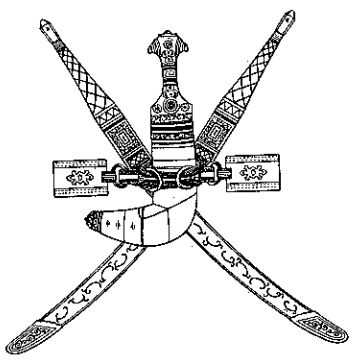
SULTANATE OF OMAN

MINISTRY OF ELECTRICITY & WATER



STANDARD - OES 32

DOUBLE CIRCUIT 132KV OVERHEAD TRANSMISSION LINE 400 SQ.MM ALL ALUMINIUM ALLOY TWIN CONDUCTORS ON LATTICE STEEL TOWERS

FIRST EDITION

JANUARY 1995

STANDARD : OES - 32

DOUBLE CIRCUIT 132 KV OVERHEAD TRANSMISSION LINE
400 SQ.MM ALL ALUMINIUM ALLOY TWIN CONDUCTORS
ON LATTICE STEEL TOWERS

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTD...)

SCHEDULES

TABLE OF CONTENTS

SULTANATE OF OMAN
MINISTRY OF ELECTRICITY & WATER

STANDARD OES - 32

DOUBLE CIRCUIT 132KV OVERHEAD TRANSMISSION LINE 400 SQ.MM ALL ALUMINIUM ALLOY TWIN CONDUCTORS ON LATTICE STEEL TOWERS

1.0 SCOPE

The specification covers complete supply, erection and commissioning of 132 KV double circuit transmission line on Lattice Steel towers with twin conductor 400 sq. mm all aluminium alloy conductor and shield conductor of aluminium clad steel 7/3.26.

The scope of work shall include the design, manufacture, supply, testing, inspection at manufacturer's works, insurance, packing for export shipment, delivery to the site, unloading, survey and profile plotting of support position, pegging out, clearing and provision of access roads where necessary complete erection, setting to work and maintenance for a period of 12 calendar months of the 132 KV double circuit line.

The scope also shall include all parts of work to be completed in every respect for commercial operation to the satisfaction of MEW.

The three phase of each circuit are to be in vertical formation at suspension position and a single over running earth wire.

The parameters and ratings of the 132 KV line shall be established for a normal electrical load transfer of 300 MVA through each circuit at 132 KV nominal voltage in Oman climatic condition as mentioned in OES 11.

2.0 LINE CONDUCTORS

Line conductors shall be twin 400 sq.mm nominal aluminium area. All aluminium alloy conductor "YEW" and comply with this specification. Characteristics entered in the schedule and with IEC Publication 208.

Each conductor inner layers shall be covered with an approved grease such as Shell ENSIS compound or equal having a minimum drop point of 100 Deg. C, which shall completely fill the innerstics between the strands of the outer layer. The mass of grease shall represent a minimum of 0.7% of the total conductor weight.

There shall be no excess grease remaining on the outside surface which may cause sand the dust particles to adhere during pulling out and erection of conductor. The outer most layer of the conductors shall be stranded with a right hand lay.

Aluminium alloy conductor shall be made of heat treated aluminium magnesium silicon alloy wires having mechanical and electrical properties as per IEC 208.

Joints in individual wires are permitted in any layer except the outer most, in addition those made in the base rod or wire before final drawing, but no two such joints shall be too less than 15 meters apart in the complete stranded conductors. Such joints shall be made by resistance built welding and shall be annealed after welding over a distance of atleast 25 cm on each side of the joints. They should conform to the mechanical and electrical requirements for unjointed wires.

The conductors shall be supplied on impregnated drums of approved material so as to enable the conductor to run smoothly and in lengths convenient to handle and erect.

The cut ends of conductors, together with the joints, clamps and fittings attached to the conductor themselves shall be treated in an approved manner to prevent the ingress of air or moisture.

3.0 EARTH WIRE / SHIELD WIRE

The earth wire / shield wire shall be aluminium clad steel conductor consisting of seven strands. The size of conductor shall be 7/3.26mm (58.3 sqmm) aluminium clad steel.

Stranding 7/3.26
Max. resistance at 20 Deg. 0.0101 ohm/km

The conductor shall be suitable for climatic condition and electrical system prevailing in Oman as per OES 11.

The direction of lay of the outer layer of strands shall be right handed. Lay ratio of any layer shall be not greater than the lay ratio of the layer immediately beneath it.

The make up of shield wire shall be such that the strand shall remain and shall not twist when the conductor is cut. The shield wire shall be manufactured so that no twisting occurs when they are subject to axial loads; i.e. when unrolling and stringing.

All wires used in the manufacture of the shield wires shall be free from protrusion, sharp edges, abrasion and any other imperfections.

No joining of the aluminium clad steel wires shall be permitted.

The creep characteristics of the finished shall shield be virtually unvarying so a to maintain uniformity.

3.1 INSULATORS

The suspension and tension insulator units shall comply with IEC 305, 383, 120, 433 and 471 as appropriate.They shall be of a porcelain long rod aerofoil and open profile type; designed to minimise build up of dust deposits. Semi conducting glaze type insulators will not permitted. Insulators shall be designed with a view to service in a hot dusty climate with high humidity.

Severe pollution with high conductivity dust deposits must be expected. This dust combined with a high salt content is adhesive and wind protected zones of insulators will be filled with dust deposits.

An open profile insulator arrangement is required with sheds shaped to allow the wind to blow through giving a good self cleaning action under rain, which may only occur for a few days in the year in the form of light to medium shower.

The string of insulators shall provide minimum creepage of 5940 mm (45mm/KV). The insulator shall conform to the Electrical and Mechanical characteristics shown in Schedule-7. The insulator string shall be capable of withstanding the required mechanical loads within the specified factor of safety. Calculations to be submitted to demonstrate that the mechanical failing load of the insulator string is satisfactory base on the factor of safety specified. The minimum failing load for insulator string shall be 230 KN for suspension and 320 KN for tension.

Double suspension and double tension shall be used at Wadi or road crossings.

Retaining pins or locking devices for the insulator units shall be of phosphor bronze in the hard condition.They shall be so made and shaped such that when installed and under any condition of handling and service, they shall not be displaced. The design shall be such as to allow easy removal for replacing of insulator units or fittings without the necessity to remove the insulator string from the cross arms.

Retaining pins or locking devices shall be incapable of rotation when in position.

All ball and socket joints on insulator sets shall be lightly coated with an approved grease before erection.

4.0 LINE ACCESSORIES

4.1 FITTINGS

Fittings shall comply with BS 3288 Pt. I. Suspension and tension clamps shall be as light as possible and shall be of aluminium alloy. All clamps shall be designed to avoid any possibility of deforming the stranded conductors and separating the individual strands.

Suspension clamps shall be free to pivot in the vertical plane containing the conductor and shall permit the complete conductor to slip at a load lower than the breaking load of the conductor. The conductor supporting groove shall be curved at its ends in the vertical plane to a radius of 150mm and for a sufficient distance to allow for the conductor leaving the clamp at the maximum angle of inclination obtained in service.

The grooves in the clamping piece or pieces shall be bell mouthed at each end and all conductor grooves and bell mouth shall be smooth and free from waves ridges or other irregularities.

Particular attention shall be paid to the climination of corona emission from all parts of suspension clamp. The mechanical efficiency of tension clamp shall not be affected by methods of erection involving the use of come-along or similar clamp before, during and after assembly, nor by erection of the tension clamp itself.

Bolts and Nuts shall be in accordance with the appropriate clauses of this specification. Bolt threads shall be coated with an approved grease immediately before tightening down at erection. Split pins for securing attachment of fittings of insulator shall be of stainless steel and shall be backed by washers of approved size and gauge.

All insulator strings shall be attached to cross arms by means of shackles. Hooks shall not be used.

4.2 MIDSPAN JOINTS, DEAD ENDS, JUMPER TERMINALS, REPAIR SLEEVES

All midspan joints (tension splices), dead ends (tension clamps) and jumper terminals shall be of the compression type.

The ends of compression accessories shall be tapered in such a manner that the pressure will be gradually reduced to zero on that part of the conductor leaving the accessory and that the conductor stresses caused from bending and vibration will be reduced to a minimum.

The midspan joints, dead ends and repair sleeves shall not permit slipping of, or cause damage to, or failure of the conductor at a load less than 95% of its nominal ultimate strength.

Jumper terminals for conductor should have a guaranteed slipping strength not less than 25% of conductor strength.

The conductivity of all conductor splice fittings in which the conductor is not continuous shall not be less than that of an equivalent length of conductor.

The design of dead ends shall be such as will facilitate the formation and fittings of jumper loops for the electrical or mechanical continuity of the conductor or shieldwire. The design of all compression fittings (tension clamp and tension splices and compression type repair sleeves) shall be such that only one pair of dies is necessary for each size of conductor.

Where mating surfaces of jumper terminals are to be bolted to the main body of the tension clamp, they should be protected from the manufacturer's works by removable plastic or other means.

Repair sleeve shall be suitable for repairing accidental minor damage to conductors and shieldwires. They shall be used on conductors where not more than two wires of the outer layer are broken and shall only be used for the shieldwire to repair damage to the aluminium coating of the wires and shall not be used where the steel portion of a wire is damaged or broken.

Repair sleeves shall consist of two interlocking parts of aluminium alloy suitable for compressing over the conductor. The dies used for compressing repair sleeves shall be the same size as those used for compressing the aluminium parts of midspan joints and dead ends.

Performed aluminium alloy rods may also be used to repair conductor. Their performance must be proven by type testing on the conductor size in use.

The temperature rise in midspan joints, compression dead ends, tension clamps, jumper terminals and similar components shall not be greater than the temperature rise in the conductor when a current is passed through properly assembled components.

The ferrous parts of midspan joints and dead ends shall be adequately protected against corrosion by the use of a rust inhibiting compound and a superimposed aluminium sleeve.

4.3 VIBRATION DAMPERS

Dampers shall be of the Stockbridge type with clamps made of aluminium alloy with two or four degrees of resonance. They shall be designed to minimise vibrations to conductors caused by wind speeds of 0.5 meters per second to 10 meters/second for the phase conductors and shieldwires.

The dampers shall be so designed that for the specific conductors and range of span lengths given it should not allow the bending strain at the conductor clamp to exceed + or - 150 microstrains.

Specific consideration should be given also to spans of either shieldwire or conductor which are to have aircraft warning spheres or aircraft warning lights erected on them.

The resonant points of the damper impedance characteristic should be within the vibration frequencies set up in the conductor or shieldwire in question by the range of wind velocities mentioned and should be proven in the type tests.

The design shall be such that drooping of the counter-weights does not occur during service.

The dampers shall be designed to minimise the risk of corona discharge or radio interference.

The clamping device shall be such as to avoid damage to the conductors when tightened, or at any time during the service life of the dampers, and it shall be free from slipping.

Dampers shall be so designed that during operation, the conductor is not damaged due to the impact of the damper.

The vibration dampers shall be capable of being installed and removed from energised lines by means of hot-line tools, without completely separating components. In addition, the clamp shall be capable of being removed and re-installed on the conductor at the design torque, without shearing or damaging bolts, nuts or cup screws.

4.4 SPACERS

Conductor spacers shall be fitted to maintain 450 mm between the subconductors under normal operating conditions.

Spacers shall not collapse under short circuit currents.

Spacers shall be so designed as to permit relative torsional and axial movement between subconductors. This flexibility shall be obtained without the use of metal-to-metal hinged joints or sliding parts which could be subject to wear. Spacer parts consisting of organic materials are not acceptable.

Spacers shall withstand a compression load to 13 KN applied between conductors and maintained for 1 minute without failure. The spacing between clamps after this load shall be within 5% of the initial spacing.

Clamping bolts should be of the captive type of permit fitting of the spacers on the subconductors without removal of the bolts.

The clamping device shall be such as to avoid damage to the conductors when tightened or at any time during the service life of the spacer and shall be free from slipping.

4.5 SPACER DAMPERS

Spacer dampers shall be fitted to maintain 450mm between subconductors under normal operating conditions and to protect the subconductors from aeolian vibrations.

