ODISHA POWER TRANSMISSION CORPORATION LIMITED

OFFICE OF THE SR. GENERAL MANAGER,

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TECHNICAL SPECIFICATION

FOR

SUB STATION LIGHTING

SUBSTATION LIGHTING

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1. GENERAL

The scope comprises design, engineering, supply, installation, testing and commissioning of the following:

- Complete installation and lighting fixtures complete with lamps, supports and accessories;For indoor and outdoor
- Ceiling fans complete with electronic regulators, accessories;
- lighting panels and lighting poles complete with distribution boxes;
- Galvanised rigid steel conduits and fittings, lighting PVC ables GI Earth wire receptacles, switchboards, switches, junction boxes, pull out boxes complete with accessories;
- Lighting transformer.
- Any other items required to complete the indoor and outdoor lighting in complete shape.

The details of area to be illuminated are given in Table 1. along with the required lux levels.

Area	Lux
Control Room	350
PLCC Room	300
LT Room	150
Charger Room	150
Cable Gallery	150
Heating Plant	100
Battery Room	100
Computer Room	300
Entrance lobby	150
Corridor and landing	150
Conference and display	300
Rest Room	250
AHU Room	100
DG Set Building	150
Fire Fighting Pump House	150
Switchyard - Main equipment	50
Switchyard - general equipment and balance	30
Street/Road	30

Table 1. Areas to be lit and required lux levels

Contractor shall submit detailed calculation for verifying that the required lux levels will be attained by the proposed lighting system

Any material, cables, wire, conduits, fittings, accessories etc. whether mentioned specifically or not but required for installation of lighting fixtures are included in the scope of Contractor.

1. SYSTEM DESCRIPTION

1.1 Normal lighting - AC

AC lights will be connected to AC lighting panels. All the lights connected to the AC lighting system in different areas will be connected to the main lighting distribution boards to be supplied.

1.2 Emergency lighting - AC

This system will be available in control room building, switchyard and diesel generator building. AC lighting load will be connected to this system which will be normally óONô. The lighting panels of this system will be connected to the Emergency lighting board which is fed from diesel generator during the emergency.

1.3 Emergency lighting - DC

DC emergency lighting fixtures operated from the DC system shall be provided in strategic locations so that the operating personnel can safely find their way during a total AC failure. These lights will be normally **'OFF'** and will be switched **'ON'** automatically when under voltage occurs in the AC mains lighting distribution board.

1.4 Emergency lighting - portable

Emergency portable light shall be provided as per relevant clause of this section. Three portable lights for control room and two portable lights for PLCC room shall be provided for every substation.

1.5 Temperature Rise

All lighting fixtures and accessories shall be designed to have a low temperature rise according to IEC 598 Part-I/ IS 10322 (Part-4).Temperature rise of panels should be as per IS 8623 (Part-l)/IEC 439-1.

2. LIGHTING FIXTURES

2.1 General

Fixture shall conform to latest IS / IEC .and its latest amendment.

All fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.

All lighting fixtures shall be complete with required lamps such as LED (to be fitted inside switch yard and all street light), & LED light (adopt as per Govt nerms for energy efficiency) for indoor lighting..

LED lamp fixtures shall be complete with all necessary wiring and accessories such as ballasts, ignitors, power factor improvement capacitors etc if required. These shall be mounted in the fitting assembly only. The Contractor shall indicate starting time of these lamps to attain full light output. Curves for starting characteristics with varying supply voltage etc. are to be furnished by the Contractor.

Flood lighting shall have suitable base plate/frame for mounting on structural steel member.

Each fixture (other than bulk head fixtures) shall have terminal blocks suitable for 2.5 mm^2 stranded flexible copper conductor. The internal wiring should be completed by the manufacturer and terminated on the above terminal blocks. The Contractor shall specifically furnish details of internal size of wires and type of insulation. The terminal blocks shall be as specified under General Equipment and Substation Accessories (GESA) section of this Specification.

Each lighting fixture shall be provided with an earthing terminal suitable for connection to 16 SWG GI earthing conductors.

All metal or metal enclosed parts of the housing shall be suitably constructed so as to ensure satisfactory earthing continuity throughout the fixture up to the earthing terminal.

The mounting facility and conduit knock-outs for the fixtures shall be provided and shall be suitable for 20 mm conduit entry.

On completion of manufacture, all surfaces of the fixtures shall be thoroughly cleaned and degreased. The fixtures shall be free from scale, rust, sharp edges and burrs.

The housing shall be stove-enamelled or vitreous enamelled or anodised aluminium as indicated in the specification of the relevant fixture.

All enamel finishing shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 degrees. over 1.5 inch die mandrel.

All light reflecting surfaces shall have optimum light reflecting coefficient so as to ensure the overall light output as specified.

The different types of lighting fixtures to be provided shall be to the approval of the OPTCL.

REMARKS: ALL THE LAMPS TO BE USED INSIDE & OUTSIDE THE SUB-STATION AREA SHALL BE OF "LED" ONLY. BIDDERS ARE ADVISED TO QUOTE ACCORDINGLY.

2.2 Accessories

2.2.1 Reflectors

The reflectors shall be manufactured from sheet steel or aluminium more applicable of not less than 22 SWG thickness. They shall be securely fixed and of captive type.

2.2.2 Lamp holders

Lamp holders shall preferably be for LED lamps etc.. Holders shall be designed and manufactured in accordance with relevant standard to give long and satisfactory service.

2.2.3 Ballasts(if required)

Ballasts shall be designed, manufactured and supplied in accordance with IS 3021 and function satisfactorily under site condition specified. The ballasts shall be designed to have a long service life. The power loss in ballasts (if required)for LED lamps shall not be more than the specified watts as per relevant standard and for the fluorescent lamps it shall be the minimum commercially available in the industry.

Ballasts shall be mounted using self locking anti-vibration fixing and shall be easy to remove without dismantling the fixtures. They shall be totally enclosed units.

The ballasts shall be of the inductive, heavy duty type, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. The ballast wiring shall be of copper wire. Ballasts shall be designed for maximum winding temperature rise of 55C under rated conditions. They shall be free from hum. Ballasts for LED lamps shall be provided with suitable tapping to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure.

Separate ballasts for each lamp shall be provided in case of multi-lamp fixtures.

The Contractor shall submit general arrangement and wiring diagram with all terminal details for approval of the OPTCL.

2.2.4 Capacitors

Capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

Capacitors shall be suitable for operation at the supply voltage as specified and shall have a value of capacitance so as to correct the power factors of its corresponding lamp circuit to the extent of 0.98 lag.

Capacitors shall be hermetically sealed in a metal enclosure.

2.2.5 Lamps

The LED lamps to be supplied shall conform to IS 9974. LED lamps shall be suitable for use in any position. Restrictions, if any, shall be clearly stated. The lamps shall be capable of withstanding small vibrations with out breakage of connections at lead-in wires and filament electrodes.

The constructional features of LED lamps for special applications shall be clearly brought out in the bid.

The Bidder shall furnish typical wiring diagrams for all fittings including all accessories. The diagrams shall include technical details of accessories i.e. ignitors, ballasts, capacitors etc.

2.3 Receptacles

All receptacles shall be of cast steel or aluminium, heavy duty type, suitable for fixing on wall or column and complete with individual switch.

In general the receptacles to be installed are of the following types:

- Type RO-15A, 240V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having cable gland entry suitable for 2 core 6 mm^2 PVC armoured cable and a metallic cover fixed to it with a metallic chain. Receptacles shall be suitable for installation in moist location and/ or outdoor. The switch shall be of rotary type. Receptacles shall be housed in an enclosure made out of 2 mm thick GI sheet with hinged doors with padlocking arrangements. Door shall be lined with good quality gaskets. This shall conform to IP 55.

- Type RI-Combination of 5A and 15A, 240V, 3 pin type with third pin grounded, suitable for flush mounting. The switch shall be of piano key type and shall be flush mounted.

- Type RP-63A, 415V, 3 phase, 4 pin interlocked plug and switch with earthing contacts. Other requirements shall be same as type RO. The receptacle shall be suitable for 3½ core 35mm^2 / 3½ core 70mm^2 aluminium conductor cable entry and shall also be suitable for loop-in-loop-out connection of cables of identical size. Receptacle shall be suitable for outdoor application. Receptacles shall be housed in a box made out of 2 mm thick G. I. sheet, with hinged door with padlocking arrangement. Door shall be lined with good quality gaskets. This shall conform to IP 55.

3. LIGHTING POLES

The Contractor shall supply, the following types of hot dip galvanised steel tubular lighting poles required for street lighting:

a) Type Al street lighting pole - for one fixture

b) Type El post top lantern pole - for one fixture

Street/flood light poles shall conform to the drawings approved by the OPTCL.

Lighting poles shall be complete with fixing brackets and junction boxes. Junction boxes should be mounted above ground level at 1 mtr height from the ground.

The lighting poles shall be steel hot dip galvanised

The galvanised sheet steel junction box for the street lighting poles shall be completely weather proof conforming to IP 55 and provided with a lockable door and HRC fuse mounted on a fuse carrier and

fuse base assembly. The terminals shall be stud type and suitable for two nos. 16mm^2 cables. Necessary arrangement for cable glands along with supply of double compression glands are included in Contractorôs scope.

Wiring from junction box at the bottom of the pole (minimum height from the bottom of the pole shall be 1.0mtrs) to the fixture at the top of the pole shall be 2.5 mm^2 wire.

4. LIGHTING WIRES & CABLES

The wiring used for lighting shall be of 1100V grade, PVC insulated cable of standard products of reputed manufacturers.

The conductor sizes for wires used for point wiring beyond lighting panels shall be single core 4 mm^2, 6mm^2 and 10mm^2 stranded aluminium wires and 2.5 mm^2 stranded copper wire.

The wires used for connection of a lighting fixture from area rest junction box or for loop-in loop-out connection between two fluorescent fixtures shall be single core copper stranded conductor, 1100V grade flexible PVC insulated cords, unsheathed, conforming to IS 694 with nominal conductor cross sectional areas of 2.5mm^2.

The Contractorôs scope covers supply of all wiring, cabling and accessories.

The wires shall be colour coded as follows:

- Red for R - Phase
- Yellow for Y - Phase
- Blue for B - Phase
- Black for Neutral
- White for DC (Positive)
- Grey for DC (Negative)

5. TESTS AND TEST REPORTS

Type tests, acceptance tests and routine tests for the lighting fixtures and accessories covered by this specification shall be carried out as per the relevant standard for the respective fixtures and their accessories.

Manufacturerôs type and routine test certificates shall be submitted for the fixtures and accessories. Type test certificates shall be furnished along with the bid.

Rates for type tests for all types of fixtures and accessories for light fittings as required under relevant section of this specification shall be provided in the relevant price schedules.

6. LIGHTING SYSTEM INSTALLATION WORKS

6.1 General

In accordance with the specified installation instructions as shown on manufacturerôs drawings or as directed by Project Manager. Contractor shall supply, erect, install, test and put into commercial use all the electrical lighting equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Tolerances shall be as established in manufacturerôs drawings or as stipulated by Project Manager.

The Contractor shall prepare the lighting layout and erection drawings and obtain the Project Managerôs approval before commencing the erection works.

6.2 Flood lights.

Contractor shall install flood lights on switchyard structures to be erected inside switchyard. The GI structural are also suitable for protection from lightening by providing spikes cones at all the column peak. Proper design in this respect to be carried out along with numbers of such towers required. Plotting of lightening protection area showing details of equipment installed in switch yard. A platform provided in the mast tower shall be used for fixing of lighting fixtures.

Fixtures shall be mounted on galvanised making use of shop provided holes or by suitable clamps. No cutting or drilling of galvanised structure is permitted.

The Contractor shall mount the assembled fittings and install necessary cabling.

6.3 Lighting fixtures for flood lights

Flood lights shall be mounted on steel base facing the tentative direction shown on drawings. Fixing holes shall be provided with slot to turn the fixture by approximately 5 degrees on both sides. Bolts shall be finally tightened with spring washer. The Contractor shall supply and install the steel base, channels, angles etc. for fixing the flood light on the flood light towers. Terminal connection to the flood light shall be through flexible conduits, and these flexible conduits shall be included in the installation rate of fixture itself.

The scope of Contractor shall include the supply of necessary brackets and sundry material, for installation of lighting fixtures.

6.4 Lighting panels

Lighting panels shall be erected at the locations to be indicated in the approved drawings.

Necessary foundations and/or supporting structures for all outdoor type lighting panels and necessary supporting structures for indoor lighting panels shall be provided by the Contractor.

6.5 Street lighting poles

Street lighting poles shall be installed as per the approved drawings.

Steel tubular hot dip galvanised pole,s which are specified for the above purpose are to be installed as per the approved lay out for street lighting system. Contractor shall erect the poles (including foundation works), mount the assembled fittings and install necessary cabling.

7. TECHNICAL PARAMETERS OF LIGHTING TRANSFORMERS

i)	Type of transformer	Dry type natural air
ii)	Rating	1 00 kVA or 75kVA
iii)	Voltage ratio	415/415 volts
iv)	No. of phase	Three
v)	Frequency	50Hz
vi)	Winding connection	Dyn 1
vii)	Class of insulation	B class
viii)	Percentage Impedance	4%, ±10%
ix)	No. of taps and steps	5 in steps of 2.5%
x)	Reference standard	IS 2026
xi)	Any latest amendment standards of the above.	

Transformers shall be located in ACDB room, in separate enclosure. Enclosure shall have degree of protection not less than IP 42 as per IS 2147.

8. EMERGENCY PORTABLE LIGHTING FIXTURES

The portable emergency lighting fixtures supplied shall have a built in battery rated for six hours and be complete with battery chargers and solid state inverters, and be supplied with all necessary supporting brackets of galvanised steel suitable for wall/column mounting..

The portable emergency lighting fixtures shall be of a single unit, completely tropicalised, suitable for prolonged use with no maintenance, and shall light up automatically in the event of failure of normal supply.

The Contractor shall submit schematic along with all details and general arrangement drawing for approval.

9. CEILING FANS AND REGULATORS

The Contractor shall supply 1400 mm sweep ceiling fans complete with electronic regulator and switch, suspension rod, canopy and accessories.

The Contractor shall supply the switch, electronic regulator and board for mounting switch and electronic regulator.

Winding of the fans and regulators shall be insulated with Class-E insulating material. Winding shall be of copper wire.

Electronic regulator with smooth control shall be provided.

Precautions shall be taken in manufacture of fans and regulators to ensure reasonable degree of silence at all speeds.

Type tests, acceptance tests and routine tests for the fans and regulators shall be carried out as per latest relevant standard.

Fans and electronic regulators shall be from established manufacturers or brands.

10. FOUNDATION AND CIVIL WORKS

All foundations and civil works shall be included in the Contractorôs scope of work. Civil works shall be in accordance with the relevant part of this specification.

11. GROUNDING

All lighting panels, junction boxes, fixtures, conduits etc. shall be grounded in compliance with the provision of I.E. Rules.

Ground connections shall be made from nearest available station ground grid. All connections to ground grid shall be done by arc welding.

Lighting panels shall be directly connected to ground grid by two 50 x 6mm G.S. flats.

A continuous ground conductor of 16 SWG GI wire shall be connected to each panel ground bus. All junction boxes, lighting fixtures shall be connected to this 16 SWG ground conductor.

All lighting poles shall be earthed as per standard. 16 SWG GI wire shall be taken up to junction box from the lighting fixture.

12. TESTING AND COMMISSIONING

On completion of erection work, the Contractor shall request the OPTCL to undertake the inspection as required by this Specification.

The OPTCL shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Contractor.

The installation shall be tested and commissioned in the presence of the Contractor and OPTCL

The Contractor shall provide all men, material and equipment required to carry out the tests.

All rectification, repairs or adjustment work found necessary during inspection, testing and commissioning shall be carried out by the Contractor, without any extra cost to the Employer.

The Contractor shall measure and furnish to the Project Manager, the actual lux level in all the areas of the substation to prove compliance to this specification.

**** Armoured PVC cables are to be used for the switch yard lighting, street lighting and any other out door lighting system.**

**** For indoor lighting ,each fixture shall be controlled by one switch.**

**** Minimum two nos 5 Amp multi purpose power sockets with switch are to be provided in each switch.**

***** Contractor to furnish the design details for the locations (like Switch yard area,Road street light,Control room building area,Quarter ,Gate etc), which can be adopted after approval from OPTCL. Design to be carried out as per the LUX level indicated at the beginning of this chapter.**

TECHNICAL SPECIFICATION FOR LED FLOOD / NORMAL LIGHT FITTINGS 1 PH A.C OPERATION

1.GENERAL DESCRIPTION

LED Flood/Normal Light luminaries of 240V, A.C,50 Hz ,suitably decided the wattage of the lamp (to be decided after detail Engineering) in Single piece High Pressure Die Cast Aluminium alloy Housing having high conductivity acting as heat sink, with Powder coating with suitable colour with distortion free, clear, Heat Resistant Toughened UV stabilized Glass in the front fixed to the die cast Aluminium frame which shall be fixed to the housing with high quality long lasting Neoprine Rubber gasket duly impregnated with insecticide and water repellant chemical on the periphery of lamp compartment by means of stainless steel screws to render it dust proof, water proof and vermin proof and having minimum IP-65 Protection conforming to IS:10322 (part-2) ï 1982.

Note: The capacity LED Luminary is to be suitably decided after conducting the detail Engineering for the locations , where these Luminaries are to be used. The Locations are generally in EHV grade Sub-station switch yard area,Street Lighting, Control Room Building, Colony Quarters etc. Details design for adoption of LED Luminary system to be furnished for review of design and its acceptance. Latest practice of adoption of these system are to be strictly followed.

2. TRAINING :

Train the staff on Hardware /Software ,installation, commissioning and maintenance of the Luminaries at different locations (Different Sub-stations).

3. TECHNICAL SPECIFICATIONS:

The LED Luminaries are as per the following parameters

a	**Mid Power White LED's**	Should be of reputed make as indicated in the Tender specification.
b	Wattage of Mid Power White LED,s offered	Low power LED 5252 0.3W
c	LED Lumens	
d	Life span as per LM70(@70%) light output	>50000 Hrs. 0r Better
	Lux at centre at height of 4.5 meter	>150 LUX 0r Better
e	Uniformity Ratio(Emin./Emax.)(mounted at 4.5m height @90 Angle)	>0.35 0r Better
f	Luminary Efficacy	>65 0r Better
g	Control of Distribution	Fully Cutoff
i	Driver current(With Constant Current Driver)	<100mA/LED 0r Better
j	**Electronic** Efficiency@230V	**>85% 0r Better**
k	Beam angle of the Luminary	> 120° 0r Better

l	color Temperature of LEDs	6500K to 7500K 0r Better
m	P/N junction temperature (High thermal conduction must be achieved by silicon heat conducting greases as adhesive	<85 ºC 0r Better
n	Luminary Body Temperature	The Body Temperature shall be <(Ambient+35º C) even after continuous burning of Luminary for 24 Hrs.**0r Better**
o	color Rendering Index(CRI)	>70 **0r Better**
p	weight	Preferably less weight & may be of Maximum up to 4 Kgs (comfortably can be carried and fixed)
B	**ELECTRICAL**	
a	AC Input Voltage Range	100V TO 270V AC
b	AC Input frequency .(The LED circuitry shall function at an operating frequency that must be greater than 120 Hz to prevent perceptible flicker to the unaided eye over the entire voltage range specified above.)	47 ~ 53Hz
c	Power Factor (Source Power Factor varies from 0.5 Lag to 0.5 Lead)	> 0.95 **0r Better**
d	Luminary Wattage variance at 100 V to 270 V	± 10%
e	Luminary Lux Levels Variance at 100 V to 270 V	± 5%
f	Total Harmonic Distortion(THD)	< 15% **0r Better**
g	Electrical Connection System	3 wire system (Phase,Neutral & Gnd)
h	System of earthing (The luminaries offered shall conform to Level-1 classification)	Solidly grounded
i	There shall be electrical isolation between input and output circuits of the driver.	
C	**MECHANICAL**	
a	Construction of Casing	High Pressure Die Cast Aluminum. Should be durable for extreme climatic
b	Finish	Powder Coating and gray/black color and should be durable. The colour should not fade in extreme climate conditions.

c	Heat Sink type (It shall be designed in such a way that the heat generated within the LED source is efficiently dissipated to the surrounding atmosphere without abnormal rise in temperature. Any debris build up shall not degrade heat dissipation performance of the luminaries.	Aluminium Metal Core PCB
d	Lamp Cover	Toughened Glass or any suitable material which can be used in the extreme climate and should be durable
e	Gross Weight and Dimensions (L x W x T) mm of Luminaries (Efforts shall be made to keep the overall outer dimensions as minimum as possible with out compromising on the performance, mainly thermal management of the luminary)	
f	Heat Dissipating Area (Luminary Rating wise)	
g	IP Level ï Minimum IP 65	

18W AC DOWN LIGHT

DATASHEET

Applications :

Area: Indoor
Purpose: Home and Office Lighting.

Features:

(1) Optical

- » Optical pattern meets all standard Home and Office Light Standards.
- » Uniform illuminance distribution.

(2) Power

» Switched mode constant current power supply.
» Over-heat, Over-voltage, Over-current protections are provided.
» Lightning Protection provided.

(3) Thermal

» Luminaire surface temperature is 48°C @ Ta=30°C, the temperature variation is controlled under 5°C.
» Junction temperature is controlled ot 70°C @ Ta=30.
» Overheat protection will operate to adjust as the LED module surface reaches 80°C.

(4) Luminaire

» Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
» Dust and water protection design meeting IP65 standards.
» Super-high luminaire efficacy.

DETAILED TECHNICAL SPECIFICATION

Electrical Characteristics:

PARAMETER	DRIVER RESULT
Input Voltage	160 -300 V AC
Rated Power	18Watt
Maximum Power	21Watt
Efficiency	>85%
Power Factor	>0.9
Voltage Harmonics (THD)	<5%
Current Harmonics (THD)	<10%

Operating Conditions:

Operating Frequency	100kHz to 200KHz
Operating Temperature Range	-25°C to +70°C
Storage Temperature Range	-65°C to 125°C
Humidity	95% RH

LED Details:

Led Make	As per approved vendor
No Of LEDs	12
Led Viewing Angle	120º by using reflector
Colour Temperature	Cool White (5500 to 6500K)

Luminous Flux	>2160 Lumens
Life Span	> 80,000 Hours
Colour Rendering Index	>70 Ra

LED Luminary Details:

Body	Alluminium Body
Heat Sink	Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
Dust and Water protection	IP 65 Standards

Protection Parameters:

Over-Current Protection	Inbuilt
Short-Circuit Protection	Inbuilt
Over-Voltage Protection	Inbuilt
Over-Temperature Protection	135 °C
Dust and Water Protection	IP 65
Lightning Protection	Inbuilt

50W AC LOW BAY LIGHT

LED bay light fixture is designed and developed to replace traditional high bay or low bay fixtures for industrial and other rugged applications. Light weighted and easy for installation, the LED High Bay/Low Bay fixtures are all designed to offer maximum energy saving, substantially reduced maintenance costs and superior quality.

Major Applications :

Factory production floors, Workshop, Warehouses, Road toll gates, Petrol stations, Supermarkets, Sports stadiums, Convention center halls, Airport passenger halls, etc., where high ceiling lighting required.

Features :

1)Low power consumption. More than 60% energy saving compared to conventional HID/HPS.

2) Environmental friendly. Lead and mercury free. Long operation life time, above 50,000hours. Low maintenance costs.

3)Voltage input 160-300 V AC,

4)Instant ON/OFF operation.

5)Superior color rendition compared to conventional industrial luminaries.
6)Selectable color temperature.
7)Single piece 30W-100W high power LED light source with unique multi-chip integration design ensure high light purity, high heat conduction and slow brightness derating.
8)Unique heat sink design ensures superior heat management.
9)Resistant to shock and vibration.

Specifications :

Input Voltage	AC 160-300V
Power Frequency of Driver	47～63Hz
Power Efficiency of Driver	Ó85%
LED Power Consumption	50w
Power Factor(PF)	Ó0.90
Total Harmonic Distortion	Ò10%
Luminaries Efficiency	Ó90%
Flux (Lumens)	4000
Color Rendering Index	Ó80
Color Temperature	2700～7000K Optional
Beam Angle	90/120 Degree Optional
Light Effect	70～80lm/W
Working Ambient Humidity	-25℃～+45℃
Working Ambient Humidity	15%～90%RH
IP Rating	IP30/IP54 Optional
Service Life	Ó50000 Hours
Light Fixture Material	Aluminum Alloy

100W AC LED STREET LIGHT

DATASHEET
Applications :
Area: Outdoor
Purpose: Street and Roadway Lighting.

Features:
(1) Optical

» Optical pattern meets all standard Street Light Standards.
» Uniform illuminance distribution.

(2) Power

» Switched mode constant current power supply.
» Over-heat, Over-voltage, Over-current protections are provided.
» Lightning Protection provided.

(3) Thermal

» Luminaries surface temperature is 48°C @ Ta=30°C, the temperature variation is controlled under 5°C.
» Junction temperature is controlled ot 70°C @ Ta=30.
» Overheat protection will operate to adjust as the LED module surface reaches 80°C.

(4) Luminaire

» Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
» Dust and water protection design meeting IP65 standards.
» Super-high luminaire efficacy.

DETAILED TECHNICAL SPECIFICATION

Electrical Charatcteristics

PARAMETER	PROMPT DRIVER RESULT
Input Voltage	160 -300 VAC
Rated Power	100W
Maximum Power	115W
Efficiency	>85%
Power Factor	>0.9
Voltage Harmonics (THD)	<5%
Current Harmonics (THD)	<10%

Operating Conditions:

Operating Frequency	100kHz to 200KHz
Operating Temperature Range	-25°C to +70°C
Storage Temperature Range	-65°C to 125°C
Humidity	95% RH

LED Details:

Led Make	As per approved vendor
No of LEDs	48-70
Led Viewing Angle	120º by using reflector
Colour Temperature	Cool White (5500 to 6500K)
Luminous Flux	>8500 Lumens
Life Span	> 50,000 Hours
Colour Rendering Index	>70 Ra

LED Luminary Details:

Body	Alluminium Die casting Body

Heat Sink	Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
Protection	IP 65 Standards for Dust and Water

Protection Parameters:

Over-Current Protection	Inbuilt
Short-Circuit Protection	Inbuilt
Over-Voltage Protection	Inbuilt
Over-Temperature Protection	135 °C
Dust and Water Protection	IP 65
Lightning Protection	Inbuilt

120W AC LED FLOOD LIGHT

DATASHEET
Applications :
Area: Outdoor
Purpose: Street and Roadway And Area Lighting.

Features:

(1) Optical
- » Optical pattern meets all standard Street Light Standards.
- » Uniform illuminance distribution.

(2) Power
- » Switched mode constant current power supply.
- » Over-heat, Over-voltage, Over-current protections are provided.
- » Lightning Protection provided.

(3) Thermal
- » Luminaries surface temperature is 48°C @ Ta=30°C, the temperature variation is controlled under 5°C.
- » Junction temperature is controlled ot 70°C @ Ta=30.
- » Overheat protection will operate to adjust as the LED module surface reaches 80°C.

(4) Luminaire

» Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.

» Dust and water protection design meeting IP65 standards.

» Super-high luminaire efficacy.

