be 1.2m for 33 kV and 1.3 m for 132 kV cables.

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

After the trench has been excavated to the necessary depth, a minimum of 100 mm for 33 kV cables and 150 mm for 132 kV cables of approved soft sand material shall be placed to form a smooth bedding before the cables are laid.

Pulling-in of cables shall not commence until the Authority/Engineer has inspected and approved the depth of the trench.

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 which are likely to damage the cables.

Until all the cables in the trench have been covered with their protection tiles 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.

After the cables have been laid they shall be covered with additional soft fill or sand well tamped down to a level of 200 mm for 33 kV cables and 250 mm for 132 kV cables above the bottom of the trefoil cable formation. In each layer where protective covers are required they shall be carefully centred over the cables forming each circuit, each cover being closely interlocked with the adjacent covers throughout the length of the cable.

The covers shall be of adequate width to protect the cables and provide a minimum overlap on each side of 50 mm.

Where in the opinion of the Engineer, the soil on Site is unsuitable for riddling or back-filling, the Contractor shall arrange for the importation of material with suitable thermal properties which shall be of approved type and quality.

Thermal resistivity of the finished backfilled trench material shall not be more than 1.40C m/W for 33 kV cables and not more than calculation input value for 132 kV cables, in dry condition. Measurement of the actual thermal resistivity of the completed backfilled trench shall be carried out by an approved method for HV cables. A measurement shall be carried out in each characteristic section in intervals, as decided by Authority.

Where more than one horizontal layer of cables is laid (only in exceptional cases approved by Engineer), the level of the upper layers of cable shall be gauged from the level of the finished bottom of the trench and marked on the side of the trench at frequent intervals

before the installation of the lower layers, to ensure that the correct vertical spacing is maintained.

The Contractor shall be solely responsible for ascertaining whether the soil is chemically active and for taking special precautions to protect the cables against chemical action. The Contractor shall take precautions to avoid electrolytic and/or electro-chemical action occurring in situations where the cable and accessories are likely to be installed in close proximity to other dissimilar metals in the presence of moisture.

Please note that wherever cables are to be laid directly in trenches shall be ignored and shall be treated as laid inside troughs.

7.6. Precast concrete troughs and covers

The outer dimensions of trough are 2000mm width and 600mm height without cover and the R.C.C. cover shall be minimum 100mm thick. The inside dimensions of trough shall be an average width of 1700 mm and 450 mm height without cover. The length of the troughs shall be normally 6000mm and 1000 mm. For bends, 6 identical pieces of angular troughs shall form 90 degree bend, (i.e) 15 degree angle for each piece. The covers shall be 2000 mm width and 1000 mm length for straight troughs and angular cover shall be of same as angular trough width and breadth. FEWA - HIGH VOLTAGE CABLES shall be engraved on the outer surface of each cover. Suitable lifting holes shall be provided at suitable locations for troughs and covers. Any special tools required for lifting the troughs and covers are to be supplied at free of cost to each area (two sets per one area) The proposed trough and cover drawings with required steel and concrete are furnished in the tender drawings.

The proposed manufacturers of precast troughs and covers are to be pre qualified, proving their previous experience on supply of the same. The manufacturing process shall be properly supervised by the contractor's supervisor at the factory. Proper factory quality check lists are to be got approved by FEWA and followed strictly.

7.7. Backfilling and Reinstatement

Filling-in of trenches shall not be commenced until the Authority/Engineer has inspected and approved the cables and accessories at site.

After the cables have been laid, the Contractor shall backfill the trench with natural and properly riddled soil in 0.15 m layers.

On top of these layers and further up to the warning tape, the excavated material shall be well compacted, watered if necessary, and consolidated. The Contractor shall carefully reinstate the surface finish, all to the satisfaction of the Engineer.