Spacer dampers shall be so designed as to permit relative torsional and axial movement between subconductors. This flexibility shall be obtained without the use of metal-to-metal hinged joints or sliding parts which could be subject to wear. Spacer parts consisting of organic materials are not acceptable.

Spacer dampers shall not collapse under short circuit current.

Clamping bolts should be of the captive type to permit fitting of the spacer dampers on the subconductors without removal of the bolts.

The clamping device shall be such as to avoid damage to the conductors when tightened or at any time during he service life of the spacer damper and shall be free from slipping. The spacer dampers should supply the damping ability required of dampers in Section 4.3 and the spacering ability of spacers required in Section 4.4. The Supplier should specify the number of spacers required per span to carry out this requirement.

4.6 JUMPER SPACERS

For multiple subconductor lines jumper spacers shall be fitted to maintain 200 mm between the subconductors. They shall be of the rigid type designed to maintain a good electrical connection between subconductors.

Jumper spacers shall be so designed as to permit relative torsional and axial movement between subconductors without damage.

The jumper spacers shall be designed to incorporate weights of upto 500N to reduce the swing of the jumpers.

The spacers and weight should conform to the galvanising and corona requirements of this Specification.

The clamping device shall be such as to avoid damage to the conductors when tightened or at any time during the service life of the jumper spacer and shall be free from slipping.

4.7 AIRCRAFT WARNING SPHERES

Daylight warning spheres shall be fitted to shieldwires of overhead lines in approaches to airports or in the normal flight paths of low flying aircraft or where helicopter traffic is present. These should be as light as possible with a diameter of not less than 600 mm and made of either plastic fibreglas or aluminium. They should be single coloured spheres in the colour aviation orange. They should be bolted or otherwise securely fixed to the shieldwire with non-corroding metal clamps in such a manner that will not damage the shieldwire and will not permit slipping.

Aircraft warning spheres should conform to the requirements of the civil, military aviation civil defence authorities of the Sultanate of Oman and the recommendations of the ICAO, FAA and CAA.

They should be fitted with draining holes in the lower half to prevent water accumulation in the sphere.

The clamp hardware should be compatible with the shieldwire material.

4.8 AIRCRAFT WARNING LIGHTS

Conductor Marking Lights

Night time warning lights shall be fitted to phase conductors of overhead lines in approaches to airports or in the normal flight paths of low flying aircraft or where helicopter traffic is present.

These should be operated by induced currents from the phase conductor and should conform to ICAO, FAA and CAA requirements for light output and visibility. The lights should have an average life of 25,000 hours and should conform to the corona and radio interference requirements of other line hardwire. Any other proven type for this purpose will be also considered.

The conductor marking lights should conform to the requirements of the civil, military aviation and civil defence authorities of the Sultanate of Oman.

4.9 ARMOUR RODS

Armour rods shall be used for phase conductors and earthwire at every suspension support. Armour rod shall performed type.

4.10 ARCING HORNS

All insulator sets shall be fitted with line end and earth end arc horns. The Arc horns shall be designed that in the event of flashover no damage will be suffered by the conductor or conductor fittings or by the insulator itself.

For multiple unit insulator string, intermediate arc horns shall be fitted to ensure that the power arc is kept away from the porcelain so that excessive thermal stroke of the surface is avoided.

Gap in between arcing horns shall be as such that to withstand maximum value of impulse flash over voltage.

4.11 LIVE LINE CLEANING ARRANGEMENT

All towers shall be provided with fixed live line cleaning arrangement for insulators. The arrangement shall be complete with pipes, nozzles and couplings for connecting to mobile water tanker. The pipe line shall be extended to the nearest location where mobile unit can approach.

5.0 132KV TOWERS AND FOUNDATIONS

5.1 GENERAL

The double circuit towers shall be suitable for twin bundled conductor 400 sq.mm all aluminium alloy (YEW) conductor for phase in vertical formation, with a single 7/3.26m aluminium clad steel earth wire giving a maximum shade angle of 30 Deg. to the top most conductor.

Towers shall be of self supporting broad based lattice steel construction and shall be provided with 3m, 6m and 9m extensions above standard height where required.

5.2 DESIGN SPANS

The design of all structures shall provide for the following basic and weight spans :

Basic span	:	335 m
Wind span		
All tower - Normal working	:	410 m
Broken wire	:	310 m
Weight Span		
Suspension towers - Normal working	:	670 m
Broken wire	:	505 m
Tension towers - Normal working { }		
Broken wire { }	:	1010 m

N.B.

Spans for broken wire condition apply only for the conductor considered broken. Loadings for the intact conductors are to be based on Normal Working Spans.

The term basic span length shall mean the horizontal distance between centres of adjacent supports on level ground from which the height of standard supports is derived with the specified conductor clearances to ground in still air at maximum temperature.

The term wind span shall mean half the sum of adjacent horizontal span lengths supported on any one tower.

The term weight span shall mean the equivalent length of the weight of conductor supported at any one tower at minimum temperature in still air. At suspension positions, the minimum weight of conductor supported shall not be less than 30 percent of the total weight of conductor in the two adjacent spans.

In steeply sloping country where the gradient between adjacent support points exceeds 15 degrees to the horizontal special consideration shall be given to the vertical loading on towers.

5.3 TYPES OF SUPPORTS

structures will be designated as follows :

Suspension Tower (0 Deg. - 2 Deg.)	DS
" + 3m Ext.	DS + 3
" + 6m Ext.	DS + 6
" + 9m Ext.	DS + 9
2-20 Deg. Angel, Section, Heavy Suspension	D2
" " + 3m Ext.	D2 + 3
" " + 6m Ext.	D2 + 6
" " + 99m Ext.	D2 + 9
20 Deg. - 90 Deg. Angel	D9
" " + 3m Ext.	D9 + 3
" " + 6m Ext.	D9 + 6
Terminal	DT
" + 3m Ext.	DT + 3
" + 6m Ext.	DT + 6

Suspension structures shall be equipped with suspension insulators and all other towers with tension insulators.

Extensions are to be fitted without change to the standard height tower.

5.4 CONDUCTOR AND EARTHWIRE SPACING AND CLEARANCE

For all towers, the clearances from conductors, arc horns, jumper loops and all live metal to the tower steel work shall not be less than those specified in Schedule 5 under still air conditions and at assumed maximum swing of jumpers. For D2 type towers 20 Deg. angle/section/heavy suspension)these clearance shall also be maintained in the event that heavy suspension insulators are used instead of tension sets. Where uplift occurs at tension tower positions the minimum clearance between any arcing horn and the jumper loop of the phase immediately above it shall not be less than the minimum still air clearance from live to earth metal stated in Schedule.

The length of angle tower crossarms shall be such as will ensure that the distances between conductors of the two circuits at straight line structure, are maintained in a plane normal to the conductors.

For angle towers carrying deviation angles upto 60 Deg.C (i.e. types D2 and D9) crossarms shall generally be so proportioned that live metal clearances are maintained under all conditions without the use of jumper suspension insulators. Jumper suspension insulators may be used, if required, for angles greater than 60 Deg. (type D9).

Allowance should be made for increasing or decreasing the length and varying the arrangement of all terminal crossarms to enable downlead span connections to be made in any desired phase sequence.

The maximum angle of shade protection of the earthwire to the top conductor shall not be greater than 30 Deg to vertical at any point in the span.

In addition, at every-day temperature with 335m basic span the still air direct distance between earthwire and conductors at mid-span shall not be less than 6 meters, of which one meter shall be provided by differential sagging.

5.5 CLEARANCE TO GROUND AND OTHER FEATURES

The clearance between the line conductors and the ground in still air under the maximum specified temperature and final tension shall not be less than the figure stated in the Schedule of Technical Particulars. An additional clearance of 0.6m is required to allow for conductor creep, which shall be included in the calculation of tower heights.

The clearance under all specified conditions between any part of any fences, walls, buildings or other structures on which a man may stand or against which a ladder may be placed and the nearest line conductor shall be as specified in Schedule.

5.6 ASSUMED NORMAL WORKING LOADINGS

The assumed maximum simultaneous working loadings on towers shall be as follows :

A) Suspension Towers

i) Vertical Loadings - the weights of insulators, spacers and all other fittings and the actual dead weight of specified span lengths of line and earth conductors.

ii) Transverse Loadings - a wind pressure of 971 N/m2 (99 kgf/m2) at right angles to the lines on the whole project areas of the conductors insulators and earthwires.

In addition a wind pressure 15999 N/m2 (163 kgf/m2) on 1 1/2 x the projected area of the members on one face of the tower. Suspension towers may be used at very small angle deviation positions where wind spans and design considerations permit.

B) Angel Towers

Maximum vertical and transverse loadings as described above plus the transverse and longitudinal components of the maximum conductors and earthwire tensions stated in Schedule, resolved for the most critical angles of deviation concerned. In addition, angle towers shall be designed for uplift loading equivalent to a negative wight span of 335m.

C) Section, 20 Deg. angle and Heavy Suspension Tower (Types D2)

The loadings for towers type D2 shall be any one of the following four conditions, which shall in all cases include for transverse loadings as applied to straight line supports :

i) 0-20 Deg. Angle. As for angle tower loadings.

ii) Section Loading at nil angel deviation; weight span 1340m; unbalanced longitudinal loading at 15%, maximum working tension for all conductor and earthwire points.

iii) Uplift Loading. As for condition (ii) but with negative weight span of 670m.

iv) Heavy Suspension Tower. In special positions the tower strength capacity derived from loadings (i) or (ii) may be utilised in positions of extra long wind and weight spans, using heavy suspension insulator sets. The tower shall be so arranged that electrical clearances are maintained either with tension insulators or with heavy suspension insulators, in accordance with Clause 5.4. The Tenderer shall indicate the maximum wind span available for towers under this condition. The lowering in conductor attachment level when suspension sets are fitted will be taken into account when plotting profile, and need not be allowed for in calculating the height to the lowest crossarm.

D) Terminal Towers

Loadings for DT type towers shall be the vertical and transverse loadings as for straight line supports together with full maximum longitudinal conductor and earthwire tensions as given in Schedule, together with a plan angle of entry upto 45 Deg. on the line side. In addition the towers shall be designed for droppers having a maximum tension of :

a) 1200 Kg. for each sub-conductor, and

b) 500 Kg. for earthwires, respectively, acting at any plane angel of deviation from 0-90 Deg. to the incoming line and from the horizontal to the vertical plane.

All terminal towers shall be designed for 2 slack span earthwires to substation structures. Where necessary auxiliary conductor and earthwire crossarms shall be used for a large angle of deviation into the Substation and the bodies of terminal towers shall be designed to accommodate such auxiliary crossarms. Terminal towers shall also be designed to take slack spans into substation gantry for other substation equipment connection.

Auxiliary conductor crossarms and crossarm extensions shall be designed to carry the down dropper tensions mentioned above, together with the relevant weights of insulators etc.

E) Tension Tower Erection Loads

The loading conditions for these transmission lines shall be considered and shall provide adequate margins of strength in the designs for unbalanced erection loadings shall be provided. Points of support for tower back stay when stringing shall be stated.

Factor of safety obtained for 20 Deg. tower under these conditions shall be stated.

5.7 BROKEN WIRE CONDITIONS

Suspension structures shall be designed for the reduced vertical and transverse loadings derived from Clause 5.2 plus the unbalanced longitudinal force at maximum tension due to the breakage of two sub-conductors or one earthwire.

In the case of a conductor breakage the pull on a suspension tower may be assumed to be reduced to 70% of the specified maximum working tension.

Tension structures shall be designed for vertical and transverse loadings plus the full unbalanced longitudinal forces at maximum working tension due to the simultaneous breakage of 4 adjacent sub-conductors on the same side of the tower or of one earthwire.

Calculation of the stresses in angle tower members under broken wire loadings shall be made for the worst conditions of loading of that particular member for the range of loadings for which the tower may be employed.

For D2 towers, the design shall take account of the possibility that the unbalanced tensions referred to Clause 5.6 (C) (ii) and (iii) may act either in the same direction as broken wire forces, or in the opposite direction, applying increased torsion moments to the tower body.