DETAILED TECHNICAL SPECIFICATION

Electrical Charatcteristics

PARAMETER	PROMPT DRIVER RESULT
Input Voltage	160 -300 VAC
Rated Power	120W
Maximum Power	140W
Efficiency	>85%
Power Factor	>0.9
Voltage Harmonics (THD)	<5%
Current Harmonics (THD)	<10%

Operating Conditions:

Operating Frequency	100kHz to 200KHz
Operating Temperature Range	-25°C to +70°C
Storage Temperature Range	-65°C to 125°C
Humidity	95% RH

LED Details:

Led Make	As per approved vendor
No of LEDs	48-70
Led Viewing Angle	120º by using reflector
Colour Temperature	Cool White (5500 to 6500K)
Luminous Flux	>8500 Lumens
Life Span	> 50,000 Hours
Colour Rendering Index	>70 Ra

LED Luminary Details:

Body	Alluminium Die casting Body
Heat Sink	Optimized thermal design to ensure maximum life to LED. The Heat sink grade aluminium has the highest surface area for efficient heat diffusion and the entire luminary with Aluminium acts as heat sink.
Protection	IP 65 Standards for Dust and Water

Protection Parameters:

Over-Current Protection	Inbuilt
Short-Circuit Protection	Inbuilt

Over-Voltage Protection	Inbuilt
Over-Temperature Protection	135 °C
Dust and Water Protection	IP 65
Lightning Protection	Inbuilt

ODISHA POWER TRANSMISSION CORPORATION LIMITED

OFFICE OF THE SR. GENERAL MANAGER,

CENTRAL PROCUREMENT CELL,

JANAPATH, BHUBANESWAR – 751022.

TECHNICAL SPECIFICATION

FOR

TESTING INSTRUMENTS AND MAINTENANCE KITS
OTHER TOOLS & PLANTS
&
FURNITURE

TESTING INSTRUMENTS AND MAINTENANCE KITS AND OTHER T&P'S & FURNITURE

TABLE OF CONTENTS

1. GENERAL

The testing and maintenance equipment covered here are generally meant for carrying out testing and measurement at site and shall be complete with all materials and accessories. These shall be robust in design, so that they give accurate results even in adverse site conditions.

All equipment furnished shall be of reputed make, type tested and shall be subjected to acceptance and routine tests in accordance with the requirements stipulated under respective equipment specification.

At least two sets of descriptive leaflets, catalogues, outline drawing, principles of operation etc. shall be sent along with the offer, for all the equipment offered. Weight and dimensions of items should also be mentioned.

Four sets of inspection and calibration report, operation and maintenance manual shall be sent along with Despatch documents. One set will be kept inside the equipment.

In the event of bidder offering equipment manufactured by different manufacturers, it will be his responsibility to fully co-ordinate the activities of each manufacturer in such a way that the complete equipment contracted for, is manufactured, supplied and guaranteed for successful operation.

2. TRAINING

Necessary training shall be provided to Employer's personnel for using and maintaining the equipment at Employer's premises.

3. CLIMATIC CONDITION

The equipment covered under this specification shall be suitable for operation under climatic condition stated else where in the specification. The offered equipment as such shall be suitable for satisfactory operation under the tropical climate.

4. 100 KV TRANSFORMER OIL BREAKDOWN VOLTAGE TEST SET (MICROPROCESSOR BASED WITH LAP TOP)

The equipment offered shall be suitable for determination of electric strength (breakdown voltage) of insulating oil upto minimum100 KV or above to IS:335 when measured in accordance with IS:6792.

The test cell shall be as per IS:6792 suitable for BDV upto 100 KV or above without external flashover.

The unit shall be of composite type having control unit and high voltage transformer in a common cabinet with necessary partition. HV chamber interlocking and zero start interlocking shall be provided.

The unit shall have motorised drive to increase voltage linearly as per the rate specified in IS:6792. Provision should also be available for manual increase of voltage. The unit shall be complete with test cell, stirrer and "GO" and "NO GO" gauge for adjusting the gap.

The instrument shall have

a) Operating temperature: 0 ï 50 deg C

b) Humidity > 90% and nearly equals to 99%

c) Low/High level interlocking for drive motor. Earth open interlocking,reverse interlocking.

d) Protection: Quick acting D.C relay to isolate the H.T.

e) Test cup: The test cup with cover shall be made of Methyle Mathacrylate(Acrylic) having oil between 300 and 500 ml, with adjustable and removable mushroom head and ground to adjust the electrode gap distance.

f) Motorised and manual operation.

g) A linear scaled A.C rectifier voltmeter marked kV to measure output voltage.

h) Shall have magnetic strainer provision for removing the bubbles.

The equipment shall be suitable for operation at 240 volts 50 Hz. Single phase AC supply.

4. INSULATION RESISTANCE TESTER (MEGGER)

The equipment offered shall be used for measurement of insulation resistance of electrical equipment.

4.1 Technical Requirements

- Rated voltage selection : 1, 2, 3, 4, and 5 kV (DC Volts)
- Rated resistance (megohms) 0 to 100000 multi-range type. Resistance range

		for each rated voltage shall be indicated in the offer.
•	Type	Portable, compact and direct reading type of multi-voltage with multi-rated resistance ranges. The tester shall be suitable for hand operation as well as operation by a continuously rated motor with AC mains supply of 230V, single phase, 50 Hz.
•	Ambient temperature	0 to 50C
•	Infinity adjustment	There should be provision
•	leather carrying case	The instrument shall be supplied with 7 metre long mains leads (shall have insulation level as per required) and leather carrying case.
•	Standards	The tester shall generally comply with the requirements of IS:2992-1987 and IS:11994-1986 and latest.
•	Preferable make	The equipment offered shall be of reputed make preferably Megger/ Avo International make or equivalent(on approval of OPTCL)
•	Other required spec.	High voltage indication by LED for user safety
•		Auto discharge of capacitive load with indication after the IR test.
•		Recessed terminals and shrouded leads for enhanced user safety.
•		Linear and accurate reading
•		Protected against accidental connection to 230/440 V AC supplies.
•		Portable and light weight suitable for field and Lab use.

4.2 Test Requirements

Type test certificate for all ten tests as per Cl.11.1 of IS:2992. All routine tests as per Cl.11.3 of IS:2992 shall be conducted.

Make of the megger shall be: M/S Megger (UK).

5. OIL SAMPLING BOTTLE

Oil Sampling bottles shall be suitable for collecting oil samples from transformers, for testing of the oils (BDV, Dissolved Gas Analysis, resistivity etc). Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1 litre.

Oil sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle and seal shall be such that loss of hydrogen shall not exceed 5% per week.

An impermeable oil-proof, plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

6. RELAY TOOLS KITS (ALSO REFER THE SPECIFICATION OF PCM)

The relay test kit shall consist of the following minimum items:

1. Test plugs for use with testing equipment
2. Special type test plugs for using with modular type cases
3. Screw driver set with multiple fixing feature
4. Long nose pliers
5. Wire cutting pliers and stripper
6. Ordinary pliers
7. Adjustable wrench
8. Soldering irons of
    - Watts rating - 1 No.
    - Watts rating - 1 No.
    - Watts rating - 1 No.
9. De-soldering pump
10. Printed Circuit Card-extender; Printed circuit card - `Puller' Suitable for all supplied relays
11. Test leads (Pair with 2 Mts. length) - 1 set
12. Shorting plugs, `pistol' prods (2 Nos.) - 1 set

7. SF6 GAS LEAK DETECTOR

The SF6 gas leak detector shall meet the following requirements

The detector shall be free from induced voltage effects.

The sensing probe shall be such that it can reach all the points on the breaker where leakage is to be sensed .Latest standard in this effect may be followed..

8. Digital Multimeter

The digital multi meter shall have a LCD screen for displaying 3 and 3/4 digits and having auto ranging facility. Instrument shall have single rotary selection switch. Instrument shall have automatic polarity, low battery and over range indication and a range of 0.1mV to 1000V DC, 0.1mV to 750V AC, 0 -10A DC , 0-10 A ,AC and 0-10 mega ohm . Instrument shall have auto selection of AC/DC ampere and AC/DC Voltage. It shall have auto power off and data hold facility. Instrument shall have rugged casing and other measurement facilities (resistance, diode, continuity etc measurement) as per standard.

9. Digital clamp-on- meter: (AC)

The digital clamp meter shall have LCD screen for displaying 3 and 3/4 digits, multifunction, 1000 Ampere range of AC current at (i) 0.01 Amp to 20 Amp, (ii) to 200Amp and (iii) to 1000Amp; AC/DC voltage range 0.01 V to 200V and in the other scale up to 1000V, Provision of measurement of resistance up to 0 ï 10 mega ohms at different scale selection and also other facilities. Instrument shall have single rotary selection switch. It shall have auto power off and data hold facility. Instrument shall have rugged casing and other measurement facilities (resistance, diode, continuity etc measurement) as per standard.

10. Digital Earth Tester.

The digital earth tester shall have 4 points ,three range (0 .01 ohms to 20 ohms, 200 ohms and up to 2000 ohms) type. Battery operated type instrument.3 and 1/2 digit LCD display with maximum reading 1999 ohms. Instrument shall have rechargeable internal Ni-MH Battery. Instrument shall be of 4 wire soil resistivity measurement. Type tested as per IS-9223.Instrument shall have low bat indication and data hold facility. Instrument shall have over range indication. Single, measuring time below 1

minute. Instrument shall consist of required nos of standard length of spikes (minimum 1 mtr), flexible copper PVC wires of required length (minimum length shall be 30mtrs two pieces and 15 mtrs two pieces ,and two more pieces for connecting to the instrument), one no. suitable hammer for hammering the spike for inserting into the earth. There shall be crocodile clamps on one side of each wire and round clips on the other side for connecting to the instrument.

11. Discharge Rods:

Discharge rods shall be good quality and as per the latest relevant standard. Required length of PVC good insulation flexible copper cable, required clamp connected at the end of wire shall be connected. The top portion of the discharge rod shall be adjustable to fit in for proper gripping by screwing from the bottom side. The entire handle shall be of latest insulating materials for the safety of the user. The discharge rod shall be reliable, durable and shall meet the safety requirement of the users.

12. Rubber Hand Gloves:

Good quality rubber gloves for using during operation of isolators and earth switch. Latest standard for the rubber gloves shall be followed. The gloves shall be reliable, durable and shall meet the safety requirement of the users.

13 Portable Emergency Light:

Reputed make (BPL/CGL/Bajaj) portable emergency light, having twin tube, shall be supplied to each sub-station. It shall have chargeable battery (durable) and having provision of selection switch for selecting single or double tube. It shall have chargeable feature during not in use and automatically switch on in the event of power failure. CFL tubes are preferred. It shall have provision of wall hanging/table mounting and shall be durable one. Latest standard in this effect shall be followed.

14. SCHEDULE OF REQUIREMENTS OF MAINTENANCE TESTING EQUIPMENT

ANNEXURE – I

Item nos.	**Units**	**ALL 132/33KV**	**ALL 220/132/33 KV S/S**	**220/33 KV S/S Gopinathpur (keonjhar)**
100 kv transformer oil breakdown voltage test set	Nos	1	1	1
Insulation resistance tester (megger)	Nos	1	1	1
Oil sampling bottle	Nos	4	4	4
SF6 gas leak detector	Nos	1	1	1
LCD, digital multimeter	Nos	2	2	2
Analogue Multimeter(features same as digital multimeter)	Nos	1	2	1
LCD, clamp on meter	Nos	2	2	2
Digital earth tester	Nos	1	1	1

Discharge rod as per standard for carrying out the switch yard maintenance work	Nos	6	6	6
Rubber gloves of operation of isolators and earth switch	Pairs	2	2	2
Relay tools kit	Sets	1	1	1
Portable emergency light	Nos	4	4	4
Latest version desktop PC of reputed make with all its accessories including CPU, Monitor, UPS and having all latest loaded software and also its back up in shape of CD and separate pen drive . suitable for loading of software as recommended by the relay manufacturer. It includes supply of one no portable laser printer of reputed make. Make of PC and printer: HP/DELL	Set	1	1	1

** The multimeters (both digital and analogue), clamp on meters, earth tester shall preferably of ñMotwaneò make. Prior approvals of OPTCL for all the testing equipments are to be taken.

15. OTHER TOOLS AND PLANTS (T&P'S) REQUIREMENT:

(ANNEXURE- II)

Following T&Pôs of reputed make are also in the scope of this contract.

Sl No	Description of Items	unit	Quantity against Each Package		
			ALL 132/33 KV	**ALL 220/132/33 KV S/S**	**220/33 KV S/S Gopinathpur(keonjhar**
1	Set of ñDò spanner(6mm ï 42mm)	Set	1	1	1
2	Set of ñRingò spanner(6mm ï 42mm)	Set	1	1	1
3	Socket wrench with sockets,handles,and other attachment(6mm-42mm)	Set	1	1	1
4	Insulated cutting plier	Nos	2	2	2
5	Insulated nose plier	Nos	2	2	2
6	Monkey plier	Nos	1	1	1
7	Circlip plier	Nos	1	1	1
8	Pipe wrench a)12 inch ï 1 no	Set	1	1	1

	b)18 inch ï 1 no				
9	Sly wrench a)12inch ï 2 nos b)18inch ï 1 no	Set	1	1	1
10	Insulated handle screw drivers of different sizes as per required a)12inch plain head ï 2 nos b)8inch plain head ï 2 nos c) 12inch star head ï 1 no d) small size6inch plain and star head ï 2 each e)Complete set of different head in one box/set -1set	Set	1	1	1
11	ñLò-N keys set of different sizes in one box/set	Set	1	1	1
12	M.S Files(12inch and 6inch sizes) Round files and flat files-one each of different sizes)	set	1	1	1
13	Hammar with handle a)1 lb ï 2 nos b)1/2 lb-2 nos c)2 lb-1 no	Set	1	1	1
14	Crow bar a)5 ft ï 2nos b)3ft-2 nos	set	1	1	1
15	Steel scale(12inch)	Nos	2	2	2
16	Steel tape a)5 mtrs-2 nos b)30mtrs-1 no	Set	1	1	1
17	Oil cane	Nos	2	2	2
18	Spirit level (8inch)	No	2	2	2
19	Plumb head with string and attachment	No	1	1	1

20	Maintenance safety belt with all attachment and helmets(complete one set)	Set	3	4	3
21	Hand drill machine with different bits and key.(Wolf make)	No	1	1	1
22	Vacuum cleaner having hot blower provision with all attachments (Eureka Forbes make)	No	1	1	1
23	230-250VAC,80W,450mm sweep,1400 rpm stand(rugged) FAN Make: Almonard,CGL	No	2	4	2

** All the T&Pôs shall be of Taparia make. The hand drill and vacuum cleaner shall be wolf and Eureka Forbes make.

16. OFFICE FURNITURE:

Supply and installations of the office furniture are in the scope of this contract. All the furniture shall be of Godrej & Boyance make. Before supply of the furniture to the sub-station, approval from OPTCL is required. Details of the scope of supply are as indicated below.

ANNEXURE – III.

Sl No	Description of Items	unit	Quantity against Each Package		
			ALL 132/33 KV	**ALL 220/132/33 KV S/S**	**220/33 KV S/S**
1	5ftX3ft executive table with drawer both sides	Nos	5	6	5
2	3ftX2&1/2ft Table with one side drawer	Nos	7	8	7
3	Computer table suitable keeping monitor,CPU,UPS and printer with two nos revolving arm chair suitable for computer use.	Set	1	1	1
4	Executive revolving ,adjustable(height) chairs with arm	Nos	5	6	5
5	Cane gutting ñSò type steel chairs with arm	Nos	18	24	18
6	6ftX3ft conference table	Nos	1	1	1
7	Cushion arm steel chairs for conference table purpose	Nos	6	8	6
8	6ft height steel almirah (only with selves) for keeping records and other valuable items	Nos	4	6	4

9	6ft height steel almirah with glass doors for library purpose	Nos	2	2	2
10	6ft height (having minimum 6 lockers facility) steel cupboard with locking arrangement	Nos	2	2	2
11	4ft steel rack (minimum three selves) for keeping the files and other items	Nos	8	10	8

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TECHNICAL SPECIFICATION

FOR

CONSTRUCTION OF

1)132 KV SC/DC,

2)220 KV SC/DC AND

3)400 KV DC

TRANSMISSION LINES

Nature of work

The work covered by this Specification is for 400 kV and/or 220 kV and/or 132 kV transmission lines as specified herein and in the attached Schedules. The overhead transmission lines will form part of the OPTCL Transmission System.

General particulars of the system

The following are the general particulars governing the design and working of the complete system of which the Works will form a part ð

a) Electrical energy is generated at interconnected power stations as three-phase current at a frequency of 50 Hz, and transmitted therefrom by means of overhead lines.

b) The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons

1.0 SCOPE-

Construction of 400 KV, 220 KV and 132 KV

As indicated in the Bidding Proposal Sheet & scope of work.

Important: Contractor has to obtain project license from the competent authority in respect of the mentioned works prior to commencement of the works. The expenses towards the project license have to be borne by the contractor.

2.0 SURVEY (detail & check, estimating of quantities & spotting of towers)

2.1.1 General: Preliminary route alignment in respect of the proposed transmission lines has been fixed by the employer subject to alteration of places due to way leave or other unavoidable constraints. The Right of way shall be solved by the contractor and all expenses there of shall be borne by him. However, OPTCL shall render all helps in co-ordination with law and order department for solving the same. Forest clearance if any shall be arranged by OPTCL.

2.1.2 Provisional quantities/numbers of different types of towers have been estimated and indicated in the BOQ Schedule given. However final quantities for work shall be as determined by the successful bidder, on completion of the detail survey, preparation of route profile drawing and designing of the different types of towers as elaborated sin the specification and scope of work.

2.1.2.1 The contractor shall undertake detailed survey on the basis of the tentative alignment fixed by the employer. The said preliminary alignment may, however,

change in the interest of economy to avoid forest and hazards in work. While surveying the alternative route the following points shall be taken care by the contractor.

(a) The line is as near as possible to the available roads in the area.

(b) The route is straight and short as far as possible.

© Good farming areas, religious places, forest, civil and defence installations, aerodromes, public and private premises, ponds, tanks, lakes, gardens, and plantations are avoided as far as practicable.

(d) The line is far away from telecommunication lines as reasonably possible. Parallelism with these lines shall be avoided as far as practicable.

(e) Crossing with permanent objects are minimum but where unavoidable preferably at right angles.

(f) Difficult and unsafe approaches are avoided.

(g) The survey shall be conducted along the approved alignment only in accordance with IS: 5613 (Part-II/Section-2), 1985.

(h) For river crossing/ Crossing of Nallas : Taking levels at 25 metre interval on bank of river and at 50 metre interval at bed of river so far as to show the true profile of the ground and river bed. The levels may be taken with respect to the nearest existing towers, pile foundation of towers, base or railway/road bridge, road culvert etc. The levels shall be taken at least 100 m. on either side of the crossing alignment. Both longitudinal and cross sectional shall be drawn preferably to a scale of 1:2000 at horizontal and 1:200 vertical.

After completing the detailed survey, the contractor shall submit the final profile and tower schedule for final approval of the employer. The final profile and tower schedule shall incorporate position of all type of towers. To facilitate checking of the alignment, suitable reference marks shall be provided. For this purpose, concrete pillars of suitable sizes shall be planted at all angle locations and suitable wooden/iron pegs shall be driven firmly at the intermediate points. The contractor shall quote his rate covering these involved jobs.

Only approved sag template shall be used for tower spotting and the final profiles.
However preliminary survey has been done by OPTCL and any further survey required shall be done by the contractor.

2.1.2.2 PROFILE PLOTTING AND TOWER SPOTTING

The profile shall be plotted and prepared to the scale 1 in 2,000 for horizontal and 1 in 200 for vertical on squared (mm) paper. If somewhere the difference in levels

be too high, the chart may be broken up according to the requirements. A 10 mm overlap shall be shown on each following sheet. The chart shall progress from left to right for convenience in handling. The sheet size may be conveniently chosen.

With the help of sag template, final tower location shall be marked on the profiles and while locating the tower on survey chart, the following shall be kept in mind:

(a) The number of consecutive span between the section points shall not exceed 10 in case of straight run on a more or les plain stretch.

(b) Individual span shall be as near as to the normal design ruling span.

In different crossing the contractor shall take into consideration the prevailing regulations of the respective authorities before finalizing type and location of the towers. While carrying out survey work, the contractor has to collect all relevant data, prepare and submit drawings in requisite number for obtaining clearance from the PTCC, road, aviation, railways, river and forest authorities.

The contractor shall remain fully responsible for the exact alignment of the line. If after erection, any tower is found to be out of alignment, the same shall have to be dismantled and re-erected after corrosion by the contractor at his own cost, risk and responsibility, including installation of fresh foundation, if belt necessary by the employer.

After peg marking of the angle tower or tension towers, the contractor shall obtain approval from the employer and thereafter pegging of suspension type tower shall be done by the contractor and pegging of all the four legs of each type of towers at all the locations shall be done.

2.1.2.3 SCHEDULE OF MATERIALS

When the survey is approved, the contractor shall submit to the employer a complete detail schedule of all materials to be used in the line. Size and length of conductor etc. are also to be given in the list. This schedule is very essential for finalizing the quantities of all line material. The contractor shall furnish the same.

2.1.2.4 CHECK SURVEY

The contractor shall undertake the check survey during execution on the basis of the alignment profile drawing and tower schedule approved by the employer. If during check survey necessity arises for minor change in route to eliminate way leave or other unavoidable constraints, the contractor may change the said alignment after obtaining prior approval from the employer.

The contractor, while carrying out the check survey, shall peg mark the power position on ground conforming to the survey charts. In the process, it is necessary to have the pit centers marks according to the excavating marking charts to be prepared by the contractor and approved by the employer. The levels up or down of each pit center with respect to the center of the tower location shall be noted and recorded for determining the amount of earth work required to meet the design. At the charting point of the route survey, an angle iron spite shall be driven firmly into the ground showing a little above the ground level.

2.1.2.5 WAY-LEAVE AND TREE CUTTING

Way-leave permission which may be required by the contractor shall be arranged at his cost. While submitting final-survey report for approval, proposals for way-leave right of way shall be submitted by the contractor. Employer may extend help to get the permission within a reasonable time as mutually agreed upon for which due notice shall be given by the contractor in such a way so that obtaining permission from appropriate authority do not hinder the continued and smooth progress of the work.

The employer shall not be held responsible for any claim on account of damage done by the contractor or his personnel to trees, crops and other properties.

The contractor shall take necessary precaution to avoid damage to any ripe and partially grown crops and in the case of unavoidable damage, the employer shall be informed and necessary compensation shall be paid by the contractor.

All the documents required for application to the statutory authorities must be prepared by the contractor & submission to the employer for Submission of the application towards approval of PTCC, Railway Crossing etc. However, the responsibilities lies with the contractor to get the clearance.

Trimming of tree branches or cutting of a few trees en-route during survey is within the scope of survey to be done by the contractor. Contractor shall arrange for necessary way-leave and compensation in this regard. During erection of the line, compensation for tree cutting, damage caused to crops, actual cutting and felling of the trees including way-leave permission for such route clearance shall be arranged by the contractor at his cost. The contractor will identify the number of trees and detail of obstructions to be removed for erection of the line and intimate the employer well in advance in case of any help. Other related works like construction of temporary approach roads, etc. as required, shall be done by the contractor and the same will lie within the scope of contractorôs work and such cost shall be considered to be included in the rates quoted by him.

While quoting the rate for detailed and check survey as per bidding activity schedule, the contractor shall include all costs involved in different activities described herein earlier.

2.0 SUB-SOIL INVESTIGATION

To ascertain soil parameters in various stretch inter, the contractor shall carry out sub-soil investigation through reputed soil consultant as approved by the employer.

2.1 SCOPE OF WORK

The scope of sub-soil investigation covers execution of complete soil exploration for the transmission line under this contract including boring, drilling, collection of undisturbed soil sample where possible, otherwise disturbed samples, conducting laboratory test of soil samples to find out the various parameters as detailed in this specification and submission of detailed reports in 6 copies along with specific recommendation regarding suitable type of foundation for each bore-hole along with recommendation for soil improvement where necessary.

2.1.1 QUALIFYING REQUIREMENTS OF SOIL CONSULTANTS

The soil consultants shall provide satisfactory evidence concerning the following as and when asked for.

That, he/they has/have adequate technical knowledge and previous practical experience in carrying out complete soil investigation jobs in any kind of soil.

That he/they has/have well equipped, modernized soil testing laboratory of his/their own. If asked for by the employer, the contractor shall arrange inspection of such laboratory of the soil consultant by the representative of the employer.

If in the opinion of the employer, the soil consultant (proposed by the contractor) is not well equipped or capable to undertake the sub-soil investigation job relating to this contract, then such soil consultant shall not be engaged to undertake the job. In that case, they shall have to engage other agency as will be approved by the employer.

2.1.3 TEST BORING

The boring shall be done at the major locations/crossing, special towers. However, it is desirable that there should be at least one sub-soil investigation bore-hole for the line. Such locations for sub-soil investigation shall be selected and finalized in consultation with the employer.

The test boring through different layers of all kinds of soil shall have to be carried out by the contractor through the approved soil consultant as briefed hereunder.

(a) Method of boring, selection of sampling tubes, sampling, recording of boring, protection, handling, leveling of samples shall be done as specified in IS: 1892/1977, if any, after obtaining approval from the employer. The contractor/consultant shall furnish in the soil report in details, the equipment and method of boring actually adopted.

(b) Depth of boring below ground level shall be 15 M. only unless continuous bedrock is encountered earlier. In case rock is encountered at any depth within 15 M.

adequate study of rock and assessment of strength characteristics shall be done and recommendation shall be given.

(c) Undisturbed soil samples shall be obtained for the initial 4M depths at every 1.5M interval and at change of strata. After these initial 4M depths, samples shall be obtained preferably at every 3M or where there is a change of strata, or as advised by the employer.

(d) In case collection of undisturbed samples becomes difficult/impossible detailed soil testing on remoulded soil samples is to be considered and reported in the soil report.

(e) Standard penetration test as per IS: 2131 with latest amendment shall have to be conducted in different strata and recorded properly.

(f) The ground water table shall be recorded during boring operation and incorporated in the bore log. If possible, the position of the water table just after monsoon period be ascertained from local people and indicated in the report.

(g) Plate Load test shall have to be conducted at special tower location.

3.0 LABORATORY TESTS OF SOIL SAMPLES

The method and procedure of testing of soil sample to be followed shall be as per relevant IS codes. Adequate volume of test samples shall be collected from site. Ample shall be properly sealed immediately after recovery as specified in relevant IS code and transported carefully to laboratory for carrying out necessary laboratory tests to find out the following parameters of every samples. Data and time of taking of the sample shall be recorded in the test report.

(a) Natural moisture content, Liquid limit, Plastic limit and Plasticity index.
(b) Bulk, dry and buoyant density of soil.
(c) Void ratio (e-long P curve shall be submitted)
(d) Specific gravity.
(e) Grain size distribution (Sieve analysis and hydrometer analysis)
(f) Tri-axial and consolidation tests (consolidation undrained and consolidated drained as and when application in table, graph and drawing.
(g) Permeability tests
(h) Chemical tests for both water and soil samples at different layers.
(i) Evaluation of safe bearing capacity at different strata for square footings shall be done for a maximum value of 25-mm. settlements.
(j) At depts. From 3M to 10M be different strata.
(k) Factor of safety shall be considered as 3 for evaluation of safe bearing capacity of soil.
(l) Unconfined compression test for cohesive soil (=0) if encountered.