Each refilled trench shall be maintained in a thoroughly safe condition by the Contractor at his expense until such time as he can carry out permanent reinstatement of the upper levels and surface so as to restore these to their original condition, or to the level of the surrounding curb stones, respectively, whichever is higher.

All slabs being removed during performance of the work shall be re-established or replaced. All excess excavation products shall be removed without extra cost for the Authority.

7.8. Fencing

The Contractor shall provide and maintain at his own expense all lighting, guarding, temporary fencing and watching when and where necessary or required by the Authority/Engineer for the protection of the work and for the safety and convenience of the public.

7.9. Cable in Concrete Trenches Troughs etc.

All concrete trenches/troughs and covers shall be provided by the Contractor and shall be subject to the approval of the Authority/Engineer.

All 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.

They 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 shall be kept separate. 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.

Where there is a fire risk formed trenches/troughs shall be filled with imported material of suitable thermal resistivity carefully consolidated and covered with concrete or pre-formed covers.

7.10. Road Crossings

All main road crossings shall be carried out by means of thrust boring, with tentative cross section arrangement shown in relevant drawing. Secondary roads, asphalted car parks, interlocking tile surfaces etc. shall be crossed by means of cutting and ducts installation.

Care shall be taken to make the bends of pipe or duct lines as easy as practicable and in no case of a radius less than 3 metres. Where approved, split pipes may be used on bends, the pipes being fitted round the cable after laying.

In road crossings, the Contractor shall provide the ducts for each circuit separately including one spare per circuit in the required positions. Except where the Contractor considers that a larger size is necessary, ducts shall consist of 200 mm for 132 kV cables minimum internal diameter hard uPVC pipes with a minimum wall thickness of 4.0 mm set in a surround of not less than 150 mm thick concrete of grade 30 N for 132 kV cable ducts.

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. Ducts shall extend to a distance of 1.0 m beyond road curb stones.

The Contractor shall be responsible for all work involved, including breaking-up of a road surface and subsequent reinstatement in accordance with the requirements of the municipality.

At situations where buried cables cross other cables a suitable arrangement of ducts encased in concrete or a formed concrete trench shall be provided to effect the crossing and to facilitate the removal of one cable without disturbing the others.

Pitch fibre type pipes will not be permitted.

After pipes and ducts have been laid they shall be thoroughly cleaned. A mandrel of diameter slightly less than the pipe or duct shall be drawn through. After the mandrel has been drawn through the pipes a draw wire or rope shall be left in each pipe or duct, if required by the Engineer, to facilitate the drawing in of cables. The duct ends shall be sealed temporarily to prevent the entry of foreign matter. The pipes and ducts shall be cleaned again immediately before the cables are drawn in.

Any pipes or ducts not used shall be sealed by an approved method before back-filling. As far as not asphalted (subsidiary) roads are concerned, the crossing shall then be backfilled with excavated material and compaction to be done to the satisfaction of local authority

Excavation for road crossings shall be carried out as to leave in any case at least half of the road open to the traffic at a time. This shall be co-ordinated with the local traffic police. Cables installed both along and under asphalted roads and car parks shall be protected by a concrete raft having a minimum thickness of 150mm and a width extending to a minimum, and to the satisfaction of the local authorities of 100mm beyond the sides of the cable ducts. This concrete shall be laid immediately below the metalled surface of the road which shall then be reinstated to the satisfaction of the local authorities.

The Contractor shall be bound to co-ordinate, if required, all his work for road crossings with the relevant road constructor. The costs for complete reinstatement works after crossing of roads, including topping and reinstatement of the surf aces, are to be borne by the Contractor.

Existing spare pipes or ducts, if available, may only be used with the permission of the Authority/Engineer.

7.11. Installing Cables in Ducts & Duct Seals

To provide uniform constraint against thermo-mechanical forces and maintain thermal environment on long duct runs, unless otherwise agreed with the Engineer, all power cable pipes or ducts shall be completely filled, after cables have been installed, with the fluidised weak concrete mixture with low thermal resistance (less than 1.0°C m/W in completely dried condition). The mixture shall be such that it can be removed with high pressure water jets. Ducts shall have watertight joints and watertight duct seals provided at each end.