5.8 FACTORS OF SAFETY FOR TOWERS AND FOUNDATIONS

The DS type tower shall be designed so that no failure or permanent distortion shall occur when tested with applied forces equivalent to twice the maximum simultaneous working loadings specified in Clause 5.6.

Each type of angle, terminal, or special tower shall be designed so that no failure or permanent distortion shall occur when tested with applied forces equivalent to 2.5 times the maximum simultaneous working loadings specified in Clause 5.6.

Foundations for all towers shall be designed to have a factor of safety against overturning or uprooting of not less than that for the tower. All towers shall also be designed so that no failure or permanent distortion occurs when tested with applied forces equivalent to 1.25 times the maximum simultaneous working loadings resulting from the assumed breakage of conductor(s) specified in clause 5.7.

The factor of safety of foundations shall not be less than 1.5 when the towers are carrying the maximum simultaneous working loadings as resulting from the broken wire conditions set out in Clause 5.7.

Design tests on tower types selected by the Engineer will be required to be carried out as specified in Section 7.

5.9 CONSTRUCTION OF SUPPORT STEELWORK

All designs shall be such that no trouble shall arise in service from vibration or excessive deflection due to the use of too light a section.

Rolled steel sections, flats, plates, bolt and nut bars shall, unless otherwise approved, consist of mild steel to I.S.O. R630 Grade Fe44A, or such standard as may be approved.

High tensile steel where approved shall be to the requirements of I.S.O. R630 Grade Fe52C or such standard as may be approved. Steel shall be free from blisters, scale or other defects.

High tensile steel, when stored in the fabricators stockyard prior to fabrication and galvanising, shall be marked continuously throughout its length with a light blue water paint line. In addition the grade number of the steel shall be painted on and ringed round with paint.

The standard rolled steel sections used for all main members including legs, tower top verticals, crossarm members (except bracing), shall be not less than 6mm thick. No standard rolled steel section is to be less than 5mm thick. Bolt holes are not to be more than 1.5mm larger in diameter than the corresponding bolt diameter. The design is to be such as to keep the number of different parts as small as possible, and is to facilitate transport, erection and inspection.

The ultimate design stress in tensile members shall not exceed the elastic limit strength of the material. The ultimate stress in the compression members shall not exceed a figure obtained from an approved formula to be entered in Schedule based on the elastic limit strength.

The maximum allowable slenderness ratio for various classes of member shall not exceed the values given in Schedule.

The crossarm tips of tension towers shall be so arranged that two holes for the attachment of conductor erection and maintenance tackle are provided adjacent to each hole for tension set shackles. It shall be possible to apply full conductor tension safely to either additional attachment point.

The nuts of all bolts attaching insulator set droppers, U bolts and earth conductor clamps to the tower shall be locked with a locking nut.

At locations with steeply sloping ground one or more of the tower legs is to be extended or reduced in lattice steel framework in convenient intervals in an approved manner to give minimum interference with standard body design.

For use on steeply sloping ground independent single leg extension shall be designed and provided where necessary for standard and extend towers within the range -2m to +3m in steps of 1m.

The provision of hillside or special extensions, crossarm steelwork, to standard towers will be made. The calculation of weight of additional steelwork is to be made on the standard weight per meter of the cross sections employed ungalvanised, measured to centers of frame intersections plus 7 1/2 percent to allow for all guessting, bolts, plates, ends, galvanising etc.

5.10 FOUNDATIONS

The following types of concrete block foundations may be employed. :

A) Normal Foundation

This type of foundation shall be suitable for soft soil sand or loose gravel occurring generally for the full foundation depth.

B) Soft Rock Foundation

This type of foundation shall be suitable for when soft rock occurs for more than the bottom 50% of the soft soil foundation setting depth. The soft rock encountered may be of a homogeneous limestone or coral nature or of a harder limestone or other rock but being fissured and stratified. The soft rock foundation shall be suitable for both conditions.

C) Hard Rock Foundations

This type of foundation shall be suitable for homogeneous hard rock occurring less than 1 meter below ground level.

D) Other Foundations

In addition, where ground conditions exist which do not allow for any of the above designs in an original or modified form other types of foundations may be employed.

The design of foundations shall follow the Specification and assumptions set out below and given in Schedule. Such designs are subject to modification to suit Site conditions.

Ultimate foundation loadings per leg shall be calculated as follows :

SUSPENSION TOWERS

Compression - (Overturning force + 1/4 applied vertical loads + 1/4 tower weight) x factor of safety.

Uplift - (Overturning force 1/4 + 1/3 max. applied vertical loads - 1/4 tower weight) x factor of safety.

TENSION TOWERS

As above but zero or negative applied vertical loads in uplift case.

In computing compression ultimate bearing stresses the weight of concrete in foundations shall be multiplied by the relevant factor of safety.

Foundations are to comply with requirements as follows :

A) Normal and (B) Soft Rock Concrete Block

Where concrete block foundations are used a concrete cover of at least 100mm is to be provided over any part of the steelwork below ground and extended above ground for a minimum distance of 150mm. The maximum allowable bearing pressure, lateral pressures, the adhesion value between concrete and steel and the assumed weight of earth shall be as specified in Schedule. The stub leg shall not be of less thickness than the main tower leg and cleats shall be attached at the base to assist in transfer of leg load to the concrete pyramid in accordance with Schedule.

For uplift foundations preference will be given to undercutting or other approved method allowing upward bearing of the pad against undisturbed soil for a minimum width of say 250mm all round. Alternatively, the concrete pad shall be cast to the edge of the escavation for a minimum height of 250mm in order to gain assistance by adhesion to the original ground.

Proposals shall be submitted with the Tender. In cases where the concrete block is cast in contact with the edge of the excavation for at least 250 mm the earth frustum assumed to resist uplift shall be considered to start from the bottom of the vertical edges of the block. Otherwise, the frustum shall be assumed to start from the top of the block edges. Allowance shall be made for loss of uplift resistance due to overlap of frustam where necessary.

The slope of all concrete pyramid top faces unless reinforced shall not be less than 45 degrees to the horizontal.

The concrete block foundation design data is preliminary only and that at the conclusion of soil investigation tests along the route the Engineer may modify the values and request re-design of foundations on a new basis.

C) Hard Rock

Where foundations are installed in rock, the depths of the support or stub leg grouted or concreted into rock are in no case to be less than 0.9 m. The upper part of the stub is to be encased in concrete to a height of 150mm above ground level. To ensure adequate uplift resistance, a sufficient number of reinforcing bars shall be grouted into the rock, using an expanding grout, for a minimum depth of 1.2 m from the base of the excavation. The reinforcing bars are to be tied together with the concrete block. Such foundations are to be approved before the erection of the support or stub legs proceeds.

5.11 AGGRESSIVITY OF SOILS TO BURIED CONCRETE

Throughout the line routes the Contractor must at regular intervals and at the time of preliminary survey, obtain samples of the subsoil and ground water, which he shall have analysed to ascertain if any agents be present which may have an adverse effect on concrete made with normal Portland cement.

5.12 CONCRETE

Concrete for concrete block foundations is to consist of one part surface resisting cement, two parts sand, and four parts approved gravel or broken stone. Gravel, stone and sand shall be clean and free from dust, earthing or organic matter, or salt. All gravel and broken stone is to be of approved grading to be retained on a mesh not less than 13 mm square, and of a maximum size to pass a mesh not more than 40 mm square. Where specially approved in writing by he Engineer, aggregate of uniform size not larger than will pass a 25mm mesh may be used throughout. All sand to be coarse, sharp, clean and free from dust, salt, clay, vegetable matter or other impurity and to be screened through a mesh not more than 5mm in the clear. It is to be a well-graded mixture of coarse and fine grains from 5mm gauge downwards. Water to be clean and free from all earth and vegetable matter and alkaline substances either in solution or in suspension.

All cement used is to be of Portland or other approved composition obtained from an approved maker. Portland cement to conform in all respects to BS 12. All concrete to be thoroughly compacted during the operation of placing.

The upper surface of the concrete of all types of foundations to be finished smooth and sloped in an approved manner to prevent accumulation of water. A concrete additive of approved type may be used.

The concrete compaction may be by means of an appropriate size vibrator, concrete shall not be directly poured from a height more than 1.5 meters to avoid mix segregation.

Concrete cubes are to be taken and tested to verify the concrete strength. The test specimens shall be 150 mm cube and the mould shall be of metal with inner faces accurately machined in order that opposite sides of the specimen are plane and parallel. Each mould shall be provided with a metal base having a smooth machined surface. The interior surfaces of the mould and base should be lightly oiled before concrete is placed in the mould.

Test specimens should be moulded by placing the fresh concrete in the mould in 5cm layer being thoroughly compacted with a steel bar 38cm long and having ramming face 2.54 cm square and weighing 2.8 kg. The concrete should be subjected to at least 35 strokes per layer. Alternatively, the concrete should be compacted by vibration, each layer being vibrated by means of an electric or pneumatic hammer or by means of a suitable vibrating table.

Concrete for the test specimens should be taken at the point of deposit. To ensure that the specimens are representative of the concrete in the foundations a number of samples should be taken from different points. Each sample shall be large enough to make one test specimen and should be taken from one point in the work.

The test specimens should be stored at the site at a place free from vibration, under damp sacks for 24 hours + 1/2 hour, after which time they should be removed from the moulds, marked and stored in water at a temperature of 10 Deg. to 21 Deg. C until the test date. Specimens which are to be sent to a laboratory for testing should be packed for transit in damp sand, or other suitable damp material, and should reach the laboratory at least 24 hours before test. On arrival at the laboratory they should be similarly stored in water until the date of the test.

The tests should be made at the age of the concrete corresponding to that for which the strengths are specified. Compression tests should be made between smooth plane steel plates without end packing, and a load should be applied axially at the rate of approximately 13.8 N/mm2 per minute. One compression plate of the testing machine should be provided with a ball seating in the form of a portion of a sphere, the center of which coincides with the central point of the face of the plate. Test specimens should be placed in the machine in such a manner that the load is applied to the sides of the specimens as cast.

Cube strengths for 1:2:4 concrete are to be not less than 13.8N/mm2 within 7 days after mixing and 20.7N/mm2 within 28 days after mixing. The cost of cube testing is deemed to be included in the Contractor's general schedule rates.

For tower foundations where excavations are to be backfilled immediately following the striking of shutters, the concrete is to be thoroughly wetted before backfilling commences. Where shutters are to be struck and backfilling of the excavation is not to take place immediately, the concrete is to be covered by hessian sacking and is to be kept continuously moist to avoid rapid drying of the concrete.

In the event that the Contractor proposes to use mixed concrete for foundation work, approval must first be obtained from the Engineer, who will inspect the batching plant and sand, cement and gravel used in the making of concrete at the works. No ready mixed concrete is to be used in foundation work if it has been mixing in the lorry during its journey to site for more than 45 minutes.

At the discretion of the Engineer, ready mixed concrete may be used in foundations if the journey to site is in excess of 45 minutes, if the cement is added to the drums at site and be thoroughly mixed prior to placing. Alternatively, and at the discretion of the Engineer, if the ready mixed lorry carries its own water drum, water may be added to the cement and aggregate in the mixing drum during the lorry's journey provided the concrete is not mixed for more than 45 minutes prior to placing. The Engineer's decision to reject any of the above methods of supplying ready mixed concrete shall be final.

5.13 ANTI-CLIMBING GUARDS AND CLIMBING STEPS

Each straight line, angle and terminal tower shall be fitted with an approved anti-climbing device with gates, which shall provide climbing facilities for use by authorised personnel. The height of the anti-climbing device may be either adjustable or on members forming an integral part of the tower designed within the limits of 3m and 4.5m from the ground on the normal height tower.

Where the support or tower is erected on sloping ground the height should be measured from the foot of the support where the ground is highest.

Each tower shall be provided with step-bolts on diagonally opposite legs at not more than 400 mm centers starting immediately above the anti-climbing device and continuing to the earthwires. Step-bolts shall be of 20mm diameter and shall protrude from the tower leg by at least 150 mm. Where appropriate, step-bolts shall comply with the requirements of Clause 1.30.

Holes for removable step-bolts below the anti-climbing guards shall be provided at not more than 400mm centers on the legs to which the permanent step-bolts are fitted.