3.1 REPORT ON SUB-SOIL INVESTIGATION

The contractor shall make analysis of soil samples and rock cores as collected by him in the field and approved by the employer as collected by him in the field and approved by him in the field and approved by the employer as well as field tests and laboratory tests. A comprehensive report shall have to be prepared by him, finally incorporating all the data collected in proper tabular forms or otherwise along with the analysis.

The 3(three) copies of report in the draft form shall be submitted for employerôs approval. 6(six) copies of final report incorporation employerôs comments, if any shall be submitted within 3(three) weeks after completion of this work.

Recommendations shall include but not be limited to the following items (a) to (p)

(a) Geological information of the region.
(b) Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.
(c) Procedure of investigations employed and field and field as well as laboratory test results.
(d) Net safe bearing capacity and settlement computation for different types of foundations for various widths and depths of tower and building.
(e) Recommendations regarding stability of slopes, during excavations etc.
(f) Selection of foundation types for towers, transformers and buildings etc.
(g) Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata etc.
(h) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how the soil/rock strata are varying vertically and horizontally.
(i) Modulus of sub grade reaction from plate load test for pressure ranging up to 6 kg/cm. The recommended values shall include the effect of size, shape and depth of foundations.
(j) Deformation modulus from plate load test in various test depth/stratification.
(k) Coefficient of earth pressure at rest.
(l) Depth of ground water table and its effect on foundation design parameters.
(m) Recommendations regarding stability of slopes, during shallow excavation etc.
(n) Whether piles are necessary or not. If piles are necessary, recommendation of depth, diameter and types of piles to be used.
(o) Recommendations for the type of cement to be used and any treatment to the underground concrete structure based on the chemical composition of soil and sub-soil water.

3.1.2 MEASUREMENT OF SOIL RESISTIVITY

For the purpose of grounding design, soil resistance measurement shall be taken in the locations as stated under clause 1.0 above and based on which the value of soil resistance shall be derived.

Wennerôs four (4) electrode method shall be used for earth resistance measurement in accordance with the procedure and the calculation detailed in IS:3043 1987. At

least 8(eight) test direction shall be chosen from the center of the locations to cover the whole site.

The employer reserves the right to carry out separate soil investigation at his cost by engaging a separate agency for cross checking the result obtained by the contractor.

In case the results are at variance, the soil parameters to be adopted for final design will be at the sole discretion of the employer and such will be binding upon the contractor.

IMP:-The material and services covered under these specifications shall be performed as per requirements of the relevant standards and codes referred hereinafter against each set of equipment and services. In case of a conflict between such codes and/or standards and the Specifications, the latter shall govern. Other Internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

SL. No.	Indian Standards	Title	International & Internationally recognised Standards.
1.	2.	3.	4.
1.	IS 209-1979	Specification for Zinc	ISO/R/752-1968 ASTM B6
2.	IS 226-1975	Structural steel (Standard quality)	ISO/R/630-1967 CAN/CSA G40.21 BSEN 10025
3.	IS 269-1976	Ordinary rapid hardening and low heat Portland cement.	ISO/R/597-1967
4.	IS 383-1970	Coarse and fine aggregates from natural sources for concrete.	CSA A23.1 /A23.2
5. a)	IS 398-1982 Part-I	Specification for aluminium conductors for overhead transmission purposes	IEC 1089-1991 BS 215-1970
b)	IS 398-1982 Part-II	Aluminium conductor galvanised steel reinforced	BS 215-1970 IEC 1089-1991
c)	IS 398-1994 Part-IV	Aluminium alloy stranded conductor	BS 3242-1970 IEC 1089-1991 ASTM 8393M86

	d) IS 398-1982 Part-V	Aluminium conductor galvanised steel reinforced for Extra High Voltage (400kV and above)	BS 215-1970 IEC 1089-1991
6.	IS 278-1978	Specification for barbed wire.	ASTM A 121
7.	IS 406-1964	Method of chemical analysis of Zinc slab	
8.	IS 432-1966 (Part 1 & 11)	Mild steel and medium tensile bars and hard drawn steel wire for concrete reinforcement.	BS 4449 CSA G-30. BS 4482
9.	IS 456-1978	Code of practice for plain and reinforced concrete.	ISO 3893-977
10.	IS 731-1971	Porcelain insulators for overhead power lines with nominal voltage greater than 1000 Volts.	BS 137-1982 (Part-I & II) IEC 383-1993 (Part-I& II)
11.	IS 800-1962	Code of practice for use of structural steel in general building consruction.	CSA S 16.1 BS 5950
12.	a) IS 802-1995 (Part-I/Sec.I) (Part-I/Sec.II) -1992	Code of practice for use of structural steel in overhead transmission Line: materials, loads and permissible stresses.	IEC 826 ANSI/ASCE 10-90 (1991) BS 8100
	b) IS 802-1978 (Part-II)	Code of practice for use of structural steel in overhead transmission line: Fabrication, galvanising, inspection and packing.	ANSI/ASCE 10-90 (1991)
	c) IS 802-1978 (Part-III)	Code of practice for use of structural steel in overhead transmission line towers: Testing.	ANSI/ASCE 10-90 (1991) IEC 652
13.	IS 1139-1966	Hot rolled mild steel, medium tensile steel and high yield strength deformed bars for concrete reinforcements.	CAN/CSA G30.18 ASTM A615 BS 4449

14.	IS 1367-1967	Technical supply conditions for threaded fasteners	
15.	IS 1489-1976	Portland pozzolena cement.	ISO/R 863-1968
16.	IS 1521-1972	Method of tensile testing of steel wires	ISO 6892-1984
17.	IS 1573-1976	Electroplated coating of zinc on iron and steel	
18.	IS 1786-1966	Cold twisted steel bars for concrete reinforcement.	
19.	IS 1778-1980	Reels and drums for bare conductors	BS 1559-194
20.	IS 1893-1965	Criteria of earthquake resistant design of structures.	IEEE 693
21.	IS 2016-1967	Plain washers	ISO/R 887-1968. ANSI B18.22.1
22.	IS 2071 Part-I-1974 Part-II-1974 Part-III-1976	Method of high voltage testings	IEC 60
23.	IS 2121	Specification for conductor and earthwire accessories for overhead power lines.	
	a) Part-I -1981	Armour rods, binding wires and tapes for conductors.	
	b) Part-II -1981	Mid-span joints and repair sleeve for conductors.	
	c) Part-III-1992	Accessories for earthwire.	
	d) Part-IV-1991	Non-tension joints.	
24.	IS 2131-1967	Method of standard penetration test for soils.	ASTM D 1 883
25.	IS 2551-1982	Danger notice plates	
26.	IS 2486	Specification for insulator fittings for overhead power lines with a nominal voltage greater than 1000 Volts.	
	Part-I	General requirements and tests.	BS 3288 IEC 1284
	Part-II	Dimensional requirements	IEC 120-1984
	Part-III	Locking devices	IEC 372-1984
27.	IS 2629-1966	Recommended practice for hot dip galvani-	ASTM A123 CAN/CSA G 164

		sing of iron and steel.	BS 729
28.	IS 2633-1972	Method of testing uniformity of coating of zinc coated articles.	ASTM A123 CAN/CSA G164
29.	IS 3043-1972	Code of practice for earthing(with amend-ment No.1 and 2).	
30.	IS 3063-1972	Single coil rectangular section spring washers for bolts nuts, screws.	DIN 127-1970
31.	IS 3188-1965	Dimensions for disc insulators.	IEC 305-1978
32.	IS 4091-1967	Code of practice for design and construction of foundation for trans-mission line towers and poles.	ASCE/IEEE 691
33.	IS 4826-1979	Galvanised coating on round steel wires.	IEC 888-1987 BS 443-1982
34.	IS 5358-1969	Hot dip galvanised coat-ings on fasteners.	CAN/CSA G 164 ASTM A153
35.	IS 5613 (Part-II/Sec-1) -1985 (Part-III/Sec.1) -1989	Code of practice for design, installation and maintenance of overhead power lines (Section-I: Designs)	ANSI/ASCE 10-90(1991)
36.	IS 5613 (Part-II/Sec-2) -1985 (Part-III/Sec.2) -1989	Code of practice for design, installation and maintenance of overhead power lines (Section 2: Installation and maintenance)	
37.	IS 6610-1972	Specification for heavy washers for steel structures.	
38.	IS 6639-1972	Hexagonal bolts for steel structure.	ISO/R 272-1968 ASTM A394 CSA B33.4
39.	IS 6745-1972	Methods for determination of weight of zinc coating of zinc coated iron and steel articles.	ASTM A90 ISO 1460
40.	IS 8263-1976	Method of radio interference tests on high voltage insulator	IEC 437-1973 NEMA 107-1964
41.	IS 8269-1976	Method of switching impulse tests on HV insulators.	IEC 506-1975

42.	IS 8500-1977	Specification for weldable structural steel (medium and high strength qualities)	BSEN 10025
43.	IS 9708-1980	Specification for Stock Bridge vibration dampers for overhead power lines.	
44.	IS 9997-1988	Aluminium alloy redraw rods	IEC 104-1987
45.		Hard drawn aluminium wires for overhead line conductors.	IEC 889-1987
46.		Thermal mechanical performance tests and mechanical performance tests on string insulator units.	IEC 575-1977
47.		Salt fog pollution voltage withstand tests.	IEC 507-1991
48.		Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric.	IEC 797-1984
49.		Guide for the selection of insulators in respect of polluted conditions.	IEC 815-1986
50.		Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 Volts.	IEC 383-1993 (Part I and II)
51.		Ozone test on elastomer	ASTM D-1171
52.	IS 1363	Hexagonal head bolts, screws and nuts of product Grade - C	
	Part - 1	Hexagonal head bolts	ISO 4016
	Part - 3	Hexagonal nuts	ISO 4034
53.	IS 1367	Technical supply conditions for threaded steel fasteners	
	Part III	Mechanical properties and test methods for bolts, screws and studs with full loadability	ISO 898-1
	Part VI	Mechanical properties and test methods for nuts with full loadability	ISO/DIS 898/II
		54.	Indian Electricity Rules - 1956

55.		Indian Electricity Act - 1910	
56.	IS 1498-1970	Classification and identification of soil for general engineering purposes	
57.	IS 1888-1982	Method of load test on soils	
58.	IS 1892-1979	Code of practice for subsurface investigation for foundation	
59.	IS 2911-1979 (Part-I)	Code of practice for design and construction of pile foundations	
60.	IS 4453-1980	Code of practice for exploration by pits, trenches, drifts and shafts	
61.	IS 6935-1973	Method for determination of water level in a bore hole	
62.	IS 8009-1976 (Part-I)	Code of practice for calculation of settlement of foundation subjected to symmetrical vertical loads (Shallow Foundation)	
63.	IS 2386-1963 (Part-3)	Methods of test for aggregates for concrete : Specific gravity, density, voids, absorption and bulking	
64.	IS 14000-1994	Quality management and quality assurance standards	ISO 9000-1994
65.		GRIDCO Safety Manual (draft)-1997	
66.		Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V : Definition, test methods and acceptance criteria	IEC 1109-1992 ANSI C29-11 IEEE 987

SUPPLY OF TOWER STRUCTURES FOR THE TRANSMISSION LINES

1.0 SCOPE

1.1 This specification provides for design, proto fabrication, galvanizing and delivery FOR (destination) of transmission line towers including super-structure stubs, tower extensions, stub-templates, tower accessories (Hangers, U-bolts, bird guards, anti-climbing devices), bolts and nuts, step bolts, flat and spring washers etc. as described hereinafter in this volume.

THE PRELIMINARY SURVEY WORK HAS ALREADY DONE AND THE FOLLOWING TOWERS HAVE BEEN DECIDED.

The contractor shall design the tower foundation and the concreting shall be done by M-20 grade concrete.

a) Wind effects:

Tower shall be designed for **reliability Level-I, Terrain category-I & Wind Zone-V** Design wind pressure on towers, conductors, earth wire and insulator string in the range of 30.45 mt. And above 45 mt. Height shall be computed as per IS-802(Part/Sec-I) 1995 Bidder shall furnish the maximum wind pressure adopted in their design against each component mentioned above.

b) Design Temperatures:

The following temperature range for the power conductor and ground wires shall be adopted for the line design:

(i) Minimum temperature: 5 deg. C

(ii) Everyday temperature of conductor: 32 deg. C

(iii) Maximum temperature of :

a) Conductor:ACSR 75 deg. C for ACSR

Moose/Zebra/Panther 90 deg. C for AAAC.

(**Double Moose conductor in 400 KV system)

b) Ground wire exposed to sun. 53 deg. C

The above values are subject to latest revision if any made in IS-802 (part-I/Sec-I) 1995

Maximum Tension:

Maximum tension shall be based on either:

a) at 5 deg. C with 2/3rd. full wind pressure or Conform to IS 802-1995

b) at 32 deg. C with full wind pressure whichever is more stringent. Part-I/Sec-I-Clause No.10.3

Factors of Safety & Span details:

Factor of Safety: Should conform to IS-802 Part-I-1995

Normal span: The normal span of the ine shall be 350 meters of 220KV and 320 meters for 132 KV.

Wind & Weight Span:The wind and weight span to be adopted in the design of the structures shall be as follows:

(i) Wind span: The wind span is the sum of the two half spans adjacent to the support under consideration. In case of towers located on a perfectly horizontal terrain,

this shall be the normal span. For design purpose the wind on conductor shall be calculated on a wind span of at least 1.1 times the normal span.
Weight Span: The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. All C and D type towers shall be designed for uplift spans (minimum weight spans in the following table) also. These are applicable both for pointed and square cross arms.
For details of cross arms and towers , the span limits given below shall prevail.

Tower type.	400KV/220 KV				132 KV			
	Normal condition.		Broken wire condition.		Normal condition.		Broken wire condition.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A/DA & B/DA	525	100	315	100	500	100	300	100
C/DC & D/DD	600	100	360	100	500	100	300	100

1.1.1 The design of towers and their extensions shall be done conforming to the design parameters specified herein, the scope of design also includes supply of design calculation for towers and extensions including detailed structural/shop drawings of towers extensions and stub setting templates. The bidder, who has already type tested the various tower viz: 0-2ę, +3, +6; 0-15ę, +3, +6; 0-30ę, +3, +6; 0-60ę, +3, +6 (400/220/132 KV) in any nationally or internationally recognized laboratories, and conforming to our specification, may also offer the same.

1.1.2 STANDARDS

Except as modified in this specification, the material and work covered under this specification, shall conform to the latest revision with amendments thereof of the following of Indian Standards and equivalent International Standards whenever indicated below.

Sl. No.	Bureau of Indian standards (BIS)	Title	International & Internationally recognized standard
1.	IS:209	Specification for Zinc	ISO/R/752
2.	IS: 2062	Structural steel (Standard quality)	ISO/R/660
3.	IS: 432	Mild steel and medium tensile bars and for concrete reinforcement	BS-785CSA-G-30
4.	IS: 802	Code of practice for use of structural steel in overhead transmission line Part-I/Section-I & Section2: Load and permissible stresses Part-II: Fabrication Galvanizing Inspection and Packing	
		PART-III: TESTING	
5.	IS: 1367	Technical supply conditions for threaded fasteners	
6.	IS: 1893	Criteria of Earthquake resistant design structures	
7.	IS: 2016	Plain washers	ISO/R/987
8.	IS: 2551	Danger Notice Plates	
9.	IS: 2629	Recommended practice for hot dip galvanizing of iron and steel	
10.	IS: 2633	Method of testing uniformity of casting of zinc coated articles	
11.	IS: 3063	Single coil rectangular section spring washers for bolts, bolts, screws	DIN-127
12.	IS: 5358	Hot dip galvanized coatings on fasteners	
13.	IS:5613 Part-1 & 2 Of Section-I	Code of Practices for design, installation & maintenance of overhead power line	

14.	IS: 6610	Specification for heavy washers for stell structures.
15.	IS: 6745	Methods of determination of weight of zinc coating of zinc coated iron and steel articles.
16.	IS: 12427	Hexagonal bolts for steel structures
17.		INDIAN ELECTRICITY RULES 1956
18.		Publication for Regulation for electrical crossing or railway tracks

1.1.3 The standards mentioned above are available from

Reference/ Abbreviation	Name and Address from which the Standards are available
IS	BUREAU OF INDIAN STANDARDS Manak Bhavan, 9, Bahadur Shah Zafar Marg, NEW DELHI(India)
ISO	INTERNATIONAL ORGANISATION FOR STANDARDISATION, Danish Board Standardisation, Danish Standardisening Street, Aurehoegbvej-12, DK-2900, Helleprup, DENMARK
CSA	CANADIAN STANDARD ASSOCIATION 178, Rexdale Boulevard, Rexdale, Ontario, CANADA M9W IR
BS	BRITISH STANDARDS British Standard Institution, 101, Pentonvile Road, N-19-ND-UK
DIN	DEUTSCHES INSTITUTE FIIR NOR Gurggrafenstrasse 5-10 Post Fach 1107 D-1000, Berlin ï 30
INDIAN ELECTRICITY RULES 1956, REGULATION FOR	KITAB MAHAL Baba Kharak Singh Marg,

1.1.4 PRINCIPAL PARAMETERS

1.1.5 Electrical System Date:

a)	System voltage (kV rms)	400/220/132
b)	Max. voltage (kV rms)	420/245/145
c)	Lightning impulse withstand voltage (dry & wet) (kVp)	1550/1050/650
d)	Power frequency withstand voltage (wet) (KV rms)	630/395/275
e)	Short circuit level (KA for 1 sec.	40/40/31.5

1.1.6 Line data /

1.1.7 Conductor

a)	Name	ACSR Zebra	ACSR Moose	ACSR Panther
b)	Strength & wire dia			
i)	Aluminium	54/3.18	54/3.53	30/3.00
ii)	Steel	7/3.18	7/3.53	7/3.0
c)	Conductors per phase 1) 400 KV 2)220 KV 3)132 KV	Single	Double	Single
d)	Spacing between the conductors of same phase (sub-conductor spacing) (mm)	----	As per standard	----
e)	Inter-phase spacing (mm)	8,400	8,400	6800
f)	Configuration			

i)	Single circuit	Delta	Delta	Delta
ii)	Double circuit	Vertical	Vertical	Vertical
g)	Nominal Aluminium area (mm²)	420	528.5	212.1
h)	Section area of Aluminium (mm²)	428.90	597	261.5
i)	Total sectional area (mm²)	484.50	597	262
j)	Calculated resistance at 20 c (Max.) ohm/km per conductor	0.06915	0.05552	0.140
k)	Approx. calculated breaking load (KN)(Minimum)	130.32	161.2	89.67
l)	Modulus of elasticity (GN/M²)	69	69	82
m)	Co-efficient of linear exp. Per degree cent.	$19.3X10^{-6}$	$19.3X10^{-6}$	$17.8X10^{-6}$
n)	Mass of zinc in gms/sqm	é é é é é é	275é é é é é é	
o)	Overall diameter (mm)	28.62	31.77	21.00
p)	Weight (kg/km)	1621	2004	974
q)	Minimum ultimate tensile strength (KN)	130.32	161.2	89.67
r)	Conductor tension at 32ę C without external load			
i)	Initial unloaded tension	é é é é é é	..35%é é é é é é	
ii)	Final unloaded tension	é é é é é é é	25%é é é é é .	

1.1.8 Galvanized Steel Ground Wire

a)	Size (no. of strands/strand dia)	7/3.15 for 132 and 220 KV, and 7/3.66 for 400 KV
b)	Overall diameter (mm)	9.45(7/3.15) and 10.98(7/3.66)

c)	Standard weight (Kg/km)	432(7/3.15) and 583(7/3.66)
d)	Location of ground wire	One continuous ground wire Wire to run horizontally on the top of the towers for 132 and 220 KV and two ground wire for 400 KV lines.
e)	Tensile load in each ground wire (to be furnished by the Bidder)	
i)	At min. temp. of 5ę C and in still air (kgs)	
ii)	At every day temp. of 32ę C and still air (kgs)	
iii)	At 5ę C and 2/3rd of full wind (kgs)	

1.1.8.1 Towers

a)	Span lengths in metres	ACSR Zebra	ACSR Moose	ACSR Panther
i)	Ruling design span	300	300	250
b)	Wind load (kg/sqm) on conductor	52	52	52
c)	Shielding angle with vertical	20ę	20ę	20ę
d)	Towers to be designed for heavy wind zone	V-zone	V-zone	v-zone

1.1.8.2 Insulator Strings(Disc)(Antifog type)

Sl. No.	Particulars	Single Suspension string	Double suspension string	Single Tension string	Double Tension string
1.	No. of standard Discs (nos)				
	1) 400 KV	1X25	2X25	1X25	2X25
	2) 220 kV	1X15	2X15	1X15	2X15
	3) 132 Kv	1X10	2X10	1X10	2X10
2.	Size of Disc (400kv/220kV/132 kv)	280x145/ 255X145/ 255X145	280x145/ 255X145/ 255X145	305x170/ 305x170/ 280x145	305x170/305x170/280x145
3.	Electromechanical strength (KN)	120/90/90	120/90/90	160/160/120	160/160/120

(400 KV/220 kV/132 KV)

4.0 GENERAL TECHNICAL REQUIREMENTS

4.1 Tower Design ï General

The employer is looking for a structurally safe design of transmission line towers to be installed on EHV lines keeping the loadings and line parameters detailed in this specification and in compliance with IS: 802 (Part-1/Sec-1)-1995, IS: 802(Part-1/Sec-2)-1992.

The Bidder may offer economical designs with rational sections or offer towers of recent design, proven in service and accepted by other reputed Central and State Sector Utilities and by OPTCL (Previously OSEB) confirming to this technical specification.

The technical particulars for vibration analysis and damping design of the system are as follows:

FOR 400kV LINES.

SL. No.	Description	Technical Particulars
1.	Configuration	Double Circuit Twin ACSR Moose 54/7//3.53 mm, conductor bundle per phase in horizontal formation and all three phases of each circuit in vertical configuration on each side of tower.
2.	Span length in meters	
	(i) Ruling design span	400 meters
	(ii) Maximum span	1100 meters
	(iii) Minimum span	100 meters
3.	Tensile load in each sub-conductor for ruling span	Wind Zone : 5 (50 m/s).
	a) At temperature of 5 deg-C and still air	3267 Kgf.
	b) At temperature of 5 deg.C and 36% full wind	4646 Kgf.
	c) At temperature of 32 deg.C and full wind	7805 Kgf.

4.	Armour rods used	Standard preformed armour rods/AGS
5.	Maximum permissible dynamic strain	+/- 150 micro strains

FOR 220 kV and 132 kV LINES

SL.NO.	Description	Technical Particulars	
		220kV **ACSR ZEBRA** 54/7/ 3.18mm	132kV **ACSR PANTHER** 30/7/3.0mm
1.	Configuration	Double Circuit Single ACSR conductor per phase in verti-cal formation	Double Circuit Single ACSR conductor per phase in verti-cal formation
2.	Span length in metres		
	(I) Ruling design span	350 metres	300 metres
	(ii) Maximum span	1100 metres	1000 metres
	(iii) Minimum span	100 metres	100 metres
3.	Tensile load in each conductor for ruling span	Wind Zone:5 (50 m/s.)	Wind Zone:5 (50 m/s.)
	a) At temperature of 5 deg.C and still air	2919 Kgf.	1791Kgf.
	b) At temperature of 5 deg.C and 36% full wind	4090 Kgf.	2735Kgf.
	c) At temperature of 32 deg-C and full wind	6551 Kgf.	4469 Kgf.
4.	Armour rods used	Standard performed armour rods/AGS	Standard performed armour rods/AGS
5.	Maximum permissible dynamic strain	± 150 micro-strains	± 150 micro-strains

4.0 **DETAILS OF SOLID CORE LONG ROD INSULATORS**:

5.1 The insulator shall consist of standard-discs for a three-phase 50 Hz effectively earthed 220 KV transmission system heavily polluted atmosphere. The insulator shall be ball and socket type.

5.1 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanically strength and mechanical strength of insulator string alongwith hardware shall be as follows:

Sl. No.	Type of string.	Size of long rod insulator (mm)/(Unit) 132/220 KV	Minimum creepage distance (mm) 132/220 KV	No.of unit 132/220 KV)	Electromechanical strength of insulator (KN) 132/220 KV)
1.	Single suspension	200X 1305 /210X2030	4000 / 6125	'1/2	90 KN
2.	Double suspension	-do-	-do-	'2/4	90 KN
3.	Single tension.	205 X 1450 / 215X2550	4300/7130	'1/2	120 KN/160 KN
4.	Double Tension.	-do-	-do-	'2/4	120 KN/160 KN

5.0 **SPECIFICATION DRAWINGS**:

6.1 A list of specification drawings in respect of the long rod insulators indicated above is given at Annexure-II. These specification drawings are attached herewith for information and guidance of the bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and shall be distinct and separate from these specification drawings.

6.0 **GENERAL TECHNICAL REQUIREMENT**:

7.1 **PORCELAIN**:

The porcelain used in the manufacture of the shell shall be ivory white, nonporous of high dielectric, mechanical and thermal strength free from internal stress blisters and thermal strength from internal stresses blisters, laminations, voids, foreign matter. Imperfections or other defects, which might render it in any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid alkalis, and zinc of dust. The manufacturing shall be by the wet process and impervious character obtained by through vetrification.

7.2 **PORCELAIN GLAZE**:

Surfaces to come in contact with cement shall be made rough by stand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of the glaze shall be uniform throughout and the colour of the glaze shall be brown. The glaze shall have a visible luster and smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain

under compression on the porcelain body throughout the working temperature range.

7.3 METAL PARTS:

7.3.1 Cap and Ball pins:

Twin Ball pins shall be made with drop forged steel and caps with malleable cast iron. They shall be in one single piece and duly hot dip g galvanized. They shall not contain parts or pieces joined together, welded, shrink fitted or by any other process from more than one piece of material. The pins shall be of high tensile steel, drop forged and heat malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity with minimum of 6 dips. The bidder shall specify the grade, composition and mechanical properties of steel used for caps and pins.

7.3.2 **SECURITY CLIPS**:

The security clips shall be made of phosphor bronze or of stainless steel.

7.4 **FILLER MATERIAL**:

Cement to be used as a filler material shall be quick setting, for curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contract with it and its thickness shall be as small and as uniform as possible.

7.0 **MATERIAL DESIGN AND WORKMANSHIP**:

8.1 **GENERAL**:

i) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw materials quality control and to stage testing quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

ii) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion good finish, elimination of sharp edges and corners to limit corona and radio interference voltage

8.2 **INSULATOR SHELL**:

The design of the insulator shell shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

8.3 **METAL PARTS**:

a) The twin ball pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces

concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the insulator or is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

b) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting parts or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly. Pins shall not show any macroscopically visible cracks, insulations and voids.

8.4 **GALVANIZING**:

All ferrous parts shall be hot dip galvanized six times in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.5 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from impurities such as flux ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

8.4.1 **CEMENTING**:

The insulator design shall be such that the insulating medium shall not directly engage with hard metal. The surfaces of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials.

8.5 SECURITY CLIPS (LOCKING DEVICES

The security clips to be used as locking device for ball and socket coupling shall be of Rôshaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for sore adding after installation to prevent complete withdrawal from the socket. The locking device shall be resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation when placed in position and under no circumstances shall it allow separation of insulator units and fitting of Wôtype security clips are also acceptable. The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked position shall not be less than 50 N (5 Kgs.) or more than 500N (50 Kgs.)