Special care shall be taken that all cable entries to joint pits substations and at all fire partition walls and sections, whether utilised or not, are durably and permanently sealed against water penetration, to the satisfaction of the Authority/Engineer.

7.12. Route Plan

During the progress of the Work the Contractor shall record on a set of route plans and cross-section drawings of an approved form, such particulars as will allow an accurate reference to be made in the case of any fault or projected modification. These marked up records shall show, amongst other data, both indoors and outdoors the exact position of every joint, cable box, earth electrode and connections thereto and also particulars of the

depth of the trench, the arrangement of the cables and the position of all obstructions revealed during the course of excavations.

Two copies of the marked up cable route records shall be submitted by the Contractor (one copy to Authority, one copy to Engineer) within 10 days after completion of installation works.

Final route As Installed drawings shall be handed over not later than 15 days prior to commissioning of each particular circuit. The above requirements will be a part of the conditions for the payment certification of the cable installation and commissioning works.

7.13. Diaries

The Contractor shall provide suitable diaries of an approved type (to which at all times the Authority/Engineer shall have access) and shall enter in these diaries all the measurements of the Work on the Site as completed on the day on which the measurements are taken, together with full particulars and details of all obstructions, modifications, extra works and incidents and the number and grades of men employed in each of the several portions of the work in progress.

The diaries shall be presented for the Engineer's examination and approval on a daily basis. The diaries shall, when signed by both parties, be deemed to be a true record of the work executed. A signed copy of diary record shall be retained by the Engineer.

7.14. Reports and Certificates

As each section of the Works are completed the following reports in duplicate shall be submitted to the Authority/Engineer for record purposes and shall be incorporated in the 'As-Constructed Records'.

- (a) Jointing Reports detailing the date, weather conditions, jointers and supervising Engineer's names, details of type of cable and type of joint or termination, location and joint bay number, ambient temperature and any other information relative to the jointing process.
- (b) Electrical Test Certificates shall be submitted detailing the test results of insulation resistance and any other electrical tests required by the Authority/Engineer together with similar detail as required for Jointing Reports.
- (c) Full written reports will be required of any damage occurring to cable or equipment together with remedial action proposed which will be subject to the approval of the Authority/Engineer.

7.15. Jointing Instructions

As soon as possible after the commencement of a Contract and before materials are despatched, copies of the jointing instructions applicable to the joints, sealing ends and terminations to be supplied shall be submitted to the Authority/Engineer for approval, together with details of the physical and electrical characteristics of the filling medium proposed.

Jointing/termination instructions shall be comprehensive and fully illustrated to enable any qualified jointing team to use the instructions. A fully dimensioned true to scale drawing shall

accompany the instruction together with a complete list of all special tools employed and an indication of their use together with a description of any precautions necessary.

7.16. Cable Jointing and Termination

The Contractor shall be responsible for obtaining drawings of all boxes or apparatus into which cables are terminated and shall ensure that the design is suitable for use with the cables supplied under this Contract.

No cable joint shall be installed without the agreement of the Engineer.

The Contractor shall submit drawings showing the types of joints, cable sealing end, terminal box or gland, he proposes to supply under this Contract.

During jointing the joint bays shall be shuttered to prevent subsidence and damage and shall be adequately covered with tents or other waterproof sheeting suitably supported. Proper precautions will be taken to guard against fire and to ensure temperature and humidity conditions suitable for jointing operations.

7.17. Joint Bays for 132 kV Cables

The contractor shall submit drawings of the layout and construction of joint bays, which shall be designed, precast trough or cast in situ concrete bay of required width and length for making joint shall be provided. On completion of joints, filled with soft sand compacted and covered with precast cover. Suitable approved concrete boxes should be provided for link boxes. Joint bay arrangement with proposed joint location has to be get the approval of the cable manufacturer to confirm the required space for making a joint. The joint location shall be free from other services, manholes etc.

