G.3.3 Fittings

All fittings shall be malleable iron hot dip galvanized or copper alloy.

Suspension and tension clamps shall be as light as possible and of approved types. All clamps shall be designed to avoid any possibility of deforming the stranded conductors and separating the individual strands. Tension clamps shall be bolted type except compression type for conductors of connecting circuits, and shall not permit slipping off or damage to conductors or any part thereof. Suspension clamps shall be free to pivot in the vertical plane containing the conductor.

Clamps shall not exhibit excessive heating by magnetizing or other reasons.

U-volts, ball hooks, socket-eyes and other necessary fittings required for the above insulators and clamps shall be provided.

G.3.4 Tests

The following tests shall be carried out before shipment:-

(1) Withstand voltage and flashover voltage test of insulator set.
(2) Electro-mechanical strength test.
(3) Dimensions of insulators and fittings.
(4) Galvanizing test.

G.4 STEEL STRUCTURES AND TOWERS

G.4.1 General

The contractor shall furnish all steel structures, and steel framework of switchgear equipment excluding framework of circuit breaker in main transformer yard, 138 kV switchgear yard at Severino and 138 kV switchgear yard at Daule Peripa, and one steel tower for 138 kV connecting line.

Erection work at site shalll be carried out by the Contractor, but the foundation work will be performed by other Contractor.

The post structures and frameworks shall be located in accordance with the layout shown on the attached drawing. The outline of frameworks may be varied slightly in accordance with the specifications of switchgear equipment.

One tower for connecting citcuit between main transformer yard and 138 kV switchgear yard at Severino shall also be supplied as shown on the attached drawing.

All complete foundation drawings which other contractor can easily perform the foundation works for them shall be submitted for approval of the Engineer.

G.4.2 Details of Design

The steel structures and framework shall be designed in accordance with the following requirements:-

(1) Vertical Loading

The weight of conductors, groundwires, insulator strings, and structures and tower themselves shall be considered.

(2) Wind Load

(a) On conductors and groundwire

65 kg/m^2 on projected area.

(b) On insulators and all other circular section

130 kg/m^2 on projected area.

(c) On lattice structures or beam structure

195 kg/m^2 on the exposed area of one face.

(3) Working Tensions of Conductor and Ground wire

(a)	Conductors	400 kg for 138 kV bus and slack spans in both Severino and Daule Peripa. 2,400 kg for connecting line and 138 kV transmission line
	Overhead ground wire	300 kg inside 138 kV switchgear yard 1,750 kg for connecting line and 138 kV transmission line

(4) Seismic coefficient ..... 0.15g in horizontal direction

(5) Unbalanced Loading for Connecting Line Tower

For the connecting line tower, 100% of the maximum working tension of conductors and ground wire shall be applied as longitudinal loading.

(6) Factor of Safety

The structures shall be designed so that no failure or permanent distortion shall occur when the load equivalent to 1.5 times the maximum simultaneous working loads are applied.

(7) Ratio of Slenderness

The ratio of slenderness shall not exceed 200 for main and 220 for web members and 250 for nominal members as compression member and 400 for tension member.

(8) Member Size

No leg members less than 5 mm in thickness and 60 mm in width of flange for main, and 3 mm in thickness and 45 mm in width of flange for web and nominal members shall be used.

(9) Bolts and Nuts

All the members shall be connected by bolts and nuts. The size of the connection bolts shall be more than 16 mm for leg member and 12 mm for web member. The suitable anchor bolts shall be provided. The size of step bolts shall be 16 mm.

The Contractor shall submit full details and drawings for the steel structures to the Engineer for approval prior to commencing fabrication.

G.4.3 Foundation

The concrete foundation for switchyard equipment, structures and connection tower will be placed by the other Contractor under the Contractor's supervision, and the Contractor shall submit the necessary design drawings with calculation for foundation for approval.

The Contractor shall also submit the installation drawing giving full erection particulars for approval of the Engineer.

Safety factor of concrete for uplifting force shall not be less than 2.0. The allowable bearing capacity of earth shall be assumed to be 20 t/sq meter for main transformer yard, 60 t/sq.mm for 138 kV interconnection tower and 40 t/sq.meter for 138 kV switchgear yard at both Severino and Daule Peripa. The weight of earth shall be assumed to be 1.8 ton/cu.meter and weight of concrete to be 2.4 ton/cu.meter with reinforcement.

The angle of repose will be reckoned as 30, 20 and 10 degrees for 60, 40 and20 t/sq.meter bearing capacity of earth respectively.

The seismic coefficient shall be taken as under the Clause G.4.2 (4).

G.4.4 Materials

All steel employed for the structures and tower shall have high yield point and high ultimate tensile strength and shall be subject to the approval of the Engineer.

G.4.5 Workmanship

The cutting, drilling, punching and bending of all fabricated steel work shall be in accordance with the best practice for the materials being used and subject to the approval of the Engineer. Diameter of bolt holes shall not be more than 1.5 mm larger than the diameter of the bolts.

All members shall be hot dip galvanized after fabrication. Bolts and nuts shall also be galvanized.

All members shall be stamped or marked in an approved manner with numbers and/or letters corresponding to number and/or letters on drawings or material list approved by the Engineer.

The erection marks shall be stamped before galvanizing and shall be clearly legible after galvanizing.

G.4.6 Tests

The following tests shall be carried out before shipment.

(1) Mechanical strength of materials.
(2) Galvanizing test.
(3) Shop assembly.

G.5 OTHER MATERIALS

All construction materials such as conduit pipes, angle steel, channel steel, steel plate, cable supporting brackets, wooden cleats, bolts, nuts and other items required for putting the plant into operation shall be provided whithout extra charge and shall comply highest grade specified in the relevant standard. Coloured phase mark plates to be fitted each beam of 138 kV steel structures shall be also provided.

G.6 ERECTION

The Contractor shall be responsible for the erection works stated hereunder.

(1) Cabling and connecting the power cables, control cables and insulated wires with machineries, equipment, cubicles, control switchboards and panels, water level indicators, etc.
(2) Stringing the conductors and insulators.
(3) Connecting all equipments supplied under this Contract with grounding system.
(4) Assembling the steel structures, tower and frameworks.
(5) Other works associated with the miscellaneous materials.
(6) Painting and finishing.

SUBSECTION - H

13.8 KV DISTRIBUTION LINE

H.1 GENERAL

H.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

(1) 13.8 kV line from the pumping station to 138 kV switchgear yard, approximately 80 m,single circuit, ACSR 58 mm^2 (Al 6/3.5, St 1/3.5).

(2) 13.8 kV line from the pumping station to Base camp, approximately 500 m, single circuit, ACSR 58 mm^2 (Al 6/3.5, St 1/3.5).

(3) Receiving substation at;

(a) 13.8 kV switchgear yard
(b) Base camp site

H.2 DISTRIBUTION LINE MATERIALS

H.2.1 Power Conductor and Ground Wire

Power conductor shall be aluminium conductor steel reinforced (ACSR) and the overhead ground wire shall be galvanized steel wire (GSW). They shall comply with the following requirements and characteristics.

	ACSR	GSW
Size (sq.mm)	58	22
Stranding (mm)	Al 6/3.5, St 1/3.5	7/2.0
Ultimate strength not less than (kg)	1,980	1,820
Resistance at 20°C (Ohm/kg)	0.497	-
Minimum coating of zinc (g/m^2)	-	200

The power conductor and ground wire shall be wound on a stout wooden drum. The length of conductor and ground wire shall be 1,000 m per drum.

H.2.2 Joints and Connectors

Midspan joints shall be of compression type and shall be free from slipping off, damage to or failure of the conductor, ground wire or any parts thereof at a load less than 95% of the ultimate strength of the power conductor or ground wire.

The electrical conductivity and current carrying capacity of joints for power conductor shall not be less than those of equivalent length of the conductor.

Connectors for conductor shall be of bolted type, with grooves and alloy bolts, complete with compound for connectors to prevent breaking out of oxide film on the conductor's surface.

H.2.3 Insulators

Insulators shall be of brown coloured porcelain, and both line post and tension insulator sets of disc insulator units for 13.8 kV line. Insulators disc shall be of ball-socket type and the dimension of socket and pins shall comply with the JIS standard C-3817, "pin and socket" or equivalent.

Their sizes and characteristics shall be as follows:-

			Line Post Insulator	Tension (Disc)	Insulator Set (String)
Withstand Voltage					
Power frequency, wet	(kV)	:	40	30	55
Impulse	(kV)	:	100	100	200
Cantilever strength	(kg)	:	2,500	-	-
Tension strength	(kg)	:	-	10,000	4,000

H.2.4 Fittings for Insulators

The line post insulator shall have a suitable clamp to support the power conductor on the top of the insulator.

Insulator set for tension support shall consist of two insulator discs and tension string assembly including a tension clamp shaped as shown on the Drawings for Tender, No. 3-I-020.

All bolts, nuts and cotter pins shall be not less than 16 mm in diameter.

The tension clamp shall be of wedge type and made of bronze casting or malleable iron and be free from slipping off, damage to or failure of the complete conductors at a load less than 800 kg.

H.2.5 Fitting for Overhead Ground Wires

The overhead ground wires of 22 mm^2 shall be supported by a parallel hook hung on the top of the support at straight section and by double V-hangers with wire clips at angle and strain section respectively. These fitting assemblies are shown on the Drawings for Tender, No. 3-I-020.

H.2.6 Supports

Supports shall be local made precast concrete poles, complete with galvanized steel arms, step bolts, anchor logs and guy wire sets where necessary.

Concrete poles shall be of round section. The diameter of top section shall be not less than 18 cm.

Line conductors shall be arranged in horizontal on one cross arm and overhead ground wire shall be fixed on the top of the support.

The standard types of supports are as follows:-

Type-A : Straight line and light angle support up to 5 degrees with line post insulators on a single cross arm.

Type-B : Heavy angle support up to 30 degrees with double line post insulators on a double cross arm.

Type-C : Terminal and heavy angle support up to 60 degrees with tension insulator sets and jumper line posts on a double cross arm.

Type-D : Heavy angle support up to 90 degrees with tension insulator sets and jumper line posts on two double cross arms fitted rectangularly.

Type A shall be designed to be used without guy wires. Other types shall be r einforced with necessary guy wires.

Type A support will not be used for 10 continuous sections.

The standard design span shall be 50 meters.

The height of the lowest arm from the ground level, spacing of conductors and other dimensions shall be as given on the Drawings for Tender, Nos. 3-I-018 and 3-I-019.

Note: (1) For the section from pumping station to 138 kV switchgear yard, Type As, Cs and Ds poles for double circuit shown on the Drawings for Tender, No. 3-I-019 shall be provided.

(2) Type-C pole shall be designed to be used as a terminal pole at pumping station to be provided with 3 lightning arresters and cable ends of 13.8 kV 3-core cable.

H.2.7 Design Conditions of Poles

All supports and arms shall withstand the following loads:-

(1) Vertical loads ..... a) Weight of supports, conductors, ground wires, communication cable, insulators, etc. The weight span shall be taken as 150% of the standard span.
b) Vertical load caused by installation of the guy wires.
c) Weight of worker 200 kg.

(2) Transverse loads ..... a) Wind pressure at right angle to the line and support on the whole projected area.
b) Transverse component of angle effect due to the maximum working tension of conductors and ground wires.

(3) Longitudinal loads ..... 100% of the maximum working tension of conductors, ground wire and communication cable for type C and D.

Wind loads shall be assumed as follows:-

(1) On conductor, ground wire and communication cable
..... 50 kg/m^2 on projected area at -5°C.
60 kg/m2 on projected area at +60°C.

(2) On concrete pole ..... 50 kg/m^2 on projected area at -5°C.
60 kg/m2 on projected area at +60°C.

(3) On arm, insulator set, etc.
..... 100 kg/m^2 on projected area at -5°C.
130 kg/m2 on projected area at +60°C.

(No wind pressure may be considered for guy wires and jumper conductors.)

The temperature shall be assumed to vary within the range, 60°C maximum and -5°C minimum.

The maximum working tension shall be as follows:-

Line conductors ..... 350 kg
Ground wires ..... 290 kg

In design of support for 13.8 kV lines, consideration shall be given on the following communication cable to be hung on the supports.

1 x CPEV-SS 30P, 0.9 mm; Pump Station to Base Camp.

The design calculation and drawings of supports shall be submitted by the Contractor for approval.

H.2.8 Guy Wire Assembly

A guy wire assembly shall consist of a steel band with a thimble and preformed grips, a guy insulator with preformed grips, steel guy wire and a screw type anchor with a thimble and a preformed grip as shown on the Drawings for Tender, No. 3-I-020. All items shall be galvanized and the guy wire may be so designed as to withstand the load of the angle effect and conductor tension with a factor of safety of more than 2.5. The design calculation and drawings of guy wires shall be submitted by the Contractor for approval.

H.2.9 Grounding Materials

Grounding rods shall be made of copper clad steel rods and provided with copper lead wires. The lead wire shall be 20 mm^2 in size of 1.5 m in length. The size of rod shall be 16 mm in diameter and 1.8 m in length.

Insulated grounding wire of 20 mm^2 copper wire shall also be supplied to connect the overhead grounding wires and other metal part to the grounding rods.

Grounding wire will also be connected to the lead wire.

H.2.10 Arm, Bands and Others

Galvanized steel arms with arm ties shall be as shown on the Drawings for Tender, No. 3-I-020.

Pole bands for fixing arms, arm ties and pole anchors shall also be supplied. All bands shall be made of galvanized steel as shown on the above mentioned drawings.

H.2.11 Foundations

The setting depth shall be so designed that the overturning load may be supported with a factor of safety of not less than 2.0, but in no case shall be less than 1/6 of total length of the pole.

The properties of soil for design of supports shall be assumed as follows:-

Ultimate soil bearing capacity	:	20 t/m^2
Weight of soil	:	1.8 t/m^3
Angle of inverted pyramid of soil acting against uplift force of stay anchor plate	:	10 degrees from the direction of anchor

Where required, support foundations shall be reinforced with concrete logs or by wrapping concrete around the concrete poles.

The design calculation and drawings for the foundation shall be submitted by the Contractor to the Engineer for approval.

II.3 RECEIVING FACILITIES

II.3.1 General

The substation facilities to receive the power from Pump Station are constructed at the following two sites.

(1) 138 kV switchgear yard.
(2) Base camp site.

Each substation shall consist of the following equipment:-

(1) One (1) set of transformer, 3 phase 13.8 kV/220-127 V, installed on the concrete foundation.
(2) One (1) set of 13.8 kV disconnecting fuse switch and 13.8 kV lightning arresters fitted on the pole.
(3) Terminal pole with fittings and stay guy wires etc.
(4) Connecting conductors and grounding system.
(5) Complete guard fence with accessories.

These substation facilities shall be of outdoor type and shall be surrounded by metal net guard fence with door providing sufficient space for operation, which shall also be provided under this contract.

The single line diagram and arrangement of the equipment of these stations are shown on the Drawings for Tender, No. 3-I-021.

The erection work including land formation and foundation works shall be carried out by the contractor.

II.3.2 Transformers

(1) General

Transformers for the substation facilities shall be of oil immersed, natural cooled, outdoor stationary type with voltage ratio of 13.8 kV to 220-127 V, connected in delta-star.

Quantity and capacity of transformers shall be as follows:-

(a) One (1) set of three phase 50 kVA transformer for 138 kV switchgear yard.
(b) One (1) set of three phase 100 kVA transformer for Base camp site.

(2) Voltage Ratio

All transformers shall have a no-load voltage tap changer for the ratio of F14.5-R13.8-F13.1 kV/220-127 V.

(3) Bushings

All bushings on both 13.8 kV and low tension side shall be of solid type with bolt type clamp.

II.3.3 Particulars of 13.8 kV Apparatus

Particulars of the main component of the 13.8 kV apparatus shall be as given hereunder:-

(1) 13.8 kV Disconnecting Fuse Switch

The disconnecting fuse switch shall be of outdoor, three pole, single throw hook rod operated type with detachable fuse holder and other necessary accessories and ratings shall be as follows:-

Rated voltage	:	15.5 kV
Rated current	:	400 A
Fuse (general purpose)	:	5 A for 138 kV switchgear yard
		10 A for Base camp site

(2) 13.8 kV Lightning Arrester

The lightning arrester shall be of outdoor use, pole mounted type, provided with a clamp type terminal and grounding terminal.