8.6 **BALL AND SOCKET DESIGNATION**:

The dimensions of the balls and sockets for 80 KN long rod insulators shall be of 16mm and for 120 KN shall be of 20mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-III).

8.7 DIMENSIONAL TOLERANCE OF INSULATORS DISCS

It shall be ensured that the dimensions of the long rod insulators are within the limits as per relevant IEC/ISS.

Bundle spacer (only for 400kV lines)

Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors.

The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

The placement chart shall be provided for spans ranging from 100m to 1100m. The number of spacers recommended for a nominal ruling span of 400m shall however be not-less than six.

The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the Bid.

Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm. Bidder shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers. For slack span also rigid spacers shall be used with maximum spacing of 30 metres.

The spacer offered by the Bidder shall satisfy the following requirements:

Spacers shall restore normal spacing of the subconductors after displacement by wind, electromagnetic and electrostatic forces under all operating conditions, including the specified short circuit level, without permanent deformation or damage either to conductor or to the assembly itself. They shall have uniform grip on the conductors.

For spacers requiring preformed retaining rods, the retaining rods shall be designed for the specified conductor size. The rods shall be made of high strength special aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The ends of retaining rods shall be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.

Four rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall 7.87 +/- 0.1 mm. and the length of the rods shall not be less than 1100 mm.

Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert shall be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded. Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened. The clamp grooves shall be in uniform contact

with the conductor over the entire clamping surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material, which may cause damage to the conductor when the clamp is installed. For the spacers involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation. Universal type bolted clamps, covering a range of conductor sizes will not be permitted. No rubbing, other than that of the conductor clamp hinges or clamp swing bolts shall take place between any parts of the spacer. Joints incorporating a flexible medium shall be such that there is no relative slip between them.

The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service. Rigid spacers shall be acceptable only for jumpers. The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance. The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep. The spacer assembly shall not have any projections, cuts, abrasions or chattering parts which might cause corona or RIV. The spacer tube shall be made of aluminium alloy of type 6061 or equivalent aluminium alloy. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacers involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 amps., 50 Hz alternating current per subconductor. Elastomer, if used, shall be resistant to the effects of temperature up to 85 deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.

The spacer assembly shall have complete ease of installation and shall be capable of removal and reinstallation without any damage. The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.

Spacer damper (only for 400kV lines)

As an alternative to vibration dampers and bundle spacers combination, suitable spacer dampers for twin bundle AAAC 61/3.45 conductor may be offered. The spacer damper covered by this Specification shall be designed to maintain the bundle spacing of 450mm under all normal operating conditions and to effectively control aeolian vibrations as well as subspan oscillations to nominal conductor spacing after release of any external extra-ordinary load.

The spacer damper shall restore the normal subconductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.

The design offered shall be presented as a system consisting of a recommended number of spacer dampers together with their spacing schedule for spans ranging from 100m to 1100 m.

Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line in order to

prevent damage to conductor at suspension clamps, dead end clamps and at the spacer clamps.

The spacer damper system shall also control the sub span oscillations in order to prevent conductor damage due to chafing and due to severe bending stresses at the spacer damper clamps as well as suspension and dead end clamps and to avoid wear to spacer damper components.

The spacer damper shall consist of a rigid central body called the frame, linked to the conductors by two articulated arms terminated by suitable clamping system. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.

The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.

The clamp of the spacer damper, when installed, shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation. The slip strength of the clamp shall be maintained between 2.5kN to 5kN. The tightening torque for the bolts, if applicable, shall be specified by the manufacturer to achieve the above slip strength.

Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices using small loose components shall not be accepted.

Bolts and nuts shall be of mild steel, stainless steel, or high strength aluminium alloy in accordance with the design of the spacer damper.

Where elastomer surfaced clamps are used, the elastomer elements shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.

If clamps involving preformed rods are used, these rods shall be designed for specific conductor size. They shall be made of high strength aluminium alloy of type 6061 or equivalent aluminium alloy having a minimum tensile strength of 35 kg/sqmm. The rods shall be ball ended. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service.

The spacer damper body shall be cast/forged from suitable high strength corrosion resistant aluminium alloy. The aluminium alloy shall be chosen in relation with the process used. However a combination of aluminium alloy and steel shall also be accepted.

The rubber components like damping elements involved in the design shall be made with rubber compound selected specifically for that particular application. The Bidder shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable ASTM or other Internationally recognised standards.

The rubber compounds used shall have good resistance to the effects of temperature up to 85 deg.C and to ultra violet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

The spacer damper involving ferrous material shall not have magnetic power loss more than one watt at 600 amps., 50 Hz alternating current per sub conductor.

The spacer damper assembly shall have electrical continuity. The electrical resistance between the subconductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.

The spacer damper assembly shall have complete ease of installation and shall be capable of removal and reinstallation without any damage.

The spacer damper assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.

The Bidder shall recommend the spacing between spacer dampers on the line which shall ensure the most satisfactory fatigue performance of the line as specified. The scheme shall indicate the number of spacer dampers per phase per span and the sub-span lengths to be maintained between spacer dampers when installed on the twin bundle conductors.

The number of spacer dampers and their spacing shall be provided for spans ranging from 100 to 1100m. The number of spacer dampers for a nominal ruling span of 400 m shall be not less than six.

No sub-span shall be greater than 70m and no end sub-span shall be longer than 40 metres.

The proposed scheme shall be such that the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent sub-spans for oscillations of sub-span mode and to ensure bundle stability for wind speeds up to 30 kms/hr (8.33 m./sec.).

The Bidder shall furnish all the relevant technical documents in support of the staggering scheme recommended for the spacer damper.

The Bidder in the latter case shall forward documentation of proto type tests conducted and acceptance given by the user authorities as also performance report for such towers in service.

Vibration dampers

All the requirements for vibration damper suitable for line conductors, shall also be applicable for galvanised steel earthwires (7/3.66mm. for 400kV and 7/3.15mm. for 220kV/132kV lines). Minimum one damper on each side per earth wire at suspension point and two dampers on each side at tension point shall be used for ruling design span. Bidders may offer damping systems involving a greater number of dampers for ruling design span; however, suitable price compensation shall be considered for evaluation.

The vibration analysis of the system, with and without dampers, dynamic characteristic of the damper as detailed shall be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows :

For 400kV Lines

Sl. No.	Description	Technical Particulars

1.	Configuration	Two galvanised steel earthwires in horizontal configuration
2.	Span length in meters	
	Ruling design span	400 meters
	Maximum span	1100 meters
	Minimum span	1 00 meters
3.	Tensile load in each earthwire for ruling span (50m/s)	Wind Zone : 5
	a) At temperature of 5^{o} C and still air	1368 Kgf
	b) At temperature of 5^{o} C and 36% full wind	2056 Kgf
	c) At temperature of 32^{o} C and full wind	3593 Kgf
4.	Maximum permissible dynamic strain	+/- 150 micro strains

For 132kV and 220kV Lines

Sl. No.	Description	Technical Particulars	
1 .	Configuration	One galvanised steel earthwire in horizontal configuration .	
2.	Span length in meters	220 kV Line	132 kV Line
	Ruling design span	350 meters	300 meters
	Maximum span	1100 meters	1000 meters
	Minimum span	100 meters	100 meters
3.	Tensile load in each earthwire for ruling span	Wind Zone:5 (50m/s)	Wind Zone:5 (50m/s)
	a) At temperature of 5 deg.C and still air	1120 Kgf.	1120 Kgf.
	b) At temperature of 5 deg.C and	1667 Kgf.	1606 Kgf.

36% full wind		
c) At temperature of 32 deg.C and full wind	2815 Kgf.	2625 Kgf.
4 . Maximum permissible dynamic strain	+/- 150 micro strains	+/- 150 micro strains

Flexible copper bond

At suspension and tension towers the earth wire suspension and tension clamps shall be securely bonded to the tower steelwork by means of a multi-strand flexible copper bond wire. The copper bond shall be sufficiently flexible to allow movement of the suspension clamp under all operating conditions and terminated with compression lugs.

The flexible copper bond shall be of nominal 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as seven stranded ropes, each of 37 bunched wires. The tinning shall be as per IS 9567. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia. bolt. The complete assembly shall also include one 16 mm dia., 40 mm long mild steel bolt hot dip galvanised with nut and lock washers

Arcing horn

The arcing horn shall be either ball ended rod type or tubular type and shall be formed from galvanised mild steel and of approved types. The arcing horns shall be attached in an approved manner to all suspension and tension insulator sets. The horns shall be attached to the insulator fittings, but not directly to conductor clamps or to the caps of insulator units. The design of the arcing horns shall be such as to reduce, as far as reasonably possible, damage to the line conductors, clamps, insulator strings and arcing horns themselves under all flashover conditions. The general shape and method of attachment of the live end arcing horn shall also not restrict the replacement of insulators under live line conditions.

The total effective arcing distance shall be 1530mm., 2130mm. and 3050 mm. for 132kV, 220kV and 400kV respectively under nominal dimensions of insulator.

Arcing horns shall be provided on tower and/or line side as indicated on the enclosed string sketches, however, same has been tabulated below for ready reference :

SL.No.	Voltage Level	Types of Strings	Arcing horns to be provided on	Min. Arcing dist. to be maintained(mm)
1.	2.	3.	4.	5.
1.	132kV and 220kV	Single or suspension strings	Line side only	1530(for132kV)& 2130(for 220kV)
1.	2.	3.	4.	5.
2.	-do-	Double suspension strings	Both on line side and tower side	1530(for132kV)& 2130(for 220kV)

3.	-do-	Single tension strings	Line side only	-do-
4.	-do-	Double tension strings	Both on line side and tower side	-do-
5.	400kV	Single suspension and pilot strings	Tower side (corona/grading rings on line side)	3050
6.	-do-	Double suspension strings	-do-	-do-
7.	-do-	Single tension strings	-do-	-do-
8.	-do-	Double tension strings	-do-	-do-

4.1.1 Transmission Towers

4.1.2 General Description

The towers shall be of the following types:

(b) Double Circuit (A, B, C & D)
(c) Special Towers (River Crossing, Railway Track Crossing, Power Line Crossing etc.)

Types Of Towers

The towers shall normally be of the following standard types, and as stated in Schedule C.

Type of Tower (1)	Deviation Limit (2)	Typical Use (3)
DA/OA/PA	0deg- 2deg	a) To be used as tangent tower with suspension strings. b) Also to be designed for specified broken wire conditions.
DB /0B/PB	0 deg- 15deg	a) Angle towers with tension insulator string b) Also to be designed for unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m

		(for 220kV) and of 300m and 200m (for 132kV)on each side of the tower. c) Also to be designed for uplift forces resulting from an up-lift span of 200m under broken wire conditions. d) Also to be designed for specified broken wire conditions. e) Also to be designed for anti-cascading condition.
DB/OB/PB tower.	0 deg.	f) To be used as section
DC/OC/PC	15 deg-30 deg.	a) Angle tower with tension insulator strings. b) Also to be designed for unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m and 200m (for 132kV)on each side of the tower. c) Also to be designed for uplift forces resulting from an up-lift span of 200m under broken wire conditions. d) Also to be designed for specified broken wire conditions. e) Also to be designed for anti-cascading condition.
DC/OC/PC	0 deg.	f) To be used as transposition tower with modifications (only where specified)
DD	30 deg-60 deg	a) Angle tower with tension insulator string

b) Also to be designed for the unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m and 200m (for 132kV) on each side of the tower.

c) Also to be designed for uplift forces resulting from an uplift span of 300m(for 400kV) and 200m (for 132kV and20kV) under broken wire conditions.

d) Also to be designed for specified broken wire conditions.

e) Dead end with 0 deg to 15 deg deviation on line and 0 deg to 30 deg for sub-station side (slack span side).

DD 0 deg f) Complete dead end.

g) For river crossing anchoring with longer wind span with 0 deg deviation on crossing span side and 0 deg to 30 deg deviation on other sides .

Note: The above towers can also be used for longer span with smaller angle of deviations. (To be decided as per the tower spotting data to be submitted by the Contractor and approved by Project Manager.)

4.1.3 The towers shall be of the self-supporting type, built up of lattice steel sections or members and designed to carry the power conductors with necessary insulators. Ground wires and all fittings under all loading conditions. Outline diagrams of the towers required are to be furnished by the Bidder.

4.1.4 The towers shall be fully galvanized structures built up of structural mild steel sections. All members shall be connected with bolts, nuts and spring washers.

For design of structure weight span limits given in Table 5.1 shall prevail.

TABLE 5.1 (a)
For 132 kV Line

Tower Type	Normal Condition		Broken Wire Cond	
	Max. (m)	Min. (m)	Max. (m)	Min. (m)
DA	450	150	270	100

DB, DC & DD	450	0	270	-200

TABLE 5.1 (b)
For 220 kV Line

Tower Type	Normal Condition Max. (m)	Min. (m)	Broken Wire Cond Max. (m)	Min. (m)
DA	525	200	315	100
DB, DC & DD	525	0	315	-200

TABLE 5.1 (c)
For 400 kV Line

Tower Type	Normal Condition Max. (m)	Min. (m)	Broken Wire Con Max. (m)	Min. (m)
DA	600	200	360	100
DB, DC	600	0	360	-200
DD	600	0	360	-300

However, for calculating the tower height, an allowance of 150mm shall be provided, over and above the specified ground clearances, at still air and maximum conductor temperature, to account for any stringing error.

TABLE

Situation	Minimum clearance (metres)		
System voltage (kV):	**132**	**220**	**400**
Normal ground (open country)	6.10	7.015	8.84
* Road crossings, road level	7.00	7.90	9.7
Rail crossings, rail level:	17.9	17.9	19.3
River crossings, bank level River crossings, navigable rivers, above highest as specified by the Authority flood level;(data to be obtained from Navigation Authority)			
Above trees	4.0	4.6	5.5
Buildings, poles, structures and walls, etc. upon which a man may stand : horizontal clearance	4.6	5.5	7.3
Same above : vertical clearance	2.9	3.8	5.6
Power lines	3.1	4.6	6.1

*Any road which is normally maintained by Government and/or other recognised public authority.

4.1.5 Stubs and Superstructures:

(i) The stub shall mean a set of four stub angles fully galvanized from the and shall include cleats, gussets, bolts and nuts, etc. the black portion of the stub being cast in foundation footings. Stub length shall correspond to foundation depth of 3-0 metres from ground level.

(ii) Superstructure shall mean the galvanized tower assembly above the stubs which includes structural members like angle sections, cross arms, ground wire peaks, accessories and fittings such as gusset plates, pack washers, spring, washers, ladders, step bolts, anti climbing devices and such other items which are required for completing the towers in all respect. Steel and zinc required for manufacturing these items will be arranged by the supplier.

(iii) Supply of bolts and nuts and spring washers, hangers/D-shackles for attaching suspension strings and ôUô bolts for attaching ground wire suspension assemblies are included in the supply of tower.

(iv) The following provisions shall apply in connection with the procurement of steel and zinc by the supplier.

(a) The steel used for fabrication of tower parts extensions, templates etc. shall be of mild steel of tested quality as per IS:2062 GRA.

(b) The Bidder shall take into account the fabrication wastage while quoting the rates. The employer will not accept any liability in connection with the wastage of steel during fabrication or otherwise.

(c) The Bidder shall indicate in his offer the sizes of steel sections which are proposed to be used by him in the design of towers.

(d) Substitutions, if any, of steel sections of the tower parts by higher sizes, due to non-availability or otherwise shall be to the supplierôs account. The employer will not accept any liability on this account.

(e) The steel shall be procured exclusively from the main steel producers. However, sections not rolled by main producers, can be procured from re-rollers provided.

Re-rolling of structural steel sections is done from billets/ingots of tested quality.

Re-rolled sections are duly tested as per relevant standard.

(f) The zinc used for galvanizing fabricated material shall be of High Grade Electrolytic zinc.

4.1.6 Extensions:

a) The towers shall be designed so as to be suitable for adding 3 metres, 6 metres, 9 metres extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner.

b) The Buidder shall have to design leg extensions for all types of towers ranging from minus 3 metres to plus 9 metres at intervals of 1.5 metres and such leg extensions shall be suitable for being fitted to a normal tower as well as a tower with extensions. This is to enable tower spotting in hilly terrain.

4.1.7 Stub setting Templates:

Stub templates shall be designed and supplied by the supplier as per requirement for all types of towers with or without extensions. Stub templates for standard towers and towers with extension shall be fined type. The stub templates shall be painted with anti-corrosive paints.

4.1.8 Fasteners: Bolts, Nuts & Washers

4.1.9 All bolts shall be of property class 5.6 and nuts of property class 5.0 IS: 1367 (Part ï 3) 1991 and IS: 6639-1972 shall conform to IS: 12427, they shall be galvanized and shall have hexagonal heads and nuts, the heads being forged out of solid steel rods and shall be truly concentric and square with the shank. The shank shall be perfectly straight.

4.1.10 ully threaded bolts shall not be used, the length of bolts should be such that the threaded portion shall not extend into the place of contact of the members.

4.1.11 ll bolts shall be threaded to take the full depth of the nut and threaded far enough to permit firm gripping of the members, but not any further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit hand tight to the point where the shank of the bolt connects to the head.

4.1.12 lat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of electro-galvanized steel and of the positive lock type. Their thickness shall be 2.5 mm for 12 mm dia bolts, 3.5 mm for 16 mm dia bolts and 4.5 mm for 20 mm dia bolts.

4.1.13 he Bidder shall furnish bolt schedules giving thickness of members connected, size of bolts and nuts, the length of the shank, the length of the threaded portion of bolts, sizes of bolt holes, thickness of washers and any other special details of this nature.

4.1.14 To obviate bending stress in bolts or to reduce it to a minimum, no bolt shall connect aggregate thickness of more than three (3) times its dia.

4.1.15 he bolt positions in assembled towers shall be as per IS: 5613 (Part-I/Section-I) (Part-II/Section-2)-1985.

4.1.16 olts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

5.0 Tower Accessories

5.1 Step Bolt Ladders: These bolts shall be of property class 4.6 conform to IS: 6639-1972.

5.1.1 Each tower shall be provided with step bolts on one of the main legs, of not less than 16 mm diameter and 175 mm long, spaced not more than 400 mm apart and extending from about 2.5 metres above the ground level to the top of the tower. Each step bolt shall be provided with two nuts on one end to fasten the bolt security to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN and shall be used as a ladder for climbing.

5.1.2 Anti-climbing devices: This shall conform to IS: 5613 (Part-I/Sec ï I), 19085.

Fully galvanized barbed wire type anti-climbing device shall be provided at a height of approximately 3 metres as an anti-climbing measure. Four layers of barbed wires will be provided each inside and outside the tower in horizontal plane, spacing between the layers being 140 to 150 mm. The towers to be designed by the supplier shall have provision to fixed the barbed wire as indicated above. Thus the angle pieces with notches for accommodating barbed wire shall be designed and supplied with the towers along with provision for suitable bolt holes on leg members for fitting bolt holes on leg member for fitting the angles. The scheme of the anti-climbing device shall be submitted along with the tower drawing. Barbed wire shall be included in the scope of bidder.

5.1.3 Insulator strings and ground wire clamp attachments

(a) For the attachment of suspension insulator strings a suitable swinging hanger on the tower shall be provided so as to obtain requisite clearance under extreme swinging conditions and free swinging of the string.

The hanger shall be designed to withstand an ultimate tensile strength of 11.500 kg.

5.1.4 (a)For ground wires at suspension towers suitable ôUô Bolts strong enough to withstand the full designed loads shall be provided to accommodate the hook of the ground wire suspension clamps.

(b) At tension towers, horizontal strain plates of suitable dimensions on the underside of each power cross-arm tip and at the top ground wire peak shall be provided for taking the ôDô Shackles of the tension insulator strings or ground wire tension clamps, as the case may be. Full details of the attachments shall be submitted by the supplier for the employerôs approval before commencing with mass fabrication.

5.1.5 Phase Plate

Phase plate shall be of mild steel of 16 gauge vitreous enameled at back and front, circular in shape and diameter 75 mm. One set of phase plate shall be consisting of 3 plates red, yellow and blue coloured accordingly to indicate the phase of the conductor. There shall be one fixing bolt on the plate. This shall conform to IS: 5613 (Part-II/Section01) of latest edition.

5.1.6 Number Plate

The number plate shall be mild steel vitreous enameled at back and front, 200 mmx 150 mm, rectangular shape and inscribed thereon shall be the number of the tower location preceded by letter corresponding to the short name of the line and the type of towers. There shall be two fixing bolts on both end of the plates. The dimension and details of the number plate shall be as per IS: 5613 (Part-II/Section1 & Section-2), 1985.

5.1.7 Danger Plate

These shall be of mild steel vitreous enameled at back and front 250 x 200 mm rectangular shape and inscribed thereon shall be in signal red the work ôDANGERô with its Oriya and Hindi translation and also with the inscription of Bone and Scull and voltage of the line. There shall be two holes on the plates for fixing. This shall conform to IS: 2551 (latest edition).

5.1.8 Details to Tower Fabrication Workmanship

5.1.9 Except where hereinafter modified details of fabrications shall confirm to IS: 802 (Part-II)-1978.

5.1.10 But splices shall generally be used such that the inside cleat angle and outside plates are designed to transmit load. The inside cleat angle shall not be less than half the thickness of the connected heaviest member plus 2 mm. Lap splices may also be used for connecting members of unequal size in such a manner that the inside angle of the lap splice shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the members connected through bolts. But as well as lap splices shall be made as above and as close to and above the main panel point as far as possible.

5.1.11 Points shall be so designed so as to avoid eccentricity. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where connections are such that the elimination of the gusset plates would result in eccentric joints then gussets plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plate, required to transmit stress, shall not be less than that of the thinnest of connected member but not less than 5 mm in any case.

The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary so as to avoid the use of filler and it shall be connected at the point of inter-section by one or more bolts.

5.1.12 The tower structures shall be accurately fabricated to bolt together easily at site without any strain on the bolts.

5.1.13 No angle member shall have the two leg flanges brought together by closing the angle.

5.1.14 The diameter of the hole shall be equal to the diameter of bolt plus 1.5 mm.

5.1.15 The structure shall be designed such that all parts are accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depressions are likely to hold water.

5.1.16 All similar parts shall be made strictly interchangeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which shall not injure the materials so that when assembled, the different matching surfaces are in close contact throughout. No rough edges shall be permitted any where in the structure.

5.1.17 Drilling and Punching

(a) Before any cutting work is started, all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

(b) Holes for bolts shall be drilled of punched with a jig but drilled holes are preferred. The following maximum tolerance of accuracy of punched holes is permissible.

(i) Holes must be perfectly circular and no tolerance in this respect is permissible.

(ii) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8 mm i.e. the allowable taper in punched holes should not exceed 0.8 mm on diameter.

(iii) Holes must be square with the plates or angles and have their walls parallel.

© All burrs left by drills or punches shall be removed completely. When the tower members be truly opposite to each other. Drilling or reaming to enlarge defective holes is not permitted.

5.1.18 Erection Mark:

Each individual member shall have an erection mark conforming to the component number given to it in the fabrication drawings. This mark shall be done with marking dies of 16 mm size before galvanizing and shall be legible after galvanising.

The erection mark shall be A-BB-CC-DDD where

A Employer code assigned to the supplier (Alphabet).

BB Supplierôs Mark (Numerical)

CC Tower type (Alphabet)

DDD Number mark to be assigned by Supplier (numerical).

5.1.19.1 Galvanizing

The super structure of all towers and stubs upto 150 mm below plinth level (Top of concrete pedestal) shall be galvanized. Galvanizing of tower members and stub shall be in conformity with IS: 4759-1984 and shall be done after all fabrication work has been completed except that the nuts may be tapped or return after galvanizing. Threads of bolts and nuts after galvanizing shall have a neat fit and shall be such that they can be turned with fingers throughout the length of the threads of bolts and they shall be capable of developing the full strength of the bolts. Spring washers shall be electro-galvanized as per Grade ï 4 of IS: 1573 ï 1986. Galvanizing for fasteners shall conform to IS: 1367 (Part-XIII) ï 1978.

5.1.19.2 Quantities and Weights

5.1.20 The quantities stated in Annexure ï I are only provisional. Final quantities will be informed by the employer to the supplier on completion of detailed survey. However, bids will be evaluated based on quantities indicated in the Annexure ï I.

5.1.21 The employer reserves the right to order for the final quantities at the rates quoted in the bid, which shall be valid throughout the pendency of the contract.

5.1.21.1 The unit weight of each type of tower stubs, super structure and extension be furnished by the Bidder. The weight of tower shall mean the weight of tower calculated by using the black section(ungalvanized) weight of steel members including stubs, of the sizes indicated in the approved fabrication drawings and bills of materials, without taking into consideration the reduction in weights due to holes, notches, cuts, etc. but taking into consideration the weight of special fittings.

5.1.21.2 Tower designs Superstructure

5.1.21.3 Wind Pressure

The wind pressure on towers, power conductors and earth wire shall be as per IS: 802 (Part-I/Sec-I) ï 1995.

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5.1.21.4 Design Temperatures

The following temperature range for the power conductor and ground wires shall be adopted for the line design confirming to IS: 802 (Part ï I/Sec ï I) ï 1995.

i) Minimum temperature 50ęC.

ii) Every day temperature 32ęC

iii) Maximum temperature of:

a)	Conductor	75ęC for ACSR Moose/Zebra/Panther 90ęC for AAAC (Moose equivalent)
b)	Ground wire exposed to Sun.	53ęC

5.1.21.5 Factors of Safety & Span details

a) Factory of safety.

The factor of safety based on crippling strength of struts and elastic limit of tension members shall not be less than 2(two) under normal condition and 1.5 (one and a half) under broken wire conditions for all the members of the towers and their cross arms.

b) Normal Span

The normal span of the line shall be 300 metres for 400 KV and 220 kV and 250 meters for 132 kV.

c) Wind and weight spans

The wind and weight spans to be adopted in the design of the structures shall be as follows:

i) Wind Span

The wind span is the sum of the two half spans adjacent to the support under consideration. In case of towers located on an perfectly horizontal terrain, this shall be the normal span. For design purposes the wind on conductor shall be calculated on at least 1.1 times the normal.

ii) Weight Span

The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower.

All C and D type towers shall be designed for uplift spans (minimum) weight spans in the following table also. These are applicable both for pointed and square cross arms.

For details of cross arms and towers, the span limits given below shall prevail.

WEIGHT SPANS

Tower Type	400/220 KV				132KV			
	Normal Condition		Broken wire condition		Normal Condition		Broken wire condition	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A & B	525	100	300	100	320	100	250	100
C & D	600	100	300	100	320	100	250	100

5.1.21.6 Conductor and Ground wire Configuration

For single circuit towers the three phases shall be Delta formation. One number of ACSR conductor shall be used for each phase. One galvanized steel wire shall be used as ground wire. The ground wire shall be continuous and shall be provided above the conductors at suitable elevation to offer effective shielding and safe clearances. For double circuit towers the phases shall be in vertical formation with phase to phase horizontal spacing of not less than 8.4 meters and vertical 4.9 meters for 220 kV.