5.14 DANGER, NUMBER AND PHASE PLATES

Danger plates are to be provided and fixed in approved positions on all structures. Danger plates shall be red with a white background.

Phase plates of approved types coloured red, yellow and blue to indicate the line phases shall be provided and fixed in approved positions on each structure.

Tower number plates are to incorporated circuit colour identification. Two number plates are required for each tower, one on a step-bolt leg under each circuit and to be positioned just above anti-climbing gates.

The background colour of each plate will indicate the circuit colour identification. The required number and background colouring will be advised.

All plates shall be of anti-corrosive material. If enameled iron plates are used, the whole surface of each plate including the back and edges shall be properly covered and resistant to corrosion. On all plates the colours shall be permanent and free from fading. With enameled plates, washers of approved material shall be provided back and front of the securing bolts or screws. Lettering and size of plates shall be to the Employer's requirements and approval.

5.15 SUPPORT STRUCTURE EARTHING

Steel supports need not be fitted with a separate earth bond and earthing continuity will therefore depend upon surface contact of bolted members and the contact between earthwire fittings and structure steel, except at tension towers where earthwires are to be made electrically continuous by jumpers or other approved means, and are to be bonded to the tower steel work.

The grounding of tower shall be of means of copper rod of not less than 25mm dia. and of adequate length to achieve the footing resistance not exceeding 20 ohms but not less than 3m buried in good soil as available and electrically connected to tower grading pad provided at the base of tower.

Where the tower stands on rock, efforts shall be made to obtain good earth by providing earth mat connected to the tower leg as near as possible.

Alternatively, counter poise earthing system nominally comprising two 60m legs of 25mm x 3mm tinned copper tape and connected individual leg members run one in each direction underneath the lines where possible. The earth counter poise is to be buried not less than 600mm in the ground. Suitable precautions shall be taken to avoid electrolytic action where the tinned copper tape is bolted to the galvanised steel tower leg.

5.16 WORKMANSHIP

All steel lattice members shall be cut to jig and all holes in steelwork shall be drilled or punched to jig. All steel parts shall be carefully cut and holes located so that when the members are in position the holes will be opposite each other before being bolted up. The drilling, cutting, punching and bending of all fabricated steelwork shall be such as to prevent any possibility of irregularity occurring which might introduce difficulty in the erection of structures on the site. High tensile steel members shall be bent hot. Care shall be taken not to punch holes too close to the edge of metal.

Means shall be provided to enable the Engineer to carry out such checking of members as he may consider necessary. Built-up sections, when finished, shall be true and free from all kinds, twists and open joint and the materials shall not be strained in any way.

In order to check the workmanship, not less than 1 percent, of the members corresponding to each type of support or crossarm shall be selected at random and assembled to form complete latticed supports or crossarms in the presence of the Engineer at the manufacturer's works.

If the towers are fabricated or galvanised by subcontractors, the contractor shall, if required by the Engineer, provide a resident inspector at the works of each sub-contractor during the time that the bulk of the steelwork is being fabricated or galvanised.

5.17 AIRCRAFT WARNING PAINTING

Steel structure shall be painted alternate Bands of aviation orange and white paint for aircraft warning. The width of bands shall be equal. The width of band shall be 1/7th of height of structure as laid down by Director General of Civil Aviation. The paint used shall be of approved make and carried out as per the recommendation of the manufacture.

6.0 ACCESS, CLEARING AND ERECTION

6.1 CONSTRUCTION ACCESS TO SITE

The MEW will provide the following facilities :

a) Such right of access to the route of each line section as which is necessary to enable the Contractor to proceed with the clearance of any trees and scrub for erection and investigation of foundation conditions.

b) The right to construct and make use of a reasonable width of track along the route for the transport of stores and material and the carrying out of erection operations, except where the route crosses buildings, gardens or other ground over which that such a truck is not reasonably practicable.

c) The right to transport material from road on to each continuous length of the route at agreed points of access provided that this right of access shall not involve the MEW in excessive compensation claims or wayleave charges.

d) The right to transport material and equipment, from suitable road side dumps to tower positions and from one tower position to adjacent tower positions.

After obtaining preliminary approval of the Engineer, the Contractor shall at an early stage of the Contract arrange all proposed points of access with landowners or other interested bodies and thereafter prepare Access Maps and supplied by the MEW for agreement and approval of the Engineer. The Engineer shall then submit the approved Access Maps to the Employer for settlement of wayleave arrangements and compensation claims etc.

Where the above facilities have been provided no other access shall be used except with the consent of the Engineer. When submitting construction Access Maps, they shall be so arranged that the MEW shall have access for patrol and maintenance to all parts of the finished line where considered practicable by the Engineer. The Contractor shall make all necessary arrangements (other than for matter of wayleaves and permanent access tracks) with the occupiers before going on to private land, but if any difficulty should arise, the Contractor shall inform the Engineer thereof.

6.2 ROUTE AND ACCESS CLEARANCE

Where clearing is necessary the following requirements shall be observed. Trees and tall scrub shall be cleared to a distance of 15m on either side of the centre-line of the route. Trees and bushes shall be cut down to a height of not more than 1.25m above ground level. In addition, tall trees outside the cleared area, of such height that they could fall within 2m of conductors, shall be felled by the Contractor after obtaining the necessary permission from owners.

Felled trees and scrub shall be removed from a path 2.5m wide and running as far as possible continuously along the route. The Contractor shall grub up tree stumps and rots from this track and leave a graded way for negotiation by four-wheeled drive light vehicle for patrolling and maintenance by the MEW.

The Contractor shall clear 2.5m wide agreed construction access tracks from public roads, of all trees, stumps, scrub and vegetation.

6.3 PRELIMINARY SURVEY

As soon as the contract is awarded the Contractor shall make immediate arrangements to investigate the proposed route on the ground and set out the angle tower positions. He shall report to the Engineer on the suitability of the route and recommend for approval any change of route considered necessary to avoid bad ground, built up areas etc.

6.4 ALIGNMENT SURVEY

The Contractor shall peg out all terminal and angle positions on the proposed line route details given in the tender. He shall then establish a preliminary line between angle points. After obtaining the Engineer's approval to the route the Contractor shall proceed to peg out the center line and the limits of clearing and to mark trees for felling, both inside and outside the line trace (see Clause 6.2, paragraph 1).

It will be the duty of the Contractor in the course of making the alignment survey to determine whether local deviations may result in an overall economy, and report to the Engineer accordingly for instructions.

After alignment survey and submission of the proposed route plan, the Contractor must allow a reasonable period for the MEW to obtain approval from Government or other Authorities for the work to proceed and also for a further thirty days thereafter pending the issuing of notices on occupiers of land, etc. In this respect it is imperative that the Contractor commences preliminary and alignment survey with the minimum delay after award of Contract.

6.5 PROFILE SURVEY

Immediately after the Engineer has inspected and approved the route after alignment survey, route clearing shall proceed as specified in Clause 5.2 in order to commence the profile survey with the minimum of delay.

Clearing and profile survey shall proceed in convenient sections and shall not await completion of the alignment survey over the whole route.

Strip plans and longitudinal sections are to be prepared by the Contractor for the complete length of the lines at scales approved by the Engineer, preferably at horizontal scale of 2000 to 1, and 200 to 1 vertical. The Contractor is to plot there on the proposed tower positions and submit the profile to the Engineer for approval. A "sinkage" of 300mm should be allowed in plotting tower positions but this should not be added to the design height of towers.

Before submitting profiles for approval the Contractor shall provide the Engineer with two complete sets of transparent sag templates in stout perspex or similar material based on the range of equivalent spans required.

The templates are to show the sag in still air at maximum temperature, the ground clearance line, and a line showing the sag in still air at minimum temperature. Each template is to be clearly endorsed with the design loading conditions, particulars of conductors, equivalent span and the scales which shall be appropriate to the scales of the relevant profile drawings.

The profile drawing is to include the following features :

Continuous longitudinal chainage for each section, ground line salient levels, ground line, ground clearance line, line of lowest conductor at maximum sag, indication of side slopes (below the outer conductor phases, due account being taken to swing of conductor under wind loading), which could affect clearance of conductor to vertical or other steep slopes, buildings, streams and rivers, roads, power and telecommunication lines crossed or to be crossed or to be deviated, sections unsuitable for support positions, vegetation, and any other features affecting the line construction. . The test of the sub-soil conditions along the whole of the line route at not more than 1 Km intervals and additionally at individual tower locations in poor ground conditions as agreed by the Engineer, shall be made by means of an approved hand-operated penetrometer sampling tool and indicate results on the profile drawing or separate Schedule, together with ground encountered likely to require special foundations.

Soil resistivity test,using an approved method, shall be made by the Contractor at 1 Km intervals as above and the values so obtained shall be indicated on the profile drawing or separate schedule.

Quantities given in Schedule 13 are provisional only and the Contractor is to loose no time in expediting survey and profile work at the commencement of the Contract in order to establish final quantities at an early stage in the manufacturing programme. Any delay in survey and profile wok will not be held a a valid reason for lack of progress in manufacture and the Contractor will be expected to commence manufacture on a provisional basis even though final quantities are not known until a later stage. Attention is drawn to the urgency of having tower stubs and templates on site in order that foundation work can proceed with a minimum of delay.

The cost of foundations in Schedule 13 shall include for excavation through any material and no extra payment will be made for rock. Payment for any additional excavation carried out in the instructions of the Engineer shall be the same irrespective of the nature of the ground, whether it be rock or soft soil. It is therefore advisable that the Tenderer visit the site in preparation of his Tender to ascertain site and ground conditions.

6.6 WAYLEAVES

Where required, wayleaves and wayleaves for access (subject to the requirements of landowners and their tenants) will be provided by the Employer to enable the Contractor to carry out the Contract Works.

Before the Contractor commences work on any property he shall be responsible for obtaining from the Engineer a Wayleave Schedule giving details of any special requirement of the tenants or owners concerned. The Contractor shall also be responsible for giving adequate notice of commencement of work.

Before construction commences the Contractor shall provide the Engineer (at not less than seven day's notice) with lists of the towers that have been and are available for inspection.

6.7 CROSSING OF PUBLIC SERVICES

When the Contractor is about to carry out erection of the conductors, along or across power lines or telecommunication circuits, public roads, waterways or the like, he shall be responsible for giving requisite notice to the appropriate authorities of the date and time at which he proposes to carry out the work.

Where it is necessary to provide scaffolding over roads or telecommunication lines in order not to interfere with the passage of traffic etc., this shall be carried out by the Contractor at such times as may be convenient to the requisite Authority. Flagmen and approved types of danger or warning notices shall be provided by the Contractor to ensure safety of the public.

Scaffolding and decking shall be erected in a safe manner to the approval of the Engineer and the time taken to effect the crossing and remove the temporary work shall be kept to a minimum. The Contractor shall provide with his tender, drawing showing the live line scaffolding proposed.

6.8 OTHER CROSSINGS

The Contractor shall at his own expense make the necessary arrangements and any necessary precautions where the routs crosses rivers or streams, buildings, orchards, plantations, gardens, or other obstacles or ground over which erection cannot be carried out in the normal manner.

6.9 LIVESTOCK

Adequate provision shall be made by he Contractor to prevent the straying of or damage to livestock during the execution of the Current Works and until the permanent reinstatement of fences, walls, hedges, gates and the like is completed, he Contractor shall be held responsible for any loss or damage to livestock due to failure to comply with the above requirements.

6.10 DAMAGE TO CROPS AND PROPERTY

The Contractor shall take all precautions to avoid damage to crops and shall ensure that the work is adequately supervised so that damage is reduced to the minimum.

Otherwise the Contractor shall be responsible for all damage to land, property, roads, filed drains, fences, walls, trees, hedges, crops, gates and like which are damaged or disturbed during the execution of the Contract Works and shall remove all surplus material after erection. He shall also be responsible for payment necessary to owners for agreed passage over private roads.

6.11 REMOVAL OF OBSTRUCTIONS

The necessary agreements for the removal of obstructions such as pipes, or for the removal of telecommunication and power lines which are to be deviated or placed underground will be arranged by the Engineer upon advice from the Contractor, with adequate notice, that he is ready to commence work in the section so affected.