Rating shall be as follows:

Rated voltage	:	15 kV
Rated frequency	:	60 Hz
Nominal discharge current	:	10 kA
Max. discharge voltage (Peak) 10 kA	:	63.4 kV

(3) Other Materials

Regarding conductors, insulators, supports, grounding materials, etc., the specification required for the distribution line shall be applied as far as applicable

The fence and entrance door surrounding the transformer shall be fabricated of steel framing and wire net fence, to the sizes and dimensions as shown on the Drawing No. 3-I-021.

The steel framings and wire net fence are painted with oil paint. The wire net shall be of vinyl coated material. The fence shall be grounded to the any grounding rods. All materials and tools to install the above fence at site shall be provided.

H.4 TEST

Before shipment, the equipment specified in this Subsection shall be tested on the items mentioned below.

H.4.1 Receiving Transformers

The following tests shall be carried out at the manufacturer's shop.

Dimension check
Ratio and polarity
Impedance and load loss test
No load loss test
Measurement of insulation resistance
High voltage test

H.4.2 Switchgears

The 13.8 kV switchgears shall be tested on the following items.

(1) Disconnecting Fuse Switches

High voltage test
Operation test

(2) Lighting Arresters

Measurement of insulation resistance
Power frequency sparkover voltage test
Impulse sparkover voltage test

H.4.3 Spare Parts

The following items shall be furnished and quoted as spares:-

(1) For Receiving Transformers

(a) One lot of necessary spares recommended by the manufacturer

(2) For Switchgears

(a) 15 pcs. of fuse element for disconnecting fuse switches
(b) One lot of necessary spares recommended by the manufacturer

H.4.4 Test at Site

After complete installation at site, the equipment shall be tested on the following items:-

(1) Insulation resistance.
(2) Withstand test voltage test.
(3) Operation test.

H.5 ERECTION

The contractor shall perform the erection work in order to complete the power supply system according to the construction schedule approved by the Employer. The distribution line shall be erected to be in conformity with the appropriate standards.

SUBSECTION - I

138 KV TRANSMISSION LINE

I.1 CONDUCTORS, OVERHEAD EARTHWIRE AND FITTINGS

I.1.1 Conductors and Overhead Earthwire

The power conductors shall be Aluminium Conductor Steel Reinforced (ACSR) "ORIOLE" and shall comply with ASTM B232-92, except where otherwise specified or approved.

The overhead earthwire shall be Galvanized Steel Wire Strands (GSW) and shall comply with JIS G-3537 Grade 90 kg/mm^2, Except where otherwise specified or approved.

The outmost layer of the conductors and earthwire shall be right-handed (Z-lay).

The aluminium shall be of the highest purity commercially obtainable, which shall not be less than 99.5 percent. The technical particulars of the conductors and earthwire shall be summarized below.

(1) Conductor

Particulars				ACSR ORIOLE
Nominal Section (mm^2)			:	170
Calculated Section	:	Aluminium (mm^2)	:	170.5
	:	Steel (mm^2)	:	39.8
Conductor Stranding (Al + Steel in nos/mm)			:	30/2.69 + 7/2.69
Outside Diameter (mm)			:	18.83
Unit Weight of Conductor (kg/km)			:	737.0 approximatery
Ultimate Tensile Strength (kg)			:	7.590
DC Resistance at 20°C (ohm/km)			:	0.1579 or less
Approximate current Carrying Capacity (A)			:	490.0

(2) Earthwire

Particulars		Galvanized Steel Stranded Wire
Nominal Section (mm^2)	:	55
Stranding (nos/mm	:	7/3.2
Calculated Section (mm^2)	:	56.29
Outside Diameter (mm)	:	9.60
Unit Weight of Conductor (kg/m)	:	0.446
Ultimate Tensile Strength (kg)	:	4.660

The conductors and earthwire shall be supplied on impregnated drums of approved materials constructed so as to enable the conductors and earthwire to run smoothly, and those as spare materials shall be supplied on steel drums of approved materials for storage for long duration.

Length of conductors and earthwire on one drum shall preferably be more than 2,000 meters but not less than 2,000 meters.

I.1.2 Joints and Repair Sleeves

Tension joints of the conductors and earthwire shall be of compression type and shall be free from slipping off, damage to or failure of the complete conductors, earthwire or any parts thereof at load less than 95 percent of the ultimate breaking strength of the conductors and earthwire.

Electrical conductivity and current carrying capacity of the tension joints for the power conductors shall not be less than those of equivalent length of the conductors.

The cut ends of steel wires and steel component inside the joint shall be protected from the weather in an effective and permanent manner.

Aluminium sleeves shall have plug holes for injecting filling compound.

All tension joints shall be supplied with aluminium fool-proof gauges or anti-displacement pins for correct positioning, adequate quantity of filling compound in injectors, and aluminium collars for gap filling.

Full details of the joints, including an illustration of practices for filling the air gap between sleeves, method of correct positioning of steel sleeves, gauges for ascertaining the compressed size, etc. shall be submitted with the Tender.

Repair sleeves for the power conductors shall be of compression type and the conditions stated above for the tension joints shall apply to the repair sleeves where applicable.

I.1.3 Vibration Dampers

Vibration dampers shall be of Stockbridge type for both of conductors and earthwire. The dampers shall be designed to be attached to the conductors and earthwire in a manner which will prevent damage thereto and free drop of the weight in service. Clamping bolts shall be provided with domed self-locking nuts designed to prevent corrosion to the thread.

The nominal weight of damper shall be 10 pounds (4.5 kg) for the conductors and 4 pounds (1.81 kg) for the earthwire.

I.1.4 Armour Rods

Preformed armour rods shall be applied to all suspension points of the power conductors except jumper suspension points.

I.1.5 Corona and Radio Interference

The design of all line conductor fittings, vibration dampers, etc., shall avoid sharp corner or projections which would produce high electrical stress in normal working. The design of adjacent metal parts and matching surfaces shall be such as to maintain good electrical contact under service conditions. Particular care shall be taken during manufacture of conductors and fittings sand during subsequent handling to ensure smooth surfaces free from abrasion.

I.1.6 Inspection and Test

The following tests shall be carried out at the manufacturer's work. Unless otherwise specified in this Contract, selection of test samples, number of specimen and acceptance of the results shall be in accordance with the terms of the relevant IEC 209 or as instructed by the Engineer for the conductor and earthwire.

Where no applicable terms, the Engineer is to instruct details in advance of the inspections and tests in response to request of the Contractor.

(1) Conductor :

(a) Aluminium wire

i) Outside view and construction

ii) Tensile strength, elongation and twist

iii) Resistivity

(b) Steel wire

i) Outside view and construction
ii) Tensile strength, elongation and twist
iii) Galvanizing (quantity and wrapping)

(c) Stranded conductor

i) Outside view and construction
ii) Resistivity
iii) Tensile strength
iv) Weight

(2) Overhead earthwire:

(a) Steel wire

i) Outside view and construction
ii) Tensile strength, elongation and twist
iii) Galvanizing (quantity and wrapping)

(b) Stranded earthwire

i) Outside view and construction
ii) Tensile strength
iii) Weight

(3) Joints:

(a) Conductor joint

i) Outside view and construction
ii) Compression and tensile strength
iii) Electrical resistance
iv) Galvanizing (quantity of zinc on steel sleeve)

(b) Earthwire joint

i) Outside view and construction
ii) Tensile strength
iii) Galvanizing (quantity of zinc)

(4) Repair sleeve:

i) Outside view and construction
ii) Electrical resistance

(5) Vibration dampers:

i) Outside view and construction
ii) Weight of dampers
iii) Galvanizing (quantity of zinc)

(6) Armour rods :

i) Outside view and construction
ii) Tensile strength
iii) Assembly on the conductor

I.2 INSULATORS AND FITTINGS

I.2.1 Insulators

Suspension and tension insulator sets shall consist of the porcelain (preferable) or toughened glass insulator units of the cap and pin type with ball and socket clevis couplings and shall comply with IEC 305 in all respect.

The colour of the insulator units shall be brown and glazed surface shall be free from bulges, hair line cracks and other defects. The glaze shall be uniform throughout the surface.

The dimension of insulator unit shall be 254 mm in diameter and 146 mm in spacing. The dimension of ball and socket shall comply with the IEC Recommendation, Publication 120, 16 mm ball and socket.

Electrical and mechanical characteristics of each unit shall be as under-mentioned.

(a)	Withstand voltage :	
	i) Power frequency, Dry	70 kV
	ii) Power frequency, Wet	40 kV
	iii) Impulse, 1.2 x 50 micro-sec.	110 kV
(b)	Puncture voltage	110 kV
(c)	Combined mechanical & electrical strength	12,000 kg

Retaining pins shall be of stainless steel or phosphor bronze and so made and shaped that when set and under any condition of handling and service nothing but extreme deformation

of the retaining pin shall allow separation of insulator units or fittings or shall cause any risk of the retaining pins being displaced. The design shall be such as to allow easy removal for replacing of insulator units or fittings.

I.2.2 Insulator Sets

Suspension and tension insulator sets shall consist of single string of insulator units as mentioned below:

	No. of string	No. of discs
Suspension insulator set	1	9
Tension insulator set	1	10
Jumper insulator set	1	9

The composition of the above insulator sets are shown on the drawing No. 3-I-026.

All insulator sets shall have the following electrical and mechanical characteristics when assembled with the specified insulator units and arcing horns:

(a) Electrical characteristics (except jumper suspension set)

Power frequency withstand voltage (wet)	:	300 kV for suspension set
		330 kV for tension set
Impulse, 1.2 x 50 μ-sec. (wet)	:	530 kV for suspension set
		575 kV for tension set

(b) Mechanical characteristics (except clamp)

Minimum breaking strength

- Suspension set	7,000 kg
- Tension set	7,000 kg

The insulator sets shall be designed so as to withstand a long service in an area subject to intense lightning storms.

The manufacturer shall guarantee characteristics of insulator strings to be proposed in the Technical Particulars of Schedule VII of Volume II.

I.2.3 Fittings

All fittings to make each insulator set complete for beneficiary use shall be supplied and included in the rate for each insulator set. Such bolts, nuts, washers, cotter pins, and

retaining pins with necessary spares as may be necessary for the use of erection shall be deemed to be included in the appropriate items.

All ferrous fittings shall be made of steel, ductile iron or malleable iron hot dip galvanized, and shall have sufficient strength for abrasion and weariness produced by repeated vibration. Cotter pins shall be made of non-ferrous metal or stainless steel and designed as the self-locking type.

Fittings for the tension insulator sets shall be so designed as to apply to inverted tension insulator sets according to replacement of tension clamps and anchor shackles in reverse.

(1) Suspension clamps for conductors

Suspension clamps of trunnion type shall be as light as possible and shall be of aluminium alloy, and shall be designed to avoid any possibility of deforming the stranded conductors and of separating the individual strands, and shall be free to pivot in the vertical plane containing the conductor.

Suspension clamps except jumper suspension sets shall have a suitable dimension for clamping the conductor with preformed armour rods and shall not permit the complete conductor with armour rods to slip at load less than 2,400 kg for ACSR ORIOLE. Particular attention shall be paid to the elimination of corona emission from all parts of the clamps.

(2) Tension clamps for conductors

Tension clamps shall be of compression type and each clamps shall consist of a galvanized steel sleeve with clevis or eye end, an aluminium deadend body and an aluminium jumper socket of the compression type with bolted connection between the jumper socket and the deadend body.

The conditions stated in Clause I.1.2 (Joints and Repair Sleeves) for the tension joints of conductors shall apply to the tension clamps where applicable.

(3) Arcing horns

Arcing horns shall be fitted at both the line and earth end of the insulator sets except the jumper insulator sets. The design of lift and shape of the arcing horns are to be such as to obviate damage to clamps and conductors and to prevent flashover cascading over the insulator units.

The arcing horns shall be fitted to the attachment fittings with two or more bolts or with carriage bolts or other approved means.

I.2.4 Overhead Earthwire Sets

(1) Earth wire suspension sets

An earthwire suspension set shall consist of a suspension clamp, fittings and a bonding wire and to be hung on the top of towers. The suspension clamps of free-center type shall be made of galvanized malleable iron, ductile iron or drop-forged steel, and shall not permit the earthwire to slip at a load less than 1,750 kg for GSW 55 mm^2. The conditions stated in Clause I.2.3 (Fittings) (1) for suspension clamps of conductors shall also be applied to the suspension clamps for the earthwire.

The bonding wires shall be copper stranded wires and shall be designed to ground the suspension clamps to the tower steel works.

(2) Earthwire tension set

An earthwire tension set shall consist of two tension clamps and a jumper clamp as shown on the Drawings for Tender, No. 3-I-026. The tension clamps shall be attached to the tension plate on the tower by means of shackles, and the jumper clamp shall be fixed on the top of towers.

The tension clamps shall be of bolted type suitable for GSW 55 mm^2 and shall be made of galvanized malleable iron, ductile iron or drop-forged steel. The jumper clamp shall be so designed that one (1) number of jumper earthwires can be securely bonded to the tower.

Each earthwire tension clamp to be fitted to substation structure shall consist of a tension clamp and an insulator disc as shown on the Drawings for Tender, No. 3-I-026.

The minimum breaking strength of the earthwire tension set shall be not less than 95% of the ultimate breaking strength of the earthwire and its minimum slipping load shall be not less than 50% of the ultimate breaking strength of the earthwire.

I.2.5 Extension Rod

Extension rods shall be furnished in case that enough clearance can not be obtained between the arcing horn and the tower cross-arm members in horizontal plane. Use of the extension rods shall not be allowed for the tower type SS.

I.2.6 Interchangeability of Fittings

In spite of the specified mechanical strength in Clause I.2.2 (Insulator Sets), all similar fittings such as shackles, ball-eyes, ball-clevises, socket-clevises, etc. shall be interchangeable for suspension, jumper and tension insulator sets as far as practicable.

I.2.7 Inspection and Test

Unless otherwise specified in this Contract, selection of test samples, numbers of specimen and acceptance of the results shall be in accordance with the terms of the relevant standard where applicable.

(1) Tests of Insulators

The rules of IEC publications 383 (1976) shall be applied for the tests of insulators. The test results shall comply with the requirement of Clause I.2.1 (Insulators)

(a) Type test

The Tenderer shall include with their offers the test certificates including thermal mechanical performance carried out in accordance with IEC publication 575 which are issued by an approved internationally acknowledged reputable independent testing laboratory. This means that the laboratory can prove that it has performed testing services for known insulator manufacturer from all over the world and this laboratory shall be outside the country of manufacturer.

The Engineer may call for type tests to be carried out at the Manufacturer's works. Such tests would be conducted to random samples at the discretion of the Engineer and failure to meet the conditions of test could result in the rejection of the complete batch insulators.

When such tests are called for they will comprise the following:

i) Impulse withstand voltage test.
ii) One minute dry power frequency withstand voltage test.
iii) Wet power frequency withstand voltage test.

(b) Sample test

The insulators for the sample test shall be selected at random from the batch. The number of test pieces shall be p, or the nearest whole number greater than p given by the following formulae:

$p : 4$, when $n < 500$

$p = 4 + 1.5n/1{,}000$, when $500 \pounds n < 20{,}000$

$p = 19 + 0.75\ n/1{,}000$, when $n > 20{,}000$

Where, n = the number of insulators in the batch.

After having passed the routine tests described in (c) hereunder, the test pieces of insulators shall be subject to the following tests:

i) Verification of dimensions
ii) Temperature cycle test
iii) Puncture test
iv) Porosity test
v) Galvanizing test
(Verification of the mass of zinc per unit surface)

Re-test Procedure:
In only one insulator or metal part fails to comply with any of the sample tests, a new quantity equal to twice the quantity originally submitted to that test shall be subject to re-testing.

If two or more insulator or metal parts fail to comply with any of the sample tests, or if any failure occurs on insulators or metal parts subject to re-testing, the complete batch will be considered as not complying with the specifications and will be rejected.

(c) Routine test:
i) Visual examination
ii) Mechanical routine test
iii) Electrical routine test
iv) Thermal shock routine test (for toughened glass parts only)

These tests shall be carried out at the manufacturer's factory.

(2) Factory test

The following tests shall be carried out at Manufacturer's factory before shipment.

(a) Insulator sets:
i) Assembly
ii) Mechanical loading and breaking test
iii) Withstand voltage (Power frequency and impulse)
iv) 50% impulse flashover voltage (Positive and negative)

(b) suspension clamps:
i) Outside view and construction
ii) Slipping load
iii) Ultimate breaking strength
iv) Galvanizing (quantity of zinc)

(c) Tension clamps:

i) Outside view and construction
ii) Electrical resistance measurement
iii) Tensile strength
iv) Galvanizing (quantity of zinc)

(d) Other fittings:

i) Outside view and construction
ii) Load test
iii) Galvanizing (quantity of zinc)

I.3 TOWERS

I.3.1 General

All towers shall be of self-supporting broad base latticed steel construction.