5.1.21.7Loads on Towers

i) Transverse Loads:

Transverse load due to wind on towers conductors and under broken wire earthwire shall be calculated in accordance with IS: 802(Part-I/Sec-I)-1995.

ii) Longitudinal Loads due to wind on towers conductors and shield shall be calculated as per IS: 802 (Part-I/Sec-I)-1995.

iii) Vertical Loads:

The vertical load due to conductors and ground wire shall also include 150 kg. As weight of a Lineman with tools. These loads are in addition to the vertical loads due to insulator fittings and the dead weight of the structure. The weight of a Lineman with tool should not be considered in minimum vertical load calculation. An additional erection load of 3.5 KN shall also be considered for the design of the tower. The stringing procedure shall ensure that the above vertical loads are not exceeded. For calculating vertical loads the following insulator weights may be considered.

400/220/132 KV

Each single suspension insulator string	160 kg
Each double suspension insulator string	320 kg
Each double tension insulator string	420 kg
Pilot string for 60ę tower	160 kg

iv) Broken Wire condition

a) Suspension Tower Type A/DA

Breaking of any one power conductor in one phase only, resulting in instanceous unbalance tension of 50% of conductor tension at 32ęC without wind or breaking of one earthwire resulting in an unbalance tension equal to the maximum tension of the ground wire whichever is more stringent is to be considered for design along with appropriate impact factor.

b) Tower Type B & C

Breakage of two phases on the same side and on the same span or breakage of any one phase and any one ground wire on the same span whichever combination is more stringent along with appropriate impact factor for a particular member.

c) Tower Type D/DD

Breakage of all the three phases on the same side and on the same span or breakage of two phases and any one ground wire on the same span, whichever combination is more stringent along with appropriate impact factor for a particular member. Cross arms for angle tower shall be of equal length for both sides.

v) Design Load

Employerôs requirement for design longitudinal and transverse loads shall confirm to IS: 802(Part-I/Sec-I)-1995.

The Bidder shall furnish the details of design loads proposed to be adopted in the tower design in accordance with this specification.

The design criteria and other special requirements as stipulated for special towers shall be applicable for river crossing/special towers.

5.1.21.8Tower Steel Sections:

i) Steel sections of tested quality in conformity with IS: 2062 GRA are to be used in towers, extensions and stub setting templates. No individual members shall be longer than 6000 mm.

For designing of towers only rationalized steel sections shall be used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost. However, design approval for such substitution shall be obtained from the employer.

ii) Thickness of Members

The minimum thickness of angle sections used ion the design of towers, shall be kept not less than the following values:

a) Main corner leg members excluding the ground wire peak and main cross arm 6 mm.

b) For all other main members 5 mm.

c) Redundant members 4 mm.

iii) Bolt Arrangement

The minimum bolt spacing and rolled edge distance and sheared edge distances of sections from the centers of the bolt holes shall be provided as furnished in Table-1.

Dia of Bolts (mm)	Hole Dia (mm)	Min. bolt Spacing (mm)	Min. rolled Distance (mm)	Min. Sheared Edge distance (mm)
12	13.5	30	16	19
16	17.5	40	20	23
20	21.5	50	25	27

Bolts sizes mentioned above shall only be used. The minimum width of flanges without bolt holes shall be 30 mm.

For the purpose of calculating stress and bearing stress for bolts refer clause 14.4 and 14.5 of IS: 802 (Part-I/Sec-2)-1992.

iv) Allowable Stress:

Structural steel angle section manufactured according to the latest ISL: 808(Part-V & VI) and tested according to the latest edition of IS:2062 and having its yield strength not less than 255 N/mm. sq. shall be used in the fabrication of tower members.

v) Axial Stress in tension:

The estimated tensile stress in various members multiplied by the appropriate factors of safety shall not exceed the value given by the formula specified in Clause 9.2.1 of IS:802(Part-I/Sec-2)-1992.

vi) Axial Stress in Compression

The estimated compressive stress in various members multiplied by the appropriate factors of safety shall not exceed the value given by the formula specified in Clause 9.2.1 of IS:802(Part-I/Sec-2)-1992.

vii) Slenderness ratio:

Slenderness ratio for members shall be computed in accordance with IS:802(Part-I/Sec-2)-1992. Slenderness ratio for compression and tension members shall not exceed the values specified therein. The following maximum limits of the slenderness ratio shall be adopted i.e. the ratio of unsupported length of the section in any place to the appropriate radius of gyration.

a)	For main corner leg member including the corner members of earth wire peak and the lower corner members of the armsé	150
b)	For other members having calculated stressesé .	200
c)	For redundant membersé .	250
d)	For members having tensile stress onlyé .	375

viii) Erection Stress

Where erection stresses combined with other permissible co-existent stresses could produce a working stress in any member appreciably above the specified working stress, then additional materials shall be added to the member or such other provision made so as to bring the working stress within the specified limit. For the purpose of this clause the specified working stress shall be the ultimate stress divided by the factor of safety of 2.0.

ix) Design calculation and Drawings

The following design calculations and drawings are required to be furnished to the employer.

a) Along with the Bid:

Detailed design calculations and drawing for each type of tower.

b) On award of Contract

The supplier shall submit design of tower extension, stub templates and loading/rigging arrangement of tower testing to enable the employer to make preliminary check regarding structural stability of tower tests.

Upon successful testing of tower and subsequent approval of designs, drawings and bill of materials, the supplier shall furnish Photostat copies of the following in 6(six) copies to the employer for necessary distribution along with one copy of reproducible print.

a) Detailed design calculations along with drawings of towers and foundations.

b) Detailed structural drawings indicating section size, length of member. Sizes of plate along with hole to hole distances, joint details etc.

c) Bill of materials indicating cutting and bending details against each member.

d) Shop drawings showing all details relevant to fabrication.

e) All drawings for the tower accessories.

The supplier is required to submit four copies of the drawings with Photostat copies mentioned above for approval by the employer while submitting the designs, structural drawings. Bill of materials and any other drawings pertaining to the subject transmission line. The supplier shall clearly indicate in each drawing the project code number, if any, specification no.;, name of transmission line, letter reference no. and date on which the submissions are made. The said procedure is to be followed while submitting the distribution copies.

5.1.21.9 Statutory Electrical Clearances:

i) Ground Clearances:

The minimum ground clearance from the bottom conductor shall not be less than 7.00 metres for 220 kV at the maximum sag conditions i.e. at maximum temperature and in still air. However, to achieve the above clearance the height of the tower shall be increased in the following manner:

a) An allowance of 4% of the maximum sag shall be provided to account for errors in stringing.

b) Conductor creep shall be compensated by over tensioning the conductor for a temperature of 26ęC lower than the stringing temperature.

In case of rail track crossings the minimum height above rail level of the lowest portion of any conductor under conditions of maximum sag, in accordance with the regulations for Electrical Crossing of Railway Tracks are given in Table ï 5.

TABLE – 5

Type of work	Inside stn. Limits(mm)	Outside stn. Limits(mm)

a)	For unelectrified track and tracks electrified on 1500 V.DC		
	i) For metre/narrow gauge	10,00017,600	
	ii) For broad gauge	11,200	8,800
b)	Tracks electrified on 25 kV AC for metre, narrow and broad gauge	15,300	13,300

Minimum clearance between the subject power line and any other power line crossing shall not be less than 7000 mm.

ii) Live Metal Clearance:

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as given in IS:5613 (Part-2/Sec-I).

The Bidder may adopt separate cross arm design and length for ôDôtype towers under dead end conditions provided adequate live metal clearance is available with at least 15ę angle and also provided that all the other specified conditions of this specifications are fulfilled. In case pilot insulator strings are proposed to be used, the angle of swing to be considered shall be minimum of 15ę.

In computing live metal clearances, the dimensions of suspension and tension string shall be taken as given in drawings attached herewith. The design of the towers shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the insulator strings.

iii) Angle Shielding

The angle shielding, defined as the angle formed by the line joining the center lines of the ground wire and outer conductor in still air, at tower supports, to the vertical line through the center line of the ground wire shall not be more than 30ę. The drop of the ground wire clamp which is employer supplied item should be considered while calculating the minimum angle of protection. For estimating the minimum angle of protection the drop of ground wire suspension clamp along with U-bolt may be taken as 150 mm.

iv) Mid Span Clearance

The minimum vertical span clearance between any of the earthwire and the nearest power conductor under all temperatures and in still air condition in the normal ruling span shall be 8.10 metres for 220 kV. Further the tensions of the earthwires and power conductors, shall be so co-ordinated that the sag of earthwires shall be at least 10% less than that of the power conductors under all temperatures and loading conditions.

5.1.21.10 Packing

Angle sections shall be wire bundled, cleat angles, gusset plates, blackets, filler plates, hanger and similar other loose items shall be netted and bolted together in multiples or securely wired together through holes.
Bolts, nuts, washers and other attachments shall be packed in double gunny bags, accurately tagged, in accordance with the contents.

The packings shall be properly done to avoid losses/damages during transit. Each bundle or package shall be appropriately marked.

5.1.21.11 Special Towers:

i) Special towers are to be used for major river crossing requiring very long spans. These towers shall form part of the Bidderôs scope.

Unit rates for design, fabrication, galvanizing, testing and supply for such towers shall be quoted in the appropriate schedule of Volume IB.

Anchoring of major river crossing towers, shall be with óDôor DD type towers.

All the requirements as meant for standard towers shall apply for such special towers except those noted in the following clauses.

ii) Shielding Angle:

The shielding angle shall not be greater than 30ę.

iii) Clearances:

The minimum clearance of lowest point of power conductor from the highest flood level in navigable rivers for crossing towers shall be obtained from the navigation authority.

The minimum electrical clearances between live parts and tower body and cross arm member shall be the same as for normal towers.

iv) Stub Location:

The approximate height of foundation on which stub for river cross towers are to be set, over the highest flood level of the river shall be fixed only after employerôs approval.

v) Angle of Deviation

The minimum angle of deviation to be considered for special towers is 2ę and all live material clearances are to be computed considering double suspension insulator strings as per drawing enclosed.

vi) Factors of Safety:

Towers:

The minimum factors of safety for towers shall be:

a) Under normal conditions 2.0
b) Under broken wire conditions 1.;5

vii) Conductor and Earth wire:

The minimum factor of safety for conductors and ground wire shall be 2.5 maximum tension corresponding to 2/3rd full wind pressure at minimum temperature or full wind pressure at the mean annual temperature such that the initial unloaded tension at the mean annual temperature do not exceed 30% of the ultimate strength of conductor and ground wire respectively.

viii) Wind Loads:

a) The procedure for wind load calculation on conductor and ground wire shall be the same as for normal structures.

b) The wind pressure values on tower shall be based on IS:802(Part-I/Sec-I)-1995.

ix) Longitudinal Loads:

a) The longitudinal loads due to power conductors and earth wires for suspension towers shall be nil under normal conditions and 100% of the maximum tension of bundled conductors or earth wire under broken wire conditions.

b) Under normal conditions, unbalanced longitudinal pull due to difference in tension in ruling span for river crossing towers on one side and span of the line on the other wise shall also be considered for the design of anchor towers.

5.1.22 TESTS

5.1.23 General

a) All standard tests including quality control tests in accordance with IS:802(Part-III)-1978 shall be carried out.

b) A galvanized tower of each type complete with 6 metres extension shall be subjected to design and destruction test. The tower shall be tested with nuts and bolts of the same make and type which are proposed to be used on the line. The supplier shall submit to the employer for approval, a detailed programme and proposal for testing the towers showing the method of carrying out the tests and the manner of applying the loads. The supplier on receipt of such approval shall intimate the employer about carrying out of the tests at least 30 days in advance of the scheduled date of tests during which time the employer will arrange to depute his representatives

to witness the tests. Six copies of the test reports thereof shall be submitted to the employer for approval.

c) In case of premature failure, the tower shall be retested and steel already used in the earlier test shall not be used again. The supplier shall provide facilities to the employer for inspection of materials during manufacturing stage and also during testing of the same.

d) No part of any tower subject to test shall be allowed to be used in the work. The prices to be quoted for such type tests shall be after allowing rebate for the scrap value of the tested tower which is to be retained by the supplier

e) The supplier shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully undergone the tests. In case any deviation is detected the supplier shall replace such defective towers free of cost of the employer. All expenditure incurred in erection, to and fro transportation, any other expenditure or losses incurred on this account shall be fully borne by the supplier.; No extension in delivery time shall be allowed on this account. The employer, however, reserves the right to waive off the testing of the towers, provided the supplier had earlier successfully tested, erected and commissioned similar towers and certificates for such tests carried out earlier are furnished duly certified by the employer and are found acceptable.

f) Each type of tower to be tested shall be a full scale prototype galvanized tower and shall be erected vertically on rigid foundation with the stub protruding above ground level as provided in the design/drawing between ground level and concrete level.

g) The suspension tower to be tested shall be with hanger and õUô Bolt as per approved design/drawings. The tension tower to be tested shall similarly be with the strain plate as per approved design/drawings.

h) In case of any premature failure even during waiting period, the tower shall be retested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected then in such cases all the tests which have been carried out earlier are to be reconducted to the entire satisfaction of the employer.

i) The sequence of testing shall be at the discretion of the employer.

5.1.23.1Test for Galvanization

Galvanization of the members of the tower shall withstand tests as per IS:2633.

5.1.24 INSPECTION

5.1.24.9 The supplier shall keep the employer informed well in advance of the commencement of manufacture, progress of manufacture thereof and fabrication of

various tower parts at various stages. So that arrangements could be made for inspection by the employer.

5.1.24.10 The acceptance of any batch of items shall in no way relieve the supplier of any his responsibilities for meeting all the requirements and intent of this specification and shall not prevent subsequent rejection if any item of that batch is later found defective.

5.1.24.11 The employer or his authorized representatives shall have free access at all reasonable time to all parts of the supplierôs works connected with the fabrication of the material covered under the contract for satisfying themselves that the fabrication is being done in accordance with the provisions of this specification.

5.1.24.12 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

5.1.24.13 Should any member of the structure be found not to comply with the approved design, it shall be liable for rejection. No member once rejected shall be resubmitted for inspection except in cases where the employer or his authorized representative considers that the defects can be rectified.

5.1.24.14 Defects which occur during fabrication shall be made good with the consent of and according to the procedure to be laid down by the employer.

5.1.24.15 All gauges and templates necessary to satisfy the employer for conducting tests shall be made available at the test site by the supplier.

5.1.24.16 The correct grade and quality of steel shall be used by the supplier. To ascertain the quality of steel the employer may at his discretion get the material tested at an approved laboratory.

5.1.25 SCHEDULE OF REQUIREMENTS

5.1.25.1 The schedule of requirements of different types of towers is indicated in Volume-III. The quantities indicated therein are tentative and based on preliminary survey conducted by the employer. The exact quantity will be informed to the supplier on completion of detailed survey.

5.1.25.2 The time frame for executing the work is also indicated in this schedule. The supplier has to match the supply and delivery of stubs, tower-parts etc. to complete the work within the time schedule desired by the employer.

5.1.25.3 The supplier shall, as far as possible, dispatch the tower material as completed towers in order to enable erection of complete tower structures at site. Payment for the initial dispatches, to the extent of 30% of the total ordered quantity will be released on the basis of weight (i.e. Metric tones of steel supplied). Beyond this limit, however, payment will be released only for material supplied to complete towers.

5.1.26 SCUEDUALE OF PRICES

5.1.26.1 The prices for supply of materials shall be furnished in the relevant schedule in the manner specified in Volume-III.

5.1.27 GENERAL TECHNICAL REQUIREMENTS

Particulars	Design details	- foundation
Line voltage	-	400/220132 kV
No. of circuits	-	Double/Double/Double

a) Properties of soil for bidding purpose only

Sl. No.	Details	Soft Loose	Mud	Hard Soil	Soft Rock	Hard Rock
1.	Angle of repose of soil(in degree)	30	15	0	0	0
2.	Ultimate bearing strength of earth (T/M^2)	10	5	20.0	50.0	125.0

b) Properties of concrete

All concrete shall be RCC with ratio(1:1.5:3).

c) Factor of safety for foundation against over turning due to up-lift and thrust.

i) Normal condition 2.2

ii) Broken wire condition 1.65

d) Concrete Mixture

i) pad 1:3:6

ii) Pyramid or stepped part of foundation 1:1:5:3

iii) Chimney 1:1:5:3

e) Minimum thickness of chimney 300 m

f) Minimum thickness of concrete over stub
Dry soil 100 mm
Wet & WBC 150 mm

g) Minimum length of stub 2000 mm
in concrete.

h) Distance above ground level of 450 mm
Tower stub and super structure

5.1.28 .Foundation General Description

5.1.29 Design, construction and other relevant drawings shall be furnished by the tower designer for all types of towers (including special towers) for different kinds of soil as detailed below. According to the locations foundations for towers shall be normally of the following types:

a) Soft/Loose Soil
b) Mud
c) Hard/Dense soil
d) Hard/Disintegrated rock

5.1.30 For rock foundations the holes in rocks shall be made in an approved manner so as to eliminate the possibility of serious cracking of the rock. The concrete block shall be properly secured to rock base by adequate no. of anchor bolts and further secured by concrete lodge section by the sides.

TECHNICAL SPECIFICATION

ERECTION OF

400/220/132 KV D.C. TRANSMISSION LINES

CONSTRUCTION OF TOWER FOUNDATION AND ERECTION OF TOWER

1.0 ERECTION OF TOWER AND TOWER FOUNDATION

1.1 SCHEDULE OF ERECTION PROGRAMME

After due approval of the detailed and check survey, the contractor shall submit to the employer a complete detailed schedule of erection programme with a Bar-Chart for construction of the lines indicating therein the target date of completion.

1.1.1 DRAWINGS FOR TOWER AND FOUNDATIONS

The same shall be supplied by the contractor.

1.1.2 TAKING OVER

Tower and tower accessories received at site stores are to be stored item-wise and mark-wise to facilitate joint inspection of the materials (with reference to packing list and detailed order).

If the materials/equipment or any part thereof is damaged or lost during the transit, the replacement of such materials shall be effected by the contractor timely so as to maintain programme of work. However, the line under erection shall be taken over by the purchaser only when the entire line is completed in all respect and made ready for commissioning at rated voltage. Partly erected line will not be taken over.

Taking over of the line shall be in no way relieve the contractor from his responsibility for satisfactory operation of the erected line in terms of the guarantee clause of the specification.

1.1.3 MATERIALS HANDLING AND INSURANCE

The contractor shall deliver all equi9pment/materials against this contract to his site stores under cover of Transit Insurance to be taken in his name. Cost of such insurance is to be borne by the contractor.

Cost of transportation of materials from contractorôs store to the site of work shall be borne by the contractor irrespective of made of transportation and site condition.

The contractor has to bear the cost of premiums for all materials, tower accessories, total erection cost of the line including cement, torsteal for foundation.

It will be the responsibility of the contractor to report to the concerned Police Station about all incidents of thefts and lodge, pursue and settle all claims with Insurance Company in case of damage/loss due to theft, pilferage, flood and fire etc. and the employer of the work shall be kept informed promptly in writing about all such incidents. The loss, if any, on this account shall be recoverable from the contractor if the claims are not lodged and properly pursued in time or

if the claims are not settled by the insurance company due to lapses on the part of the contractor. The contractor shall have to replenish promptly damaged, stolen tower members and accessories conductors, earth wire, hardwares etc. and repair/re-erect the damaged lines, free of cost to the employer so as to maintain the programme of work. The employer will not be responsible in any way for such loss of materials.

1.1.4 EXCAVATION FOR FOUNDATION PITS, DE-WATERING AND SHORING SETS

The contractor shall execute the open excavation job in the foundation pits in all type of soil including latterite and or bounder mixed soil as detailed abelow including removing, spreading and/or stacking the excess spils (as directed by the employer). The item includes the necessary trimming of the sides, leveling, dressing and ramming (as necessary) the bottom of the pits including bailing out water, dewatering by manual and/or mechanical means by emplying water pumps including removing of slushes from foundation pits and nominal open plank shoring with vertical poling boards placed at suitable intervals as directed with required runners, struts, battens for framing as required complete. While quoting the unit rate for foundation as per the activity schedule, the contractor shall include cost of design, all cost of labour, materials, tools, plants, incidentals for earth excavation, dewatering, cement, water, sand, coarse and find aggregates, steel reinforcement, steel angles, forms, mixing, finishing, protection and curing of concrete, back-filling with carried earth, if necessary, disposal of surplus, spoils, stub setting and template. The contractor shall also include in the quoted unit rate for foundation, all charges/costs for preparing the pit marking and foundation layout drawing, grounding of towers including supply of pipe/concrete pipe, earthing, measurement of ground resistance before often growing etc.

1.1.5 CEMENT CONCRETE :

A) Materials

All materials whether to be consumed in the work or used temporarily shall conform to relevant IS specification, unless stated otherwise, and shall be of the best approved quality.

B) Cement

Cement to be used in the work under the contract shall generally conform to IS:269/455-1989. Cement bags shall be stored by the contractor in a water tight well ventilated store sheds on raised wooden platform/dunnage (raised at least 150 mm above ground level) in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter. Sub-standard or partly set cement shall not be used and shall be removed from the site by the contractor at his cost on receipt of approval from the Engineer.

C) Coarse Aggregates Stone chips or stone ballast

D) Reinforcement : Different size of reinforcement(MS ROD-FE-500) as per latest IS.

Remarks: All foundation of tower shall be of RCC: M20 Grade(1:1.5:3) nominal mix

General Technical Particulars
C. 1 - Span Lengths

		132kV	220kV	400kV
Normal span	m	300	350	400
Tower design spans:				
Wind spans:				
Suspension towers	m	300	350	400
Tension towers	m	300	350	400
Maximum weight spans:				
Suspension towers	m	450	525	600
Tension towers	m	450	525	600
Minimum weight spans:				
Suspension towers	m	100	100	100
Tension towers (uplift net)	m	-200	-200	-200 (for DB&DC) -300

			(forDD)

C . 2 - Line Conductor (132 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm^2	288.3
Number of conductors per phase		ONE
Horizontal distance between conductor centres of one phase	mm	-
Each single conductor:		
Equivalent to ACSR conductor of code name		ACSR PANTHER
IEC STANDARD No INDIAN STANDARD No		IEC 1089 IS 398 (Pt 4) 1994
Material of conductor		AlumIminium
Number and diameter of wires: Aluminium	No./mm	30/3.0
Total area of conductor	mm^2	261.5
Overall diameter of stranded conductor	mm	21
Mass of conductor per kilometre	kg	974
Ultimate strength of conductor	Newton	89670
Assumed equivalent modulus of elasticity of conductor	N/mm^2	81580
Assumed equivalent coefficient of linear expansion of conductor	per °C	$17.8x\ 10^{-6}$
Maximum length of conductor supplied on one drum	km	2.4+/-5%

C . 3 - Line Conductor (220 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm^2	484.5
Number of conductors per phase		ONE
Horizontal distance between conductor centres of one phase	mm	-
Each single conductor:		
Equivalent to ACSR conductor of code name		ACSR ZEBRA
IEC STANDARD No INDIAN STANDARD No		IEC 1089 IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium	No./mm	54/3.18
Total area of conductor	mm^2	428.9
Overall diameter of stranded conductor	mm	28.62
Mass of conductor per kilometre	kg	1621
Ultimate strength of conductor	Newton	130320
Assumed equivalent modulus of elasticity of conductor	N/mm^2	81580
Assumed equivalent coefficient of linear expansion of conductor	per °C	19.3×10^{-6}
Maximum length of conductor supplied on one drum	km	1.8 +/- 5%

C . 4 - Line Conductor (400 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm^2	597.00
Number of conductors per phase		TWO

Horizontal distance between conductor centres of one phase	mm	450
Each single conductor: Equivalent to ACSR conductor of code name		ACSR MOOSE
IEC STANDARD No INDIAN STANDARD No		IEC 1089 IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium alloy	No./mm	54/3.53
Total area of conductor	mm^2	597
Overall diameter of stranded conductor	mm	31.77
Mass of conductor per kilometre	kg	2004
Ultimate strength of conductor	Newton	161200
Assumed equivalent modulus of elasticity of conductor	N/mm^2	68600
Assumed equivalent coefficient of linear expansion of conductor	per °C	19.3×10^{-6}
Maximum length of conductor supplied on one drum	km	1.8 +/- 5%

****ALL THE CONDUCTORS ARE ACSR CONDUCTORS HAVING 7 STRANDS OF GI STEEL WIRE.**

C . 5 - Earth Wire (132 kV And 220 kV Constructions)

		GSW
Complete earth conductor:		
Appropriate Indian Standard No		398(Part-2)
Appropriate British Standard No		183
Material of conductor		galvanised steel
Number and diameter of wires	No./mm	7/3.15
Overall diameter of conductor	mm	9.45
Mass of conductor per kilometre	kg	428
Ultimate strength of conductor	Newton	56000
Lay length	mm	160 +/- 15
Direction of the lay of the outer layer		Right hand
Chemical composition of the steel wire	%	
Carbon		not more than 0.55
Manganese		0.4 to 0.9
Phosphorous		not more than 0.04
Sulphur		not more than 0.04
Silicon		0.15 to 0.35
Purity of Zinc for galvanising	%	99.95
Galvanising after stranding		
a) Minimum weight of Zinc coating per sq. m. of the uncoated wire surface	gms	240
b) Minimum no. of one minute dips that the galvanised wire can withstand in Standard Preece Test		3 and 1/2
Maximum length of conductor on drum #	km	4 +/- 5%
D.C. resistance at 20 ^{o}C	ohms/km	3.375

C . 6 - Earth Wire (400 kV Construction)

	GSW
Complete earth conductor:	

Appropriate Indian Standard No		398(Part-2)
Appropriate British Standard No		183
Material of conductor		galvanised steel
Number and diameter of wires	No./mm	7/3.66
Overall diameter of conductor	mm	10.98
Mass of conductor per kilometre	kg	583
Ultimate strength of conductor	Newton	68400
Lay length	mm	160 +/- 15
Direction of the lay of the outer layer		Right hand
Chemical composition of the steel wire	%	
Carbon		not more than 0.55
Manganese		0.4 to 0.9
Phosphorous		not more than 0.04
Sulphur		not more than 0.04
Silicon		0.15 to 0.35
Purity of Zinc for galvanising	%	99.95
Galvanising after stranding		
a) Minimum weight of Zinc coating per sq. m. of the uncoated wire surface	gms	240
b) Minimum no. of one minute dips that the galvanised wire can withstand in Standard Preece Test		3 and 1/2
Maximum length of conductor on drum #	km	4 +/- 5%
D.C. resistance of the complete earthwire at $20^{O}C$	ohms/km	2.5

C.14 * - Disc Insulator Units (Anti-Fog Type)

		70kN	90kN	120kN	160kN
Size and designation of the ball pin shank	mm	16	16	20	20
Diameter of the disc	mm	280/305	280/305	280/305	280/305
Tolerance on the diameter	+/-mm	13/15	13/15	13/15	13/15

Ball to ball spacing between disc	mm	145	145	145	170
Tolerance on ball to ball spacing	+/-mm	4	4	4	5
Minimum creepage distance of a single disc **	mm	430	430	430	475
Steepness of the impulse voltage which the disc unit can withstand in Steep Wave Front Test	kV per micro sec.	2500	2500	2500	2500
Purity of Zinc used for galvanising	%	99.95	99.95	99.95	99.95
Purity of Zinc used for sleeve	%	99.7	99.7	99.7	99.7
No. of dips in Standard Preece Test		6	6	6	6
1) Cap socket		6	6	6	6
2) Ball pin					