The removal of obstructions by he Contractor such as pipes (other than filed drains) and where agreed with the engineer will be paid for by the MEW at rates entered in the Dayworks Schedule.

Where a tower is set across a hedge, bank, or wall the MEW will pay for the removal and reinstatement of such obstruction to the extent necessary for the foundation setting and tower erection.

6.12 FOUNDATIONS

The Contractor shall be responsible for ascertaining that the sub-soil is suitable for the type of foundation used and shall provide details of site investigations and relevant tests carried out. He shall be responsible for any subsidence or failure due, in the opinion of the engineer, to insufficient care having been taken either in the preliminary examination of ground conditions or in the choice or installation of the foundations

Where, in the opinion of the Engineer, after examination of the Contractor's soil investigation data,the nature of the ground warrants special investigation and tests the Contractor shall carry these to the instruction of the Engineer until satisfactory information is obtained on the ground bearing properties. Such test will be paid for at the rate set out in Schedule. This may involve excavation of trail pits to at least foundation depth.

The decision of the Engineer as to which type of foundation shall be employed at any given location shall be final.

In general, for steeply sloping hillsides the formation of a level tower platform by digging the high side and using the soil to fill the low side will not be accepted. Heavy rains are liable to wash away the fill in certain areas.

Concrete foundation shall extend to at least 150mm above ground and shall be sloped off around the steel leg section and smoothly finished to ensure drainage away from the steel work.

Where required by the Engineer, exposed concrete shall be painted with two coats of an approved bitumen based paint. Each coat of paint shall extend at least 150mm above the highest point of the shaped concrete cap and at least 150mm below finished ground level. The first coat of paint shall be applied not less than 48 hours after any shutters used in forming the concrete cap have been removed. The second coat shall be applied not less than 24 hours after the first. Before painting, all surfaces shall be clean and dry and free of dust and grease.

Stubs for steel tower foundations may be erected along with the lower part of the tower or carefully adjusted to template. In the former case the steel shall be supported and the concreting carried out in an approved manner so that no stress is thrown on the Structure. In the latter, the stubs shall be held in correct position by the template while the concrete is placed. The templates are not be be struck until at least twenty four hours after the foundations have

been completed and backfilled. Stub setting templates shall be approved type with sufficient rigidity to ensure correct setting of the stub having regard to the steeply slooping nature of the ground and necessity for packing at low spots where using hillside extensions. The spacing and level of the stubs after the templates have been struck are to be such as to ensure correct alignment of the supports without forcing members during erection.

Unless otherwise approved, supports having concrete foundations are not to be erected until ten days after completing the foundation concrete work.

The backfill of all types of foundations shall be thoroughly rammed, the ramming to be carried out at intervals of not greater than 300mm to ensure thorough consolidation. Probe tests are to be carried out to prove the degree of compacting of the backfill as the Engineer required.

In no circumstances shall peat or equivalent material be used as backfill for concrete block foundations. Where necessary, excavations in patty material shall be back filled in an approved manner with suitable soil or hardcore from an approved source at rates agreed by the Engineer. Where a foundation is located in shifting sand or soil, the area surrounding the tower shall be sprayed with crude oil in an approved manner. The sprayed area shall include the frustum of earth on which the foundation is designed.

The use of vibrators in concreting of foundations may be necessary and should be executed in accordance with the request of the Engineer or his Representative.

6.13 ERECTION OF SUPPORTS

All towers and supports shall be vertical under the stresses set up by the competed overhead line.

Proper precautions shall be taken to ensure that not parts of the towers or supports are strained or damaged in any way during erection and drifting shall not be allowed.

Where tower members arrive on Site with slight distortions due to handling in transit, they shall be straightened by the Contractor using an approved means and offered to the Engineer for inspection and acceptance or rejection before erection commences.

Suitable ladders shall be used whenever necessary during erection, but such ladders and removable step bolts shall be removed when erection work is not in progress.

After erection all supports shall be cleaned of all foreign matter or surplus paint.

Spanners used during erection shall be well shaped and fit closely on the hexagon to avoid damaging nuts and bolt heads.

6.14 ERECTION OF CONDUCTORS

The fullest possible use shall be made of the maximum conductor lengths, in order to reduce the number of joints to the minimum. The number and location of line and earth conductor tension joints shall be approved. Tension joints shall not be less than 25m from the nearest conductor clamp, and joints between different wires in the same span should be adequately segregated to the satisfaction of the Engineer.

Mid-span joints shall not be used :

A) with less than 2 complete spans between joints;
B) in spans crossing power lines, telecommunication lines, public road or buildings.

Conductor repair sleeves shall not be used without the permission of the Engineer.

The ground which the transmission line traverses is in many part of boulder strewn or rocky and the Contractor must employ an approved method of pilot wire tension stringing to keep the conductor off the ground during stringing operations whist the conductor is in motion. The Contractor is to forward with his tender, full details of the tension stringing methods together with details of the machines and equipment he will use. The Schedule rate for stringing shall be deemed to include for all costs associated with the above stringing methods.

The conductors, joints, and clamps shall be erected using the approved tools and in such a manner that no bird-caging, over-tensioning of individual wires or layers or other deformation or damage to the conductors occurs. Clamps or hauling devices used in erection shall be of approved design and shall allow no relative movement of strands or layers of the conductors. The Contractor shall keep a record of each joint, clamp, etc., giving the location of the fitting, the date of assembly of the conductor and the name of the linesmen responsible for the assembly. This record shall be handed over to the Engineer on completion of each section of lines.

Where records of joints made by any particular linesmen show a repeated performance below the required standard the Contractor, at the request of the Engineer, shall cease to employ the linesman on joining operations and shall immediately replace him with other qualified personnel.

At each suspension clamp the conductor shall be suitably cleaned and coated with an approved grease immediately before final assembly in the clamp.

At least three months before stringing commences the Contractor shall give due consideration to all the factors involved and submit to the Engineer for approval a fully detailed stringing schedule stating locations of conductor drums for stringing and the proposed position of mid-span joints, together with temporary staying of supports and all other relevant information.

The Contractor shall at the same time forward his proposals, together with supporting calculations, for over tensioning in order to partially compensate for conductor stretch and long term creep. Pre-stressing of about 10% of everyday tension for all conductors should be applied for a minimum of one hour with the conductor resting in the running out blocks before regulating the sag at about the same overtension and marking off for fitting dead end clamps. The "temperature difference" methods shall preferably be employed for evaluating sag reductions.

6.15 SAGS AND TENSIONS

The assumed minimum, everyday, and maximum temperatures of conductors are stated in Schedule.

The conductors shall be erected with such sags that at everyday temperature in still air the final tensions shall provide a factor of safety on the ultimate tensile strength of the conductor of not less than that stated in Schedule.

The term "Final Tension" shall mean the tension existing in a line conductor, for any given condition of loading, after sufficient period in service to allow for "bedding down" stretch and creep to take place. For purposes of calculated creep allowances this should be taken as ten years from erection.

For determining sags the "equivalent span" methods is to be used, in which the tension in any section length is that would apply to a single span equal to the square root of the figure arrived at by dividing the sum of the cubes of the individual span lengths, in the section considered, by their sum. The calculated tensions at the time of initial erection shall be increased by an approved amount to allow for settling of the conductors. Other means may be adopted subject to the approval of the Engineer.

Immediately after the conductors have been erected and clamped in, the means sag of the conductors shall not depart from the correct erection sag by more than minus 4%. In addition the sag of any one line conductor is not to depart by more than 150mm from the sag of other line conductors in the same span.

Where required by the Engineer, prior to the issued of the Taking Over Certificate, the Contractor shall be responsible for checking that the relative sages of the conductors and earthwires are within the specified tolerance. Such checks shall be carried out at selected points along the route as requested by the Engineer.

Clearances between conductors and ground and between jumpers and structures shall be checked during erection and before handing over the line.

The Contractor shall provide suitable dynamometers, sighting boards and levels or other approved apparatus necessary for the proper checking of work. When required by the Engineer dynamometers shall be tested and if necessary recalibrated. Sag adjustment should be done through sighting boards and sighting levels; sag should be adjusted and measured mid-spans to the satisfaction of the Engineer.

The Contractor shall keep a record of the particulars of the sagging of conductors in each section of the route showing the mean actual sag of the line conductors and date of stringing as well as the ambient and conductor temperature. The data shall be handed to the Engineer at the conclusion of erection work.

7.0 INSPECTION AND TESTING

GENERAL

7.1 INSPECTION AND TESTING DURING MANUFACTURE

The plant shall be inspected during manufacture and tested by the Engineer.

Every facility is to be provided by the Contractor to enable the Engineer to carry out the necessary inspection of the plant and the costs of all tests during manufacture and preparation of test records are to be borne by the Contractor.

The passing of such inspection or test will not, however, prejudice the right of the Engineer to reject the Plant if it does not comply with the Specifications when erected, or give complete satisfaction in service.

Instruments shall be approved and shall, if required by the Engineer, be calibrated by the National Physical Laboratory or such other body as may be approved, at the expense of the Contractor.

Breakdown test voltages shall be measured by means of a crest or electrostatic voltmeter connected to the high voltage side of the transformer, or by an instrument connected to the low voltage side of the transformer supplying the test voltage and calibrated in an approved manner by means of a sphere spark gap. Electrical test, other than impulse test, shall be carried out at a frequency of 50 Hz.

The following tests shall be carried out at the manufacturer's works :

7.1.1 CONDUCTORS

Routine Tests

Samples of individual wires from each length of finished conductor shall be taken at the option of the Engineer and subjected to the tests stated in I.E.C. Publication No. 208 or such other standard as may be approved. Where practicable, tests shall be taken on samples of individual wires before stranding and related to the tests taken after stranding. In the event of the sample from any length not passing these test, a second and third sample shall be taken from the same length, and if one of these also fails under the test the length from which it has been taken shall be rejected.

Sample Tests

Sample tests shall be carried out on the complete conductor to prove compliance with the details entered in Schedule.

7.1.2 EARTHWIRES

Samples of individual wires from each length of finished earthwire shall be taken at the option of the Engineer and subject to the tests stated in ASTM B415-69, or such other standard may be approved.

7.1.3 INSULATORS

Routine, sample and type tests shall be carried out on all types of insulators used in the Contract /Type tests, including radio interference type tests, may be waived on the production by the Contractor of the requisite number of certificates by a Testing Authority showing that the insulators concerned have successfully passed type test in accordance with I.E.C. Publication No. 137 or such other standard as may be approved.

7.1.4 INSULATOR STRINGS

Design Tests

One suspension and one tension string of each type, selected by the Engineer, shall be subjected to the following tests in accordance with the provisions of I.E.C. Publication No. 383, B.S. 137 or such other standard as may be approved :

1) Impulse Tests. Dry withstand, positive and negative polarity.

2) Power frequency tests.

One string of each type, selected by the Engineer, shall also be subjected to Radio Interference Tests (Grade I) in accordance with the provisions of B.S. 137 or such other standard as may be approved.

Tests shall include vibration dampers, spacers and any other fittings attached to the conductors in service, and shall be made with arc horns.

7.1.5 INSULATOR AND EARTHWIRE FITTINGS

Routine and sample mechanical tests shall be carried out on fittings in accordance with the appropriate section of BS. 3288 Part I or such other standard as may be approved.

7.1.6 TENSION CLAMPS AND JOINTS

Two samples each of tension clamps and tension and non-tension joints shall be subjected to mechanical and electrical type tests, galvanising and mechanical routine tests in accordance with the appropriate section of BS. 3288 Part I or such other standard as may be approved. The Engineer, from time to time, shall make further similar tests as may be required to ensure that the quality of the product is being maintained throughout the Contract.

7.1.7 SPACERS - Overall Movements Tests

The movements detailed in Clause 2.4 shall be demonstrated.

Mechanical Strength Tests

i) With the clamps in the normal attitude, spacers shall withstand for one minute each, without permanent distortion, a compressive load and than a tensile load of 0.1 times maximum working tension of one sub-contractor. The loads shall be applied through rigid bars simulating the conductors. These bars shall be free to rotate about their axes.

ii) One clamp of the spacer shall be fitted to a conductor. The clamp shall be held rigid in its normal position and a load of 0.1 times maximum working tension of one sub-conductor shall be applied along the axis of the conductor. The conductor shall not slip through the clamp.