The towers shall be designed so as to be suitable for supporting single circuit of ACSR ORIOLE conductors in vertical formation and a GSW 55 mm^2 earthwire as shown on the Drawings for Tender, No. 3-I-025.

Towers shall be provided with body extensions from minus 3 to plus 9 meters in 3 meters interval. In addition to body extensions, each type of towers shall be designed with hillside extensions of plus 1, 2 and 3 meters.

I.3.2 Type of Towers

The standard types of tower shall be as follows:

(a) Type-SS : Use at tangential positions or angle points up to 2 degrees of horizontal deviation, provided with suspension type insulator sets.

(b) Type-LA : Use at positions of light angle up to 15 degrees of horizontal angle deviation with tension type insulator sets.

(c) Type-MA : Use at positions of medium angle up to 30 degrees of horizontal angle deviation with tension insulator sets.

(d) Type-HA : Use at positions of heavy angle up to 45 degrees of horizontal angle deviation with tension type insulator sets.

(e) Type-TA : Use at positions of line termination or 60 degrees of horizontal angle deviation with tension type insulator sets.

In case a special type of tower is required, the tower shall be designed by the Contractor according to the instruction of the Engineer. The cost of the special tower including design charge shall be adjusted by rate of additional steel works, in the Price Schedule.

I.3.3 Design Criteria

The towers shall be designed for the following wind and weight spans.

Type of tower	SS	LA	MA	HA	TA
Wind span (m)					
- normal working condition	500	500	450	450	450
- broken wire condition	400	400	350	350	350
Weight span (m)					
- normal working condition	700	1.000	800	600	600
- broken wire condition	400	700	700	350	350
- uplift weight for cross-arms	300	800	300	300	300

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 conductor or earthwire weight supported at any one tower at minimum temperature in still air.

Spans for the broken wire condition shall be applied only for a conductor or an earth wire considered broken. Intact conductors or earthwire shall be loaded with Normal working condition.

The height of bottom conductor cross arm shall be determined in the following way:

$$H = Gc + Sg + Li + 2Hc + Hg$$

where, H = total height of tower
Gc = necessary ground clearance of power conductors above ground or other objectives
Sg = maximum conductor sag
Li = length of a suspension insulator set, but nil for a tension type towers
Hc = vertical spacing of upper and lower conductor cross-arm spacing
Hg = vertical spacing between upper conductor cross-arm and overhead earthwire

For all the towers the clearance of the conductors, arcing horns, jumper loops and all live metals to the tower steel work shall not be less than those specified hereunder, under still air conditions and at assumed swing of the insulator sets and jumper loops.

(a)	Minimum clearance in still air and at 20 degrees transverse swing of insulator sets and jumper loops	1,300 mm for suspension set 1,400 mm for jumper loops
(b)	Minimum clearance at 40 degrees transverse swing of jumper loops	900 mm
(c)	Minimum clearance at 60 degrees transverse swing of jumper loops	350 mm
(d)	Jumper loop droops to be assumed	1,700 mm

I.3.4 Normal Working Loads

(1) The following loads shall be taken into consideration in calculation of stresses on the members:

(a) Vertical loadings

The weight of the insulators and all other fittings, tower members and the actual dead weight of specified length of conductors and earthwire.

(b) Transverse loadings

Wind pressure at right angle to the line on the whole projected area of the conductors and earthwire, tower members, insulators and all other fittings, and the transverse horizontal component of maximum conductor and earthwire tensions due to horizontal angle deviation of the line.

(c) Section loadings

Type MA towers will also be used as section towers under the conditions of no angle deviation but unbalanced longitudinal loading of 25 percent of maximum working tensions of conductors and earthwire shall be considered.

(d) Eccentric loadings caused by unbalanced arrangement of conductors shall be considered for towers.

(e) Tower erection loading

Adequate margins of strength for unbalanced erection loadings shall be considered in designs. Tenderer shall indicate the points on the supports on

Tender drawings to which he proposes to use tower back-stays when stringing conductors.

(f) Terminal tower

Type TA tower will be used as terminal tower and the following criteria shall also be applied:

f-1) The angle between the main cross-arm and the center line of the transmission line up to 60 degrees.

f-2) Unbalanced longitudinal loading to be 100 percent of the maximum working tension of the conductors and earthwire.

f-3) Maximum tension of the conductors for the slack span to be 500 kg.

f-4) Maximum tension of the earthwire for the slack span to be 300 kg.

f-5) Numbers of earthwire in the slack span to be two (2).

(2) Wind loads are as follows:

(a) On conductor and earthwire : 39 kg/m^2 on projected area

(b) On steel tower : 80 kg/m^2 on the exposed area of front face only

(c) On insulator set : 50 kg/m^2 on projected area

(3) Maximum working tensions of the conductor and earthwire will be as follows:

(a) Conductor : 2,400 kg
(b) Earthwire : 1,750 kg

Those tensions shall be confirmed or amended by the Tenderer in accordance with the requirement mentioned in Clause I.5.9 (Sags of Power Conductor and Overhead Earthwire).

I.3.5 Loading Under Broken Wire Condition

Under the broken wire condition, any one conductor or an earthwire is assumed to be broken for both suspension type and tension type towers in addition to loadings specified in the above Clause I.3.4 (Normal Working Loading).

In case of power conductor or overhead earthwire breakage, the tension on the suspension type tower is assumed to be reduced to 70 percent of the specified maximum working tension. This reduction shall not be assumed for the tension type towers.

I.3.6 Design of Towers

Each type of towers shall be designed so that no failure or permanent distortion shall occur when tested with applied force equivalent to 2.0 times the maximum simultaneous working loadings specified in the Clause I.3.4 (Normal Working Loading) and also equivalent to 1.25 times (1.5 times for crossarms) the maximum simultaneous working loadings resulting from the assumed broken wire condition specified in Clause I.3.5 (Loading Under Broken Wire Condition). Design calculations and stress tables for towers shall be submitted for Approval of the Engineer as required in Clause GS.2.1 (f)(Schedule for Submission of Drawings) of General Specification.

The ultimate design stress, obtained from the working stress multiplied by the factor of safety of 2.0 under the normal condition and 1.25 under the broken wire condition, in tension members shall not exceed the yield point of materials. The ultimate design stress, obtained from the working stress multiplied by the above mentioned factor of safety, in compression members shall not exceed a figure obtained from an approved formula to be entered in Tender based on the yield point of materials.

No member of a tower shall be less than 3 mm in thickness and 40 mm in width of flange for leg members of towers and main members of the cross-arm, and 3 mm and 45 mm for the web and nominal members respectively.

The slenderness ratio shall not exceed 150 for the leg and arm members, 200 for the web members and 250 for the nominal members as compression member and 350 for all as tension member.

I.3.7 Materials and Fabrication

The towers shall be fabricated with mild and/or high tensile steel of the finest quality or other approved materials, of which mechanical properties shall comply with Grade Fe 430 and Fe 510 specified in ISO 630-1980 or equivalent.

All the connection shall be made by mild and/or high tensile steel bolts and nuts. No bolt shall be less than 12 mm in diameter. All bolts and nuts shall be provided with approved spring washers.

Bolt holes shall not be more than 1.5 mm larger in diameter than the corresponding diameter of bolts. Holes shall be drilled for the members not less than 13 mm in thickness. For the members having thickness below 13 mm, holes may be drilled or punched, but the former is preferred.

All burrs shall be removed completely by reaming and smoothing before galvanizing.

I.3.8 Rectangular and Auxiliary Cross Arm

The type HA and TA towers may be provided with rectangular arms where horizontal angle exceeds 45 degree.

The prices of the rectangular arm set shall be included in the prices for the towers.

I.3.9 Hillside Extension

The towers situated at undulated area may have hillside extension of plus 1, 2 or 3 meters according to the site configuration. Every type of towers shall be designed to be provided with such hillside extension.

Cost of such hillside extension shall be adjusted by the rate of additional steel work, quoted in the price schedule. For making adjustment of cost, detailed calculation of additional steel work due to such hillside extension shall be submitted to the Engineer for approval and to the Employer simultaneously.

In addition to the abovementioned requirement, detailed calculation of additional steel work for each shipment shall be submitted together with application for delivery to the Engineer.

I.3.10 Foundation Stubs

Length and size of the foundation stubs shall be proposed by the Tenderer based on his foundation design.

Consideration shall be preferably given so that same foundation stubs are to be applicable various type of concrete foundation by adjusting stub length. Bolt holes for cleats shall be provided on the stubs of each type of foundation. All cleats shall have a bolt hole for fixing a grounding rod.

I.3.11 Setting Templates

Setting templates for each type of tower will be required for setting foundation stubs in correct positions.

I.3.12 Attachments for Insulator Sets and Overhead Earthwire Fittings

Towers shall be provided with fixing steel plates with necessary bolt holes for the suspension and tension insulator sets of the conductors and tension sets and suspension

clamps of the earthwire. Tension plates shall be bent downward or upward, where required.

Bent angles of tension plates shall be obtained from the Profile and Plan of the transmission line.

I.3.13 Anti-climbing Devices and Climbing Steps

Each tower shall be fitted with an approved anti-climbing device with a gate as indicated on the Drawings for Tender, No. 3-I-027. The height of the anti-climbing device shall be between 3 m and 4.5 m above the ground. Where hillside extensions are applied, the height shall be measured from the highest ground. Gates should be secured with bolts and nuts of stainless steel.

Each tower shall be provided with step-bolts on diagonal legs.

Step-bolts shall start from 2 meters above the ground and continue to the top of the tower at a step interval not more than 450 mm.

The prices of step bolts shall be deemed to be included in the price for the towers.

I.3.14 Danger and Number Plates

A danger plate and a number plate shall be provided with each tower.

The details of these plates are shown on the Drawings for Tender, No. 3-I-027.

All plates shall be of aluminium or aluminium alloy. On all plates the colour shall be permanent and free from fading.

I.3.15 Tower Grounding Materials

Grounding angles and counterpoise wires to ground the tower shall be supplied.

A set of grounding angles shall consist of 4 pieces of galvanized steel angle having a cross section of 50 mm x 50 mm x 4 mm and a length of 1,000 mm, each provided with a lead wire made of an annealed copper wire strand of 22 mm^2 connected to the angle, complete with a copper terminal on both ends and bolts and nuts of 12 mm in diameter. The details of the grounding angle set are shown on the Drawings for Tender, No. 3-I-027.

A set of counterpoise wire shall comprise two 50 meters length of galvanized iron wire strand of 38 mm^2, complete with compressed terminal at both ends of the wire and bolts and nuts of 12 mm in diameter.

Holes of 14 mm in diameter for connecting grounding angle and counterpoise wire shall be provided on each leg and cleat member of the towers.

I.3.16 Foundations

(A) General

Concrete pad and chimney type foundations will be applied to most of the towers. The design of the concrete foundations of the towers shall be performed based on the requirements and assumptions set out below, and the details of the design and drawings for each type of foundations shall be submitted with the Tender.

Such design of foundations for the towers are subject to modifications to suit the site conditions as indicated in writing by the Engineer during execution of the Contract without any price adjustment of the items of the foundation stubs.

(B) Concrete Block Foundation

The types of the concrete foundations and natures of earth to be considered shall be as follows.

Type of concrete foundation		L	M	H
Assumed natures of earth ultimate bearing capacity:				
- Vertical	(t/m^2)	60	40	20
- Lateral	(t/m^2)	30	20	10
Mass	(kg/m^3)	1,600	1,500	1,400
Angle of frustum	(degree)	30	20	10

Concrete may be reinforced with steel bars. Deformed steel bars are preferable for the reinforcement.

The abbreviations L, M and H of the concrete foundation types shall mean as follows:

L : Light concrete foundation
M : Medium concrete foundation
H : Heavy concrete foundation

The angle of frustum of earth shall mean the angle to vertical of earth frustum to resist the uplift force.

Natures of concrete to be considered shall be as follows:

Assumed natures of concrete		
Allowable strength:		
- Compressive	(kg/cm^2)	60.0
- Tensile	(kg/cm^2)	6.0
- Shearing	(kg/cm^2)	6.0
Mass:		
- Concrete without reinforcement	(kg/m^3)	2,300
- Concrete with reinforcement	(kg/m^3)	2,400
Allowable adhesive strength on:		
- Galvanized steel action	(kg/cm^2)	3.6
- Round reinforcing bars	(kg/cm^2)	7.2
- Deformed reinforcing bars	(kg/cm^2)	12.0

Each type of foundations shall be designed based on the following formulas:

(1) Against compression load

$$q/F \geq (C + G + Ws)/A$$

Where, q : Ultimate bearing capacity of earth (t/m^2)
F : Factor of safety
C : Compressive load (t)
G : Weight of concrete (t)
Ws : Weight of earth above foundation pad (t)
A : Area of foundation pad (m^2)

(2) Against uplift load

$$G + Ws'/F \geq T$$

Where, T : Uplift load (t)
Ws' : Weight of earth in frustum (t)

(3) Against lateral load

$$(q' \times A')/F \geq Q$$

Where, Q : Horizontal load (t)
q' : Yield lateral bearing capacity of earth (t/m^2)
A' : Projected area of foundation chimney and pad (m^2)

The factor of safety shall not be less than 2.5 under the normal working conditions and 1.5 under the broken wire conditions.

The upper surfaces of the foundation pads unless reinforced shall be either sloped within 45 degrees to the horizontal or flattened providing the difference of a width between the pad and chimney shall be not more than twice a thickness of the pad. The minimum thickness of the edges of base bad shall be not less than 300 mm.

The frustum shall be assumed to start from the top edges of the pad. Where frustums overlap each other, allowance shall be made for loss of uplift resistance.

Concrete shall cover any part of the steelwork at least 100 mm and shall extend above the ground for the minimum height of 250 mm. The upper surface of chimney shall be sloped to ensure drainage water.

The cleats shall be attached at the base of each stub to assist in transfer of leg load to the foundation pad as shown on the Drawings for Tender, No. 3-I-027. Minimum portion of stub loads in the design of cleats shall be assumed at 50 percent.

(C) Special Foundation

Besides the abovementioned concrete foundations, such special foundations as raft type foundation, piled foundation or others may be required. Final type of foundation to be applied for each tower shall be determined in accordance with results of soil investigation performed by the Contractor during execution of the Contract.

For the purpose of tendering, basic designs shall be submitted with the tender under the following assumptions, and prices for the special foundations shall be quoted based on the design.

(1) Raft type foundation

The foundation shall be designed under ultimate bearing capacity to be 10 ton/m^2, weight of soil to be 1.4 t/cu.m and no angle of frustum of soil. Weights of reinforced concrete and soil shall be taken as entirely submerged.

Other design conditions specified in this subsection will be applied.

(2) Piled foundation

Piles used for the foundation shall be either precasted concrete pile or in-situ concrete pile.

i) Pile data

Pile diameter	300 mm
Pile depth below ground level	12 m
Ratio of ultimate bearing/uplift capacity of pile	2.5 : 1

ii) Uplift

The mass density of concrete below ground level shall be assumed as 1,600 kg/m^3 to allow for hydrostatic effects and similarly soil as 960 kg/m^3. Additional weight of concrete shall be included as necessary to provide the specified resistance to uprooting under any condition. Where bored or driven piles are proposed having no specially made bulb or enlarged concrete foot to provide having positive uplift resistance but relying on skin friction alone, at least 75% of the net working uplift force, and 50% of the net broken wire uplift force shall be provided in dead weight of concrete, whichever is the greater. The cost of such concrete shall be included in the piled foundation rate.

iii) Compression

Mass density of concrete shall be assumed as 2,300 kg/m^3 on their technical acceptability and cast.

Contractors must justify assumptions of equal performance of their piling system with that proposed. No extra payment shall be made for access tracks necessary for heavy piling rigs.

Piles shall be embedded in a reinforced concrete cap of adequate dimensions and the caps tied with nominal reinforced concrete beams of a minimum size of 460 mm deep by 300 mm wide with at least eight 19 mm diameter main reinforcing bars per beams.

Piling shall be carried out using an approved procedure throughout. The actual length and numbers of piles required at any given location shall be approved by the Engineer on the basis of the final agreed design data.

(D) Other Foundations

Where special ground conditions exist which do not allow for any of the above designs in an original or modified, special types of foundations may be employed. They will be paid for on basis of schedule variation rates for concrete, steel and excavations applying throughout, irrespective of special conditions.

Foundation prices shall cover for all costs not covered by special scheduled rates where admissible including the provision of access tracks and standings for piling equipment or building of bund for the Contractor's convenience in paddy fields or other flooded areas.

