

FEWA-PL-SS-E-0067 REV.0

**TECHNICAL SPECIFICATION
INSTALLATION OF CABLES AND ACCESSORIES**

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1. GENERAL

1.1. INSTALLATION OF CABLES

1.1.1 33/11kV/LV Power and Control Cables and Accessories

The scope of work for 33/11kV cables includes receiving materials from FEWA Stores, Sharjah, transportation to site, installations, jointing, terminating, glanding, earthing, supporting, cleating, protecting, painting, at site where required, testing, setting to work, rectification during maintenance period etc. All LV power and control cables required for the entire substations shall also be supplied and installed by the erection contractor.

The scope also cover the complete design work associated with installations including the route survey, cable route layout drawings, cable tray layout drawings, for the entire substations area.

All accessories required for the entire installations shall be supplied and installed by the erection contractor. The erection contractor shall properly co-ordinate the cable tray layout in the basement with other services including ventilation, fire protection, lighting etc. The cable tray layout shall be designed in such a way a clear head height of 1.8 m is left and it is not obstructing the walkways and escape routes enabling free movement in the basement. The cable trays in the basement shall be supplied and installed for the future equipments also.

The cable tray layout shall be prepared based on the future consideration and permissible cable tray loading as per manufacturer's standard.

All the cables laid in cable tray shall be properly dressed in a neat manner. The cable tray supports shall be based on the loading/manufacturers recommendations and FEWA standard practice.

The duct banks shall be provided by the civil contractor as indicated in the relevant drawings. Any additional duct banks required shall be supplied and installed by the erection contractor.

All power cables and auxiliary/multicore control cables shall be laid in separate cable trays and cable ducts.

The erection contractor shall properly co-ordinate with the civil contractor for cable installations.

2. JOINTS & TERMINATIONS

Joints and termination shall have provisions for carrying out periodic sheath integrity test on the cable.

2.1. JOINTS FOR 33/11KV CABLES

All joints shall be of heat shrinkable type or pre moulded type.

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 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.

Jointing shall take place under environmentally clean conditions.

2.2. TERMINATIONS FOR 33/11KV CABLES

Terminations shall be of heat shrinkable type.

Heat shrink tubing and moulded parts shall be flexible, flame retardant, polyolefin-based material of electrical insulating quality, and shall be obtained from an approved manufacturer. They shall be suitable for use indoors or outdoors in the conditions prevailing on site.

Outdoor terminations suitable for tower line termination shall be approved by FEWA. The creepage distance of insulation shall not be less than 50 mm/kV based on rated system voltage (line-to-line). The termination shall be supplied complete with fixing brackets, etc.

Each part shall bear the manufacturer's mark, part number and any other necessary markings to ensure correct identification for use on the correct size and type of cable. Each set of parts shall be packed as one unit with full and complete installation instructions and clearly marked to show the application.

Terminal lugs must be of the closed type and incorporated in the termination to prevent moisture ingress through the conductor. Where practicable, terminal boots shall enclose the electrical connection to equipment bushings.

The copper core screen connections and aluminium armouring shall be brought out of enclosed cable boxes and incorporate an earth disconnecting arrangement for periodic external insulation testing necessary for the end point bonding arrangement. Purpose made insulated mechanical glands with earthing tags or insulated gland plates with normal glands may be employed.

2.3. MECHANICAL CABLE GLANDS

Cables shall be terminated in non-ferrous mechanical cable glands with integral insulating barriers and earth lugs designed for coupling copper screens and aluminium wire armour for end point bonding purposes and to facilitate testing of the cable earth insulation. The gland shall be corrosion proof and incorporate seals to prevent moisture ingress into the cable or Terminal chamber.

Glands shall have provisions for periodic sheath tests.

2.4. BONDING & EARTHING

Single core 33kV, 11kV cable metallic screens shall be solidly bonded.

Terminations may be constructed of heat shrink materials, moulded, roll over or taped designs comprising silicon rubber and other stress graded materials but the design must be type approved to acceptable standards and have a confirmed satisfactory service history.

There shall be provisions for carrying out periodic sheath integrity test on the cable.

Single point earthing is acceptable for power cables laid within the substation between switchgear and transformers etc.

3. INSTALLATION OF CABLES AND ACCESSORIES

3.1. GENERAL

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 FEWA.

Excavation, cable bedding, cable laying, backfilling operations or civil work shall not be sublet to a Subcontractor without the written approval of the FEWA.

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 Authority 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 FEWA, 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 a manner specified and wherever required shall be sealed in to bushes employing fire resisting material to minimise the risk of spreading fire. 132kV Cables to be laid in trenches and basement are to be 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.

Before starting work on site, the Contractor shall be fully responsible for obtaining the approval for cable routes and locations.

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 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 FEWA.

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.

3.2. 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. No claims for extras on any account whatsoever shall be accepted.

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.

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 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.

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 FEWA 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.

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.

3.3. 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.

3.4. METHODS OF LAYING

Cables between buildings or as otherwise indicated by the Authority in schedules or drawings shall be laid in formed trenches. Cables shall be laid direct in the ground in trenches excavated therein and shall be protected with covers of reinforced concrete, or other approved material as may be specified by the Authority. 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 Authority. 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 rat proof 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 FEWA. 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.

3.5. CABLES LAID DIRECT IN THE GROUND

Each cable circuit comprising three single-core power cables and the associated pilot and optical fibre-cables shall be laid at the minimum depth below the road level given in the typical trench crossing 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 shall be 1.2m for 33 kV and 11kV cables and 1.3 m for 132kV 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 33kV & 11kV cables and 150mm for 132kV Cables of approved soft sand material shall be placed to form smooth bedding before the cables are laid.