Dynamic Tests

Where these can be arranged the following test, or agreed equivalent tests, shall be carried out :

i) Arrangement

One clamp of the spacer shall be applied to a length of conductor of the appropriate size so that there is at least 600mm of conductor exposed on either side of the clamp. The conductor shall be tensioned atleast half maximum working tension. Under all conditions, the axis of the clamp remote from the conductor must be maintained parallel to the undisturbed axis of the conductor but no further restrains, other than those required to produce the test movements, shall be applied. The test movements shall be applied by means of a rod held in the clamp remote from the fixed conductor and shall be determined from the following load/deflection measurements.

ii) Load/Deflection Measurements

The following deflections shall be measured or the purpose of Dynamic Tests:

"l" the linear static deflection in the longitudinal direction of the conductor spacer system caused by a 110N static load or 150mm if that is less;

"v" the linear static deflection in the vertical direction caused by a 110N static load or 150mm if that is less;

"t" the angular static deflection in torsion caused by a static torque of 5.65Nm or 15 Deg. if that is less;

"m" ("1"2 + "v"2) 1/2

Should the spacer be so designed that, in any of the motions defined above, it is stiffer in one direction about its normal attitude that the other, the appropriate test parameter ("l", "v" or "t") can be taken as the mean of the two values obtained in each direction.

iii) Dynamic Test

Motions shall be applied to the clamp not attached to the test conductor as follows :

a) Motion + or - "m" - 50,000 cycles at a frequency between 30 and 100 cycles per minute at the descrete of the Engineer.

b) Motion + or "t" - 50,000 cycles at a frequency between 200 to 400 cycles per minute at the descretion of the Engineer. Motion "t" shall be applied during the application of motion "m"

The above tests need not be carried out in one continuous run, but no part of the dynamic test shall be less than two hours duration, during which time an equal number of cycles of motion "t" shall be applied as of motion "m".

Test Requirements

The sample spacer subjected to the Mechanical Strength Tests and the Dynamic Tests shall not cause fatigue or other damage, distortion or undue wear; neither shall the conductor, to which the test spacer was applied, show signs of fatigue or other damage due to the action of the spacer during the tests.

Electrical Resistance Test

The measured resistance between the conductors 25mm away from one spacer clamp and the other conductor 25mm away from the other clamp, shall be as per agreed value.

Corona Test

With the conductors in the normal attitude and with a minimum clearance of 6 meters from the spacer to any earthed plane, and with the conductors energised to the voltages given in Clause 7.1.4, the spacer shall not produce any visible or audible corona.

Routine and Sample Tests

Further routine and sampled test, including all the above design tests with the exception of the dynamic and corona tests, shall be carried out to the Engineer's requirements on an agreed basis.

7.1.8 SUPPORTS

Design Tests

The Engineer will select one straight line and one angle support of whatever types he may consider fit, which shall be assembled at the manufacturer's works, or other approved place, for test on a rigid foundation.

If the Contractor, in carrying out erection of supports on site, proposes to assemble the supports on the ground and subsequently raise them to the vertical position, the sample support submitted for tests shall be so assembled and raised to the vertical position on the test foundation in the presence of the Engineer, if so required.

Each structure, complete with crossarms, shall then be submitted to such test loads in such order as the Engineer may specify, to prove compliance with the factors of safety stated in the schedules. The test loads shall be applied in an approved manner and maintained for one minute without showing signs of failure or permanent distortion in any part.

If required by the Engineer, tests to destruction shall then be carried out on all or any of the structures submitted for tests.

If required the Engineer, these tests may be repeated from time to time on structures assembled from members selected by the Engineer.

No part of a tower to destruction shall be used in the permanent works and the Contractor shall confirm disposal to the Engineer.

Where tower tests are satisfactorily completed and not taken to destruction, the tower shall be carefully inspected after dismantling to ensure that no parts have been damaged, bundled separate from routine tower material, and marked for use in the permanent works at a position of relatively light loading.

Routine Tests

Samples of the material for supports and fittings shall be tested in accordance with I.S.O.R 630 or such other standard as may be approved.

7.1.9 GALVANISING

Galvanised articles other than wire shall be tested in accordance with ISO 1459, 1460, 1461 as appropriate, or such other standard as may be approved. If evidence of white rust is apparent upon receipt at site of bundled steel section, the Engineer shall order the Contractor to make such tests as he deems necessary to determine the extent of damage, if any, and the remedial measures necessary.

7.2 TESTS AT SITE

7.2.1 SOIL AND FOUNDATION TESTS

Ground Probe Tests

Tests by means of an approved type of penetrometer, or other approved means, shall be carried out by the Contractor at suitable intervals along the centre-line of the route and at selected positions during the profile survey, as provided for in Clause 5.5. Results of these test shall be included on the profile to give a preliminary indication of the ground bearing properties and water levels as specified in Clause 5.5. Borer penetration shall be at least 99m below ground level in poor ground.

Soil Resistivity Tests

Tests by an approved methods, and using an approved instrument, shall be carried out by the Contractor at suitable intervals along the centre-line of the route during the survey as provided for in Clause 5.5

Laboratory Soil Tests

Where ordered by the Engineer, the Contractor shall obtain soil samples and submit these for tests to an approved laboratory to determine the necessary properties of the soils for purpose of foundation designs. Such information is to be detailed in an approved manner and conclusions given as to be recommended bearing pressures to be adopted.

Ground Bearing Tests

Where ordered by the Engineer the Contractor shall carry out ground bearing test to determine the ground bearing capacity, by means of loading a 300mm square plate in an approved manner. Tests shall be carried out generally in the manner described in B.S. Code of Practice CP. 2001 Site Investigations or such other standard as may be approved.

Special Tests

Where ordered by the Engineer, special tests shall be carried out to determine such other data as is considered necessary for confirmation of foundation designs such as full scale uplift tests on individual fittings of normal or other type.

Records of Site Investigation Tests

All records of site investigation tests shall be detailed in an approved manner. Sample log sheets, charts etc., shall be submitted to the Engineer for approval before any investigation work commences.

All site investigation data, charts, etc., shall be handed to the Engineer in duplicate (copy to the Employer) upon satisfactory conclusion of the tests.

7.2.2 **TESTS DURING ERECTION**

Support Footing Resistance

The resistance to earth of the complete foundation of individual structures shall be measured in an approved manner before the earth conductors are erected, as specified in Clause 4.15. The placing of the test electrodes shall normally be along the centre-line of the route in such direction as to ensure that the lowest resistance to earth is recorded, and a note shall be made of the direction in the test log.

The schedule used for recording earth resistance tests shall contain, in addition to the measured ohmic values, details of the surface soils and general conditions at the time of tests.

Additional Tower Footing Tests

If, in the opinion of the Engineer, it is necessary to reduce the tower footing resistance by approved means such as counterpoise tapes, the Contractor shall make further tests after the additional measures have been carried out and before the earthwires are erected, at no extra charge.

Conductor Joint Tests

In the case of tension clamps, joints and bimetal terminal, the resistance of each part shall be measured by instruments supplied by the Contractor and approved by the Engineer. The resistance of such fittings shall not exceed 75% of the electrical resistance of an equivalent length of conductor and the current carrying capacity of such joints shall be at lest equal to 100% that of the conductor. These tests shall be carried out in the presence of the Engineer. Stringing shall not commence until suitable instruments are on site and ready for use.

Measurement of Galvanising Thickness

The Contractor shall have available on site for the Engineer's use an instrument suitable for the accurate checking of galvanising thickness. The gauge shall be available from the time of arrival of the first consignment of steelwork until the issue of the taking over certificate.

TESTS ON COMPLETION

7.2.3.1 The lines shall be engergised at full working voltage before handing over and the arrangement for this, and such other tests as the Employer or the Engineer shall desire to make on the complete line, shall be assisted by the Contractor who shall provide such labour, transport and other assistance. Apparatus for special tests shall be provided by the Employer.

7.2.3.2 Measurement of positive and zero sequence impedance shall be done.

7.2.3.3 The line shall be tested for insulation by the continuous application for 24 hours of the rated line voltage between phases.

7.2.3.4 The line washing shall be demonstrated and necessary adjustment made.

7.2.4 TESTS AT END OF MAINTENANCE PERIOD

The Contractor shall be responsible for checking that total and relative sags of conductors are within the specified tolerances. Such checks shall be carried out at selected points along the route as requested by the Engineer and the Contractor shall provide necessary surveying instruments to enable the checks to be carried out with the lines live and in service.

TECHNICAL SCHEDULES

TECHNICAL SCHEDULES

SCHEDULE - 1

SYSTEM DETAILS

ITEM	DESCRIPTION	DETAIL
1	System Nominal Voltage KV	132
2	System Highest Voltage KV	145
3	System Frequency Hz	50
4	Number of Sub-Contractors per Phase	2
5	Number of Phases per Circuit	3
6	Number of Circuits per Tower	2
7	Number of Overhead Earthwires	1

SCHEDULE - 2

TEMPERATURE LIMITS AND LOADINGS

ITEM	DESCRIPTION		DETAIL
1.0	Temperatures		
1.1	Min. temperature of conductors	0 Deg.	5
1.2	Max. temperature of conductors	0 Deg.	80
1.3	"Everyday" temperature of conductors	0 Deg.	35
2.0	Wind Pressure		
2.1	Wind pressure on the whole projected area of conductors and earthwires	Kg/m2	99
2.2	Wind pressure on one and a half times the projected areas or rolled steel members of one face of tower	Kg/m2	163

SCHEDULE - 3

FACTORS OF SAFETY

Item	Detail	Min. Factor of Safety
	Conductors	
1	Conductors and earthwire at final maximum working tension based on ultimate nominal breaking load	2.5
2	Conductors and earthwire at still air everyday temperature final tension based on ultimate nominal breaking load	5
3	Dead-end clamps and mid-span joints based on conductor or earthwire ultimate nominal breaking load	0.95
	Towers and Foundations	
4	Straight line towers and foundations under normal working loads	2
5	Angle, terminal, special supports and foundations under normal working loads	2.5
6	Towers under broken wire conditions	1.25
7	Towers foundations under broken wire conditions	1.5
8	Complete insulator strings and fittings at conductor maximum tension based on minimum failing load	3

SCHEDULE 4

LINE MINIMUM CLEARANCE

The following are the minimum clearances between live conductors and other objects which correspond to the maximum conductor sag conditions :

Item	Description		Main Clearance in Metres
1.0	Minimum Vertical Clearances to Ground		
1.1	Open ground not accessible to vehicle		7.0
1.2	Residential area		10.0
1.3	Regional Highways		18.5
1.4	District Distributors		17.5
1.54	Graded tracks		16.5
2.0	Buildings, structures, walls, wireless and TV aerials and scaffolding, upon which a may may stand		
		Horizontal	4.5
		Vertical	4.5
3.0	Trees		3.7
4.0	Telephone lines		4.6
5.0	Power lines (above or below)		2.7
6.0	Power line supports (any part on which a man may stand)		3.7
8.0	Minimum horizontal clearance between power lines		15.3
9.0	Phase to phase clearances for down leads		2.5

Note : 1) For vertical clearances 0.6m to be added
2) Maximum earthwire shield angle 30 deg.