I.3.17 Inspection and Test

The following tests shall be carried out at the manufacturer's work. Unless otherwise specified in this Contract, selection of test samples, number of specimen and acceptance of the results shall be in accordance with the terms of the relevant IEC, ISO and other standards approved or instructed by the Engineer.

Where no applicable terms in the above standards, the Engineer is to instruct details in advance of the inspections and tests in response to request of the contractor.

(1) Material test

Pulling, bending and galvanizing of specimen taken from angle steel materials for towers, and pulling and galvanizing of bolts and counterpoise wires shall be carried out for each shipment and in accordance with ISO or equivalent.

(2) Assembly test

One of each type of tower shall be assembled before galvanizing and the following shall be checked:

Major dimension of structure
Size of member
Number and size of bolts

(3) Loading test

The tower or towers selected by the Engineer shall be subject to the loading test being assembled vertically on a rigid foundation at the manufacturer's work. The tower shall then be loaded in accordance with IEC 652 to prove compliance with the factor of safety stated in clause I.3.6 (Design of Towers) and maintained for five minutes without showing signs of failure or permanent distortion in any part.

When the loading test would not be completed by the faults of the manufacturer, the test shall be repeated after necessary improvements at the Contractor's expense.

The tower which has completed the loading test satisfactorily shall be carefully inspected after dismantling to ensure that no part has been damaged. Such tower members shall be marked in an approved manner and bundled separate from normal tower members for shipment.

The rate for the tower load test quoted in the Price Schedule shall include all necessary costs to perform the tests, but shall not include cost for tower materials. The expenses for assembling and disassembling of the test tower for load tests is deemed to be included in the cost for the tower load tests.

I.4 TOOLS, APPLIANCE AND MATERIALS FOR MAINTENANCE USE

I.4.1 General

The tools and appliance for maintenance use specified hereunder shall be adequate for the line specified in this Contract and comply with the under-mentioned requirements. The Contractor shall supply additional tools as may be required by the Engineer, at agreed rates.

The tools, appliance and materials specified hereunder shall be clearly marked with their size and/or item and shall be packed in appropriate boxes with three copies of operation and maintenance instructions.

I.4.2 Tower Erection Tools

(1) Grounding Resistance Tester

The Tester shall be used to measure the AC grounding resistance of towers and other structures. The tester shall be handy and dry-cells operated covering the range of 0 to 1,000 ohms in three operating ranges and shall be provided with a carrying case and necessary accessories such as a pair of test electrodes and test leads for each tester.

(2) Torque Wrench

Torque wrenches shall be of a spring lever type with an indicator and shall be capable to measure the torque mentioned below. Each wrench shall be provided with a set of two sockets adequate for bolts specified below.

Torque	2,800	4,200
Maximum torque	2,800 kg-cm	4,200 kg-cm
Minimum scale	50 kg-cm	100 kg-cm
Bolt sizes for socket	16 & 20 mm	22 & 24 mm

I.4.3 Stringing Tools and Appliance

(1) Steel Wire Rope

The steel wire rope shall be so constructed as to be suitable for paying out of the conductors and earthwire. The rope shall be composed of the galvanized steel wires and hemp wires and shall be with the right-hand (Z) regular lay.

The nominal diameter and ultimate breaking tensile strength of the rope shall be 14 mm and more than 9,000 kg. Steel wire rope shall be packed in coils containing 200 m each.

(2) Wire Clips
The wire clip shall be of bolt type and suitable for connecting the steel wire ropes of 14 mm diameter.

(3) Wire Connector
The wire connector shall be of shackle type and suitable for connecting the steel wire rope of 14 mm diameter.

(4) Stringing Clamp Set
The stringing clamps shall be suitable to joint a conductor or earthwire to stringing yoke during paying out of conductors and earthwire. Clamps shall be a braid type for conductors and wedge type for earth wire and so designed that no slipping off shall occur at the load less than twice the maximum working tension of the conductors and earthwire mentioned in Clause I.3.4 (Normal Working Loads).

	Allowable Tensile Strength
Braid type of ACSR ORIOLE	4.0 ton
Wedge type for GSW 55 mm2	3.0 ton

Five spare wedges and a device for driving and extracting out wedge shall be supplied for each wedge type clamp.

(5) Come-along Clamps
The come-along clamp shall be of a wedge type and so designed that no slipping off or damage to the conductors and earth wire shall occur at the load less than twice the maximum working tension of conductor and earthwire mentioned in Clause I.3.4 (Normal Working Loads).

One set of the wedge of conductors and earthwire shall be supplied for each come-along.

Each wedge shall be clearly marked with die for suitable size of conductors and earthwire.

(6) Turnbuckles
Turnbuckles shall be of the hook type and shall be composed of a pair of hooks and a body with a reversible ratchet handle. Hooks shall be made of a forged steel.

The allowable pulling capacity and adjustable stroke shall be as follows:

3.5 ton rating	:	1.8 ton	924 mm to 1,530 mm
7.0 ton rating	:	3.2 ton	1,120 mm to 1,872 mm

(7) Hanging Hook

The hanging hook shall be suitable to hold a conductor or earthwire when shifting them from a pulley to a suspension clamp. The hook shall be so designed that no damages to the conductor or earthwire shall occur.

(8) Conductor Grounding Devices

The following two types of grounding device shall be supplied.

(a) Roller type

The roller type devices shall be suitable to ground the running wire rope and conductors during the erection work, two type of the devices, one is to ground the wire ropes and conductors at the pulling side of stringing pulley and the other between the first tower and stringing tensioner, shall be supplied. The device shall be provided with rollers suitable for wire ropes and ACSR ORIOLE, grounding lead wire, grounding terminal clamps and other necessary accessories.

(b) Rod type

The rod type device are used for maintenance or repairing works of the line. Each set of device shall consist of an insulation rod, an insulated grounding wire, clamps, etc. and shall be applicable to ACSR ORIOLE.

(9) Insulation resistance tester

Insulation resistance testers shall be of all transistor type and the rated voltage shall be 1,000 V.

(10) Linemen's Hand Tools

Linemen's hand tools shall consist of the following:

(a) Safety belt set

Safety belt set shall consist of a free size belt and an adjustable safety rope with a fixing clip.

(b) Tool belt sets

Tool belt set shall consist of a belt, a leather sack for the following electrician's tools and a canvas sack.

(c) Electrician's tools

Adjustable angle wrench	:	The suitable bolt sizes be between 6 mm and 16 mm in diameter.
Double offset wrench set	:	The suitable bolt sizes shall be conformable with all bolts employed in this Contract.
Side cutting plier	:	Insulated type of 175 mm in length
Screw driver	:	Through-out type of 8 mm in with and 1 mm in thickness of a blade size.

I.5 ERECTION

I.5.1 Access to Site

The Employer will provide the following facilities free charge to the Contractor:

(a) Such right of access along the line route as the Engineer agrees is necessary to enable the Contractor to proceed with setting out, check survey of the line and the investigation of foundation conditions.

(b) The right of construction and use of a reasonable width of track along the line route for the transport of tools and materials and carrying out of erection operations, except where the route crosses buildings, sugar cane plantations, paddy fields, orchards, gardens or any other ground over which the Engineer decides that such a track is not reasonably practicable.

Provision of the above-mentioned facilities is subject to official procedures and is depend on check survey progress. The Employer does not bind himself to provide the facilities in such a manner as would enable the Contractor to work continuously from one end of the line to the other end (though efforts will be made to do so wherever feasible.) and the Contractor shall make appropriate allowance in his programme.

The Contractor shall at an early stage of the Contract examine the line route and prepare access maps showing his proposed entry route to all parts of the line and the type of plant or transport intended to traverse the route. The maps shall indicate the places where it is proposed to use existing roads or construct new tracks. New tracks shall be located as far as possible within the right of way of the line, and the number of new tracks between existing roads and the traces shall be kept to a minimum. The access maps shall be submitted to the Engineer who will arrange for the proposed routes to be examined jointly feasibility and to agree any necessary adjustments, following which the access maps will be approved.

Once the access maps have been approved, the Contractor shall not make use of any other routes without the prior approval of the Engineer.

It is emphasized that the procedure of negotiating with land owners, etc. may be lengthy, and the Contractor must submit access maps as early as possible to avoid delay. The approved maps shall finally be submitted to the Employer for information and record purposes.

Where the Contractor has approval to use existing roads which are not maintained by the Government or other statutory authorities, he shall at his own expense either:

(a) negotiate and pay a toll to the persons or organization normally responsible for maintaining the road to compensate for additional wear and tear during line construction, or

(b) undertake to maintain the road himself during line construction to such a standard that its use by the customary traffic is not impeded in any way and then restore the road to a condition at least equal to that existing before the start of line construction. Such restoration shall be completed before the issues of the Total Provisional Reception.

The Employer will assist the Contractor in negotiating with the persons or organization normally responsible for maintaining the road.

Where the Contractor has approval to construct new tracks, they shall be located in accordance with the approved maps and in such a manner that the security of supports and foundations is not jeopardized, and shall be adequate for use by such construction vehicles as are agreed by the Engineer to be necessary. The new tracks shall be designed and made in such a way as to minimize damage to property, land, crops and vegetation; shall be adequate drained to prevent washouts or soil erosion; and shall be provided at low points with bridges or culverts sufficient to prevent retention of flood waters upstream of the tracks. If the Employer requires improvement of any or all such tracks for his own use in future, the Engineer shall direct the Contractor to undertake such works as are necessary for the improvement at rates to be agreed. Notwithstanding the foregoing, if in the opinion of the Engineer, use by the Contractor of the tracks is unreasonably damaging property, the Contractor shall forthwith and at his own expense restore the tracks to remedy such damage or damage on any associated drainage channel, etc.

Responsibility for damage, compensation, etc. is defined in Clause I.5.3. All other costs of providing and maintaining entry routes for line construction shall be born by the contractor. Should it be necessary to manhandle materials and equipment to erection points, or should the Contractor opt to use helicopters for this purpose, the costs shall be deemed to have been allowed for within the several rates entered in the schedule of prices and the Contractor shall not be entitled to extra payment for such manhandling.

Should permission to use helicopter not be obtained, it must be clearly understood that the Employer will not, under any circumstances, reimburse the Contractor for any extra cost occasioned by the necessity to use other forms of transport to deliver materials or labour to tower sites.

Where it is agreed that vehicular access tracks will be provided, these shall be 2.5 m wide unless otherwise approved by the Engineer.

I.5.2 Wayleaves

Wayleaves shall be provided by the Employer to enable the Contractor to carry out the works. In order to provide wayleaves, the Employer has to obtain approvals from the Government and other statutory authorities, and also consents from owners and occupiers of property which will be affected by the line.

The procedure for obtaining approvals and consents is dependent on the check survey, as described below:

(a) Representatives of the Employer will, with landowners and occupiers, establish rights of entry for survey and agreement to limited cutting of vegetation as specified.

(b) Upon approval by the Engineer of the check survey, the Employer will initiate procedures for obtaining wayleaves, and when necessary approvals and consents have been granted, the Employer will arrange for tree, etc. to be cleared from the line trace as specified.

(c) Upon approval by the Engineer of tower center pegs, the Contractor shall submit maps as specified and the Employer will obtain the necessary rights of construction of access for the Contractor.

(d) Wayleaves procedures as described above will take place concurrently with the check survey, approval of center pegs, etc. The Contractor shall allow in his programme for a period of up to 4 months from approval of the check survey to grant of right of access for its construction.

(e) When, in the opinion of the Engineer, right of access has been granted for a sufficient portion of any line route, he shall notify the Contractor to that effect and the Contractor shall forthwith commence preparation for erection of the line. Should the Engineer not so notify, the Contractor by the date indicated in the approved programme then shall re-arrange the programme to the Engineer's satisfaction and in such a manner that erection is commenced instead on another section of line route where the notification has been given.

(f) The Contractor shall ascertain the period of notice to be given to landowners and occupiers before entry for erection of the line, and shall make appropriate allowance in his programme. Before commencing work on any property, the Contractor shall be responsible for obtaining from the Engineer a Wayleave Schedule giving details of any special requirements, and shall give landowners and/or occupiers the necessary notice prior to entering.

I.5.3 Damages to Crops and Property

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

minimum. All surplus materials shall be removed after erection and the site shall be left in a clean and tidy condition, to the satisfaction of the Engineer.

Where the contractor considers that damage can not be avoided if the work is to proceed normally, he shall notify the Engineer accordingly. If the Engineer confirms that such damage occurred unavoidably, then the Employer will be responsible for compensation in respect of it and the Contractor shall proceed with the works within the limits indicated by the Engineer. In the event of such notification not being received within fourteen (14) days from the date when the damage is caused, the Employer may at his discretion refuse to consider any subsequent claims by the Contractor for compensation resulting therefrom.

Where the Contractor causes damage beyond the indicated limits or to a degree which the Engineer considers excessive, then the Contractor shall be responsible for reinstatement and/or compensation. If in such circumstances the Contractor fails to settle compensation to the extent that, in the Engineer's opinion, the progress of the works is likely to suffer, the Employer shall negotiate and settle the matter and the cost shall be deducted from moneys due to the Contractor.

I.5.4 Removal of Obstructions

Where it is agreed that obstructions such as telecommunications lines, power lines or pipes are to be permanently removed or relocated to allow erection of the lines, the Employer will initiate procedures to obtain necessary consents and secure removal upon receipt of sufficient notice through the Engineer from the Contractor of his planned date for commencing work at the places affected. The Contractor shall be responsible for ascertaining the periods of notice required and shall make appropriate allowance in his programme.

Immediately after completion of the check survey, the Contractor shall provide sketches showing the relative positions of the line and obstructions.

Where temporary removal of hedge, wall or similar obstacle is necessary for the purpose of foundation installation or tower erection, the cost of removal and subsequent reinstatement shall be deemed to be included in the Contract rates for foundations and tower erection.

I.5.5 Crossing of Public Services

Where public services are not to be permanently removed, the Employer will obtain necessary approvals for crossings on the basis of sketches to be provided by the Contractor immediately after completion of the check survey. The shetches shall show the relative positions of the lines and the services.

Where the Contractor is about to erect conductors along or across power lines, telecommunications lines, railways, public roads or waterways, he shall be responsible for ascertaining and giving requisite notice to the appropriate authorities of the date and time at

which the work is to be carried out. Existing low voltage lines (415/230V) will generally be switched off during working (daylight) hours while conductor erection is in progress at crossing points. The Contractor shall provide scaffolds to protect the existing lines from physical damage and to maintain adequate clearance against accidential contact with lines.

For existing lines at the voltages exceeding 240/120V, extended outage will not be possible, and the Contractor shall provide live line scaffolds such that conductor erection can proceed in safety over energized lines. The Employer may arrange outages for erection and removal of live scaffolds upon receipt from the Contractor of requisite notice (which the Contractor shall ascertain and allow for in his programme), but the duration of such outage will be the minimum necessary for the work to be completed. Where essential supplies are affected, it may be possible to provide outages only at weekends or public holidays. The Engineer shall inform the Contractor the existing lines which are subject to such restriction and the Contractor shall arrange his programme accordingly.

Where it is necessary to provide scaffolding over roads, railways or telecommunications 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 authority concerned. 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 drawings showing his scaffolding proposals.

The cost of all scaffolding (including live line scaffolds for power lines up to 34.5 kV), warning signs notices and other necessary precautions shall be deemed to be included in the Contract rates for stringing.

I.5.6 Other Crossing

The Contractor shall, at his own expense, make the necessary arrangements and take any necessary precautions where the route crosses other obstacles or ground over which erection can not be carried out in the normal manner.

I.5.7 Livestock

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

I.5.8 Check Survey

The line route has been established, and all tower positions have been pegged out by the Employer. The profile and plan drawings along the whole line route will be given to the Contractor by the Engineer at the time of contract.

The drawings given to the Contractor are prepared in the scale of 1:2000 in horizontal direction and 1:500 in vertical direction.

The Contractor shall survey the line route from the Daula Peripa hydropower station to Severino pumping station for checking the straightness, profile and horizontal distance between terminal and angle points or angle points on the given line route. If the Contractor will find any discrepancy between the drawing and results of his check survey, he shall immediately inform it the Engineer and shall correct the drawings if necessary. In case the Contractor has, during his check survey, his alternative for more economical tower application to those selected by the Employer, he shall propose the Engineer the alternative of the positions and tower types showing those modifications on the drawings.

The Contractor shall submit his profile and plan along the whole line route to the Engineer for its approval immediately after completion of the survey, even in each section. The drawings shall show each tower position, its tower type and tower height to be applied by the Contractor.