Pulling-in of cables shall not commence until FEWA 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 11 kV cables and 250mm for 132kV 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 Authority, 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 1.4°C m/W for 33 kV & 11kV cables and not more than calculation input value for 132kV 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 Authority), 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.

3.6. CABLE COVER TILES FOR 33KV, 11KV CABLES AND ASSOCIATED PILOT CABLES

3.6.1 Construction

The cable covers should be made from high impact grade PVC or Polyethylene should be stiff and have high resistance against impact, corrosion and aggressive agents present in the soil. The dimensions of the cable cover tiles shall be 1000mm/length, 300mm width and 12mm thickness.

The cable covers should be capable of being interlocked to each other lengthwise.

The minimum impact strength of the cover shall be 100KJ/sq.m and as per requirement of BS 2484.

3.6.2 Cable Cover Identification

The cable covers shall have the following caption printed on top in Arabic and English and FEWA Logo with black colour letters in not less than 20mm size and shall be specially protected against deterioration. Cover must be marked

**DANGER
HV CABLE BELOW
FEWA**

3.6.3 Drawing and Samples

The Tenders shall provide drawings, samples, catalogues etc. of the items offered by them in their offer.

All drawings, catalogues and samples shall be submitted by the contractor at his expense and shall be the property of the Authority.

3.6.4 Testing

All the relevant tests pertaining to PVC cable covers should be carried out. The Contractor will be required to submit 4 sets of Test Certificates for such tests carried out with each consignment. They should also indicate standard to which tests are carried out and enclose full description of each test.

The Contractor shall submit along with his offer one copy of Test Certificate for similar product manufactured in the past.

3.6.5 Packing and Despatch

The PVC cable covers shall be packed in bundles, covers per bundle and shall not be more than 10 Nos. These bundles will be further packed in pallets and the size of each pallet should not be more than 1200mm x 1200mm x 1200mm (Length x width x height).

The pallet shall be duly covered and strapped so that the colours of the PVC cable covers do not fade when stored in open yard and the pallet should have proper arrangement for lifting by forklift from all 4 sides. Further, packing shall be such that it affords adequate protection to the enclosed materials both against climatic conditions and against mechanical damage

during transport to its final destination, including rough handling during sea, rail and road transport and transition from one to another.

3.7. BACKFILLING AND REINSTATEMENT

Filling-in of trenches shall not be commenced until the Authority 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 Authority.

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 kerbstones, 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 Engineer.

3.8. 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 for the protection of the work and for the safety and convenience of the public.

3.9. 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.

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.

3.10. 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 circuit in the required positions. Except where the Contractor considers that a larger size is necessary, ducts shall consist of 150 mm for 33/11 kV cables minimum internal diameter hard PVC pipes with a minimum wall thickness of 5.3 mm set in a surround of not less than 125 mm for 33 kV cable ducts.

The ducts shall be laid on 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 Authority. 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 Authority, 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 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.

3.11. 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 Authority, 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 FEWA.

3.12. 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 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.

3.13. REPORTS AND CERTIFICATES

As each section of the Works is completed the following reports in duplicate shall be submitted to the FEWA 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 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.

3.14. 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 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.

3.15. CABLE JOINTING AND TERMINATION

The Contractor shall be responsible for obtaining drawings of all cable 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 Authority.

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.

3.16. 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.

3.17. ROUTE MARKER TAPES

Cable route 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.

3.18. JOINT AND ROUTE MARKERS

Cable markers 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 approval before cable installation work commences. The joint markers shall differ from the markers for the cable routes.

3.19. CABLE SUPPORTED ON RACKS AND CABLE 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 Authority.

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 Authority. 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.

Approved cable identification markers shall be provided at every 20m interval.

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 Authority.

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. Only 50% locating 20 will be allowed for each cable trays.

3.20. 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.

Solid bonding shall be applied to the 132kV cables, 33kV cables and 11kV Cables.

The bonding and earthing shall be carried out for 132kV Cables through link boxes to facilitate the periodic voltage testing of outer coverings. The link box provided at transformer side shall have surge voltage limiters. The bonding and earthing system shall be subject to the approval of the Authority and shall be designed to meet the subsequent maintenance requirements.

3.21. 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.

3.22. 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 tool shall be handed over to the Authority.

4. TESTING

4.1. 33KV, 11KV CABLES

Tests at Site

- Measure conductor resistance Ohms/km.
- Measure insulation Mohms/km
- High voltage test as per IEC 502 clause 18.
- Voltage (dc) test on anti-corrosion outer covering as per Clause 5 IEC 229. This test should be carried out after laying but prior to jointing and backfilling above concrete slabs.
- Thermal resistivity measurement of the backfilled trench at characteristic locations, in intervals not less than 500 m in accordance with an approved method for HV cables (IEEE 442 or equivalent).
- After completion of the installation, all sheath insulation shall be tested in accordance with Clause 5 IEC 229.
- Capacitance test
- Earthing measurements

- Visual and functional test of solid bonding system and cable sheath temperature measurement system.
- Positive/negative and zero sequence impedance measurements.

5. LIST OF STANDARDS

BS 4066	Tests on electric cables under fire protection
BS 6346	PVC-insulated cables for electricity supply
BS6622	Specification for cables with extruded cross linked 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 60885	Electrical test methods for electric cables