SCHEDULE - 5

SUPPORT ELECTRICAL CLEARENCE DESIGN DATA

Item	Description		Details
1.0	Minimum clearance from live metal to earthed metal for suspension towers :		
1.1	From still air to 10 Deg. swing of insulator	mm	1570
1.2	From 10 Deg. to 40 Deg. swing of insulator (assumed maximum)	mm	1320
2.0	Minimum clearance from live metal to earthed metal at tension towers :		
2.1	Jumber loops in still air and other live metal	mm	1570
2.2	Jumber loops under 25 Deg. swing (assumed maximum)	mm	1320

SCHEDULE - 6

PARTICULARS OF CONDUCTORS, EARTHWIRES AND DAMPERS

Item	Description		Details	
			Line Conductors	Earth Wires
1.0	Line Conductors			
1.1	Nominal aluminium area of conductor	sq.mm		
1.2	Type of conductor			
1.3	Code name			
1.4	Total cross-sectional area	sq.mm		
1.5	Overall diameter	mm		
1.6	a) Number and diameter of aluminium strands	No/mm		
	b) Number and diameter of aluminium clad steel strands	No/mm		
1.7	Lay of aluminium strands :			
	Inner layer	mm		
	Middle layer	mm		
	Outer layer	mm		
1.8	Lay for outer aluminium clad steel strands for earthwire	mm		
1.9	Guaranteed ultimate breaking load	Kgf		
1.10	Maximum working tension (for tower design purposes)	N Kgf		
1.11	Everyday temperature still air tension	N Kgf		

SCHEDULE - 6 (Continued)

Item	Description		Details	
			Line Conductors	Earth Wires
1.12	Aluminium individual wires before stranding			
	- Tensile breaking stress	Kgf/sq.mm		
	- Elongation on 250 mm length on breaking	%		
1.13	Aluminium clad steel individual wires before stranding			
	- Tensile breaking stress	Kgf/sq. mm		
	- Elongation on 250mm length on breaking	%		
	- Elastic limit of material as % break strength			
1.14	Equivalent modulus of elasticity (final)	Kgf/sq.mm		
1.15	Equivalent co-efficient of linear expansion	per Deg. C		
1.16	Maximum calculated resistance per km at 20 Deg. C	Ohms		
1.17	Assumed maximum continuous load current with 0.5m/sec wind velocity and 105mW/cm2 solar radiation, half black condition			
	- At cold conditions 5 Deg.C ambient 70 Deg. C rise	Amps		

SCHEDULE - 6 (Continued)

Item	Description		Details	
			Line Conductors	Earth Wires
	- At moderate conditions 35 Deg. C ambient 45 Deg. C rise	Amps		
	- At highest site temperature 50 Deg. C ambient 30 Deg. C rise	Amps		
1.18	Standard weight per km	Kg		
1.19	Greased conductor weight per km	Kg		
1.20	Type of grease			
1.21	Standard length of conductor on drum	m		
1.22	Weight of complete drum plus conductor	tonne		
1.23	Diameter of drum	mm		
1.24	Earthwire UTS quality	hbar		
2.0	Vibration Dampers			
2.1	Type			
2.2	Type Number			
2.3	Mass	Kg		
2.4	Distance from clamp mouth	mm		
3.0	Compressors			
3.1	Type of compressor			

SCHEDULE - 6 (Continued)

Item	Description		Details	
			Line Conductors	**Earth Wires**
3.2	Details of dies to be supplied			
3.3	List of spares recommended to be supplied			
4.0	Earthwire Compression Fittings			
	Stainless steel			
	Hardness values			
	Before compression	V.P.N		
	After compression	V.P.N		
5.0	Spares			
	Spacing between Centres of Duplex conductors of one phase			
	Along run of line	mm		
	At suspension sets	mm		
	At tension insulator sets	mm		
	Along jumpers	mm		
	In downlead	mm		
	Min. Number of spacers/Dampers per Span, Jumber of Down Dropper			
	Max.Distance betted Adjacent Spacers (or between Spacer and Clamp in Jumper)			
	In run of line	m		
	In jumper	m		
	Spacer/Damper type	(400mm) N		
	number	(200mm) N		

SCHEDULE - 7

PARTICULARS OF LONGROD PORCELAIN AEROFOIL INSULATORS AND FITTINGS

Item	Description		Details			
			Normal suspension	**Heavy Suspension**	**Normal Tension (Twin)**	**Low Duty Tension**
1.0	Insulators					
1.1	Number of units in string					
1.2	Insulator type					
1.3	Insulator manufacturer and unit number					
1.4	Total length of creepage path of the insulator string	mm				
1.5	Ditto as 1.4, but protected creepage path	mm				
1.6A	Min. 50 Hz dry withstand of unit	KV				
1.6B	Ditto as above, but for string complete with all fittings	KV				
1.7A	Min. 50 Hz wet withstand of unit	KV				
1.7B	Ditto as above, but for string complete with all fittings	KV				

SCHEDULE - 7 (Continued)

Item	Description		Details			
			Normal suspension	**Heavy Suspension**	**Normal Tension (Twin)**	**Low Duty Tension**
1.8	Min. 50 Hz puncture voltage of unit	KV				
1.9	Min. dry 1.2/50 impulse withstand voltage of normal insulator set with all fittings	+KV -KV				
1.10	Spacing of units in string	mm				
1.11	Outside diameter of unit	mm				
1.12	Max. working load	Kgf KN				
1.13	Min. failing load, per complete insulator set (as defined in IEC. 305)	Kgf KN				
1.14	Mass of unit	Kg				
1.15	Total length of insulator string	mm				
1.16	Min. distance between earth end unit socket and line end unit ball centres	mm				
1.17	Overall length of complete set from bottom conductor to tower attachment point	mm				

SCHEDULE - 7 (Continued)

Item	Description		Details			
			Normal suspension	Heavy Suspension	Normal Tension (Twin)	Low Duty Tension
1.18	Length from tension set jumper lug to crossarm attachment point mm					
1.19	Lift of arching horn over aline end unit	mm				
1.20	Arcing distance between line end horn and earth end cap or horns	mm				
1.21	Weight of complete set with all fittings	Kg				
1.22	Min. Ratio shed spacing shed overhang					
2.0	Fittings					
2.1	Type of coupling					
2.2	Clamp manufacturer and unit number					
2.3	Material of clamp					
2.4	Elastic limit of fittings	Kgf KN				

SCHEDULE - 8

PARTICULARS OF SUPPORT AND FOUNDATION

DESIGN DATA

Item	Description	Details
1.10	Support	
1.1	Max. ratio of unsupported length of steel compression members to their least radius of gyration	
1.1.1	Main members	
1.1.2	Bracings	
1.1.3	Redundants	
1.1.4	Bracing loading in tension only	
1.2	Steel to ISO R630 Grade Fe44A	UNI
1.2.1	Elastic limit stress in tension members	N/mm2
1.2.2	Ultimate stress in compression members (expressed as function of L/R)	N/mm2
1.3	Steel to ISO R630 Grade Fe52B or other proposed standard	UNI
1.3.1	Elastic limit stress in tension members	N/mm2
1.3.2	Ultimate stress in compression members (expressed as function of L/R)	N/mm2
1.4	Bolts	
1.4.1	Ultimate shear stress on bolts	Kg/mm2
1.4.2	Ultimate bearing stress on bolts	Kg/mm2
1.4.3	Ultimate tensile quality of bolts	Kg/mm2

SCHEDULE - 8 (Continued)

Item	Description	Detail
2.0	Concrete Block Foundations	
2.1	Assumed mass of earth per cubic metre for foundation	Kg
2.2	Assumed cohesion	KN/m2
2.3	Assumed angle of frustrum of earth resisting uplift	
2.4	Assumed mass of concrete per cubic metre for foundation	Kg
2.5	Assumed ultimate earth pressure for standard foundation under specified loadings, including factor of safety	KN/m2
2.6	Ultimate adhesion value between galvanised steel and concrete, including factor of safety	N/mm2
2.7	Ultimate lateral earth pressure in KN/m2/m of depth, including factor of safety	
2.8	Ultimate shear stress between rock and concrete foundations	KN/m2
2.9	Ultimate plain concrete bearing stress for 4.2.1 quality	N/mm2
2.10	Min. portion of sub loads to be allowed for in the design of stub cleats	

SCHEDULE - 9

PARTICULARS OF SUPPORTS AND FOUNDATIONS

Item	Description		Type of Tower			
			DL	D3	D6/T	
			DS	D2	D9	DT
1.0	Supports					
1.1	Basic span length	m				
1.2	Design ground clearance of line conductor at max. temperature (including 0.6m allowance of long term creep)	m				
1.3	Final sag of line conductor in still air at maximum temperature for basic span	m				
1.4	Approximate height of lowest conductor above ground at point of support H + or - O	m				
1.5	Vertical spacing between cross arms	m				
1.6	Vertical spacing between earth wire and line conductor at support	m				
1.7	Approximate total height of support above ground H + or - O	m				
1.8	Horizontal spacing between centres of conductors	m				

Item	Description		Type of Tower			
			DL	D3	D6/T	
			DS	D2	D9	DT
1.9	Final sag of line conductor at everyday temperature still air for basic span	m				
1.10	As above for earth wire	m				
1.11	Approximate overall dimensions of support base at ground line :					
1.11.1	Transverse to line H + or - O	m				
1.11.2	Parallel to line	m				
1.12	Approximate mass of complete support steel work (normal, dry soil foundation Common body + Base + or - O + 4	KG				
1.13	Approximate total extra mass of steel for extension of 3m Base + 3M + 4LEG + or - 0	KG				
1.14	Approximate total extra mass of steel for extension of 6m Base + 6M + 4LEG + or - 0	KG				

SCHEDULE - 9 (Contd...)

Item	Description		Type of Tower			
			DL	D3	D6/T	
			DS	D2	D9	DT
1.15	Approximate total extra mass of steel for extension of 9m Base + 9M + 4LEG + or - 0	KG				
1.16	Total transverse overturning moment at ground line under specified maximum normal working loadings for standard support	KNm				
1.17	Approximate ultimate compression load per leg	KN () ()				
1.18	Approx. ultimate uplift load per leg	() () KN ()				
2.0	Foundations					
2.1	Volume of concrete block foundation per tower normal soil foundation with extensions included	m3				
2.2	Weight of reinforced steel (if required)	KG				
2.3	Volume of concrete block foundation per tower extended pad foundation	m3				
2.4	Weight of reinforcing steel (if required)	KG				

SCHEDULE - 10

DATES FOR MANUFACTURE, COMPLETION & TESTING

The Schedule is to be completed by the Tenderer and the times entered are to be binding on the Contractor.

The required completion dates given are target dates, planned to be achieved in conjunction with other contracts, and it is essential that they are adhered to.

COMPLETION REQUIRED BY :

END

420 days from order

Description	Time Required in Months after Placing Order	
	Commencement	Completion
Profile		
Access for Commencement of Erection		
STEEL STRUCTURES		
Submission of Suspension Tower Design		
Suspension Tower Manufacture		
Submission of Other Tower Designs		
Angel Tower Manufacture		
Foundation Steelwork Manufacture		
Foundation Installation		
Tower Erection		
CONDUCTORS, EARTHWIRES AND FITTINGS		
Conductor Manufacture		
Earthwire Manufacture		
Fittings Manufacture		
Stringing of Conductors and Earthwires		

Description	Time Required in Months after Placing Order	
	Commencement	Completion
INSULATORS AND FITTINGS		
Insulator String Tests		
Manufacture		
Erection		
Completion of Line Erection for Testing		
Guaranteed Date for Completion and Handing Over		
Latest Date by which Order must be Placed to achieve the above Guaranteed Dates		

Signature of Tenderer : .....

Name : .....

Position : .....

Address : .....

Date : .....

Witness : .....

Name : .....

Position : .....

Address : .....

Date : .....

SCHEDULE - 11

MANUFACTURERS AND PLACES OF MANUFACTURE, TESTING, INSPECTION AND SHIPMENT AND STANDARDS

Item	Details	Manufacturer and Place of Manufacture	Place of Testing & Inspection	Port of Shipment
1.0	Conductors			
1.1	Aluminium wires			
1.2	Aluminium Clad steel wires			
1.3	Stranding (complete conductor)			
1.4	Conduct tension joints (line and earthwire)			
1.5	Compressors			
2.0	Insulators and Fittings			
2.1	Insulators			
2.2	Line and earth conductor tension clamps			
2.3	Line and earth suspension clamps			
2.4	Insulator string tests			
3.0	Supports			
3.1	Design of supports			
3.2	Steel sections			
3.3	Fabrication			
3.4	Galvanising			
3.5	Bolts and nuts			

Note

The above manufacturers are given as reference of performance and quality and could be replaced by others giving technical equivalent guarantees.