The drawings shall include such features as continuous longitudinal distances, ground line salient levels, ground line, ground clearance line, line of the lowest conductor at maximum sag, indication of side slopes where these affect ground clearances (below the outer conductor phases, due account being taken of swing of conductors under wind loading), and where appropriate side slope which could effect clearance of conductor to vertical or other steep slopes, buildings, streams and rivers, roads and railways, power and telecommunications 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 sag template and an angle-span chart shall be submitted by the Contractor for the Engineer's approval for determining the tower type and tower height to be applied at each position. The sag template shall be prepared under the conditions specified in Subsection I.5.9. A complete set of the approved sag templates shall be submitted by the Contractor to the Engineer for the Engineer's use.

Tower heights shall be determined in consideration of the following minimum clearances of the lowest conductor(s) over the ground or other obstructions to be maintained at the maximum sag of the conductors.

(a)	general terrain	:	6.9 m
(b)	main roads	:	9.0 m
(c)	second roads	:	7.8 m
(d)	other power line	:	4.0 m

(e) telephone line : 4.0 m

(f) railway : 9.0 m

After the Engineer's approval on the profile and plan, the Contractor shall be entirely responsible for the tower positions, tower types and tower heights.

Tenderers shall enter a rate for the check survey which shall cover for all operations above-mentioned on average rate per route kilometer. He shall not be entitled to claim extra payment for realignment or re-clearing necessary to provide a true straight line between the given angle points.

The Contractor may be requested by the Engineer a profile survey in a newly established section of the line route. The survey shall be carried out in the same manner as those specified for the check survey but including the line alignment of the section. Tenderer shall enter a rate for such profile survey in the Price schedule.

I.5.9 Sags of Power Conductor and Overhead Earthwire

The sags shall be computed under the following conditions.

Basic design span length	:	350 m
Maximum wind pressure on conductor and earthwire	:	39 kg/sq.m
Assumed maximum conductor temperature	:	60 deg.C
Assumed conductor everyday temperature	:	25 deg.C
Assumed minimum conductor temperature	:	5 deg.C
Assumed maximum earthwire temperature	:	40 deg.C
Assumed earthwire everyday temperature	:	25 deg.C
Assumed minimum earthwire temperature	:	5 deg.C
Most severe design condition	:	Maximum wind pressure under 18°C conductor temperature

Maximum sags of the conductor and earthwire shall be computed under the conditions of still air at the assumed maximum temperature for them. Maximum working tensions of the conductor and earthwire will be generated under the condition of maximum wind pressure on them at the conductor temperature of 18 degree centigrade respectively assumed for them. Factor of safety of the maximum working tension of the conductor and earthwire shall be more than 2.5 against their ultimate tensile strengths, and the conductor's every stress shall be less than 25% of its ultimate tensile strength. Sag of the earthwire in the still air condition at the minimum temperature shall be less than 80% of that of the conductor at the same condition.

Standard height of each type of towers shall be determined in consideration of the maximum conductor sag thus computed. Minimum sag shall be applied for determining weight span to each tower.

Sag templates shall be fabricated of transparent and stout perspex or similar material based on the range of equivalents spans required and show the maximum and minimum sags of the conductor in the scales of 1/2000 horizontal and 1/500 vertical. Each template shall be clearly endorsed with the design loading conditions, particulars of conductor, equivalent span and the scales.

I.5.10 Route Clearing

Clearing of all trees and scrubs shall be carried out in the widths of 20 meters each side of the centerline of the line route along the whole route.

Trees and bushes shall be cut down to a height not exceeding 0.3 m above ground level, and fallen trees and bushes shall not project more than 0.5 m above ground level. In addition, tall trees outside the cleared area, of such height that they could fall within 4.5 m of conductors (called as danger trees) shall be cut after the Contractor has obtained the necessary permission from owners. The Contractor shall take effective measures to minimize growth of tree stubs other than application of such chemicals as to impair environment.

Attention shall be drawn to the necessity of avoiding damage to lines when tree fell. The Contractor shall be responsible for ensuring that the line and other existing facilities in the vicinity are not damaged by falling trees during route clearing operations.

Immediately before issue of the Total Provisional Reception Certificate for the line, the Contractor shall have re-cleared the line route to the standard specified. The rate for route clearing shall include all the works above-mentioned.

Payment for carrying out tree cutting, route clearing, grubbing up of stumps, grading, danger trees cutting, reclearing and any other included work necessary to comply with this clause shall be made at a basic average unit rate per kilometer of line, which shall be deemed to include all of the operations described above irrespective of the actual amount of work in any given area. Certification of the route clearing will be made in equivalent amount to 80% of the cleared distance for the initial clearing in monthly statements and amount of the remaining 20% for re-clearing in the last monthly statement.

I.5.11 Foundations

(1) Soil Investigation

The Contractor shall make tests of subsoil conditions at every tower site by means of an approved simple hand-operated borer (sampling) and sounding tool, and indicate

results on the approved soil test sheets together with ground water levels and proposed foundation type to be applied at the tower position.

The contractor shall obtain the Engineer's approval for the foundation type in advance of the foundation works at each tower site. Particular note is to be made where any poor ground is encountered likely to require special foundations. The test results shall show firm evidences to prove reasons why the proposed type of foundation is selected from the specified foundation types. The cost of the sub-soil tests is deemed included in the rate for foundation work. The Engineer may request the Contractor additional sub-soil tests at the bottom of excavated pits, if the Engineer judges its necessity for further confirmation on the proposed foundation types. The sub-soil tests shall be done at the earliest stage of the field works to the urgency of having tower stubs and templates on site in order that foundation works can proceed with a minimum of delay.

(2) Excavation and Backfilling

Where angle towers are fitted with unequal length crossarms at each side of the tower, the tower center shall be offset to ensure that the conductors are located as near as possible equidistant either side of the route centerline in adjacent spans.

The Contractor shall ensure that excavations are made to the correct depth and width. If excavations are taken deeper than the designed dimension, the excess depth shall be backfilled with concrete at the Contractor's expense. If excavations are made wider than the designed dimension, such modifications to the design as the Engineer may require shall be made at the Contractor's expense.

For uplift foundations, undercutting or other approved method shall be applied as far as possible for allowing upward bearing of the foundation pad against undisturbed soil for a minimum width of 250 mm all around. Alternatively the concrete pad shall be cast to by adhesion to the original ground. In cases where the concrete block is cast in undercutting, the earth frustum assumed to resist uplift shall be considered to start from the bottom of vertical edges of the block. Otherwise, the frustum shall be assumed to start from the upper top of the block edges.

The backfill of all types of foundations shall be thoroughly rammed with mechanical rammers, and the ramming shall be carried out at intervals of not greater than 300 mm to ensure thorough consolidation of the backfill as the Engineer requires.

In no circumstances shall peat or equivalent materials be used as backfill for foundations. Where excavations are made in peat ground, backfilling to the foundations shall be made with a suitable soil or hardcore from an approved source at the Contractor's expense. Backfill shall be finished in such a way that the original ground contours are restored as nearly as possible, and any subsidence of backfill shall be made good before the issue of the Total Provisional Reception.

(3) Stub Setting

Stubs for tower foundations shall only be installed with the use of templates or by use of the lower sections of the tower with the suitable temporary bracings to ensure correct spacing. The stub setting templates shall be of approved type with sufficient rigidity to ensure correct setting of the stubs. The method selected shall be such that all four stubs are supported and interconnected by a rigid steel framework. The main members of the templates must be in the position by the template while the concrete is placed. The templates are not to be removed until at least 48 hours after the foundations have been completed and backfilled.

The templates shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross-section, and shall be equipped with central alignment notches or holes, corner braces, riser-braces, and stub angle bolting legs to permit the accurate setting of stubs in respect of the following requirements:

(i) longitudinal centerline
(ii) tower lateral centerline
(iii) stub elevations (with reference to datum)
(iv) stub leveling
(v) inclination of stubs
(vi) stub hip bevels
(vii) spacing between stubs

No concreting shall be started before the stubs are confirmed to be in the design positions.

(4) Concrete Work

(a) concrete for concrete foundation and pile shall have the minimum required breaking strengths as specified in the technical schedules.

(b) Cement used shall be of Portland or other approved composition obtained from an approved maker. Portland cement shall conform in all respects to BS-12, or equivalent.

(c) Aggregates shall be clean and free from dust, earthy or organic matter or salt. Coarse aggregate shall be approved grading to be retained on a mesh not less than 5 mm square, and of a maximum size to pass a mesh not more than 40 mm square. Where specially approved in writing by the Engineer, coarse aggregate of uniform size not larger than will pass a 25 mm mesh may be used throughout. Fine aggregate shall be river sand and shall be coarse, sharp, clean and free from dust, salt, clay, vegetable matter or other impurity and shall be screened through a mesh not more than 5 mm in the clear. It shall be a well graded mixture of coarse and fine grains from 5 mm gauge downwards.

(d) Water shall be clean and free from all earth, vegetable or organic matter, salt, soil, oil, acid and alkaline substances either in solution or in suspensions.

(e) At least four weeks before commencing any concreting work, the Contractor shall make trial mixes using samples of cement and fine and coarse aggregates. The test specimens for the trial mixes shall be of cube type. Preliminary test specimens shall be taken from the proposed mixes as follows.

For each proposed mix a set of 6 specimens shall be made from each of 3 consecutive batches. Three from each set if six shall be tested at an age of seven (7) days and three (3) at an age of 28 days. The test shall be carried out in a laboratory approved.

Neither the mix proportions nor the source of supply of materials shall be altered without the prior approval of the Engineer except that the Contractor shall adjust the proportions of the mix as required, to take account of permitted variations in the materials, such approval shall be subject to the execution, to the Engineer's satisfaction, of trial mix procedures set out herein.

(f) where directed by the Engineer concrete cubes are to be taken and tested to verify the concrete strength during site concreting works. The Contractor shall provide the cube molds at site for the purpose, accordingly. The test specimens shall be 150 mm cube and the mold shall be of metal with inner faces accurately machined in order that opposite sides of the specimen are plane and parallel. Each mold shall be provided with the metal base having a smooth machined surface. The interior surfaces of the mold and base should be lightly oiled before concrete is placed in the mold.

(g) Cube strengths for 1:2:4 concrete are to be not less than 130 kg/sq.cm with 7 days after mixing and 210 kg/sq.cm within 28 days after mixing.

(h) The cost of concrete testing shall be deemed to be included in the Contractor's general schedule rates.

(i) Requirements for testing concrete samples during construction are set out in Clause I.5.15.

(j) The concrete shall 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 shall be kept continuously moist to avoid rapid drying of the concrete.

(k) In the event that the Contractor proposes to use ready mixed concrete for foundation work, approval must first be obtained from the Engineer, who will inspect the batching plant and cement, sand and gravel used for concrete. No ready mixed concrete shall be used in foundation work if it has been mixing in the lorry during its journey for more than 45 minutes. At the discretion of the Engineer, ready mixed concrete may be used in foundations in excess of 45

minutes journey, if the cement is added to the drum at site and is thoroughly mixed prior to placing, or alternatively if the ready mixing lorry carries its own water drum and water may be added to the cement and aggregate in the mixing drum during the lorry's journey and 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.

(l) Throughout the line route, the Contractor shall at regular intervals and at the time of survey, obtain samples of subsoil and ground water, which he shall have analyzed to ascertain if any agents be present which may have an adverse effect on concrete made with normal Portland cement. The analysis shall be forwarded to the Engineer without delay together with any recommendations for the use of special cement. The Engineer's decision as to the type of cement to be used will be final. The cost of obtaining soil and ground water samples is deemed to be included in the Contract Price. The cost of any special cement used will be paid at an appropriate rate to be agreed with the Engineer.

(m) Concrete shall be placed immediately after mixing. All concrete shall be thoroughly compacted by vibration during the operation of placing, and shall be free from honeycombing and other defects. The upper surface of the concrete for all types of foundations shall be finished smooth and sloped in an approved manner to prevent accumulation of water. A concrete additive of a type approved by the Engineer may be used.

(5) Piling and Other special Works

Piling shall be carried out using an approved procedure throughout. The actual length and numbers of piles required at any location will be approved by the Engineer on the basis of the final agreed design data and payment made for departures from the assumed tender design quantities on the basis of the difference of quantities times the schedule variation rates. Tender Prices shall include for all necessary casings, pumping, depreciation of piling machines, materials, transportation and others.

Where special ground conditions exist which do not allow for any of the designs in an original or modified form special types of foundations may be employed which will be paid for on the basis of schedule rates where applicable. To this extent the schedule variation rates for concrete, steel and excavations shall apply throughout irrespective of special conditions.

Piles shall be tested in accordance with Clause I.5.15.

I.5.12 Erection of Towers

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.

In general, towers shall be assembled and erected with bolts finger tight only. Final tightening of bolts shall only take place when all members are in place. As far as practicable, bolts shall be inserted with the nuts facing outwards or downwards.

Whenever wire slings or ropes are liable to abrade tower members, the members shall be suitably protected by heavy Hessian bags or strips, or by some other approved means.

The Contractor shall make use of temporary struts on panels prior to lifting, if in the opinion of the Engineer, there is a likelihood of damage occurring to that panel during lifting. where derricks are used for lifting panels they shall be securely guyed and shall be supported only at approved locations on the legs.

All towers shall be vertical under the stresses set up by the completed overhead line to the satisfaction of the Engineer. The maximum acceptable deviation from vertical shall normally be 1%.

Proper precautions shall be take to ensure that no parts of the towers or supports are unduly stressed or damaged in any way during erection. Drifting shall not be allowed.

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

Before assembly of members, joints shall be free of all earth, or any other substances which might prevent the correct alignment of members. After erection, all materials shall be cleaned of all foreign matter or surplus paint.

Spanners used during erection shall be well shaped and fit closely on the nut to avoid damaging nuts and bolt heads. After erection, all bolts from ground level up to the bottom crossarm shall have the threads smashed in an approved manner to prevent unauthorized removal.

Damage to the galvanized surfaces of bolts, tower steelwork or smashed bolts shall be repaired using zinc rich paint or similar and the cost of such repair is deemed to be included in the appropriate rates.

The contractor must ensure that tower erection, steel handling and operation of equipment shall be such as to ensure the maximum safety of all personnel associated with the project as well as the public.

Lower parts of towers erected in the submerged area during wet seasons shall be protected from corrosion with an approved paint as ordered by the Engineer. The cost for the painting shall be quoted in the Price Schedule.

I.5.13 Grounding of Towers

Before placing foundation concrete, grounding angles rods specified in the previous Clause I.3.15 shall be erected to each foundation cleats. Measurement of footing resistances of all towers shall be carried out with an approved instrument before stringing of an overhead earthwire. A target value of the resistance is less than 11 ohms. The Contractor shall report the measured value in an approved form to the Engineer. The Engineer will instruct necessitate of installation of counterpoises to the Contractor who shall then provide the counterpoises as specified in the Clause I.3.15 to the instructed towers and measure the resistances for reporting the Engineer. In case the resistance is still high, the Engineer may order the Contractor to install additional counterpoises.

All the grounding works shall be completed before commencement of operation to the overhead earthwire erection.

I.5.14 Erection of Conductor and Overhead Earthwire

(a) 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 conductor and overhead earthwire tension joints shall be approved. Tension joints shall not be less than 15 m from the nearest clamp.

(b) Unless the Engineer agrees to the contrary, midspan joints shall be not used:

(i) at locations which would allow less than 3 clear spans between mid-span joints on a given conductor and wire

(ii) in spans crossing over power lines, telecommunications lines, public roads or buildings, and

(iii) in single span sections.

(c) Conductor repair sleeves shall not be used without the permission of the Engineer, which will be granted only in exceptional circumstances.

(d) Conductor and earthwire stringing shall be carried out entirely by tension stringing methods and Contractor shall submit for approval full details of the precise method of tension stringing and of the stringing equipment which he intends to use. Conductors shall be kept off the ground at all times when the conductor is in motion. The method of tension stringing required to install all conductors and earthwire shall be continuously controlled.

(e) The conductor and earthwire tension during stringing operation shall be kept as low as possible, consistent with keeping the conductor and earthwire clear of the ground whilst in motion. At no time will the tensions be allowed to exceed 75% of the final tension.

(f) All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.

(g) Conductor and earthwire drums shall be securely anchored during stringing operation and drum jacks shall be of the self braking type to prevent conductor and earthwire over run.

(h) Conductor and earthwire pulling equipment shall be such as well ensure a continuously steady pull. Every precaution is to be taken to prevent damage to the conductor and earthwire. Clamps and other devices used for handling conductor and earthwire during erection shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor and earthwire. Grooves of sheaves and tensioners shall be lined with neoprene or rubber. Sheaves shall have an electrical conducting path between their suspension points and the conductor supported within them and shall run with minimum friction.