7.18. Timber Left and Built In

Where required for the security of the works or adjacent buildings or structures, timber installed for the support of trenches, joint bays, headings, tunnels etc., shall not be withdrawn but shall be left in position.

7.19. Route Marker Tapes

Cable route warning/marker tapes for use during installation shall be continuously installed 300 mm below the ground level.

The tape shall have a thickness not less than 0.1 mm gauge, shall be 200 mm wide and manufactured from high grade polyethylene pigmented in bright colours.

The following message in Arabic and English shall be continuously printed in a contrasting colour in characters not less than 40 mm high specially protected against deterioration and fading.

**DANGER
HIGH VOLTAGE CABLES BELOW**

The tape shall be supplied in rolls of adequate length on stout reels suitably crated for shipment.

Tapes shall be in yellow colour with black lettering.

7.20. Joint and Route Markers

Cable markers in accordance with the attached typical drawings for 132kV and 33kV cables shall be provided along each route of buried cables and 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 80 meters. The location of the markers shall be approved by the Engineer.

Samples with details of all markers proposed to be used shall be submitted for the Authority/Engineer's approval before cable installation work commences. The joint markers shall differ from the markers for the cable routes.

7.21. Cable Supported on Racks or Trays

The Contractor shall supply and install all the supports, racks, trays, cleats, saddles, clips and other parts required to carry and secure the cables, without risk or damage, in a neat and orderly manner. The spacing of all supports, racks, cleats, saddles and clips shall be agreed by the Engineer.

The design of all items shall ensure freedom from rough edges, burrs and sharp corners, and the materials used for the construction and fixing thereof shall be approved by the Engineer. No materials shall be supplied which will promote electrolytic or other corrosive action in contact either between the various parts, or with the cable sheaths or the building surfaces and other materials with which they may make contact.

The cable route within the basement shall be submitted in time and the support/ cable rack works shall be started only with approved drawings.

The cable supports required for installation with single-core cables, forming a three-phase circuit, shall be so designed as to permit the cables to be laid flat touching or spaced, or in close trefoil or quadrature formation. Metal cleats may be used for this purpose but in such cases approved insulation shall be provided between the cable and the cleats.

Cleats may also be of impregnated hardwood or composition material designed not to split or deteriorate under working conditions for the life of the cable, cleats and fixings shall not produce iron circuits around single core cables and shall be designed to restrain the cable under fault condition whether in single or trefoil arrangement.

Where single-core cables in trefoil formation are not secured in cleats, binders of approved material and construction shall be fitted around the formation to prevent the cables separating under fault conditions. The binders shall consist of a non-ferrous strap secured around the cables by means of a bolted connection. The spacing of binders shall not exceed 1.2 m be approved by the Engineer.

The design of cable support for cables installed in air in cable tunnels, basements, etc., shall consist of vertical steel members spaced at approved intervals and secured to the walls, floors and ceilings as necessary by means of bolts either cemented in position or expanded into cored holes. Each vertical support shall have bolted to it a number of steel brackets spaced at the intervals agreed with the Engineer and designed to support and retain trays constructed of galvanised sheet steel of adequate section to carry the weight of the cables,

plus space for an additional quantity of future cables not less than 25% by weight and dimensions in excess of the cables installed under this Contract and additional load of 100 kg at the extremity without distortion. The trays shall be designed with raised edges to retain the cables and shall incorporate an interlocking feature so as to prevent movement between supports. Solid sheet steel trays shall have drainage holes and shall be drilled to accommodate cable cleats at an agreed spacing to support single core cables in the desired formation.

At GIS cable chambers the cleating arrangement shall be designed to be totally self supporting and to prevent the cable imposing excessive thrust forces on the termination under any service condition.