STANDARDS

The Tenderer shall enter below the International or National Standards on which his Tender is based. Copies of such Standards as the Engineer requires shall be forwarded for the Engineer's retention together with an English translation.

Material Description	Standard
Aluminium clad steel cored aluminium conductor	
Aluminium clad steel earthwire -	
Conductor, earthwire and insulator fittings	
Insulators	
Towers :	
Mild steel sections	
High tensile steel sections	
Mild steel bolts	
High tensile steel bolts	
Galvanising	
Ground bearing tests	
Additional Standards proposed by the Tenderer	

SCHEDULE - 12

SUB CONTRACTORS

The Tenderer shall state in the following Schedule details of all Sub Contractors that he proposes to employ for the construction of any part of the Works.

S.NO.	Description	Name & Address of Sub Contractor
1	132KV Overhead line	
2	Soil test	

SCHEDULE - 13

CONTRACTOR'S SITE PERSONNEL

ERECTION STAFF

The Contractor shall give below the status and number of staff required for erection of the Plant, and the estimated period which they will be retained on site.

	EXPAT.	T.N.C.
Supervisory and expatriate staff		
Senior Engineer		
Assistant Engineer		
Surveyor		
Foreman		
Total		
Estimated period of site		
Commencement		
Completion		

SCHEDULE - 14

LIST OF CONTRACTOR'S PLANT AND TOOLS

The Tenderer shall set out below the Plant and Tools he proposes to use on the Contract.

Item	Description	Quantity
01	Excavator	
02	Bulldozer	
03	Compressor	
04	Concrete Mixer	
05	Truck Tipper	
06	Truck with HIAB Crane	
07	Truck with Trailer	
08	Crane 40 T	
09	Crane 20 T	
10	Pick-up 1 to 3 T	
11	Water Tank 2 m3 on wheels	
12	Stringing Equipment	
13	Pulley Block	
14	Sagging Tools	
15	Survey Equipment	
16	Typical O.H.L. Miscellaneous Tools	

SCHEDULE - 15

DEPARTURES FROM REQUIREMENTS OF THIS SPECIFICATION

Clause No.	Details

SCHEDULE - 16

TENDERER'S EXPERIENCE

Tenderers wish to supply details of more than one Contract additional pages should be attached.

Name and Address of Client	:
Country	:
Voltage and length of line	:
Brief description of terrain	:
No. of circuits and No. and size of conductors	:
Type of construction (e.g. Guyed portal, flat formation self supporting etc)	:
Technical coordination by	:
Steel work supplier	:
Conductor supplier	:
Installation of foundations by	:
Tower erection by	:
Stringing by	
Site supervision by	:
Max. number of expatriate supervisors	:
Max. number of local employees	:
Date of award	:
Target completion date	:
Actual completion date	:
Name and address of consultant (if any)	:

SCHEDULE - 17

DEFINITE WORK ON A LUMPSUM BASIS

The total price for the complete Works is to be entered below whether if not fully described and is to include everything necessary to leave the equipment complete and in full working order at the expiration of the maintenance period in accordance with the provisions of the Contract.

Item No.	Description	All prices to be entered in R.O.		
		C & F	LTI & E	TOTAL
1.1	132KV Docuble Circuit Transmission Line using duplex conductors from Wadi Jizzi Power Station to Sohar Town Substation			
	Totals transferredt Schedule Q of Vol. 1			

SCHEDULE - 18

SCHEDULE OF RATES FOR VARIATION

OVERHEAD LINES

Item	Description	C & F	LTI & E	Total
1	Variation (plus or minus) of length of double circuit 132 KV overhead line supplied, erected, commissioned and maintained for twelve months per Km			
2	Extra for galvanised steelwork required for extended cross-arms or other special purposes per tonne			
3	Extra for helically formed armour rod sets for conductors at heavy weight span positions each			
4	Additional excavation in any type of ground per m3			
5	Additional profile including tower spotting per km			
7	Percentage addition to cost of laboratory soil tests requested by the Engineer to cover all overheads %			
8	Boring in soil for 50mm diameter undisturbed soil sample for laboratory testing as requested by the Engineer per m			

SCHEDULE - 19

DAYWORKS (PROVISIONAL)

1) No works whatsoever may be executed as Dayworks, nor will payment be made for nay Dayworks except in accordance with the provisions of Clause ..... in the conditions of Contract, and with prior written authorisation of the Engineer's Representative.

LABOUR

2) The Contractor shall be entitled to the following payments in respect of labour employed on Dayworks :

a) The aggregate amount of wages for such labour calculated on the actual hours worked at the wage rates set out in this Schedule up to the grade of charge hand or overseer working with the men (time for foremen is to be included in the percentage under 2 (b) below).

b) ..... percent of the aggregate amount of wages calculated according to sub-paragraphs 2 (a) above.

3) The percentage addition provided in sub-paragraph 2 (b) above shall cover Contractor's profit, on cost, superintendence, insurance and all allowances to labour, time keeping and all clerical and office work as well as the use of tools, timber, light equipment and non-mechanical equipment and all incidental charges whatever.

4) The "Normal Working Day" as hereinafter referred to shall be taken to be eight hours excluding meal breaks and rest periods.

5) In calculating the sums due to the Contractor for the execution of Dayworks, the hours for which payment shall be made for all personnel and the hire of all plant and equipment shall be reckoned from the time of starting the particular item of Daywork, either at the beginning of or during the course of a normal working day to the end of the normal working day or the time of completion of the particular item of Daywork, which ever may be the sooner. No payment shall be made for personnel or plant for hours outside the normal working day unless the said personnel and plant are employed on Dayworks outside the Normal Working Day on the written instructions of the Engineer's Representative. The same Daywork rate shall apply for works done both during and outside the Normal Working Day.

6) On completion of any authorised Daywork, a written statement shall be issued by the Engineer's Representative who shall sign it together with the Contractor and which shall state the number of workmen and their grades involved in the Daywork, the number of hours worked and a detailed description of the Material used and the work carried out. A copy of this signed statement shall be retained by the Engineer and the Contractor and shall be the sole basis upon which payment for Dayworks will be made.

7) DAYWORK RATES FOR LABOUR

Class of Labour	Hourly Rate - R.O.
Local Labour	
Unskilled Labourer	2.5
Skilled Labourer	3
Driver	3
Steel Erector	3
Linesman	3
Chargehand/Overseer	3.5
Surveyor (on survey work only)	4.5
Expatriate Labour	
Linesman	-
Chargehand/Overseer	12
Steel Erector	-
Surveyor (on survey work only)	15

8) Any other class of labour envisaged by the Contractors for the execution of any Dayworks, except that covered by Paragraph 3 above, i.e. superintendence etc., shall be entered above together with the appropriate labour rates, and such rates shall be the only rates considered in any Dayworks claim.

9) The labour rates to the entered above shall include all other benefits or contributions made by the employer such as contributions to Social Insurance Schemes, Annual Leave, Termination of Employment and Redundancy Law, Provident Fund, Health Schemes etc., which are imposed either by Law or by agreement with different parties.

EQUIPMENT AND TRANSPORT

10) The rates for hire of equipment and transport shall apply only to equipment which the Contractor has on site and are to apply for the actual running hours for which the equipment is employed on work.

11) The rates shall include service, operators and necessary attendants, fuel, lubricants and other consumables.

12) The Contractor may insert additional items and quantities provided that such are extended and added into the total of the Schedule.

13) The rates for materials shall apply to the nett amount of material actually provided, erected and forming part of the Works and shall include for delivery to the site of operations.

14) The Contractor may insert additional items and quantities provided that such are extended and added into the total oft the Schedule.

RATES RELATING TO DAYWORKS

The Tenderer is reminded that this is a Turnkey Contract. No additional costs will be considered for any item which the Tenderer has overlooked.

The Tenderers shall insert rates against each of the items listed on the Schedule. The rates shall be used to evaluate minor modifications omissions or additions to the Works where these are instructed by the Engineer concurrently with the programme for the relevant section of the Works.

The rates shall be the fully inclusive value of the work described including the cost of any temporary work associated therewith. They shall also include all overheads, profit, supervision, accommodation, insurances, transport, duties, risks, liabilities, obligations and the like but shall exclude design costs which are included as a separate item Design costs shall only be applied where the nature of the work necessitates the approval of calculations and/or drawings by the Engineer.

Rates for items not included in the Schedule shall be based on those quoted where appropriate. Where no suitable rate exists a new rate based on invoices and other cost records shall be agreed.

The Contract Price shall be adjusted on the basis of the value of the Engineer's instructions priced as described in the foregoing paragraphs. All measurements shall be nett as drawings or instructions.

Item	Qty	Short Description	LTI & E	
			Rate R.O.	Total R.O.
		LABOUR		
301	—	Provisional sum for labour as described in paragraph 2 (a).		
302	—	Percentage addition as described in paragraph 2 (b) - on item 301 (to be entered and extended by Tenderer) ... 15%		
		EQUIPMENT		
303 (A)		Welding set for two welders - 5 hours		
(B)		Acetylene cutting equipment - 5 hours		
(C)		Air compressor (180 m3/hr at 7 atmospheres) complete with hoses and tools - 40 hours		
(D)		Tubular metal and scaffolding with fittings (excluding labour element) 500 m for 1 week		
(E)		5 tonne lorry - 100 hours		
(F)		2 tonne lorry - 50 hours		
(G)		Tractor with winch 50 hours		
(H)		Tractor without winch - 50 hours		
(I)		Bulldozer (D6 or similar) - 50 hours		
(J)		Land Rover, jeep or similar - 100 hours		
(K)		Saloon car 100 hrs		

Item	Qty	Short Description	LTI & E	
			Rate R.O.	Total R.O.
		MATERIALS		
304	(A)	Cement 15 tonne		
	(B)	Sand 36.0 m3		
	(C)	Crushed stone or gravel 50.0 m3		
	(D)	Reinforcing steel 2 tonne		
	(E)	Ungalvanised mild steel structural sections 1 tonne		
	(F)	Welding Rods 10 KG (1/8" rod)		
	(G)	Sawn timber 10 m		
	(H)	Galvanised folded steel sheet-1 tonne		
		Total of Daywork Schedule 15		

SUPERVISORY STAFF RATES

The following rates shall apply where, by agreement with the Engineer, supervisory staff are employed on Dayworks in a direct capacity, i.e. other than in their normal supervisory capacity.

The rates may also be used as a basis for assessing any legitimate claims for extra costs in accordance with the provisions of the Conditions of Contract, where these have not been claimed as Dayworks.

No payment shall be made without the prior written authority of the Engineer, and the provisions of the Conditions of Contract shall apply to any claim for payment.

The Contractor shall insert in the following Schedule descriptions and rates for any classes of supervisory staff envisaged which are not already included.

Class of Supervisory Staff	**Hourly Rate - R.O.**
Expariate	
Senior Engineer	
Engineer	
Surveyor	
Foreman	
Local	
Surveyor	
Foreman	

SCHEDULE - 20

QUANTITIES AND PRICES FOR SPARES OVERHEAD LINE

This Schedule shall be completed by the Tenderer. The Tenderer shall furnish a complete list of recommended spares with breakdown of prices which may or may not in whole or in part by purchased by the Employer under the Contract.

No. Off	Description	No. Off	All Prices to be entered in R.O.	
			Delivery to MEW Stores	
			C & F	(LTI)
3	Suspension string			
1	Tension string			
1	E.W. Tension string			
2	E.W. Suspension string			
2	Conductor joint			
2	E.W. joint			
2	Conductor repair sleeve			
1	Drum of phase conductor of 500 meters			
	Total Transferred to Schedule Q of Vol. 1			

SCHEDULE - 21

QUANTITIES AND PRICES FOR MAINTENANCE

TOOLS AND APPLIANCES OVERHEAD LINES

This section is to be completed by the Tenderer. The Tenderer shall furnish list of tools and appliances in accordance with the requirements of Clause AO. 14 of the specification with itemised prices. The cost of these shall be included in the Schedule of Prices for Provisional Items.

No.	Description	All Prices to be entered in R.O.	
		Delivery to MEW Stores	
		C & F	(LTI)
	Note applicable for Overhead lines See Clause AO 14		
	Total Transferred to Schedule Q of Vol. 1		