(i) Conductor and earthwire shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

(j) 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 and earthwire drums winch operation for stringing and the proposed positions of mid-span joints, together with temporary staying wires of towers and all other relevant information.

(k) Conductor and earthwire drums shall be closely examined before conductor pulling commences and all nails and other things which could damage the conductors and earthwires shall be removed. During stringing, the conductor and earthwire drums are to be supervised at all times and the conductor and earthwire shall be inspected for defects while it is being pulled off the drums. Any damage caused to conductors or earthwires shall be reported to the Engineer whose decision to replace or repair will be final.

(l) Conductors and earthwires shall be carefully regulated to the correct prestress and initial tensions by a measurement of sags. Ambient temperature shall be measured by a thermometer suspended on the tower at the sag measurement position. Making for and application of anchor clamps shall follow regulation to initial tension without delay. Immediately after regulation and clamping has been completed in a section, the sag of conductors and earthwire shall not depart from the correct value by more than +/- 1.5%. Suspension insulator sets shall be installed so that clamps are within 20 mm of their correct position on the conductor.

(m) Insulators shall be cleaned and inspected before assembly. Any defective insulator shall be removed from site forthwith. Insulators when completely assembled shall have all security clips, cotter pins and other locking devices fully in place and shall be erected in a manner avoiding damage to the discs, fittings or locking devices.

(n) Where required by the Engineer, the Contractor shall check prior to the issue of the Total Provisional Reception Certificate that the sags of conductors and earthwire in selected spans are within the specified tolerance, and shall make any adjustment necessary to ensure compliance.

(o) Joints, clamps, etc. shall be applied 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 conductor and earthwire occurs. Cutting of layers of conductors shall be carried out with tools designed to prevent damage to underlying strands.

(p) Compression fittings shall be applied only by linemen approved by the Engineer, using approved methods. The outer surfaces of conductors and earthwires and the interiors of compression sleeves shall be scratch-brushed immediately before assembly.

(q) After conductors have been made off and landed, stringing sheaves shall be removed and suspension clamps and vibration dampers shall be fitted with minimum delay. Suspension clamps shall be fitted with due regard to offsets where appropriate, and the conductor and earthwire shall be cleaned before the clamps is assembled.

(r) The Contractor shall keep a record of all sagging showing details of the section, the sagging and checking spans, ambient temperature, pre-stress, initial and final sags, the date of sagging and clipping-in offset, etc. This record shall form part of the final records for the line and shall be handed over to the Engineer prior to the issue of the Total Provisional Reception Certificate. The records shall be available for inspection at any time.

I.5.15 Test at Site

(1) General

Following investigations and tests shall be carried out by the Contractor, when ordered by the Engineer.

Those investigations and tests as mentioned in the Price schedule will be paid for at the rates entered. Other investigations and tests not scheduled in the Price Schedule shall be deemed to be included in the prices of the relative items of the works.

(2) Ground Prove Tests

Tests by means of an approved type of penetrometer or other approved means shall be carried out during the check survey as provided for in Clause I.5.11. Results of these tests shall be submitted to the Engineer on an approved form giving a preliminary indication of the ground bearing properties and water levels, etc. Bore penetration shall be at least 9 m below ground level in poor ground.

(3) 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 the purpose of foundation designs. Such information shall be detailed in an approved manner and conclusions given as to the recommended bearing pressures to be adopted.

(4) Ground Bearing Tests

Where ordered by the Engineer, the Contractor shall carry out ground bearing tests to determine the ground bearing capacity, by means of loading a 300 mm square plate in an approved manner. Tests shall be carried out generally in the manner described in BS-5930, or equivalent.

(5) Pile Bearing and Uplift Tests

Where ordered by the Engineer, the Contractor shall carry out pile bearing and uplift tests for all types of pile generally in accordance with the method given in the BS CP-2004 or equivalent. Such tests shall be carried out to determine the ultimate uplift and bearing values.

(6) Foundation Loading Tests

Where ordered by the Engineer, foundation design tests shall be carried out in full scaled individual footings.

(7) 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 commences. All site investigation data, charts, etc. shall be handed over to the Engineer in triplicate upon satisfactory conclusion of the tests, and before the issue of Total Provisional Reception Certificate.

Where the Contractor carried out other tests at his own expense, not ordered by the Engineer, such information shall be submitted to CRM to the contrary, where the Employer had independent tests made along the route of the line, such information shall be made available to the Contractor.

(8) Concrete Tests

The Contractor shall carry out tests on sample of concrete from the foundation works, as required by the Engineer as specified in Clause 1.5.11. The test specimens shall be stored at the site at a place free from vibration, under damp sacks for 24 hours. They shall be then removed from the moulds, marked and stored in water at a temperature between 10 deg.C and 21 deg.C until the testing date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in a damp sand, or other suitable

damp materials, and shall be brought in the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in water until the time of the test.

The results shall be handed in triplicate to the Engineer, as soon as possible after testing.

(9) support Footing Resistance

The resistance to earth of the complete foundation of individual structures shall be measured in an approved manner before the stringing operation of overhead earthwire, as specific in Clause I.5.13. The placing of test electrodes shall normally be along the center 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 time of the test.

(10) Additional Footing Resistance Tests

If in the opinion of the Engineer, it is necessary to reduce the tower footing resistance by means of counterpoises, the Contractor shall make further measurement after the counterpoises have been carried out and before the stringing operation of the overhead earthwire. Any further measurement shall be carried out as necessary without extra charge.

(11) Measurement of Galvanizing Thickness

The contractor shall have on site an instrument suitable for accurate checking of galvanizing thickness for the Engineer's use. The gauge shall be available from time to time of arrival of the first consignment of steel work until the issue of Total Provisional Reception Certificate. The cost of the gauge and other operating expenses shall be deemed to be included in the contract price and the gauge shall remain the property of the Contractor.

(12) Testing of Rock Anchors

Where rock anchor foundations are used in hard rock, as provided for by the Engineer's order, the Contractor shall test individual anchors by tensile test loading to failure for obtaining design data of the foundations. The test shall be considered satisfactory if the steel bar fails by yielding of the bar at or above its ultimate strength.

Anchor for the testing shall be installed away from permanent foundation anchors but in the same rock. The frequency of the test shall depend upon the different types of hard rock encountered and the number of tests performed shall be such as to give confidence in the employment of rock anchor foundations and experience of the type of rock suitable for their use. The frequency of tests shall, in the case of dispute, be reasonably determined by the Engineer.

The cost of rock anchor test shall be included in the relevant schedule rates.

(13) Tests on Completion

The line shall be energized at full working voltage before handing over, and the arrangement for this and such other test as the Employer or the Engineer shall desire to make on the completed line shall be assisted by the Contractor who shall provide such labour, transport and other assistance as required without extra charge.

I.5.16 Payment for Erected Work

The general method of payment is set out in Clause II. 1.5 of the Draft Contract. Following are practical invoicing method for the local transport and erection works.

Invoicing of inland transport and erected work shall be submitted separately in an approved form.

The Contractor shall submit to the Engineer for a draft blank printed Form of Measurement Certificate which in a complete form must accompany all invoices.

All measurements for the purpose of payments shall be made jointly by representatives of the Contractor and the Engineer. Completed Measurement forms shall signed by both the Contractor and the Engineer and shall accompany each monthly statement. Payment will not be authorized without the completed Measurement Forms.

Measurements for the purpose of payments for inland transport and works erected shall be made on the following basis:

(i) check survey and profile survey if ordered: for the horizontal distance involved, measured along the route center line.

(ii) Foundations: at the unit rates for the approved numbers of each foundation type for each tower type.

The rate for a special foundation shall be the most appropriate unit foundation rate adjusted for additional or reduced quantities of excavation, reinforcement and concrete in accordance with the variation rates provided in the schedule.

(iii) Towers: for each standard height tower and standard extension, at appropriate schedule rates which are to include for all number plates, danger plates, anticlimbing device, step bolts, insulators, etc.

(iv) Conductors and overhead earthwire: for the horizontal distance involved, measured along the route center line without allowance for sag, scrap or jumpers. Rates include for mid-span joints.

The rates in the Schedule of Prices for the standard towers, extensions and foundations shall include all works irrespective of access conditions, slope of ground, nature of the subsoil and the presence of water.

No extra payments shall be made for:

(a) Excavation necessary solely for the installation of stub setting templates or extra excavation necessary for setting foundations deeper in sloping ground.

(b) Extra encasing concrete necessary where foundations are set deeper in sloping ground.

(c) Close timbering required.

(d) Pumping out of normal overnight seepage or avoidable accumulation of water.

(e) Tower erection methods employed by the Contractor.

(f) Additional costs of transport of materials to the working site.

Earth is defined as material which can be removed in the aid of shovels and pick-axes. Rock is defined as material for the removal of which the aid of wedges, sledge-hammers and crowbars, or drilling and/or blasting is necessary but which can not be removed with shovels and pick-axes.

SUBSECTION - J

POWER LINE CARRIER TELEPHONE SYSTEM

J.1 GENERAL

J.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following :

(1) Daule Peripa power station

- (a) One (1) set of one channel PLC terminal equipment
- (b) One (1) line traps (LT)
- (c) One (1) coupling capacitor potential devices (CCPD)
- (d) One (1) coupling filter (CF)
- (e) One (1) set of surge protective device
- (f) One (1) lot of coaxial cable and cord
- (g) One (1) set of power supply unit
- (h) One (1) lot of equipment and materials for automatic telephone sets
- (i) One (1) lot of miscellaneous materials

(2) Severino pumping station

- (a) One (1) set of one channel PLC terminal equipment
- (b) One (1) line traps (LT)
- (c) One (1) coupling capacitor potential devices (CCPD)
- (d) One (1) coupling filter (CF)
- (e) One (1) surge protective device
- (f) One (1) lot of coaxial cable and cord
- (g) One (1) set of power supply unit
- (h) One (1) lot of equipment and materials for automatic telephone sets
- (i) One (1) lot of miscellaneous materials

The power line carrier telephone system over 138 kV transmission line is shown on the Drawings of Tender, No. 3-I-014. This PLC telephone system is not required to connect

to a PLC telephone system at the Daule Peripa power station which has been planned or prepared for the electric power transmission system.

J.1.2 Frequency Allocation

Frequency allocation will be informed by the Employer in an early stage of the Contract. However, the following frequency are temporally allocated for Tender purpose.

	Sending	Receiving
Daule Peripa power station	196	204 kHz
Severino pumping station	204	196 kHz

J.1.3 Transmission Line

Principal features of the transmission line from the Daule Peripa power station to the Severino pumping station are as follows:

(1)	Line length:	approx. 34 km (Daule Peripa HP.S.- Severino P.S.)	
(2)	Nominal line voltage	:138 kV	
(3)	Number of circuit	: Single circuit	
(4)	Power conductor	: ACSR 170 mm^2	: Al. 170.5mm^2 +St. 39.8mm^2
		: Aluminium (nos./mm)	: 30 / 2.69
		: Steel (nos./mm)	: 7 / 2.69
(5)	Overhead earthwire	: Galvanized steel wire	: 55 mm^2 (7/3.2 mm)
(6)	Conductor arrangement		: triangular formation
(7)	Support of conductors		: single circuit type steel towers
(8)	Equivalent spacing		: 5.5 m
(9)	Average height of conductor		: 11.5 m
(10)	Grounding system		: solidly grounding system

J.1.4 Coupling with Transmission Line

Coupling method with transmission line shall be phase-to-ground coupling system, using the middle conductor of three phase line.

J.2 POWER LINE CARRIER TERMINAL EQUIPMENT

J.2.1 General

The power line carrier (PLC) terminal equipment shall be fully transistorized and the major circuit units shall use printed-circuit modules of plug-in type. The terminal equipment shall be contained in a steel cabinet of dustproof construction to be installed on the floor and shall be designed to suit back-to-back or side-by-side alignment. The front door shall be furnished on the cabinet. Entry holes for power supply and multi-core cables shall be provided both at top and bottom of the cabinet. No live parts shall be exposed on the surface of the cabinet.

J.2.2 Technical Requirements

The PLC equipment shall satisfy the following requirements.

(a) Transmission and Communication System

The carrier equipment shall be of amplitude modulated, single side band with carrier suppressed and duplex operation. The equipment shall be apply to out-of-band frequency shift signaling system with basic carrier band of 4 kHz, voice frequency of 300 to 3,400 kHz.

(b) Output Level of Transmitter

The transmitter shall be designed to transmit simultaneously the following signals measured at the output terminals of the equipment :

Speech (test tone level)	+27 dBm
Telephone signaling	+17 dBm

(c) Input Level of Receiver

The receiver shall be so designed as to compensate the following line loss at the carrier frequency :

Maximum line loss	
Speech (test tone level)	27 dBm
Worst value	37 dBm

(d) Carrier Frequency Synchronization

Carrier frequency synchronization shall be of perfect synchronization system.

(e) Linearity

The linearity shall not differ by more than ±0.3 dB from the overall loss at 0 dBm0 for any input level between -10 dBm0 and 0 dBm0.

(f) Audio Frequency Level

Nominal input and output audio frequency levels for the test tone shall be as follows :

i)	2-W Transmit level	0 dBr
	4-W Transmit level	0 to -17 dBr
ii)	2-W Receive level	-8 dBr
	4-W Receive level	-3.5 to + 8 dBr

(g) Equipment Noise

Equipment noise power including carrier leak at the point of 4-wire output shall be less than -50 dBm without compandors.

(h) A.G.C. Characteristics

Variation in audio output level shall be compressed to be within the range of -3dB to +2 dB against input level variation within the range of -15 dBm to +10dBm.

(i) Impedance Characteristics

Impedance characteristics shall be as follows :

i)	Carrier circuit unbalanced	75 ohms,
ii)	Voice circuit balanced	600 ohms,

(j) Level Adjustable Arrangement

Carrier frequency transmitting and carrier frequency receiving levels shall be adjustable.

(k) Level Stability

Test jack points of the carrier frequency level and the voice frequency level shall be provided at main testing circuit in the carrier equipment. Variation of level at each test point shall be not more than +1 dB when variation of power source voltage is within +10%.

(l) Voice Distortion Factor

Voice distortion factor shall be better than 30 dB for a standard test tone level of 800 Hz.

(m) Spurious Emission

Maximum level of spurious emission outside 4 kHz frequency band shall be within the permitted level shown on Figure 3 of IEC-495.

(n) Pulse Distortion

Pulse distortion of the signalling channel shall be within +5 dB and -3 milli-seconds when measured with a standard impulse of 10 IPS (Impulse/Second) dial speed and 33% make ratio under the input level variation of within +3.5 dB.

(o) Group Delay Distortion

The group delay distortion shall be less than 0.5 ms/1.0 - 2.6 kHz band.

(p) Compandor

The compandor, whose compression and expansion ratios are respectively 1/2 and 2, shall be provided for telephone channel. Tenderers shall state in details the characteristics of the compandor.

(q) Repeater Unit

The repeater unit shall be equipped for speech channel. The internally equipped repeater unit shall be applied to any magnet, common battery or automatic exchange by simply changing the terminal connection through the easy means.

(r) Singing Margin

The singing margin shall be more than 12 dB when the 2-wire terminal of both power line carrier telephone terminal equipment are terminated with a 400 ohms pure resistance.

J.2.3 Alarming and Testing Apparatus

(a) Alarming Apparatus

The carrier equipment shall be provided with an alarm bell and a visual indicator that give necessary warning in the following cases :

i) when the transmitter output level decrease
ii) when the received signalling level falls outside the AGC response range
iii) when the power source fuse breaks down

(b) Testing Apparatus

The following test panels of the plug-in type shall be equipped with the carrier equipment:

1) Test panel

i) Audio frequency test oscillator ;

- Load resistance	600 ohms
- Oscillating	Six (6) points
- Frequency range	between 300 Hz and 4,000 Hz
- Maximum output	More than +5dBm at 600 ohms
- Adjustment of output	Variable
- Distortion factor	More than 25 dB at +5 dBm output

ii) Level meter :

- Measuring frequency range	300 Hz to 50 kHz and 50 kHz to 450 kHz
- Measuring level	-60 dBm to +30 dBm in 1 dB step
- Input impedance (high and low impedance)	More than 10 kilo-ohms and 600 ohms in the frequency range of 300 Hz to 50 kHz. More than 1 kilo-ohm and 75 ohms in the frequency range of 50 kHz to 450 kHz.