The design of support for situations where trays are not required shall in general consist of a metal rack within which is contained one or more pairs of cleats shaped to suit the formation of the cables. Cable cleats shall be of an approved non-corrosive material having no deleterious effect on cable coverings or supporting steelwork. Aluminium or aluminium alloy cleats shall not be used. Cleats for carrying a single-core cable shall be non-magnetic and the arrangement shall not permit any closed magnetic circuit around the cable.

The steel used in construction of cable supports shall be hot dipped galvanised.

The design and construction of all cleating and supporting arrangements shall suit the cable system design. The spacing of cable supports shall be approved by the Engineer.

Where cables are cleated to the floor of cable tunnels or basements, they shall be protected by heavy gauge galvanised steel shrouds with steep sloping top, and firmly secured to the floor. The shrouds shall be adequately ventilated. Where a cable circuit is protected by a shroud and occupies a width greater than 450 mm, a suitable heavy duty steel step shall be provided over the cables to allow personnel to easily cross the obstruction.

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.

Every non-flexible cable shall be securely supported at a point not more than 1.0 m from its terminal gland to prevent stressing of the terminal, and on vertical runs passing through floors, the cable shall be supported immediately above or below the floor.

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

Within the stations, 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 lay-out 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 other relevant building service works and the design shall be subject to the approval of the Authority/Engineer.

7.22. Earthing and Bonding

Earthing conductors shall be copper strip of not less than 120 mm² section laid in formed cable trenches or ducts, or fixed to walls, concrete or steelwork, by means of clamps or claw type cleats, appropriately secured into suitable wall plugs or tapped holes. The spacing of fixings shall not be greater than 1 m. Where earth strip is buried or laid in positions in which there is danger of corrosion it shall be provided with a corrosion-proof serving of extruded thermo-plastic or self-adhesive PVC tape which for short lengths may be hand applied on Site.

Cross bonding shall be applied to the 132 kV cables.

The bonding and earthing shall be carried out through link boxes to facilitate the periodic voltage testing of outer coverings. The bonding and earthing system shall be subject to the approval of the Engineer and shall be designed to meet the subsequent maintenance requirements.

7.23. Labelling

All cables shall be identified below the termination at each end, in cable pits and at approved positions by means of identification plates engraved with the cable number, feeder name, size of cable, number of cores, phase colour etc., or such lettering as the Engineer may require. The termination plates shall be securely fastened in a permanent manner, and shall be made of material able to resist corrosion, damp and mechanical damage.

7.24. Special Tools and Appliances

Special tools which are not listed in the relevant schedule by the Contractor during the tendering stage, but which are used by the contractor during the erection or testing works shall be supplied to the Authority free of charge.

A minimum of two of such special tools for each area shall be handed over to the Authority.

7.25. Verification of length

The contractor shall notify Engineer that the cables are laid and ready for verification of length by Engineer. The contractor should not backfill the trench before surveyor completes verification of route/cable lengths.

While doing measurements, the following aspects shall be taken into consideration.

- (i) Looping for joints
- (ii) Looping for terminations
- (iii) Looping for ducts
- (iv) Snaking

A typical format for recording cable measurements is given in Annexure.

8. TESTING OF 132 KV CABLE, CABLE JOINTS AND TERMINATIONS

8.1. Type Tests

Cables and associated jointing and terminating accessories shall have satisfactorily passed type approval tests generally in accordance with IEC 60840 in the following sequence.