***The parameters specified are for disc insulator unit only. For the Bids offering composite insulator units, the parameters may be suitably selected by the Bidder so as to meet the overall requirements of the respective strings and same shall be guaranteed at Schedules 13A and 14A of the Technical Data Requirement Schedules, Section X.**

**** The minimum creepage distance of single composite insulator unit shall be such that it matches with the total creepage distance of the respective strings with disc insulator units.**

C . 15 - Insulator Strings (Suspension Sets For 132 kV Lines)

	Single "I" Suspension Strings	Double "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions kV(rms)	275	275	275
Impulse withstand voltage			

(peak) under dry conditions				
1) Positive	Kv	650	650	650
2) Negative	kV	650	650	650
Minimum corona extinction voltage under dry conditions	kV(rms)	105	105	105
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	70	2x70	70
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	20	20	20
Number of insulator units in each string **		9	2x9	9
Purity of Zinc used for galvanising	%	99.95	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 16 - Insulator Strings (Tension Sets For 132 kV Lines)

		Single Tension Strings	Double Tension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet	kV(rms)	275	275

conditions			
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	650	650
2) Negative	kV	650	650
Minimum corona extinction voltage under dry conditions	kV(rms)	105	105
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	90	2x90
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	22	22
Number of insulator units in each string **		10	2x10
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 17 - Insulator Strings (Suspension Sets For 220 kV Lines)

		Single "I" Suspension Strings	Double "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with	kV(rms)	460	460	460

arcing horns and corona control rings / grading rings under wet conditions				
Impulse withstand voltage (peak) under dry conditions				
1) Positive	kV	1050	1050	1050
2) Negative	kV	1050	1050	1050
Minimum corona extinction voltage under dry conditions	kV(rms)	154	154	154
Radio interference voltage under dry conditions at 1MHz, at 154kV	Micro Volts	not more than 1000	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	70	2x70	70
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	13	13	13
Number of insulator units in each string**		14	2x14	14
Purity of Zinc used for galvanising	%	99.95	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 18 - Insulator Strings (Tension Sets For 220 kV Lines)

	Single Tension Strings	Double Tension Strings

Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	kV(rms)	460	460
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Minimum corona extinction voltage under dry conditions	kV(rms)	154	154
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	2x120
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	14	14
Number of insulator units in each string **		15	2x15
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 19 - Insulator Strings (Suspension Sets For 400 kV Lines)

		Single "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and	kV(rms)	680	680

corona control rings / grading rings under wet conditions			
Switching surge withstand voltage (peak) under wet conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1550	1550
2) Negative	kV	1550	1550
Minimum corona extinction voltage under dry conditions	kV(rms)	320	320
Radio interference voltage under dry conditions at 1MHz, at 305kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	120
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	9	9
Number of insulator units in each string **		23	23
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 20 - Insulator Strings (Tension Sets For 400 kV Lines)

		SingleTension Strings (Low Duty)	Double Tension Strings
Power frequency withstand voltage	kV(rms)	680	680

of the string with arcing horns and corona control rings / grading rings under wet conditions Switching surge withstand voltage (peak) under wet conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1550	1550
2) Negative	kV	1550	1550
Minimum corona extinction voltage under dry conditions	kV(rms)	320	320
Radio interference voltage under dry conditions at 1MHz, at 305kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	2x160
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	10	10
Number of insulator units in each string **		24	2x23
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

*** Voltage distribution criteria is not applicable for strings with composite insulator units.**

**** It is preferrable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.**

C . 21 - Tower Design Particulars (132 kV Construction)

Minimum clearance between live metal and tower steelwork:	

i.with suspension insulator set swing 0°	mm	1530
with suspension insulator set swing 15°	mm	1530
with suspension insulator set swing 30°	mm	1370
with suspension insulator set swing 45°	mm	1220
with suspension insulator set swing 60°	mm	1070
ii.with jumper loop swing 0°	mm	1530
with jumper loop swing 10°	mm	1530
with jumper loop swing 20°	mm	1070
with jumper loop swing 30°	mm	1070
with jumper loop swing 40°	mm	-
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 60
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	30

C . 22 - Tower Design Particulars (220 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i. with suspension insulator set swing 0°	mm	2130
with suspension insulator set swing 15°	mm	1980
with suspension insulator set swing 30°	mm	1830
with suspension insulator set swing 45°	mm	1675
with suspension insulator set swing 60°	mm	-
ii. with jumper loop swing 0°	mm	2130

with jumper loop swing 10°	mm	1675
with jumper loop swing 20°	mm	1675
with jumper loop swing 30°	mm	-
with jumper loop swing 40°	mm	-
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 45
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	30

C . 23 - Tower Design Particulars (400 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i. with suspension insulator set swing 0°	mm	3050
with suspension insulator set swing 15°	mm	3050
with suspension insulator set swing 30°	mm	1860
with suspension insulator set swing 45°	mm	-
with suspension insulator set swing 60°	mm	-
ii. with jumper loop swing 0°	mm	3050
with jumper loop swing 10°	mm	3050
with jumper loop swing 20°	mm	3050
with jumper loop swing 30°	mm	1860
with jumper loop swing 40°	mm	1860
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 30
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	20

C . 25 - Particulars Of Double Circuit Towers (132 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	300	300	300	300
Minimum ground clearance of line conductor at 85°C, normal ground	m	6.42	6.42	6.42	6.42
Minimum height of earth conductors above upper line conductor at mid-span	m	6.1	6.1	6.1	6.1
Vertical spacing between line conductors at tower (minimum)	m	3.9	3.9	3.9	3.9
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	4.5	4.5	4.5	4.5

C . 26 - Particulars Of Double Circuit Towers (220 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60

Normal span length	m	350	350	350	350
Minimum ground clearance of line conductor at 85 °C, normal ground	m	7.23	7.23	7.23	7.23
Minimum height of earth conductors above upper line conductor at mid-span	m	8.5	8.5	8.5	8.5
Vertical spacing between line conductors at tower (minimum)	m	4.9	4.9	4.9	4.9
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	5.5	5.5	5.5	5.5

C . 27 - Particulars Of Double Circuit Towers (400 kV Construction)

Type Of Tower		**DA**	**DB**	**DC**	**DD**
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	400	400	400	400
Minimum ground clearance of line conductor at 85 °C, normal ground	m	8.84	8.84	8.84	8.84
Minimum height of earth conductors above upper line conductor	m	9.0	9.0	9.0	9.0

at mid-span					
Vertical spacing between line conductors at tower (minimum) .	m	8.0	8.0	8.0	8.0
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	6.5	6.5	6.5	6.5

C . 28 - Foundation Design Particulars

Assumed density of Plain Cement Concrete (PCC) for foundation in dry soil	kg/m^3	2240
Assumed density of Plain Cement Concrete (PCC) for foundation in presence of sub-soil water	kg/m^3	1240
Assumed density of Re-inforced Cement Concrete (RCC) for foundation in dry soil	kg/m^3	2400
Assumed density of Re-inforced Cement Concrete (RCC) for foundation in presence of sub-soil water	kg/m^3	1400
28 day concrete cube strength (characteristic strength for M-20 concrete)	N/mm^2	20
28 day concrete cube strength (characteristic strength for M-15 concrete)	N/mm^2	15
Minimum proportion of stub load to be allowed for in the design of stub cleats	%	100
Density of all type of soils :		
1) under dry conditions	kg/m^3	1440
2) in presence of surface water	kg/m^3	1440
3) in presence of sub-soil water	kg/m^3	840
Ultimate bearing capacity of the soil :		
1) normal soil under dry condition	kN/m^2	214
2) normal soil in presence of surface as well as	kN/m^2	107

sub-soil water		
3) wet black cotton soil	kN/m^2	107
4) fissured rock (both for dry and wet)	kN/m^2	400
5) hard rock	kN/m^2	750
Angle of repose for :		
1) dry soil	Degree	30
2) wet soil due to presence of surface/ sub-soil water	Degree	15
3) wet black cotton soil	Degree	0
4) dry fissured rock	Degree	20
5) wet fissured rock	Degree	10
Ultimate bond between steel and concrete	kN/m^2	0.147

Note : All the soil parameters furnished above are subject to verification by actual soil investigations. The Contractor shall be required to carry-out field test for each type of foundation, as per the quoted rates in Price Schedules, to prove the design parameters considered.

The foundation classification criteria shall be as given below, depending upon type of soil and sub-soil water level / presence of surface water :

Normal Dry : To be used for locations where normal dry cohesive or non-cohesive soils are met without encountering sub-soil water table within the depth of foundation.

Wet : To be used for locations,

a) where sub-soil water is met at 1.5 m. or more below the ground level;

b) which are in surface water for long periods with water penetration not exceeding one metre below the ground level e.g. , the paddy field.

Partially Submerged : To be used for the locations where sub-soil water table is met between 0.75 to 1.5 m. below the ground level;

Fully Submerged : To be used for locations where sub-soil water table is met at less than 0.75 m. below the ground level;

Black Cotton Type : To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing the foundation for such locations, the soil is to be considered as fully submerged.

Fissured Rock : To be used at locations where decomposed or fissured rock, hard gravel, kankar, lime-stone, laterite or any other soil of similar nature is met. Under-cut type foundation is to be used for such locations.

In case of fissured rock locations where water table is met at 1.5 m. or more below ground level, wet type fissured rock foundations shall be adopted.

Hard Rock : To be used for the locations where chiselling, drilling or blasting is required for excavation . For these locations rock anchoring is to be provided to resist the uplift forces.

PILE FOUNDATION-

a) **SCOPE-** The work involved is to take up the pile foundation work of including stub setting of special type tower. The detailed survey, soil investigation and the design has to be done bidder and the design is to be approved by OPTCL, which shall be strictly followed by the contractor. The contractor shall cast the foundation including stub setting as per the design, the schedule of quantities enclosed and direction of engineer in charge.

b) 1. The pile foundation shall be of RCC, Cast-in-situ bored piles as per IS:2911 . Pile boring shall be done using Rotary Hydraulic Rigs. Two stage flushing of pile bore shall be ensured by airlift technique duly approved by the Employer

2. Minimum diameters of piles shall be 450/500mm (for under reamed piles)/ 600 mm (for bored cast in situ piles).

3. Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.

4. The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, locations of initial test piles etc.) for Engineerôs approval.

5. The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.

6. Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical		
Lateral	:	Minimum of 2 Nos. in each mode
Uplift		

7. The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test (initial test) the method of loading shall be cyclic as per IS:2911 (relevant part).

8. Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter

9. Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :
   (i) Vertical : 0.5% of the total number of piles provided.
   (ii) Lateral : 0.5% of the total number of piles provided.

10. The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.
11. In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.
12. Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

13. The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.

14. Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM.

15. Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.
16. The following shall be adhered to **PILE FOUNDATION**:

i) The pile foundation shall be of under reamed piles as per IS: 2911 part III or bored cast in situ piles as per IS 2911 part I sec2

ii) The minimum diameter of pile shall be 500 mm in case of under reamed piles and 600 mm in case of bored cast in situ piles.

iii) Under reamed piles shall be adopted only in case of clay black cotton soil or medium dense sandy soil is encountered. Design of under reamed shall be done strictly as per IS 2911 part III.

iv) The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, locations of initial test piles etc.) for Engineerôs approval.

v) The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.

vi) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical	
Lateral	Minimum of 2 Nos. in each mode.
Uplift	

vii) The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test (initial test) the method of loading shall be cyclic as per IS:2911 (part IV).

viii) Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter.

ix) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :

i) Vertical : 0.5% of the total number of piles provided.

ii) Lateral : 0.5% of the total number of piles provided.

x) The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.

xi) In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.

xii) Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

xiii) The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.

xiv) Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.

a) MATERIALS- Contractor shall supply cement, steel rod and stubs and all other materials required. All coarse aggregates, fine aggregates are to be of very good quality and to be approved by the engineer in charge.

b) Watch and Ward- The cost of watch and ward, site store, making of Islanding/platform for the pile boring, stabilization of bore hole and all other activities incidental to successful construction of the pile foundation are to be included in the cost of the tender and no additional cost shall be paid separately on any additional component.

The cement, steel shall be supplied to the contractor at the nearest tore and the contractor shall have to receive the same at designated stores and transport to site at his own cost.

The piling shall be done in presence of the engineer in charge and due certification to be done at the spot only.

Standard followed and to be followed-

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS:1080-1990	Codes of Practice for Design and Construction of Simple Spread Foundations	
IS: 1498-1992	Classification and Identification of Soils for General Engineering Purposes.	ASTM D 2487/ ASTM D 2488
IS: 1892-1992	Code of Practice For Design and Construction of Foundation in Soils : General Requirements.	
IS: 2131-1992	Method of Standard Penetration Soils	ASTM D 1586

IS: 2132-1992	Code of Practice For Thin Walled Sampling of Soils	ASTM D 1587
IS: 2720-1992	Method of Test For Soils (Relevant Parts.	ASTM D 420
IS: 2809-1991	Glossary of Terms And symbols Relating to Soil Engineering	ASTM D 653

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS: 2911-1980	Code of Practice For Design and Construction of Pile Foundations (Relevant Parts).	
IS: 3025	Methods of Sampling And Testing (Physical And Chemical) for Water used in industry.	
IS: 3043-1991	Code or Practice for Indexing and Storage Of Drill Cores.	
IS: 4091-1987	Code of Practice for Design and Construction Of Foundations for Transmission Line Towers and Poles.	
IS: 4434-1992	Code of Practice for in-situ Vane Shear Test for Soils.	ASTM D 2573/ ASTM D 4648
IS: 4453-1992	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.	
IS: 4464-1990	Code of Practice for Presentation of Drilling Information and core Description in Foundation	

	Investigation	
IS: 4968 - (Part-II) ï 1992	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS: 5313-1989	Guide for Core Drilling Observations.	

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS:6403-1990	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.	
IS: 6935-1989	Method of Determination of water level in a Bore Hole.	
IS: 7422-1990	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant Parts).	
IS:8009 (Part-I)-1993	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS:8764-1991	Method of Determination of Point Load Strength Index of Rocks.	
IS: 9179-1991	Method of Determination of Unconfined compressive Strength of Rock Materials.	ASTM D 2938
IS: 9179-1991	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS: 9259-1992	Specification for Liquid Limit apparatus.	ASTM D 4318
IS: 9640-1992	Specification for Split	ASTM D 1586

Spoon Sampler

IS: 10050-1992	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS: 11315- (Part-II)-1991	Description of Discontinuities in Rock Mass-Core Recovery	

TESTS

Tests as indicated in this specification and as may be requested by the Owner, shall be conducted. There tests shall include but may not be limited to the following :

a) **Tests of undisturbed and disturbed samples**

- Visual and engineering classification;
- Sleeve analysis and hydrometric analysis;
- Liquid, plastic and shrinkage limits;
- Specific gravity;
- Chemical analysis
- Swell pressure and free swell index determination
- Proctor compaction test.

b) Tests of undisturbed samples:

- Bulk density and moisture content;
- Relative density (for sand),
- Unconfined compression test;
- Box shear test (for sand);
- Tri-axial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):

i) Unconsolidated untrained;

ii) Consolidated drained test;

- Consolidation.

c) **Tests on rock samples**

- Visual classification:
- Moisture content, porosity and density:
- Specific gravity;
- Hardness
- Stake durability;
- Unconfined compression test (both saturated and at in-situ water content;
- Point load strength index;
- Deformability test (both saturated and dry samples)

ODISHA POWER TRANSMISSION CORPORATION LIMITED

OFFICE OF THE SR. GENERAL MANAGER,
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TECHNICAL SPECIFICATION

FOR

OPGW CABLING IN TR LINE

OPGW CABLING AND ASSOCIATED HARDWARE & FITTINGS

This section describes the functional & technical specifications of OPGW cabling and associated hardware & fittings.

1.0 Fibre Optic Cabling

This section defines the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

1.1 Physical Characteristics

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1.

Table –1

DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm (± 0.6μm)
Cladding Diameter:	125.0 μm ± 1 μm
Mode field concentricity error	≤ 0.6μm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm
1550 nm loss performance	As per G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm 0.092 ps/(nm^2xkm) maximum
Polarization mode dispersion coefficient	≤ 0.2 ps/km^½
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

2.0 Fibre Optic Cable Construction

Overhead Fibre Optic Cables shall be 24 core OPGW (Optical Ground Wire). The OPGW cable is proposed to be installed on the transmission line 400kV IBTPS -Meramandali of Orissa Power Transmission Corporation Ltd. (OPTCL). The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The exact transmission line details shall be collected by the Contractor during survey.

2.1 Optical Fibre Cable Link Lengths

The Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

2.2 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

2.2 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials such as stainless steel tube with aluminium or aluminium ï clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminium or stainless steel tube with aluminium protective coating. In case of aluminium protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

2.3 Basic Construction

The cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 2.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.
The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

2.4 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

2.5 Installation

OPGW installed under live line condition, i.e. with all circuits charged to the rated line voltage as specified in this section shall be generally in accordance with the IEEE Guide to the Installation of Overhead Transmission Line Conductors (IEEE STD. 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling. Some of the cable may be installed in off-line condition also. The stringing procedure shall be submitted by the Contractor prior to stringing for Employerôs approval.

A tower structural analysis shall be carried out by the Contractor, based on the relevant data to be provided by Employer, to ensure that with the replacement of existing earth wire with the OPGW cable, the tower members remain within the statutory safety limits as per Indian Electricity rules and if required the Contractor shall carry out the tower strengthening as necessary. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

2.6 Installation Hardware

The scope of supply of the optical cable includes the assessment, supply and installation of all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Down lead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation min@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to POWERGRID. The Contractor shall determine the exact requirements of all accessories required to install and secure the OPGW.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured in accordance with type test procedures specified in Appendix, Vol. II.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) Dead End Clamp Assemblies: All dead end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminum alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free

from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl No.	Description	TechnicalParticulars
1	Span Length in meters (i) Ruling design span : (ii) Maximum span : (iii) Minimum Span :	 400 meters 1100 meters 100 meters
2	Configuration :	As per Specifications
3	Tensile load in each :	As per sag tension calculations
4	Armour rods used :	Standard preformed armour rods/AGS

5	Maximum permissible dynamic strain :	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Bidder. Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.

(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers

3.0 Fibre Optic Splice Enclosures (Joint Box

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply to ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

3.1 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(f) All fibre splices shall be accomplished through fusion splicing.

(g) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(h) All splices and bare fibre shall be neatly installed in covered splice trays.

(i) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(j) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

4.0 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

4.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

4.2 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

4.3 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

4.4 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition.

Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

5.0 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employerôs approval.

5.1 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(k) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(l) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(m) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement

(d) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

(e) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

5.2 Optical Fibre Connectors

Optical fibres shall be connected with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

6.0 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

7.0 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specifciation .The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide

adequate communications among all crew members and support staff to ensure safe and successful installations.

Section 2

Network Configuration and Equipment Characteristics

1.0 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fibre Optic Transmission System (FOTS)
(2) Termination Equipment Subsystems
(3) Network Management System (NMS)
(4) MDF, DDF and Cabling

The requirements described herein are applicable to and in support of network configurations depicted in Appendix and Network Management System (NMS) for monitoring and control of this communication network. TMN and NMS have been interchangeably used in this specification.

1.1 General Network Characteristics

1.2 Description

The proposed fibre optic communication network shall support the voice & data communication requirements of RTUs and the SCADA/EMS system. The communication system shall provide data & voice connectivity across the various locations or connectivity of RTUs with Control Centres. The RTUs located at various locations will report to Control Center using IEC 60870-5-101 or IEC 60870-5-104 Protocol. The proposed communication system shall provide connectivity of some RTUs over TCP/IP protocol using Ethernet interface and other RTUs over serial interface.

The fibre optic network shall be based on the lowest bit rate of the Synchronous Digital Hierarchy (SDH) i.e. STM-1. However, the offered equipment can be upgraded to STM-4 by changing the optical card only.

The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices.

2.0 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system in support of the SCADA/EMS. The communications support requirement for SCADA/EMS system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

(a) High speed E1 channel support

(b) 64kbps & nx64kbps data channel support

(c) Low speed (300 -1200 bps) data channel support

(d) Voice (2 wires, 4 wires) channel support.

(e) Data transport supporting Network Management channels
(f) Interface support for teleprotection

(g) The connectivity envisaged between RTUs and Control Centre is Wide Area Network (WAN) on TCP-IP using IEC 60870-5-104 protocol and IEC 60870-5-101 protocol.

2.1 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

2.2 System Synchronization

The Contractor shall synchonize all the equipments under the contract using GPS based clock. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under

this contract should meet ITU-T G.811 criterion. The holdover quality of clock shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803.

The system equipment requiring ñclockò shall be connected to the master clock using external clocking. For this purpose, appropriate interfaces(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

2.3 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under TMN control. Such testing shall not affect the functional operation of the system.

Preventive and problem oriented maintenance of the communications system shall be performed using diagnostics tools such as TMN and test equipment. They shall support complete maintenance of all system elements and shall permit the diagnosis of any fault without requiring additional test equipment. The Contractor shall provide specialized training required to operate above mentioned diagnostic tools. For all redundant systems, disconnection and repair of any failed device shall not interrupt the operation of the system.

2.4 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies and TMN shall be sized for maximum equipped system capacity.

3.0 Equipment Availability

The availability requirements are as follows, which shall be demonstrated at site for the equipments being provided under this contract:

(1) The availability of each fibre optic link (E1 to E1) shall be at least

99.999%.

(2) The availability of network end to end (E1 to E1) shall be at least 99.998%.

(3) The average per link subscriber to subscriber availability shall be at least 99.97%. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers between RTU to reporting Control Centre.

(4) The network-wide subscriber to subscriber availability shall be at least 99.8% .The network-wide subscriber to subscriber availability is defined as the availability between any two data or voice subscribers on the wideband network.

The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations.

In order to ensure that the equipment & configuration proposed by the bidders shall be capable of demonstrating the specified availability figures it is required that the Bidders shall include in their proposal a calculated availability analysis for the proposed equipment/ sub system. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided in the proposal. The analysis shall be based on an availability block diagram and shall include the mean-time-between failure (MTBF) and mean-time-to-repair (MTTR) of all of the components on the link. The Contractor shall indicate in the analysis the MTBF and MTTR and the resulting availability of each point-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

3.1 General Equipment Characteristics

All Contractor supplied equipment shall be new and of the finest production quality. The Employer will not accept modules or printed-circuit boards that are modified by appending wires or components. Wired strapping options shall be incorporated in the board design to meet the above requirement.

All applicable requirements stated in this section shall equally apply to the TMN equipment as specified in this Section.

3.2 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or

under special circumstances, on written approval by Employer, prior to the completion of SAT.

All field modifications of the hardware, firmware and software that is required to meet installation and/or performance specifications, shall be fully documented as part of the deliverables, both as a separate field modifications record and as corrected equipment/configuration documentation.

3.3 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BOQ and configuration requirements as identified in the BOQ.. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

Data communications channelization required to support the TMN subsystems specified in Technical Specifications (TS) are not identified in the appendices. Therefore, the Contractor is required to size and equip the system to include all channelization and channel cards required to support the TMN function.

3.4 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 3-1. The failure of one element shall not prevent the use of any other that has not failed.

Table 3-1
Equipment Redundancy Requirements Summary

Fiber Optic transmission Equipment :	
SDH equipment	
Power Supply & Converters ----------	1:1 APS or distributed power supply
Common Control* Cards ----------	1:1 APS
DACS (Cross Connect)	1:1 APS or distributed power supply
Power Supply ----------	1:1 APS
Common control* cards----------	1:1 APS or distributed power supply
MUX, DROP/INSERT	
Power Supply ----------	
*** = Common control cards which are essentially required for operation of the equipment.**	

The offered equipment shall support at least SNCP **as per standard ITU-T G.841**. In case the equipment offered by the Bidder does not support the above mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The bidders shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

4.0 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

4.1 Equipment Lifespan

All equipment supplied shall have expected life of fifteen (15) years.

4.2 Fibre Optic Link Lengths

The fiber optic route lengths are as specified in appendices. The lengths specified in appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an additional cable length of 5% of given route length **+** 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project. In case of change in the specified BOQ, the contract price shall be adjusted accordingly.

5.0 Fibre Optic Transmission System

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-1 and equipped with 2 nos. of minimum 16 port E1 interface(G.703) card & one no. of minimum 4 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE 802.1P/Q), spanning tree (IEEE 802.1D) quality of service.

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

SDH Equipment

5.1 Functional Requirement

The BOQ is provided in the appendices. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical cards (Line), Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical cards and tributary cards).

The offered SDH equipment shall be upgradeable to STM-4 by changing optical line cards

only. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-4 equipment. The contractor shall demonstrate the STM-4 upgradeability during FAT.

SDH ADM

The aggregate interfaces shall be (at least) STM-1 (155 Mbit/s) towards at least two directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 2 nos., min.16 E-1 port electrical tributary cards & one no., min.4 port Ethernet interface card as tributaries. The Equipment shall provide access to full STM1 payload.

5.2 Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

5.3 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

5.4 Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the TMN.

5.5 Synchronisation

The equipment shall provide synchronisation as per Table 3-2. One 2MHz synchronisation output from each equipment shall be provided.

5.6 Electrical and Optical I/O Characteristics and General Parameters

Table 3-2 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 3-2
Electrical and Optical I/O Characteristics and General Parameters

Optical Wavelength NOTE (1)	1310/1550nm
Optical Source NOTE (2)	Laser
Optical Source Lifespan	Better than 5 $X10^5$ hours
Optical Fibre Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 q
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.813

Table 3-2
Electrical and Optical I/O Characteristics and General Parameters

Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

NOTE (2) **Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

NOTE (3) In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

5.7 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

5.8 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

(1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

(2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

(3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

(4) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed ñEnd of Life (EOL)ò parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

(5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

(6) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10}.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link in the Bid.

For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

5.9 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

5.10 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP and the SDH equipment. The Contractor shall provide FC PC coupled patch cords. The location of FODP shall be finalized during detailed engineering.

The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

6.0Termination Equipment Subsystem

The Termination Equipment Subsystem is defined to include the equipment that interfaces (adapts) the subscriber (user) to the Fibre Optic Transmission System (FOTS). A Functional description of these equipments are as follows:

6.1 Functional Description

The transmission network node provides subscriber interface to the transmission network and/or switching/routing. For clarity, the basic functions accomplished at the network nodal points, are described briefly as follows:

Primary Multiplexer shall be used to accomplish subscriber connectivity to the Digital Communication Network. Subscriber Line Units shall provide analog to digital and direct digital conversion to 64 Kbps digital channel. In the CEPT standard hierarchy, thirty (30) such 64 Kbps digital channels shall be Time Division Multiplexed (TDM) resulting in a single 2.048 Mbps (E-1) digital bit stream.

Digital Drop-Insert and Branching Equipment shall be used to digitally interface a small number of channels at spur locations without requiring successive D/A and A/D conversions of the throughput channels.

Digital Cross connect Equipment (DACS) shall be used to provide software controlled dynamic routing/rerouting of the primary (E-1) bit stream as well as the 30 channels of the E1 bit stream.

The equipment shall also have an interface for external 2048 kHz synchronisation signal according to ITU-T Recommendation G.703.

6.2 First Order (Primary) Multiplexing

The Contractor shall be required to provide E-1 Drop & Insert Multiplexer and E-1 Channel Bank primary multiplexing in compliance with the electrical input-output characteristics provided in Table 3-3.