2) Test Telephone Panel and Monitoring speaker

J.2.4 Accessories

The following accessories shall be supplied for each PLC telephone terminal equipment :

(a)	Test cords	1 kit
(b)	Extension sheet and cord	1 kit
(c)	Terminanation plug (600 and 75 ohms)	1 kit
(d)	Maintenance tools	1 set
(e)	Test telephone handset	1 set
(f)	Automatic dial telephone set	2 sets
(g)	Power supply cables, grounding wires, (14 mm^2), wiring materials, etc.	1 lot
(h)	Channel base (50 mm in height) and other materials for installation	1 lot
(i)	Other accessories essential to the correct erection, operation and maintenance of the equipment	1 lot

J.2.5 Spare Parts

The following spare parts shall be supplied for each station:

(a) One spare module of power line carrier terminal equipment of each type.
(b) Spare parts such as crystal resonators, thermistors, plugs (600 and 75 ohms), test cords, relays, lamps, fuses and vacuum tube arrester, etc. required for 5 years operation. (Items and quantities shall be recommended by the Contractor).

J.2.6 Measuring Instruments

The following measuring instruments shall be supplied:

(a) One (1) set of portable type test set

-	Oscillator	100 Hz to 500 kHz
-	Level meter	-60 dBm to +30 dBm
-	Attenuator	Max. 61 dB
-	Switches	For measuring

(b) One (1) set of universal circuit tester (digital type)

J.3 LINE TRAPS

J.3.1 General

The line traps shall be of outdoor use, filter (band tunes) type and shall be mounted on the top of the coupling capacitor potential device (CCPD) specified hereinafter.

The line trap shall be conform to IEC Recommendation, Publication 353 (1971) as far as applicable.

The line traps shall be provided with a lighting arrester for protection of tuning device against surge voltage on the transmission line and shall be equipped with a bird-barrier to prevent bird nesting, and shall also be attached with a clamp type high-tension terminal on both sides to fit the line conductors.

J.3.2 Rating

The rating of the line trap shall be as follows :

(a)	Type	band filter type
(b)	Line voltage	138 kV
(c)	System frequency	60 Hz
(d)	Rated continuous current	600 A
(e)	Rated frequency range	50 - 450 kHz
(f)	Inductance of main coil	0.2 mH
(g)	Impedance within the specified frequency range	more than 400 ohms
(h)	Tapping loss within the specified frequency range	less than 2.5 dB
(i)	Short circuit current strength	25 kA for one second

J.3.3 Accessories

The following accessories shall be supplied:

(a) Name plates
(b) Bird barrier
(c) Necessary terminal connection with clamp type terminal for ACSR 170 mm^2
(d) Mounting bolts and nuts

(e) Mounting base plate

(f) Other accessories recommended by the manufacturer

J.3.4 Spare Parts

The spare parts shall be supplied:

(a)	Lightning arrester	Two (2) units
(b)	Tuning unit	One (1) each type

J.4 COUPLING CAPACITOR POTENTIAL DEVICE

J.4.1 General

Coupling capacitor for phase-to-ground coupling shall be equipped with potential device for measurement of transmission line voltage as "coupling capacitor potential device (CCPD).

CCPD shall be of self-supporting type to be erected on galvanized steel structure and shall be so designed as to mount a line trap on the top. Grounding switch and surge protective device which are connected to the earth side of coupling capacitor shall be provided in a sealed metal box equipped under the coupling capacitor.

The sealed metal box shall contain a potential dividing capacitor and a transformer for potential device and/or a coupling filter specified in Clause J.5.2.

J.4.2 Rating

The rating of the CCPD shall be as follows :

(a) Potential device

(i)	Rated voltage	138 kV
(ii)	Rated frequency	60 Hz
(iii)	Voltage ratio	$138\ kV/\sqrt{3} : 115/\sqrt{3}$
(iv)	Burden	400 VA
(v)	Accuracy	class 0.6 ZZ
(vi)	Impulse level	650 kV
(vii)	Power frequency test voltage	275 kV for one min.

(b) Coupling capacitor

(i)	Frequency range	50 kHz to 450 kHz
(ii)	Capacitance	4,400 pF
(iii)	Rated voltage	138 kV
(iv)	Rated frequency	60 Hz
(v)	Impulse level	650 kV
(vi)	Power frequency test voltage	275 kV for one min.

J.4.3 Accessories

The following accessories shall be supplied :

(a) Name plates
(b) Terminal for primary conductor
(c) Secondary terminal for potential device
(d) Grounding terminals
(e) Lifting lugs
(f) Cable conduit
(g) Supporting structures with foundation bolts and nuts.

J.5 COUPLING DEVICE

J.5.1 Scope

The coupling device specified hereunder shall include coupling filter, surge protective device and feeder cables, etc. necessary to connect the PLC telephone terminal equipment to 138 kV line coupled with CCPD.

J.5.2 Coupling Filter

(a) General

Coupling filter shall be contained totally in the sealed metal box equipped under the CCPD specified in Clause J.4. Arrangement shall be provided for termination of the coaxial cable.

(b) Rating

The rating of the coupling filter shall be as follows :

i)	Type	:	Band-pass filter type
ii)	Frequency range	:	Refer to Clause 6J.3 (50 to 450 kHz)
iii)	Impedance :		
	- Line side	:	400 ohms for phase-to-ground coupling
	- Equipment side	:	75 ohms
iv)	Insulation strength		
	- Primary	:	A.C. 6 kV for one minute
	- Secondary	:	A.C. 3 kV for one minute
v)	Secondary side arrester		
	- Type	:	Air gap
	- Voltage	:	AC 1.0 to 1.5 kV
	- Discharge current	:	A.C. 10 A

J.5.3 Surge Protective Device

Surge protective device shall be provided between coupling filter and PLC telephone terminal equipment to protect the PLC telephone terminal equipment from surge voltage and current transferred from the power line system.

The rating of surge protective device shall be as follows :

(a)	Rated voltage	:	A.C. 100 V
(b)	Rated current	:	A.C. 2 A
(c)	Short time rated current	:	A.C. 10 A for one minute
(d)	Power frequency withstand voltage		
	- Primary	:	A.C. 6 kV for one minute
	- Secondary	:	A.C. 3 kV for one minute
(e)	Impulse withstand voltage	:	6 kV (1.2 x 50ms), positive and negative, 5 times

J.5.4 Feeder Cable and Cord

(a) General

Feeder cable connecting the coupling filter to the PLC telephone terminal equipment shall be high frequency coaxial cable, but coaxial cord may be used for indoor portion.

All necessary terminals and connectors shall also be provided herein.

(b) Rating

The ratings of the coaxial cable shall be as follows :

i)	Nominal impedance	: 75 ohms
ii)	Attenuation loss at 300 kHz	: less than 3.7 dB/km
iii)	Insulation strength	
	- Between conductors	: AC 3,000 V for one min.
	- Between outer conductor and sheath	: AC 6,000 V for one min.

(c) Spare Parts

The following spare parts shall be supplied for each carrier equipment :

i) One (1) connector of each cable and cord to surge protective device

ii) One (1) connector of cord to carrier equipment

iii) One (1) connector of the cable to coupling equipment

J.6 POWER SUPPLY UNIT

J.6.1 General

One (1) power supply unit consisting of storage battery and battery charger shall be provided for PLC equipment at each station. The power supply unit shall be operated normally in floating condition.

(a) Batteries

The storage battery shall be of Ni-Cd alkaline, enclosed type and shall have a sufficient capacity to operate the PLC telephone terminal equipment for a time of not less than one hour at full load without charging. The rated voltage of the battery shall be 48 volts.

(b) Battery charger

The charger shall be designed to give a stable floating charge with automatic equalizer. D.C. output voltage from the charger shall be maintained at 48 V ±10% for rapid power source variation of +10% of A.C. 220/127 V, 3 phase-4 wire, 60 Hz, and for rapid load variation of no load to 30% load, 70% load to full load and vice versa. Silicon dropper shall be provided with the charger.

The charger shall be so designed that equalizing charging can be performed manually when required, and shall be returned to the floating charging automatically after the preset time has elapsed. The battery and charger shall be housed in a self-standing cubicle and shall be equipped with necessary protective relays, switches, meters, terminals and lamps.

J.6.2 Accessories

The following accessories for each unit shall be supplied :

(a)	Voltmeter	1 pc.
(b)	Thermometer	3 pcs.
(c)	Tools	1 lot
(d)	Other accessories recommended by the manufacturer	

J.6.3 Spare Parts

The following spare parts for each unit shall be supplied :

(a)	Electrolyte	20% of all cells
(b)	Distilled water	20% of all cells
(c)	Signal-lamps, fuse element, etc.	300% of actual use

J.7 TELEPHONE WIRE

Indoor use telephone wire shall be of twin PVC insulated copper with 0.8 mm diameter. All necessary wiring materials shall be supplied.

J.8 TESTS

J.8.1 Test Before Shipment

The following tests before shipment shall be carried out at the manufacturer's plant :

Test report with certificate of type test may be acceptable for the test items marked with asterisk (*) hereinafter.

(1) PLC telephone terminal equipment

(a) Test on PLC terminal unit
- (i) Construction check
- (ii) Impulse withstand voltage test(*)
- (iii) Power frequency withstand voltage test(*)
- (iv) DC withstand voltage test(*)
- (v) Insulation resistance measurement
- (vi) Carrier frequency stability test
- (vii) Carrier frequency output level test
- (viii) Return loss test(*)
- (ix) Outband insertion loss test(*)
- (x) Spurious emission test(*)
- (xi) Power consumption measurement(*)

(b) Overall system test
- (i) Test on level setting
- (ii) Test on transmitting/receiving frequency difference between input voice frequency and other side output voice frequency(*)
- (iii) Test on variation with frequency of the overall loss of a pair of transmitting and receiving PLC terminals(*)
- (iv) Linearity characteristics test of voice level
- (v) Automatic gain control test
- (vi) Measurement of noise generated within the terminals
- (vii) Group delay distortion test
- (viii) Voice distortion test(*)
- (ix) Crosstalk attenuation test
- (x) Return loss test in voice frequency side(*)
- (xi) Speech check
- (xii) Ringer signal (pulse) distortion test
- (xiii) Alarm and indication check

(xiv) Other tests if the Engineer requests

(2) Line trap

(i) Construction check
(ii) Temperature rise test(*)
(iii) Impulse withstand voltage of main coil and tuning device without lightning arrester(*)
(iv) Power frequency withstand voltage test
(v) Short-time current test(*)
(vi) Main coil inductance measurement(*)
(vii) Impedance measurement
(viii) Tapping loss measurement
(ix) Impulse spark-over voltage test of lightning arrester
(x) Measurement of insulating resistance

(3) Coupling capacitor potential device (CCPD)

(i) Construction check
(ii) Impulse voltage withstand test(*)
(iii) Power frequency voltage withstand test
(iv) Polarity test
(v) Induced potential test(*)
(vi) Ferro-resonance test(*)
(vii) Accuracy test of potential device
(viii) High-frequency test
(ix) Transient response test(*)
(x) Measurement of capacitance and tangent of loss angle
(xi) Temperature rise test
(xii) Sphere gap spark-over voltage test
(xiii) Radio noise test

(4) Coupling Device

(a) Coupling filter
(i) Construction check
(ii) Impulse withstand voltage test(*)
(iii) Power frequency withstand voltage test
(iv) Temperature rise test(*)

(v) Discharge gap sparkover characteristic test
(vi) Composite loss test
(vii) Return loss test

(b) Line protective device
(i) Construction of device
(ii) Impulse withstand voltage(*)
(iii) Power frequency withstand voltage
(iv) AC voltage protection characteristics test
(v) Impulse voltage protection characteristics test
(vi) Attenuation loss

(c) Coaxial cable
(i) Construction check
(ii) Withstand voltage test(*)
(iii) Measurement of insulation resistance
(iv) Impedance test
(v) Attenuation test

(5) Power supply unit

(i) Construction check
(ii) Floating and equalizing charge function test
(iii) Efficiency test of charger(*)
(iv) Noise voltage test(*)
(v) Protective relay test
- For battery maximum voltage
- For battery minimum voltage
(vii) Voltage regulation test
(vi) Withstand voltage test(*)
(viii) Meter calibration check(*)
(ix) Temperature rise test of charger(*)
(x) Drooping current test
(xi) Battery capacity test
(xii) Measurement of insulation resistance

J.8.2 Test at Site

The following tests at site shall be carried out by the Contractor in the presense of the Engineer :

(1) PLC telephone terminal equipment

(a) Measurement of transmission loss

(b) Test on PLC terminal unit
- (i) Transmitting and receiving level measurement
- (ii) Automatic gain control characteristics
- (iii) General noise and crosstalk
- (iv) Frequency stability
- (v) Signal distortion
- (vi) Overall frequency characteristics
- (vii) Overload charcteristics
- (viii) Test speech check
- (ix) Alarm indication check
- (x) Level diagram

(2) 138 kV coupling capacitor potential device

- (i) Polarity check
- (ii) Voltage ratio

(3) Power supply unit

(a) Battery
- (i) Specific gravity of elecrolyte
- (ii) Level of electrolyte
- (iii) Check of voltage at each cell

(b) Battery charger
- (i) Construction check
- (ii) Charging voltages (floating and equalizing)
- (iii) Sequence test
- (iv) Alarm operation

SUBSECTION - K

INTAKE TRASH RACKS AND RAKE

K.1 GENERAL

K.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the site, installation/erection, commissioning and performance tests at the site of the following:

(1) Six (6) sets of fixed trash rack.

(2) One (1) set of rake and six (6) sets of its guide frame.

K.1.2 Trash Racks

Six (6) sets of the fixed type trash rack shall be provided for suction side openings of main pumps of the pumping station. The trash racks shall be designed to prevent matter, injurious to the pumps, from entering the suction pit and to adequately withstand the impact forces, static load and vibration phenomena which are likely to occur due to flow of water passing through the trash racks in 3.2 m^3/sec. per one opening. The trash rack shall be 6,000 millimeters wide by 7,300 millimeters high and the arrangement of the trash racks shall be as shown on the Drawings for Tender, Nos. 3-I-005 and 3-I-028.

K.1.3 Rake and Guide Frames

One (1) set of rake and six (6) sets of its guide frame shall be provided to assure positive removal of trash and debris from the faces of the trash racks. Due attachments shall be provided to connect the rake to the wire ropes of gantry crane described in Clause L.1.4 for operating the rake. The rake shall be provided with main and side rollers to guide the rake in the guide frames described in Clause K.4. Such rollers shall be located and sized to ensure that the rake is positioned for complete cleaning of the bar element surfaces of the trash racks.

The rake shall be operated by the gantry crane described in Clause L.1.4. The arrangement of the rake and its guide frames shall be as shown on the Drawings for Tender, No. 3-I-028.

K.2 DESIGN LOADS AND STRESSES

K.2.1 Design Loads and Conditions

(1) Trash Racks

(a) Bar Elements

i) The water load on a bar element shall be 2.25 kilograms per centimeter of length applied on the edge of the bar element.

ii) The trash rack shall be free from vibration under the given design conditions.

(b) Supporting Beams

The following loads shall be considered.

i) The reaction load due to water force on the bar elements.

ii) The load due to self-weight.

iii) The impact load due to rake operation.

(2) Rake

The rake shall be designed to withstand the dead weight and design load due to heaping full trashes of 2,000 kgs./6.0 m wide assuming a density equal to water. The rake shall also be designed to withstand all forces that may be imposed by trashes being wedged between the bucket and the trash rack, and to withstand all possible loads due to lifting force resulting from the maximum torque of the hoist motor of the gantry crane.

K.2.2 Design Stresses

The allowable stresses for steel members and concrete stresses shall conform to the requirements of Clause GS.6.1 of Part-I General Specifications, except that the bar elements shall meet the following requirements.

The stress in the bar elements shall not exceed the following critical stress.

$$\text{Critical allowable stress} = 0.6 \times \text{yielding stress} \left(1.23 - 0.0153 \frac{L}{t}\right)$$

where; L : Laterally supported length of bar element in centimeter, $L < 70\,t$

t : Thickness of the bar in centimeter (not considering corrosion allowance).

The thickness of the bar element shall be increased by 2.0 millimeters as corrosion allowance to the calculated thickness.

The frictional forces to be considered shall be those resulting from the frictional coefficient specified in Clause L.2.1.

K.3 DETAILED REQUIREMENTS FOR TRASH RACKS

K.3.1 General

Each trash rack shall consist of bar elements, supporting beams, and all other necessary components. The details of the construction of the trash racks not specified herein, will be left to the Contractor, but subject to approval of the Engineer. The trash rack panels shall be fixed on the supporting beams by using the stainless steel bolts, nuts and washers.