- i) Bending test generally to clause 5.5.3 IEC 60840 but the diameter of the test cylinder shall not be greater than $25(D + d) + 5\%$ where D - cable outer diameter in mm and d-conductor diameter in mm.
- ii) Partial discharge test as specified for routine tests at works.
- iii) Power factor/temperature test. The sample shall be heated until the conductor reaches a steady temperature which shall be between 10°C and 15°C above the maximum rated temperature of the insulation in normal operation. The power factor shall be measured at power frequency voltage U_0 and the measured value shall not exceed 0.001.
- iv) Heat cycle voltage test as per clause 5.5.6 IEC 60840.
- v) Partial discharge test as specified for routine tests at Works.
- vi) Impulse voltage test generally as per clause 5.5.7 IEC 60840. The impulse voltage shall be 650 kVp.
- vii) Power Frequency test. AC voltage of $2.5 U_0$ shall be applied for 15 minutes, as per clause 5.5.7 of IEC 60840.

No breakdown of the insulation shall occur during any of the above tests.

In addition, abrasion, penetration and saline tests on outer coverings as per clause 4.1.2 IEC 60229 and IEC 60811.

8.2. Routine Tests at Works

All the routine tests specified in IEC 60840 shall be carried out on each manufacturing cable length which shall include following tests.

- i) Partial discharge test in accordance with clause 3, IEC 60840 except that the minimum detectable discharge shall be 5 pc or less. The test voltage shall be raised to $1.75 U_0$ for ten seconds and then slowly reduced to $1.5 U_0$. The magnitude of the discharge at $1.5 U_0$ shall be recorded and shall not exceed 10 pc.
- ii) An a.c. voltage of $2.5 U_0$ shall be applied at ambient temperature between conductor and metallic sheath for thirty minutes. No breakdown shall occur.
- iii) Conductor resistance measurement to clause 4.5 IEC 60840.
- iv) Voltage test on over sheath and outer protective covering as specified in IEC 60229

8.3. Tests at Site

- a) High voltage test generally as per clause 6.1 IEC 60840.
- b) Voltage test of 10kV maximum per one minute on anti corrosion covering in accordance with IEC 60229. This test shall be carried out after the cable laying, but before jointing and backfilling above concrete slabs.
- c) After completion of the installation (including termination), all sheath insulation shall be tested in accordance with clause 5, IEC 60229.
- d) Thermal resistivity measurement of the backfilled trench in accordance with an approved method for HV cables (IEEE 60442 or equivalent)
- e) IR values are to be checked before and after HV test.
- f) Core resistance is to be measured as per IEC 60228, clause 5.
- g) Capacitance test
- h) Earthing measurements
- i) Visual and functional tests of cross bonding system and cable sheath temperature measurement system.
- j) Positive/negative and zero sequence impedance measurements.

9. 132KV CABLE SEALING END COMPOUND

9.1. 132kV Cable Sealing End compound - Requirements

At the connection point between 132 kV cables Over Head Line tower termination point there is a requirement for a Cable Sealing Compound. Cables Sealing Compound general arrangement shall be as shown in the tender drawing No.

The Cable Sealing end Compound shall be complete with the following :

- (i) Necessary sealing structures and foundations for single phase Cable Sealing ends.
- (ii) Single phase Surge Arresters with surge counter leakage measurement device as specified. Foundation and Supporting structures required for Surge Arresters.
- (iii) Support insulators anchoring complete with down leads, accessories and anchoring foundations.
- (iv) Earthing and lightning protection for the complete area within the fencing as per IEEE recommendation.
- (v) Chain link fencing and double door gate with proper locks etc.
- (vi) Gravel spreading in the complete area within the fence as per the requirements in earthing calculations.

- (vii) Connections between overhead line down lead conductors, support insulators, Surge Arresters and the cable sealing ends with adequately rated power connectors.
- (viii) Other electrical, mechanical and civil work items necessary to complete the above installations.

9.2. Boundary Wall for Cable Sealing Compound

The contractor shall construct a 2 meter high boundary wall of reinforced concrete foundation and frame and calcium silicate block work infill all around. The wall shall be plastered and painted.

The wall shall have a precast concrete coping into which shall be set an approved intruder deterrent assembly of at least 3 strands of barbed wire angle towards the outside of the site.