6.3 Drop & Insert Primary Multiplexing

Drop & Insert primary multiplexing in conformance with CEPT E-1 characteristics shall be required at locations where the subscriber requirement is minimal. The drop and insertion of up to thirty 64 Kbps channels supporting subscriber line units (SLU) shall be required at intermediate locations. The Drop & Insert Muxes supplied shall be performance and card compatible with the Channel Bank Equipment provided so that all Subscriber Line Interface cards are interchangeable.

Table 3-3
CEPT E-1 Standard First Order Multiplexing
Electrical Input/Output Characteristics

Applicable Standards:	CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712
Number of Tributaries:	30 X 64 Kbps
Alternative Sub-rate Tributaries:	n X 64 Kbps V.36 64Kb/s V.11/V.36
Output Aggregate Rate: **Interface Code:** **Impedance:** **Peak Level @ 120 ohm:** **Peak Level @ 75 ohm:** **Maximum Insertion Loss:**	2.048 Mb/s ± 50 ppm HDB3 75 ohm unbalanced 3.0 volts ± 10% 2.37 volts ± 10% 6 dB
Signal Waveform: **Frame Structure:** **Jitter Performance:**	Per CCITT G.703 Per CCITT G.742 Per CCITT G.823
Power Supply Voltage:	-48 Vdc

6.4 Channel Banks (Mux, Drop/Insert)

User voice and data equipment interfacing requirements are defined at the subscriber line level. Primary multiplexing in conformance with CEPT E-1

characteristics shall be used to provide first order multiplexing of up to thirty 64 Kbps channels supporting Subscriber Line Units (SLUs).

6.5 Subscriber Line Units\Subscriber Line Interface Cards

The terms Subscriber Line Interface Cards and Subscriber Line Units have been used interchangeably throughout the specification. Multiple configurations of SLUs shall be required to provide subscriber to primary multiplexer Bank interfacing for a variety of voice and data communications. In case there are changes in number or type of cards because of changes in channel requirements, the contract price shall be adjusted accordingly.

The SLU interface requirements are discussed in the following subparagraphs:

(A) Voice Channels

The voice channel requirement is for (I) 4-Wire E&M trunking in support of PABX trunks & PLC VF and (II) 2-Wire telephonic interfaces. 2 wire SLUs shall be DTMF/TP optioned for 2-wire loop start or 2-wire GND start. The voice cards shall utilize ITU.T A - law companded PCM G.711, 64 kbits/s encoding. The voice card requirements are indicated in the BoQ in appendices.

(B) Sub-Channel Data Multiplexing

For this Project, the RTU data interface to the wideband telecommunications network node shall be defined at the DTE level at low-speed rates of 300, 600 and 1200 baud. The port shall be compatible with RS232C interface. The Contractor shall be required to furnish 64 Kbps SLU asynchronous dataplexing for at least 4 selectable low speed DTE interfaces whenever multiple asynchronous data circuits are required.

(C) Synchronous Data

The Contractor shall provide a direct DTE interface for synchronous communications at speed of 64Kbps and compatible with CCITT G.703 Kbit/s, V.35 and X.21 interfaces. Data rate selection shall be switch selectable or programmable.

(D) Nx64 kbps Synchronous Data

There is also a requirement for N x 64 kbps V.35, X.21 interfaces. The tentative quantities have been identified in the appendices. However the final BOQ shall be worked out during detailed design and contract price shall be adjusted accordingly.

6.6 MDF, DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities and MDFs interfacing to the wideband telecommunications system. Equipment and material components for MDF, DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection with the MDF and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

6.7 MDF and DDF Patching Facilities

The Contractor shall supply and install all cabling, wiring, connectors, cross connects, Digital Distribution Frames (DDF) and Main Distribution Frames (MDF) associated with the installation and interconnection of equipments procured under this package as follows:

(i) DDF for termination of new SDH equipment E-1 ports

(ii) Cabling (including connectors) for E1 level connections from DDF to existing SDH equipments, DDF to Existing & new PDH equipments. To the extent possible, existing cable at site shall be used.

(iii) All Ethernet ports shall be terminated with RJ-45 connector. Provision for 100% expansion with connector for terminating additional Ethernet ports shall be provided.

(iv) MDF for termination of all the subscriber channels at new PDH node

(v) Cabling and connectors required to enable subscriber-to-subscriber circuits over the telecom network. The Line side of the MDF shall be cabled to the Primary Multiplex and the equipment side shall be cabled to the MDF of the assigned subscriber (PLCC, PABX, Telephone at wideband locations etc).

(vi) Any other cables, connections etc required for a fully functional, integrated telecom system.

The connections amongst various equipment such as FOTS, termination equipment and subscriber MDFs etc shall always be routed through DDF and MDF to provide maintenance access.

6.8 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

(i) "Normally thru" circuit routing
(ii) Circuit rerouting via patch cord assemblies
(iii) Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

6.9 Main Distribution Frames

The Contractor shall make provision for cross connection of subscriber services to the subscribers utilizing Krone type or equivalent and shall provide full connectivity up to and terminated on the equipment side of the appropriate DDFs and line side of MDFs. The Contractor shall terminate on the equipment side of patching facilities provided by other contracts and shall provide DSX type patching facilities supporting aggregate bit streams (i.e. dataplexers and E-1 Channel Banks). Separate Patch panels or MDFs shall be provided for Data and Voice. All cross connects shall be accomplished utilizing one, two or three pair patch cords. Patch plugs are permissible for direct one-to-one circuit "cut-thru".

7.0 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

Employer/Owner in the operations and maintenance of the wideband communication resources of the including detection of degraded circuits, system performance, the diagnosis of problems, the implementation of remedial actions and the allocation or reallocation of telecommunications resources and addition/deletion of network elements.

8.0 Applicable Standards

The TMN design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010. The offered TMN system shall be capable of integration to other supplierôs Network Management System (NMS) upwardly through North bound interfaces. The north bound interface in the EMS shall be CORBA/TMF-814 compliant.

8.1 Security Management

The TMN shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the TMN system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control.

Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

8.2 Craft Terminal

Each equipment(SDH equipment, Mux, Drop/Insert and DACS etc.) on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

a. Change the configuration of the station & the connected NEs.
b. Perform tests
c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices.

ODISHA POWER TRANSMISSION CORPORATION LIMITED

OFFICE OF THE SR. GENERAL MANAGER,
CENTRAL PROCUREMENT CELL,
JANAPATH, BHUBANESWAR – 751022.

TECHNICAL SPECIFICATION

250 KVA GENERATOR

SPECIFICATION OF 250 KVA DIESEL GENERATOR

SILENT TYPE WITH AMF ARRANGEMENT

1X 250KVA, 380 BHP, 200KW, SILENT AMF Diesel Generator set, 1500 RPM, Water cooled, 6-Cylinders, Diesel engine with AMF control panel, 250 KVA latest REPUTED

AND BRANDED make Engine , Alternator and AMF Panel as required. (Optional accessories and specification also be enclosed)

Diesel engine Specifications and accessories:-

AVM with Acoustic enclosure type, Capacity-380 BHP, 6-Cylinders engine cooling system: Water cooling, Radiator type

24V, self starting system with 2-Lead Acid batteries with automatic charging systems etc.

Diesel tank-As per manufacturer recommendation but for 350 ltr capacity minimum.

Safety Controls:

1. Low Lube oil pressure
2. High water temperature
3. Battery Charging indicator
4. Oil temperature indicators
5. Warning signals with hooters
6. Rpm indicator

Alternator

1X 250KVA capacity, 415v AC, 3phase,50Hz, 1500rpm

a) Numerical type AVR etc.
b) Control panel accessories for both DG sets
c) Frequency meter
d) Pilot lamps
e) Current transformers
f) Instrument fuses
g) Suitable rating ACB (2 Incomers + 1 bus coupler 800A, 4 Pole 50KA rating L&T/ Siemens make ACB)
h) Control cables and other accessories as per manufacturer
i) Electronic KWH meter
J) ELCB etc.

Engine shall confirm to BS. 649 or IS 10002: 1981, Alternator BS 2613: 1970 or IS 4722: 1968 etc.

Cables (a) Control cable as required

(b) Power cables-3.5 CoreX300 Sqmm three run for each Generator for a length of 200 mtr (Total 1200 mtrs) of NICCO/CCI or Gloster make Only

1. DIESEL ENGINE:

An engine of reputed make, suitable for 1X 250KVA GENSET, inline type, turbo charged, water cooled, electric starting, 1500RPM, four stroke, Multicyclinder diesel engine confirming to BS: 5514/ BS: 649/IS:10000, with 10% overloading for 01 hour in any 12hours of continuous operation in standard operating conditions in our country. The engine should be able to take 100% load with deration up to 50`C ambient temperature and up to 250m altitude.

2. COOLING SYSTEM:

- Heavy-duty radiator with fan
- Cooling water centrifugal pump
- Coolant Inhibitor

3. EXHAUST SYSTEM:

- Exhaust Gas Turbo Charger
- Exhaust manifolds
- Suitably designed critical grade Nelson silencer complete with thermal insulation and Aluminimum cladding.
- Suitably designed exhaust pipe with flexible for carrying the exhaust gases out with minimize back pressure on engine.
- Suitably designed stack of height 05mtrs above the roof of Multistoreyed building 9total 35m above ground level) so that the back pressure on engine is minimum. The exhaust stack may be supported with the building wall through clamps, rubber pads, so that vibration is not transmitted to the building.
- Suitably designed pipe for connecting silencer with stack, so that the back pressure on engine is minimum.
- The engine back pressure should not be more than 2.5inches of mercury at exhaust point.
- Port hole shall be provided as per the emission regulation part- III(CPCB publication).

4. FUEL SYSTEM:

- P.T. Fuel pump

- Fuel Injectors
- Fuel filters
- Fuel hoses

5. LUBE OIL SYSTEM:
   - Lube oil pump
   - Lube oil filters
   - Super Bypass filters

6. INTAKE AIR SYSTEM:
   - Air intake manifold
   - Air cleaner with replaceable elements-inner/outer

7. GOVERNER
   - Electronic Governor
   - Electronic control panel with digital metering

8. STARTING SYSTEM:
   - Electric starter ï 24volts DC
   - Battery Charging alternator

9. COUPLING ARRANGEMENT:
   - Flywheel to suit single bearing alternator
   - Flywheel housing (SAE housing)
   - Inbuilt AM pads to redice vibrations and eliminate misalignment of engine and alternator

10. SAFTY CONTROLS:
   - High water temperaure
   - Low lube oil pressure
   - Over speed, Over Crank

11. ENGINE INSTRUMENT PANEL (ENGINE MOUNTED):
   - Starting switch with OFF/START KEY
   - Water temperature display
   - Lube oil pressure display
   - RPM display
   - Tachometer with hour meter

12. MAUALS:
   - Engine operation and maintenance manual

- Alternator manual with Parts catalogue
- Engine maintenance schedule
- Warranty card
- Engine routine certificate

13. ALTERNATOR:

- Synchronous brushless, single bearing alternator, rated at 250KVA, suitable for continous operation at 1500rpm generating 415volts at 0.8 power factor (lag) suitable for 50Hz, 3 phase, 4 wire system. The alternator shall be self excited, self regulated, foot mounted fitted with ball and/or roller bearings. The alternator shall be suitable for tropical climate and shall conform to BS: 2613/ IS: 4722. The class of insulation shall be ñHò type.

14. BASE FRAME:

Heavy duty base frame of study design made of M.S. steel with necessary reinforcement and pre-drilled holes, to support the DG set and enclosure.

15. VIBRATION INSULATION:

Specially designed poly bond anti-vibration mounts for vibration insulation should be used between engine/alternator and base frame.

16. FUEL TANK

Base fuel tank of sheet metal (14SWG), having a capacity of min. 350liters, duly fabricated and painted, complete with drain valve, air vent, level indicator, inlet and outlet connection, locking arrangement to avoid theft of oil, and housed in the base frame.

17. BATTERIES:

Two numbers batteries or as required for starting of 12 volts, 180 AH each in dry and uncharged condition of reputed make with ignition charging, connecting leads and terminals, provided inside the enclosure.

18. COUPLING AND MOUNTING ARRANGEMENT:

The engine and alternator shall be directly coupled and mounted through in build AVM pads on a heavy duty steel base frame. There shall be no chance of mis-alignment of the DG set and the vibrations of the DG set shall not get transmitted to the base-frame and to the enclosure.

19. AMF CONTROL PANEL:

The control panel body shall be fabricated out of 16SWG MS sheet. Panel shall be floor mounted indoor installed, dust and vermin proof. Control wiring shall be 2.5sq.mm shall

be used. Cables shall be ferruled for proper maintenance/ checking/ wiring of panel. Detachable cable gland plates are to be provided. This shall be of indoor type.

The panel shall be equipped as follows:

Power Circuit:

- One contractor for mains
- One contractor for DG set interlocked with the mains contractor.

Metering:

- One voltmeter with selector switch
- One ammeter with selector switch
- One frequency meter
- Fuel level gauge

Set of push buttons, selector switches and indicating lamps

- Continuous sensing of mains and generator voltage
- Auto start and changeover in case of mains failure
- Auto stop and changeover in case of mains resumption
- Three attempt starting
- Over current relay for protection against overloading of DG set

Audio- Video annunciation with engine shutdown for

- Low lube oil pressure
- High cooling water temperature
- High canopy temperature
- Over current trip

Battery charger consisting of

- Transformer of suitable rating
- Rectifier rate selector switch for ñ Trickleò or ñ Boostò
- DC ammeter and DC voltmeter
- An indicating lamp for battery being charged

20. The DG set should comply with the noise limit of 75db(A) at 01m from the enclosure surface and other requirements given in and as per the document ñ System & Procedue for Compliance with Noise Limits for Diesel Generator Sets(upto 1000KVA)ò issued by CPCB.

21. The diesel engine shall comply with the emission limits given in G.S.R. 371, dated 17.5.02 and G.S.R. 520, dt. 01.7.03(irrespective of the date of implementation given in the notification) and certified as per emission norms of DOI already notified.

22. ACOUSTIC ENCLOSURE:

- Acoustic enclosure should be integral part of the Genset.
- The acoustic enclosure should be modular construction with the provision to assemble and dismantle easily as per site condition.
- The should be no protruding parts.
- The enclosure should be fabricated out of CRCA sheet of 14SWG.
- The sheet metal components should be dip seven tank pretreated.
- To have long life of the enclosure it should be P.P. based powder coated (inside as well outside). All nut and bolt hardwareôs be Zinc coated or Stainless Steel.
- Fuel tank at the base of the DG set should have minimum capacity of 350litres. It should be provided with breather, drain plug, fuel gauge meters to indcate fuel level and locking arrangement to avoid theft of oil.
- There should be provision for fiilling the fuel from outside as in the case of automobiles with locking arrangement.
- Battery should be accommodated in a separate tray in the enclosure.
- There should be provision for drain plugs for draining Mobil oil/ diesel from out side the enclosure.
- The doors to be provided with high quality EPDN gaskets to avoid leakage of sound.
- The lockable type door handles should be provided.
- Sound proofing of enclosure to be done with high quality rock wool confirming to IS 8183, of minimum 100mm thickness and density of 48-64 kg/m3.
- The rock wool should further be covered with fiber glass cloth and perforated galvanized MS sheet.
- A special critical grade silencer is required to be provided to control exhaust noise. (minimum 25dBA insertion loss)
- Specially designed anti is required to be provided to meet air requirment for combusion and heat removal. A blower should be used to meet total air requirement, air changes, if required.
- Temperature inside enclosure should not exceed beyond 7ôC of ambient temperature.
- A provision for emergency shut down from outside the container should be made.

- Control panel should carry warranty of respective manufacturer for diesel generating set in enclosure.
- The acoustic enclosure shall be rain/ water proof.

23. FUEL CONSUMPTION:

- Engine should be capable of providing fuel consumption of 4 units/lit of diesel, between 80 to 100% load as per BS 5514.

23. **INSTALLATION:**

(i) The base of the Genset shall be minimum 30cm from the ground level so that the oil/fuel can be drained out easily.

(ii) The ground up to 01m around the Genset shall be made of cement concrete platform of mix 1:2:4(1 cement, 2 Coarse Sand, 4 Stone Chips 20mm).

1X 250KVA, 380 BHP, 200KW, SILENT AMF diesel Generator set, 1500 RPM, Water cooled, 6-Cylinders, Diesel engine with AMF control panel, 250 KVA latest make Alternator as reqd. (Optional accessories and specification also be enclosed)

Diesel engine Specifications and accessories:-

AVM with Acoustic enclosure type, Capacity-380 BHP, 6-Cylinders engine cooling system: Water cooling, Radiator type

24V, self starting system with 2-Lead Acid batties, charging systems etc.

Diesel tank-As per manufacturer recommendation but of 350 ltr capacity minimum.

Safety Controls:

Low Lube oil pressure

High water temperature

Battery Charging indicator

Oil temperature indicators

Warning signals with hooters

Rpm indicator

Alternator

1X 250KVA capacity, 415v AC, 3phase,50Hz, 1500rpm

a) Electronic type AVR etc.
b) Control panel accessories
c) Frequency meter
d) Pilot lamps
e) Current transformers
f) Instrument fuses
g) Suitable rating ACB (800A, 50KA rating L&T/ Siemens make with 4 Poles ACB each)
h) Control cables and other accessories as per manufacturer
i) Electronic KWH meter
J) ELCB etc. Engine shall confirm to BS. 649 or IS 10002: 1981, Alternator BS 2613: 1970 or IS 4722: 1968 etc.

SCHEDULE OF WORK AND SUPPLY

250 KVA DG set - 1 No.

SL. NO.	DESCRIPTION	QTY.
1.0	Supply of 250 KVA DG set with acoustic enclosure as per enclosed technical specification.	1 Set
2.0	AMF Control Panel with Numerical relay with Bus coupler Panel	1Ste
3.0	Transportation of unloading and placement of DG set to site.	1 Job
4.0	Preparation of concrete slab with load bearing capacity sufficient to take dead load of DG set	1 Job
5.0	Earthing system 600x 600mm G.I. plate, G.I strip 50mm x 6mm, 50mm dia. G.I. pipe including fittings, Charcoal and salt, Hodi cover	12 nos.
6.0	G.I. Strip: 50mm X6mm	As per site
7.0	Cabling system 3.5 core Al. armoured cable 300 sq. mm	As per site
8.0	End termination of 3.5 Core Al. Armoured cable 300 sqmm with double compression Gland and thimbles	As per site
9.0	Control Cable 2.5sq.mm 12 core	As per site
10.0	Connection with Main/Emergency Distribution Panels along with modifications in the Main/ Emergency Panel at substation of CPCB.	As per site
11.0	Exhaust system: Provision of M.S.pipe of suitable diameter (class B pipe) to height 5mtr above rooftop of DG room (total 5mtr from the ground level). The size of the pipe should be such that there is no back pressure beyond allowable limits.	As per site

	Suitable M.S. flange, nuts & bolts with support brackets & structure, Al. Cladding on thermal insulation to be provided.	As per site
12.0	Fuel system: Min. 350 litre fuel tank at the base of DG set by 19mm M.S. pipe (C Class) with fuel fitting NRV etc. with effective locking arrangement.	
13.0	Sami Rotary Diesel Pump	One
14.0	Clearance from Various department	One Job
15.0	Testing & Commissioning	One Job

Guaranteed Technical Particulars

(To be furnished by the bidders)

(A)	**Alternator**		
1.	Name of manufacturer	:	
2.	Brand Name	:	
3.	Factory Address	:	
4.	Reference Standard	:	
5.	Frequency	:	
6.	Rated Voltage	:	
7.	No. of phases	:	
8.	Rated speed	:	
a)	No load	:	
b)	Rated load	:	
9.	Phase sequence (Viewed from driving end)	:	
10.	Power factor	:	
11.	Rated output (KW/KVA)	:	
12.	Rated Current	:	
13.	Direction of rotation		
14.	Excitation system		
15.	Duty type		
16	Class of Insulation	:	
17.	Temperature rise	:	
18.	Efficiency at rated voltage and frequency and 0.8 pf	:	
a)	In full load	:	
b)	1/3 load	:	
c)	¾ load	:	
19	Short circuit rating (Peak)	:	

20	Over speed limit	:	
21	Limits of vibration	:	
22	Type of enclosure	:	
23	Cooling system	:	
24	Variation in	:	
a)	Voltage	:	
b)	Frequency	:	
25	Fly wheel effect of rotating parts	:	
26	Cyclic irregularity	:	
27	Irregularity of wave from %	:	
28	Overload withstand capacity	:	
a)	Momentary	:	
b)	Intermittent	:	
C)	Sustained	:	
29.	Motor starting ability (Current / duration)	:	
	PRIME MOVER	:	
1.	Name of the engine manufacturer	:	
2.	Type of engine	:	
3.	Model and number of cylinders	:	
4.	IS rating	:	
a)	Rating A (With overload)	:	
b)	Rating B (Without overload)	:	
5.	Rating at site condition	:	
6.	Direction of rotation	:	
7.	No. & arrangement of cylinders	:	
8.	Whether two stroke or four stroke	:	
9.	Bore (mm)	:	
10.	Stroke(mm)	:	
11.	Cubic capacity(Litres)	:	
12.	Nominal Compression Ration	:	
13.	BMEP Developed	:	
14.	Mean piston speed	:	
15.	Muffler (silencer) type	:	
16.	Filter type and make	:	
a)	Air	:	
b)	Fuel	:	
c)	Lubricating Oil	:	
17.	Recommended fuel oil specification	:	

18.	Fuel oil tank capacity	:	
19.	Lubricating oil specification	:	
20.	Mode of starting, apparatus required	:	
21.	Specific fuel consumption in Litres per hour under standard reference conditions as per IS. 10000 part- II.	:	
a)	At rated output	:	
b)	At 110% of rated load	:	
c)	At 75% of rated load	:	
d)	At 50% of rated load	:	
e)	At 25% of rated load	:	
22.	Lubricating oil consumption at 100% load in litre/ engine operating hour.	:	
23.	Weight of engine	:	
24.	Overall dimension of engine	:	
25.	Performance curves as per IS-10000(part-VI) 1980 at Standard reference condition.	:	
26.	Accessories on engine as tested and for which a power allowance has been made in the manufacturers calculation of the site rating.	:	
27.	Voltage of electrical system	:	
28.	List of equipment and tools that will normally be supplied	:	
29.	List of supplementary equipment	:	
30.	Schedule of recommended maintenance and overhaul periods.	:	
31.	Maximum permissible back pressure in the exhaust system and maximum permissible intake depression.	:	
32.	Method of cooling and capacity of the cooling system with specific rates of water and oil circulation.	:	
33.	The maximum load that can be suddenly applied to the engine while it is running it is at full rated speed, at no load and at normal running temperatures.	:	
34.	The transient and permanent speed changes that will result from the application of this load.	:	
35.	The transient and permanent speed rise resulting from full load being thrown off.	:	
36.	The transient and permanent speed change of load, both off and on, by all steps of 25 percent of the rated full load.	:	
37.	The steady state speed band recovery time to this speed band from all the conditions stated above.	:	
38.	Aspiration	:	
	ACOUSTIC ENCLOSURE	**:**	

1.	Name of Acoustic Enclosure manufacturer	:	
2.	Enclosure material	:	
3.	Insulation materials	:	
4.	Type of shutters	:	
5.	Overall dimension LXBXH	:	
6.	Noise level to be achieved	:	
7.	Maximum rise in inside temperature above ambient at full load	:	
8	Provision of illumination inside the enclosure	:	
9.	Handling / Lifting facilities	:	

Engine **:** Cummins / Kirloskar/ Greaves / Caterpillar / Valvo make
Alternator: Stamford / KEC / Crompton / Valvo make
L.T Switchgear- L&T / Siemens/ M.G make
Cable- Nicco/ CCI/ Crystal / Gloste make,
Relays to be of numerical type

ODISHA POWER TRANSMISSION CORPORATION LIMITED
OFFICE OF THE SR. GENERAL MANAGER,
CENTRAL PROCUREMENT CELL,
JANPATH, BHUBANESWAR – 751022

TECHNICAL SPECIFICATION

FOR

SHUNT REACTOR, NGR & SURGE ARRESTER

SHUNT REACTOR, NGR & SURGE ARRESTER

CONTENT

TECHNICAL SPECIFICATION

SHUNT REACTOR, NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

1 **General**

1.1 This specification covers design, engineering, manufacture, testing at manufacturer's works, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2 **Type of Reactor**

1.2.1 The shunt reactor shall be of either gapped core type or magnetically shielded air core type construction.

1.2.2 The impedance ratio (X0/X1) specified shall be achieved by any one of the following methods:

1.2.2.1 Adopting single phase construction in separate tanks.

1.2.2.2 Adopting 5 limb core construction.

1.2.3 In case of coreless construction following requirements are stipulated.

1.2.3.1 A magnetic shield shall be provided around the coreless coils.

1.2.2.2 Non-magnetic material sheet shall form the central core to minimize the vibrations.

1.3 **Reference Drawing**

1.3.1 The list of drawings indicated below form a part of this specification & required to be furnished.

i. Standard combined foundation layout for 420 kV shunt reactor NGR surge arrester drawing .

ii. Arrangement of CTs on Shunt Reactor and NGR drawing.

iii. Standard dimensions for OIP condenser bushings (Lower portion) drawing no.

1.4 **Transportation**

1.4.1 The Contractor shall despatch the reactor filled with oil or in an atmosphere of nitrogen or dry air at positive pressure. In the former case, the contractor shall take care of the weight limitation on transport and handling facility at site. In the latter case, necessary arrangement shall be ensured by the contractor to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. The nitrogen or dry air cylinder provided to maintain positive pressure can be taken back by the contractor after oil filling. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. Reactor shall also be fitted with at least one Electronic impact recorders (on returnable basis) during transportation to measure the movement due to impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory before despatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be down loaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks the contractor shall communicate the interpretation of the data.

1.4.2 In case reactor is transported, nitrogen or dry air filled, the insulating oil for reactors shall be delivered at site not before 90 days from the date of commissioning, which will be informed by the owner.

2. **Performance**

2.1 Shunt Reactors will be connected to the 400 kV transmission system for reactive load compensation and shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection. Typical line parameters of 400kV Transmission Lines are given below:

2.2 Shunt Reactors shall be capable of operating continuously at a voltage 5%

higher than their rated voltage without exceeding hot spot temperature of 150 deg C at any part of the reactor.

Sl. No	Line	Line Positive sequence impedance ohms/km	Zero sequence impedance ohms/km	Susceptance mhos/km	Positive Susceptance mhos/km Zero
1	400 kV D/C Line	0.0265+j0.309	0.263+j1.1326	$3.69x10^{-6}$	$2.17x10^{-6}$
2	400 kV S/C line	0.0264+j0.3294	0.2015+j1.095	$3.356x10^{-6}$	$2.646x10^{-6}$

2.3 Temperature rise shall be guaranteed when shunt reactor is operating at 420 kV.

2.4 The neutral grounding reactors are required for grounding of the neutral point of shunt reactors to limit the secondary arc current and the recovery voltage to a minimum value.

2.5 The reactors shall be subjected to switching surge overvoltage of 2.5 p.u. and temporary overvoltage of the order of 2.3 p.u. for few cycles followed by power frequency overvoltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u. voltage.

2.6 DGA of oil shall be periodically monitored by the Owner and the interpretation of DGA results will be as per IEC-60599.