K.3.2 Bar Elements

The bar elements of the trash racks shall be of rectangular section, and minimum thickness of the bars shall not be less than 12 millimeters. The center-to-center distance of the bar elements (pitch) shall be kept in 75 millimeters plus or minus 2 millimeters by distance pieces. All bars shall be formed in to several panels by tie rods made of stainless steel to suit to the stainless steel fixing bolts, nuts and washers, and then fixed on the supporting beams forcibly to prevent vibration.

K.3.3 Supporting Beams

The supporting beams shall be of H-beam or built-up steel construction, and all or both ends of beams shall be embedded in the concrete. The maximum deflection of the supporting beams shall be less than 1/600 of the clear span.

K.4 DETAILED REQUIREMENTS FOR RAKE

The raking and dumping operation modes shall be capable of performing mechanically and controlled independently and/or jointly in combination with main and auxiliary hoisting equipment, so that such provisions shall be designed to be compatible with the facilities of the gantry crane of Clause L.1.4.

The rake bucket shall have rake prongs which shall project in between the trash rack bars, but shall adequately keep clearance between the distance pieces or transverse members of the trash racks. Sufficient clearance shall be provided to accommodate deflection of the rake and any deformation of the prongs.

The rake bucket shall have ample space to accommodate and hold the collected trash and debris during the raising and transfer operation. The bucket shall be so constructed as to easily tilt and dump with a reasonable operation speed, and completely discharge the contents onto truck, etc.

All sheaves and rotating joints shall have self-lubricated bronze bushing and washers.

The guide frames shall be provided on each side of the concrete piers to guide the rake. The guides shall be securely anchored to the concrete structure. The guiding surfaces shall be accurately installed so that the variation from the theoretical true plane shall not be greater than plus or minus 2 millimeters throughout every distance in 2.0 meters.

K.5 SPARE PARTS

Spare parts specified in Schedule - II A and those to be recommended in Schedule - II B in Volume-II shall be furnished by the Contractor duly.

K.6 SHOP ASSEMBLY AND TEST

K.6.1 Trash Racks

The trash racks shall be shop-assembled and checked for dimensions, tolerances and accuracy of alignment in accordance with the finally approved drawings. Any error or misalignment discovered shall be promptly corrected.

K.6.2 Rake

The rake shall be completely assembled in the Contractor's shop, in place on the crane of Clause L.1.3 and shall be operated to ensure that the rake operates with the gantry, and in accordance with the design particulars. The operational test shall be witnessed by the Engineer and the equipment shall be subject to his approval.

If any defect or improper operation is discovered, it shall be corrected and the entire test shall be repeated.

K.7 INSTALLATION

K.7.1 Trash Racks

The supporting beams shall be installed in their blockouts in accordance with the finally approved drawings, brought to line and grade within the erection tolerance specified and firmly secured in place. Alignment bolts or other necessary devices shall be used to install the supporting beams accurately. Placement of concrete in blockouts shall not proceed until the supporting beams have been completely installed and secured.

The trash racks shall be installed in accordance with the details shown on the finally approved drawings and the Engineer's instructions. Sampling inspection shall be made against the pitch of the bars in advance of installation.

K.7.2 Rake

The rake shall be operated at site to demonstrate that it conforms to the design particulars based on these specifications.

SUBSECTION - L

INTAKE GATES AND GANTRY CRANE

L.1 GENERAL

L.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the site, installation/erection, commissioning and performance tests at the site of the following:

(1) Two (2) sets of intake gates, and one (1) set of gantry crane and lifting beam.
(2) Six (6) sets of guide frame.

L.1.2 Intake Gates

Two (2) set of vertical lift, fixed wheel gate in 6.0 m wide by 3.0 m high shall be provided at the suction intake of the pump station to close the suction intake openings for inspection and maintenance purposes of pump and structures. The Contractor shall exercise special care in the design of the gates to avoid any water leakage under closed condition. The arrangement of the intake gates shall be as shown on the Drawings for Tender, Nos. 3-I-005 and 3-I-029.

L.1.3 Guide Frames

Six (6) sets of guide frame shall be provided for the intake gate by the Contractor. The arrangement of the guide frames shall be as shown on the Drawings for Tender, No.3-I-029.

L.1.4 Gantry Crane

One (1) set of conventional type gantry crane shall be provided on the intake structure to handle the intake gates of Clause L.1.2 and to operate the trash rack rake of Subsection - K. The crane will traverse along the intake structure slab at EL. 70.0 m, and shall have a modern, pleasing and functional outline, which shall subject to approval of the Engineer. The arrangement of the crane shall be as shown on the Drawings for Tender, Nos. 3-I-005 and 3-I-030.

L.1.5 Lifting Beam

One (1) set of lifting beam shall be provided to assist for handling one of the intake gates by the gantry crane of Clause L.1.4. The lifting beam shall be designed to have two-point engagement and lifting hooks for picking up or releasing the intake gate under the submerged water condition.

The lifting beam shall be capable of traveling within the same guide frames for the intake gate described in Clause L.1.2 by the gantry crane.

L.2 DESIGN LOADS AND STRESSES

L.2.1 Design Loads and Conditions

(1) Gates

The gates shall be designed for the following conditions.

(a) Water Load

Flood water at elevation (FWL)	:	69.000 meters
Sill beam at elevation	:	42.100 meters

(b) Raising and Lowering

The gates shall be capable of raising at 3.0 meters of the unbalanced head condition between up-and downstream side of the gate even though each suction pipe can be filled water by using balance pipe and valve provided inside the pump station, whereas the gates shall be lowered under the fully balanced head condition after due pump be completely stopped.

(c) Other Loads

Reaction due to its own weight. All loads imposed during starting, raising or lowering the gate.

(d) Overload Condition

All loads imposed during raising or lowering the gate, due to the overload hoist or gate jammed conditions.

(2) Guide Frames

The loading on the guide frames shall be the wheel and seal loads and other loads due to the most adverse operation of the gate and crane. The guide frames and

anchors shall be capable of transferring all loads form the main rollers, seals, side and front rollers of the gate to the concrete structure.

(3) Gantry Crane

The design of the crane shall be such that all movements take place smoothly and positively. No slipping or creeping of the loads shall occur at any time.

The crane shall be designed to hoist and travel with the heaviest load imposed by the lifting beam with the intake gate or the rake attached. The hoist shall be capable of starting and lifting the heaviest unit overwhelming the friction forces for which all units have been designed as described in Clause L.2.1 (1) and Subsection - K.2.1(2). For the purpose of designing the hoists, the starting and rolling friction of the " Oiles " bearings shall not be less than 0.2 and 0.1 respectively; the rolling friction of antifriction bearings shall not be less than 0.05, and the starting and sliding friction of the rubber seals on steel shall be 1.50 and 0.75 respectively, and those of steel on bronze, steel or stainless steel shall be 0.50 and 0.25 respectively. The auxiliary hoist shall have sufficient capacity to tilt the rake for dumping operation.

The crane shall be statically stable by itself under any operating condition, without temporary ballasting or rail clamping. It shall be designed for a wind pressure of 300 kilograms per square meter, acting on the horizontally projected surface of the crane in any direction at the rest position and/or not in operation condition. The crane shall be stable with a wind pressure of 40 kilograms per square meter, acting on the horizontally projected surface of the crane and the fully raised gate or rake in any direction during hoisting and/or traveling operation.

The crane shall be designed to move under the rated loads and wind pressure at the following speeds within plus or minus 10 per cent.

1) - Main hoist	:	1 meter per minutes
2) - Auxiliary hoist	:	A reasonable speed for rake tilting operation
3) - Trolley travel	:	10 meters per minute
4) - Gantry travel	:	10 meters per minute

The bottom height of the gate maximum raised shall mean at least 0.5 m above the deck EL.70.0 m, while those for the rake being suitable for dumping the trashes onto 4.0 tons class long body truck. The traveling length of the gantry crane shall be more than an area to cover handling operation of the gate and/or rake mentioned above, including those for crane rest position and crane assembly yard.

(4) Lifting Beam

The lifting beam shall be designed to lift the dead-weight of, plus all frictional load due to the gate. The lifting beam shall withstand all loads imparted to the beam under the condition that it becomes jammed in one of the guide frames.

The lifting beam shall be designed as the strongest member in the lifting assembly.

L.2.2 Design Stresses

(1) Structural Steel Members

The allowable stresses for normal loading of structural steel members and concrete stresses shall conform to the requirements of Clause GS.6.1 in Part-1 General Specifications, provided that :

(a) For allowable stress in case of plate thickness exceeding 40 mm, it should be reduced by 0.92 time.

(b) The allowable stresses in case of overloading condition and/or the combined stress resulting from combination of biaxial stress or triaxaial principal stress may be increased by 50 percent than those for normal loading condition. In no case, however, shall any stresses exceed 90 percent of the yield point strength and/or minimum elastic limit of the steel material used.

The combined stress shall be calculated with the following formula as developed by Mises Hencky Huber:

$$fg^2 = fx^2 + fy^2 - fx \cdot fy + 3fq^2$$

where,

fg : combined stress (kgf/cm^2)
fx : direct stress (tension is considered as positive) (kgf/cm^2)
fy : direct stress acting perpendicular to axis of fx (tension is considered as positive) (kgf/cm^2)
fq : shearing stress (kgf/cm^2)

(c) The minimum thickness of major structural steel members shall be of 8 millimeters. The critical slenderness ratio of major and secondary compression members shall be less than 120 and 150 respectively.

(2) Machine Parts

The allowable stresses for all mechanical parts of the gate and hoist subjecting to normal loading condition or rated capacity loading condition shall conform to the requirements of Clause GS.6.1 in Part-1 General Specifications, provided that:

(a) The allowable tensile of gray iron castings and bronze castings shall have factors of safety of ten (10) and eight (8) respectively against the ultimate strengths.

(b) Unit stress shall not exceed ninety (90) per cent of yield strength of the materials to be used under loading condition resulting from the maximum torque of the hoist motor.

L.3 DETAILED REQUIREMENTS FOR GATES

L.3.1 General

The gates shall consist of skin plate, main beams, wheel assemblies, seals, side rollers, front rollers and all other necessary components. The gate shall be of fixed-wheel gate type and of all welded construction, except that the high-strength friction grip bolts and reamer bolts shall be used for all field connections other than the skin plates splices. All cuttings, chamfering and other necessary preparations of each segment for field connections shall be done in the shop. Adequate temporary bolts and nuts shall be provided to hold sub-assemblies rigidly and in proper alignment during field erection. The openings for the gate shall be 6.0 meters wide by 3.0 meters high. The details of construction of the gates, not specified herein will be left to the Contractor, but subject to approval of the Engineer.

L.3.2 Skin Plates

The skin plates shall be located at the pump side of the gate. The thickness of skin plates shall include a corrosion allowance of 1.0 millimeter at both sides (due to not always submerged condition) and shall be not less than 14.0 millimeters.

L.3.3 Main Beams

The main horizontal beams shall be of H-beam or built-up plate girder construction. The deflection of the main beams shall be less than 1/1,000 of the supporting span of the gate under full load condition.

L.3.4 Wheel Assemblies

The wheel assemblies shall consist of wheel, shaft, bushing and all other necessary components. The wheel shall be cast steel or other approved materials. The wheel bushings shall be of "Oiles" metal type. To provide a true alignment of the whole wheel treads, the journal surface of the axle shall be eccentrically located with respect to its end supports, so that all wheels will contact uniformly on and distribute the water loads safely to the track frames. The wheels shall be machine-finished and hardened to the value rather lower than the Brinell Hardness Numbers of track frame surface of the guide frames.

L.3.5 Seals

Seals shall be made of natural or synthetic rubber suitable for the temperature ranges and conditions at the Site and shall be of a material that has proven successful in similar applications. Seal materials shall have the following physical properties as determined by the tests made in accordance with the relevant Standard (s):

(1)	Tensile Strength	:	210 kgf/cm^2 minumum
(2)	Ultimate Elongation	:	450 percent minimum
(3)	Durometer Hardness (Shore, Type A)	:	60 to 70
(4)	Specific Gravity	:	1.1 to 1.3
(5)	Water Absorption (70 ° C for 48 hours)	:	5 percent maximum by weight
(6)	Compression Set (as a percent of total original deflection)	:	30 percent maximum
(7)	Tensile Strength after oxygen bomb aging for 48 hours at 70 ° C	:	80 percent minimum of tensile before aging
(8)	Adhesion of metal insert to rubber		
	- Shear test	:	16 kgf/cm2
	- tenstion test (90 ° C to axis)	:	2 kgf/cm2

The gate seals shall be of the molded rubber shapes clamped to the pump side face of the gate by means of steel bars and corrosion-resisting steel bolts, nuts and washers. The seals shall be spliced at the corners by shop vulcanizing to provide a single continuous seal. The tensile strength of all shop slices shall be not less than 50 per cent of the tensile strength of the unspliced material.

The side and top seals shall be of music note or other shape activated by the upstream water pressure. The bottom seal shall be a plain bar of rubber which shall bear on the sill beam. The weight of the gate shall be transmitted to the sill beam through the skin plate.

L.3.6 Side Rollers

Two side rollers shall be provided on each side of the gate, to limit the lateral movement of the gate. The rollers shall be provided with "Oiles" metal bushing and washers. If the rollers are flanged to restrain the gate from moving in horizontal direction, the bushing inserted in the rollers shall have an integral thrust shoulder to transmit the resulting load. Each roller and pin shall be designed to resist the imposed load due to the gate becoming jammed in the guide frames.

L.3.7 Front Rollers

The gate shall be fitted with two front rollers on each side of suction pondage side of the gate for complete watertight under balanced head condition at fully closed position.

L.3.8 Lifting Attachments

The gate shall be fitted with two lifting lugs centered on the top of the gate. The attachment shall be designed to ensure that the linkage mechanism of lifting beam can catch and release on the pins of lifting lugs.

L.3.9 Tolerances

Tolerances for the alignment of roller and for roller paths and sealing surfaces shall be selected to prevent overstressing of the gate parts and to effect watertight seal. Tolerances for machined and fitted parts shall comply with the requirements of these Specifications. All tolerances and means of adjustment shall be defined on the Contractor's drawings, but subject to the Engineer's approval.

L.4 DETAILED REQUIREMENTS FOR GUIDE FRAMES

L.4.1 General

Each of six (6) guide frames shall consist of sealing frames, lintel beam, sill beam, track frames, side guide frames, front guide frames and all other necessary components. The guide frames shall include two (2) sets of dogging device for supporting the gates at the top of the guide frame at EL. 69.0 m. The bottom of guide frames shall form so as not to heap with silt or sand, so that the intake gate can make complete watertightness smoothly.

The details of construction of the guide frames not specified herein, will be left to the Contractor but subject to approval of the Engineer.

L.4.2 Sealing Frames

The sealing frames shall consist of corrosion-resisting steel plates attached to the two side guide frames, lintel beam and sill beam.

When the guide frames have been assembled, the sealing surfaces shall be straight, true and in the same plane, within a tolerance of plus or minus 1.0 millimeter per 3.0 meters. The minimum thickness of the sealing plates shall be 6 millimeters.

L.4.3 Lintel Beam

The lintel beam shall be true to form and free from twist and warps to provide a watertight seal with the gate top seal.

L.4.4 Sill Beams

The sill beam shall be straight and true providing a close fit with the bottom of the gate and to carry the weight of the gate. The sill beam shall be conservatively designed to be able to transfer all loads applied on it to the concrete structures, without any deflection.

L.4.5 Track Frames

The track frames shall be capable of transmitting the water load from the fixed main rollers of gate to the concrete structures. The upstream surface of track frames shall be true and flat. The deviation of the surface from the theoretical plane shall not exceed plus or minus 0.5 millimeters in any 3 meters length throughout the distance up to EL. 50.6 m from the sill. Both paths shall deviate in the same direction to maintain parallel paths. The surface shall be suitably machined and hardened to prevent excessive wear.

L.4.6 Side Guide Frames

The side guide frames shall extend up to the embedded frames of gratings, while up to EL. 69.0 m for Nos. 1 and 4 units, and have ample strength to resist the load from the side rollers of the gate. The variation from the theoretical true plane shall not be greater than plus or minus 2 millimeters throughout the total length in order to guide the gate properly during operation. No offset shall exist at each joint.

L.4.7 Front Guide Frames

The front guide frames shall extend up to EL. 50.6 m and have ample strength to resist the load form the front rollers of the gate. The variation from the theoretical true plane shall not be greater than plus or minus 2.0 millimeters throughout the total length in order to guide the gate properly during operation. No offset shall exist at each joint.