The walls shall be of pleasing appearance having architectural features.

The design of the walls are to take into account thermal movement and all forces to which it is likely to be subject including wind and any surcharges resulting from wind blown sand or differences in external and internal levels.

A 4 meter wide vehicular access gate shall be provided at the main entrance.

The gate is to be unclimbable and of substantial R.H.S. steel construction with vertical bars. The gate shall be complete with all fittings such as drop bolts, back latches, locking bar, cat bar, lock plates and lock etc. and the whole shall be galvanised and painted.

9.3. Equipment Support Steel Structures

Steel structure shall be designed as specified.

10. 132KV SURGE ARRESTERS

10.1. Design and Construction

In order to ensure safe operation of the HV plant under all switching conditions, surge arresters shall be applied as necessary. Surge arresters shall be suitable for the particular application. Surge arresters shall be of outdoor, polymer/Composite body, heavy duty, pressure relief Class-A, gapless, metal oxide type.

The selection of the ratings of the Surge Arresters shall be based on the insulation coordination study conducted by the Substation Contractor.

They shall be designed to prevent any oscillating over voltage which may occur during normal or abnormal operation of the cable/Over Head Line circuit and the design data shall be defined in close co-operation with the plant supplier and arrester manufacturer. It shall be subject to the Engineer's approval at an early stage.

The arresters shall comply with IEC 60099-4.

The arresters shall have polymer type body.

The arresters shall have pressure relief devices and shall be fitted with operation counters. They shall be built-up from hermetically sealed units containing valve resistor blocks with non-linear characteristics without spark gaps.

The arresters shall have a creepage distance of minimum 50mm/kV based on the rated voltage. They shall be fitted with the operation counters and resistive leakage current measurement devices for each phase separately.

The surge arresters shall be complete with mounting structures, fixing bolts, insulating bases and connectors.

Each arrester shall be identified by a rating plate which includes rated voltage, maximum continuous operating voltage, duty cycle current rating, pressure relief serial No. year of manufacture, etc.

10.2. Tests at Factory

Type test certificates for all type tests as per IEC 99-4 are to be submitted. If the above are not satisfactory, the required tests shall be carried out on one unit, in the presence of FEWA/Engineer.

Routine tests as per IEC 60099-4 are to be carried out on all surge arresters.

11. LIST OF STANDARDS

All the latest addendums and amendments are to be followed:

BS 4066	Tests on electric cables under fire protection
BS 6346	PVC-insulated cables for electricity supply
BS 6622	Specification for cables with extruded cross-lined polyethylene, ethylene propylene rubber insulation for rated voltages from 3800V upto 19 000/33 000V.
IEC 60287	Calculation of continuous current rating of cables (100% load factor)
BS 6746	Specification for PVC insulation and sheath of electric cables.
IEC 60332	Tests on electric cables under fire conditions.
BS 6121	Mechanical cable glands.
IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1kV up to 30kV.
BS 6360	Specification for conductors in insulated cables and cords.
IEC 60228	Conductors of insulated cables.
BS 6234	Specification for polythene insulation and sheath of electric cable
BS 2484	Specification for straight concrete and clay ware cable covers.
IEC 60840	Tests for power cables with extruded insulation for rated voltages above 30kV up to 150 kV
IEC 60331	Fire resisting characteristics of electric cable
BS 729	Specification for hot dip galvanised coatings on iron and steel articles.
IEC 60859	Guide for cable connections for HIS for rated voltages of 72.5kV and above.
IEC 189-2	Cables in pairs, triples, quads, quintuples for inside installations.
IEC 60099	Surge Arresters.
BS 1442	Specification for galvanised mild steel wire for armouring cable.

IEC 60287 Calculation of continuous current rating of cables (100% load factor)
IEC 60885 Electrical test methods for electric cables
BS 3573 Specification for polyolefin copper conductor telecommunication cables.

And any other relevant standards.