2.7 **Design review**

The Reactors shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc so that the reactor(s) provide long life with least maintenance. Design reviews shall be conducted by Owner or an appointed Consultant at different stages of the procurement process for Reactors, however the entire responsibility of design shall be with the manufacturer. Owner may visit to the manufacturers works to inspect design, manufacturing and test facilities. The design review will commence after placement of award with successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the reactor(s) under scope of this specification. The design review shall be conducted generally following the ñGuidelines for conducting design reviews for transformers 100 MVA and 123kV and aboveò prepared by Cigre SC 12 Working Group 12.22. The manufacturer will be required to demonstrate the use of adequate safety margin for thermal, mechanical, dielectric and vibration etc. design to take into the account the uncertainties of his

design and manufacturing processes.The scope of such a design review shall at least include the following:

Sl No.	Description
1	Core and magnetic design
2	Winding and lead design
3	Thermal design including review of localised potentially hot area.
4	Cooling design
5	Overload capability
6	Eddy current losses
7	Seismic design, as applicable
8	Insulation co-ordination
9	Tank and accessories
10	Bushings and barrier design
11	Radiators
12	Sensors and protective devices ï its location, fitment, securing and level of redundancy
13	Oil and oil preservation system
14	Corrosion protection of metallic surface and aesthetics
15	Electrical and physical Interfaces with substation
16	Earthing
17	Processing and assembly
18	Testing capabilities
19	Inspection and test plan
20	Transport and storage
21	Sensitivity of design to specified parameters
22	Acoustic Noise
23	Vibration and Tank stress
24	Spares, inter-changeability and standardization
25	Maintainability

3. **Construction Details**

The feature and construction of the reactors shall be in accordance with the requirements stated hereunder.

3.1 **Tank and Tank Accessories**

3.1.1 **Tank**

3.1.1.1 Tank shall preferably be of welded construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062). The components and fitting associated with reactor are subject to Ownerôs approval and design review.

3.1.1.2 All seams and those joints not required to be opened at site shall be factory welded and wherever possible they shall be double welded. After completion of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment for tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1.

3.1.1.3 Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

3.1.1.4 The shunt reactor tank shall have either bolted/welded joint. In case the joint is welded it shall be provided with flange suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.

3.1.1.5 Each tank shall be provided with

(a) Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete reactor when filled with oil without structural damage to any part of the reactor. The factor of safety at any one point shall not be less than 2. The lifting lugs shall be so arranged and located as to be accessible for use when the reactor is loaded on the transport vehicle.

(b) A minimum of four jacking pads in accessible position to enable the reactor complete with oil, to be raised or lowered using mechanical/hydraulic screw jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the reactor filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

(c) Suitable haulage holes shall be provided.

3.1.1.6 The tank shall be designed in such a way that it can be mounted on the plinth directly.

3.1.1.7 The base of each tank shall be so designed that it shall be possible to move the complete reactor unit by skidding in any direction without injury when using plates or rails.

3.1.1.8 Paint system and procedures:

The painting details for reactor main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given below. The detailed painting procedure shall also be submitted along with the bid which shall be finalized before award of the contract. The quality of

paint such that its colour should not fade during vapour phase drying process and shall be able to withstand temperature up to 120 deg C.

Description	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thickness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceousiron oxide (HB MIO) (75 µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimm 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil resistant , noncorr osive varnish or paint or epoxy	-	-	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)	Chemical / Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matchi ng shade of tank/ differen t shade aesthet ically y matchi ng to tank
Radiator and pipes upto 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish and flushing with transfor m er oil	-	-	-	-
Control cabinet / marshalling	Seven tank process as per IS:3618	Zinc chromat e	--	EPOXY paint with PU	Minimum 80µm	RAL 7035 shade

box	& IS:6005	primer (two coats)		top coat		for exterior and interior

Note: * indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

3.1.2 **Tank Cover**

3.1.2.1 The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

3.1.2.2 At least two adequately sized inspection openings, one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25kg. Handles shall be provided on the inspection cover to facilitate lifting.

3.1.2.3 The tank cover shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

3.1.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

3.1.2.5 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over compression. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled. Details of all gasket joints shall be submitted for approval

3.1.2.6 Current flowing in tank cover and bushing turrets.
To allow for the effect of possible induced and capacitive surge current, good electrical connection is maintained between the tank and turrets.

3.1.2.7 The reactor shall be provided with a 100 mm nominal diameter pipe flange with bolted blanking plate, gasket and shall be fitted at the highest point of the reactor for maintaining vacuum in the tank.

3.1.3 **Axles and Wheels**

3.1.3.1 The shunt reactor shall be mounted on concrete plinth foundation directly.

3.1.3.2 One complete set of flanged bi-directional wheels and axles shall be provided for each sub-station. This set of wheels and axles shall be suitable for fixing to the under carriage of shunt reactor to facilitate its movement on rail track.

3.1.3.3 The rail track gauge shall be 1676 mm.

3.1.3.4 Bidder shall supply one set of trolley in place of rollers for movement of shunt reactor per sub-station.

3.1.4 **Foundation and Anti Earthquake clamping Device**

3.1.4.1 To prevent reactor movement during earthquake, suitable a clamping device shall be provided for fixing the reactor to the foundation.

3.1.5 **Conservator & Oil Preservation System**

3.1.5.1 Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level electrically insulated alarm contacts. Magnetic oil level gauge shall be type tested. Magnetic oil level gauge and its terminal box shall conform to IP 55 degree of protection.

3.1.5.2 NGR shall have conventional type conservator with prismatic oil level gauge.

3.1.5.3 **Conservator tank and pipe work**

3.1.5.3.1 Conservator tank shall have adequate capacity between highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the shunt reactor and cooling equipment from minimum ambient temperature to 100^{ø}C.

3.1.5.3.2 The conservator shall be fitted with integral lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator, wherever applicable.

3.1.5.3.3 Conservator shall be positioned so as not to obstruct any electrical connection to reactor. Pipe work shall not obstruct the opening of inspection or manhole covers.

3.1.5.3.4 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radius elbows shall be used.

3.1.5.3.5 The feed pipe to the reactor tank shall enter the reactor cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the reactor side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.

3.1.5.3.6 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.

3.1.5.4 **Oil Preservation Equipment**

The requirements of air cell type oil sealing system are given below.

3.1.5.4.1 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth air cell.

3.1.5.4.2 The temperature of oil is likely to rise upto 100^{ø}C during operation. As such air cell used shall be suitable for operating continuously at least at 100^{ø}C.

3.1.5.4.3 Air cell of conservator shall be able to withstand the vacuum during installation/ maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under

vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator.

3.1.5.4.4 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

3.1.5.5 **Dehydrating Filter Breather**

Conservator shall be fitted with a dehydrating filter breather. It shall be so designed that

a) Passage of air is through a dust filter and silicagel.

b) Silicagel is isolated from atmosphere by an oil seal.

c) Moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.

d) Breather is mounted not more than 1200 mm above rail top level.

e) To minimise the ingress of moisture following shall be provided.

i) Three breathers (of identical size) shall be connected in series for conservator of shunt reactor.

ii) Two breathers (each of 2.5 litres minimum volume) shall be connected in series for NGR tank conservator.

3.1.6 **Pressure Relief Device**

Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall operate at a static pressure less than the hydraulic test pressure of reactor tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipe and directed away from reactor/other equipment and this shall be prevented from spraying on the tank. The terminal box/boxes of PRD should conform to degree of protection as per IP-55 of IEC- 60529. Following routine tests shall be conducted on PRD

a) Air pressure test

b) Liquid pressure test

c) Leakage test

d) Contact test

e) Dielectric test

3.1.7 **Buchholz Relay**

A double float/reed type Buchholz relay shall be provided. All gases evolved in the reactor shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper/stainless steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the reactor in service. The device shall be

provided with two electrically independent contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

3.1.8 **Temperature Indicators**

3.1.8.1 **Oil Temperature Indicator (OTI)**

All Shunt and Neutral grounding reactors shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts. The maximum reading pointer and resetting device for the thermometer shall be mounted in the marshalling box. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be ± 3 deg C or better. The setting of alarm and tripping contacts shall be adjustable at site and typical values are as given below which will be reviewed during detailed engineering based on manufacturerôs recommendation.

Alarm ï 90 degC

Trip ï 105 degC

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

a) Signal transmitter

Signal transmitter shall have additional facility to transmit signal for recording oil temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for OTI system which will be used for both remote OTI and DAS. Necessary equipment for sending the signal to remote OTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b) Remote oil temperature indicator:

It shall be suitable for flush mounting on Employer's/RTCC panel. This shall not be repeater dial of local OTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four point selector switch shall be provided.

3.1.8.2 **Winding Temperature Indicator (WTI)**

A device for measuring the hot spot temperature of winding shall be provided on shunt reactors only. It shall comprise the following:

(i) Temperature sensing element

(ii) Image coil

(iii) Auxiliary current transformers if required to match the image coil shall be furnished and mounted in the marshalling box.

(iv) 150 mm dia local indicating instrument with maximum reading pointer mounted in marshalling box and with two adjustable, electrical independent, ungrounded contacts, one for high winding temperature alarm and one for trip. Temperature indicator dial shall have linear gradations to clearly read at least every 2 deg C.

(v) Calibration device.

(vi) Accuracy of WTI shall be ± 3.0 deg C or better.

The setting of alarm and tripping contacts shall be adjustable at site and typical values are as given below which will be reviewed during detailed engineering based on manufacturer's recommendation.

Alarm :100 degC

Trip :110 degC

(vii) In addition to the above, the following shall be provided for remote indication of winding temperature for each reactor.

(a) Signal Transmitter

Signal Transmitter shall have additional facility to transmit signal for recording winding temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) or equivalent standard. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of these functions shall be provided.

(b) Remote winding temperature indicator shall be suitable for flush mounting on Employer's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between Marshalling box and remote WTI control circuit, shall be in the scope of Contractor. Drawing showing the mounting details of RWTI shall be submitted to the Purchaser.

3.1.9 **Earthing Terminals**

3.1.9.1 Two (2) earthing pads (each complete with two (2) nos. holes, M 10 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

3.1.9.2 Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

3.2 **Core**

3.2.1 In case of gapped core construction the following requirements are stipulated.

3.2.1.1 The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented, silicon steel laminations.

3.2.1.2 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

3.2.1.3 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV rms for 1 minute.

3.2.1.4 Core and winding shall be capable of withstanding the shocks during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

3.2.1.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

3.2.1.6 When bell type tank construction is offered, suitable projecting guides shall be provided on core assembly to facilitate removal of tank.

3.2.1.7 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

3.2.1.8 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

3.2.1.9 Adequate lifting lugs as required shall be provided to enable lifting of the core and winding.

3.3 **Windings**

3.3.1 The Contractor shall ensure that windings of reactors are made in dust proof and conditioned atmosphere.

3.3.2 The conductors shall be of electrolytic grade copper, free from scales and burrs.

3.3.3 The insulation of windings and connections shall be free from insulating components which are liable to soften, ooze out, shrink or collapse shall and be non-catalytic and chemically inactive in oil during service.

3.3.4 Coil assembly and insulating spacer shall be so arranged as to ensure free circulation of oil and to reduce the hot spots of the winding.

3.3.5 Coil shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

3.3.6 The conductors shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

3.4 **Unused inhibited Insulating Oil**

3.4.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer/reactor and only thereafter be brought up to the specified parameter by circulation within the transformer/reactor.

Sl.No.	**Property**	**Test Method**	**Limits**
A1.	**Function**		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm^2 /s
1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm^2 /s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm^2 /s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment.
3	Pour point	ISO 3016 or ASTM D97	(Max.)- 40$_{deg}$C
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IEC 60156 or ASTM D1298	(Min.) 50 kV(new unfiltered oil) / 70 kV (after treatment)
6	Density at 20 deg C	. ISO 3675 or ISO 12185 or ASTM D4052	0.820 - 0.895 g/ml

7.	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8.	Resistivity at 90 deg C	IEC 60247	150 X 10^12 Ohm ï cm, (Min.)
9	Negative impulse testing	. KVp @ 25 deg C ASTM D-3300	145 (Min.)
10.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds.)	IEC 60590 or ASTM D 2140	Max.Aromatic :4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds
B1.	**Refining / Stability**		
1	Acidity	. IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3.	Total sulfur content	BS 2000 part 373 or ISO 14596	0.15 % (Max.)
4.	Corrosive sulphur	IEC	62535 Non-Corrosive on copper and paper
		ASTM	D1275B Non-Corrosive
5.	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
6.	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre

C1.	**Performance**		
1	Oxidation stability -Total acidity -Sludge -Dielectric dissipation factor (tan delta) at $90_{deg}C$	IEC 61125 (method c) Test duration 500 hour IEC 60247	Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2	Gassing	. IEC 60628A or ASTM D2300	No general requirement
3.	Oxidation stability(Rotating Bomb test)	IEC : 61125(Method B) / ASTM D2112 (e)	220 Minutes (Min.)
D1.	**Health, safety and environment (HSE)**		
1.	Flash point	ISO 2719	(Min.)$135_{deg}C$
2.	PCA content	BS 2000 Part 346	Max 3%
3	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)

3.4.2 (i) Prior to filling in main tank at site and shall be tested for

1. Break Down voltage (BDV) :**70kV** (min.)
2. Moisture content : **30 ppm** (max.)
3. Tan-delta at 90 °C : **Less than 0.01**
4. Interfacial tension : **More than 0.035 N/m**

ii) Prior to energisation at site oil shall be tested for following properties &acceptance norms as per below generally in line with IS: 1866 / IEC 60422 :

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (ma x.)
4. Resistivity at 90 °C : 6 X 10 ^12 ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. *Oxidation Stability (Test method as per IEC 61125 method C,Test duration: 500 hour for inhibited oil)

a) Acidity : 0.3 (mg KOH /g) (max.)
b) Sludge : 0.05 % (max.)
c) Tan delta at 90 °C : 0.05 (max.)

7. * Total PCB content : Not detectable (2 mg/kg total)

* For Sr. No. 6 & 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of OPTCL.

3.4.3 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameter as mentioned in

serial no. 1 to 5 of clause 3.3.4.2 ii) above. The oil test results shall form part of equipment test report. Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers/reactors, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

3.4.4 Sufficient quantity of oil necessary for maintaining required oil level in tank, radiator and conservator etc. till completion of warranty period shall be supplied.

3.5 **Terminal Arrangement**

3.5.1 **Bushings**

3.5.1.1 The electrical and mechanical characteristics of bushings shall be in accordance with relevant IEC. Bushing must have been type tested successfully as per IEC 60137.

3.5.1.2 Bushing for various voltage rating shall be as follows 52 kV and above Hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator. Mounting dimensions of bushing shall be furnished for necessary action. 36 kV and below Solid porcelain or oil communicating type. Dimensions of 36 kV bushing shall conform to IS: 3347 Part-V.

3.5.1.3 Oil filled condenser type bushings shall be provided with at least the following fittings:

(a) Oil level gauge

(b) Tap for capacitance/tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable

3.5.1.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

3.5.1.5 Bushings of identical rating shall be interchangeable.

3.5.1.6 Porcelain used in bushing manufacture shall be homogenous, free from laminations cavities and other flaws or imperfection that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

3.5.1.7 Clamps and fittings shall be of hot dip galvanised steel.

3.5.1.8 Bushing turret shall be provided with vent pipe, to route any gas collection through the buchholz relay.

3.5.1.9 No arcing horns shall be provided on bushings.

3.5.1.10 Spare Bushing shall be specially packed suitable for long storage

3.6 **Terminal Marking**

The terminal marking and their physical position shall be in accordance with IEC 60076.

3.7 **Neutral Earthing Arrangement**

3.7.1 The neutral of the shunt reactor shall be brought out through 145kV class oil filled condenser bushing.

3.7.2 The neutral of shunt reactor connected to a line shall be grounded through a neutral grounding reactor. The Contractor shall provide Aluminium connectors suitable for moose conductor between neutral of the shunt reactor, surge arrester and the neutral grounding reactor.

3.7.3 Neutral of Reactors, where neutral grounding reactor is not provided, shall be grounded directly.

3.7.4 The neutral terminals of Reactors (without NGR) and Neutral grounding reactors shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

3.8 **Cooling Equipment**

3.8.1 Oil immersed with natural cooling (ONAN)

3.8.1.1 The radiator bank of the shunt reactor shall be separately mounted. For neutral grounding reactor, the radiator, if required, may be tank mounted.

3.8.1.2 Radiators shall be made from pressed steel.

3.8.1.3 Each radiator bank shall be provided with the following accessories:

(a) Top and bottom shut off valve

(b) Drain Valve and sampling valve

(c) Air release plug

(d) Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised steel flats.

(e) Thermometer pockets with captive screw caps at cooler inlet and outlet.

(f) Lifting lugs

3.8.1.4 Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches.

3.8.1.5 Expansion joint, if required, shall be provided on top and bottom cooler pipe connection.

3.8.1.6 The radiator shall preferably be hot dip galvanised or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

3.8.2 **Valves**

3.8.2.1 All valves upto and including 100 mm shall be of gun metal or of cast steel./ cast iron. Larger valves may be of gun metal or may have cast iron bodies. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

3.8.2.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

3.8.2.3 Each valve shall be provided with the indicator to show clearly the position of the valve.

3.8.2.4 All valve flanges shall have machined faces.

3.8.2.5 All valves in oil line shall be suitable for continuous operation with shunt reactor oil at 115°C.

3.8.2.6 Gland packing/gasket material shall be of teflon rope/nitrile rubber. In case of gate/globe valves, gland packing preferably of teflon rope shall be used to prevent oil seepage through the gland.

3.8.2.7 The oil sampling point for main tank should have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

3.8.2.8 A valve or other suitable means shall be provided to fix the on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detailed engineering stage.

3.8.2.9 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish. Outside surface of the valves shall be painted with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS:2932. Outside surface except gasket seating surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS:2074 followed by two coats of fully glossy finishing paint.

3.8.2.10 All hardware used shall be cadmium plated/electro-galvanised.

3.8.2.11 For estimation purpose of spares one set of valves mean one valve of each type used in Reactor and/or NGR.

3.9 **Marshalling Box**

3.9.1 A sheet steel marshalling box of a suitable construction shall be provided for the reactor ancilliary apparatus and this shall be vermin, dust & weather proof. All the terminals for remote indication shall be wired upto the marshalling box from the reactor accessories. Necessary shorting of CT secondary terminals shall be done at the marshalling box.

3.9.2 The marshalling box shall be tank mounted type. Suitable anti-vibration pads shall be provided so that vibration from tank is not transferred to the marshalling box. The marshalling box shall have sloping roof. It shall have double hinged doors and shall be provided with locking arrangement. The exterior and interior painting shall be in accordance with painting clause no 3.1.1.8.

3.9.3 All doors, removable covers and plates shall be gasketed all round with neoprene gaskets. Louvers shall have screens and filters. The screens shall be of fine wire mesh made of brass and GI wire.

3.9.4 The marshalling box shall accommodate the following :

(a) Temperature indicator for winding and oil,

(b) Terminal blocks and gland plates for incoming and outgoing cables.

3.9.5 The temperature indicator shall be so mounted that the dials are about 1200 mm above ground level. Glass doors of suitable size shall be provided for convenience of reading. A space heater and cubicle lighting with ON-OFF switch shall be provided. It shall be so designed that with the space heater switched on continuously, the temperature inside the marshalling box does not exceed the safe operating limits at the service conditions.

3.9.6 In case of single phase reactor a common Marshalling Box shall be provided and all termination for bushing CTs, PRV, Temperature Indicators, Buchholz relay, MOG, etc. shall be brought out to the common marshalling box by cable to make the scheme suitable for three phase operation. Further, cabling and terminations for spare reactor shall also be provided in each common marshalling box.

4 **Fittings**

4.1 The following fittings shall be provided with each shunt reactor and neutral grounding reactor covered under this specification.

4.1.1 Conservator for reactor main tank with filling hole and cap, drain valve, isolating valve, vent pipe and magnetic oil level gauge with low level alarm contacts.

4.1.2 Conservator for NGR main tank with drain valve, isolating valve, vent pipe and prismatic oil level gauge.

4.1.3 Air release devices.

4.1.4 Dehydrating breather complete with first fill of activated silicagel.

4.1.5 Inspection openings and covers.

4.1.6 Rating & diagram plate for reactors and current transformers. These plates shall be of material capable of withstanding continuous outdoor service.

4.1.7 Terminal marking plate conforming to IEC-60076.

4.1.8 Two earthing terminals each on shunt reactor tank, NGR tank, radiators & marshalling box, SA structures etc.

4.1.9 Ladder to climb up to the reactor tank cover with suitable locking arrangement to prevent climbing during charged condition.

4.1.10 Double float/reed type Buchholz relay with alarm and trip contacts.

4.1.11 Bottom oil sampling valve and drain valves.

4.1.12 Filter valves at top and bottom.

4.1.13 Shut off valves on the pipe connection between radiator bank and reactor tank.

4.1.14 Shut off valves on both sides of Buchholz relay at accessible height.

4.1.15 Sampling gas collectors for Buchholz relay at accessible height.

4.1.16 Four jacking pads.

4.1.17 Lifting lugs or eyes for the cover.

4.1.18 Suitable neutral terminal connectors for ACSR moose conductor on bushings (Shunt reactor & NGR) and 120kV surge arrester. ACSR Moose conductor shall be owner supplied.

4.1.19 Under carriage with provision for flanged bidirectional wheels, set of flanged bidirectional wheels, set of flanged bidirectional rollers/trolley for transportation.

4.1.20 Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

4.1.21 Pressure relief devices with alarm/trip contacts.

4.1.22 Bushing with metal parts and gaskets to suit the termination arrangement.

4.1.23 Winding temperature indicators for local and remote mounting (only for shunt reactor).

4.1.24 Oil temperature indicator

4.1.25 Protected type mercury or alcohol in glass thermometer.

4.1.26 Marshalling box.

4.1.27 Haulage lugs.

4.1.28 Bushing CT

4.1.29 The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the reactor are deemed to be included.

4.1.30 One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes as used in the reactor one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one) shall be supplied per Substation.

4.1.31 Suitable galvanized iron tray for cabling on main tank for better aesthetics.

4.2 **On-line insulating oil drying system**

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each reactor shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This on line insulating oil drying system shall be designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of purchaser during detail engineering. A valve or other suitable means shall be provided to fix the on line oil drying system to facilitate continuous on line oil drying. The location & size of the same shall be finalised during detail engineering stage. For the interpretation of DGA samples, it must be recognised that this drying system absorbs a small percentage of the DGA gas and may disturb the true equilibrium of the moisture in the oil. The contractor shall furnish necessary guide line for DGA interpretation in the manual. Original

pamphlets and details of maintenance required for the online drying system shall be included in the manual.

4.3 **On line dissolved Hydrogen and moisture monitor**

4.3.1 The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Hydrogen and Water content, even at very low concentrations, in Transformer Oil. It should be easy to install and it should be possible to retrofit it on an energized reactor, without shutting down the reactor.

4.3.2 The monitor shall be designed for permanent outdoor use in high voltage substation environments, for ambient temperatures of -20 deg C to 55 deg C and oil temperatures of -20 deg C to 105 deg C.

4.3.3 The monitor shall be suitable to detect and measure dissolved Hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm or % RS(Relative Saturation).

4.3.4 The Hydrogen sensors shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 10 psi.

4.3.5 **Technical Parameters:**

a) The measurement range:

- Hydrogen ï 0 to 2000 ppm, for dissolved Hydrogen in oil.
- Water ï 0 to 95% RS, for dissolved water in oil.

b) Alarms/Indication

Hydrogen and water ï Programmable Alarm/Indication levels, with corresponding NO/NC solid state relays, for (High/Very High)

c) Environment:

- Exterior enclosure and components all made of corrosion-proof material to IP 55
- Operating Ambient Temperature Range. : ï 20 to + 55 deg C.
- Operating Oil Temperature Range. : ï 20 to + 105 deg C
- Pressure Withstand, (Oil side) : Full Vacuum to 10 psi.

d) Communications:

- RS-232 ports and Analog 4 ï 20 mA isolated outputs.
- RSï 232 ports and suitable for Ethernet connectivity.

4.4 Flow sensitive conservator Isolation valve for Fire Control in Reactors

4.4.1 In order to restrict the supply of oil in case of a fire in reactor, provision shall be made to isolate the conservator oil from the main tank.

4.4.2 A valve which shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

4.4.3 When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm indication in control room during closing operation of valve.

4.4.4 The necessary switches shall be provided in cooler control cabinet / common marshalling box for manual open / close operation of the valve.

5. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Employer is given under Cl.5.1 below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation.

5.1 **Inspection**

5.1.1 **Tank and Conservator**

5.1.1.1 Certification of chemical analysis and material tests of plates.

5.1.1.2 Checks for flatness

5.1.1.3 Electrical interconnection of top and bottom tank by braided tin flexible

5.1.1.4 Welder's qualification and weld procedure.

5.1.1.5 Testing of electrodes for quality of base materials.

5.1.1.6 Inspection of major weld preparation.

5.1.1.7 Crack detection of major strength weld seams by dye penetration test.

5.1.1.8 Measurement of film thickness of

(a) Oil insoluble varnish

(b) Zinc chromate paint

(c) Light grey paint

5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90ø and further dimensional check.

5.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to non destructive test (NDT).

5.1.1.11 Leakage test of conservator.

5.1.1.12 Certification of all test results.

5.1.2 **Core**

5.1.2.1 Sample testing of core material for checking specific loss, bend properties, magnetisation characteristics and thickness.

5.1.2.2 Check on the quality of varnish if used on the stampings.

(a) Measurement of thickness and hardness of varnish on stampings.

(b) Solvent resistance test to check that varnish does not react in hot oil.

(c) Check over all quality of varnish on stamping, ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.

5.1.2.3 Check on the amount of burrs.

5.1.2.4 Bow check on stampings.

5.1.2.5 Check for the overlapping stampings. Corners of the sheets are to be apart.

5.1.2.6 Visual and dimensional check during assembly stage.

5.1.2.7 Check for interlaminar insulation between core sections after pressing.

5.1.2.8 Visual and dimensional check for straightness and roundness of core.

5.1.2.9 High voltage test (2 kV for one minute) between core and clamps.

5.1.2.10 Check of pressure during dimensional stabilisation of winding/core assembly.

5.1.2.11 Certification of all test results.

5.1.3 **Insulation Material**

5.1.3.1 Sample check for physical properties of material.

5.1.3.2 Check for dielectric strength.

5.1.3.3 Visual and dimensional checks.

5.1.3.4 Check for the reaction of hot oil on insulating materials.

5.1.3.5 Dimensions stability test at high temperature for insulating material.

5.1.3.6 Tracking resistance test on insulating material.

5.1.3.7 Certification of all test results.

5.1.4 **Winding**

5.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.

5.1.4.2 Visual dimensional checks on conductor for scratches, dent marks etc.

5.1.4.3 Sample check on insulating paper for pH value, electric strength.

5.1.4.4 Check for the reaction of hot oil on insulating paper.

5.1.4.5 Check for the bonding of the insulating paper on conductor.

5.1.4.6 Check and ensure that physical condition of all materials taken for winding is satisfactory and free of dust.

5.1.4.7 Check for absence of short circuit between parallel strands.

5.1.4.8 Check for brazed joints wherever applicable.

5.1.4.9 Measurement of impedance by low voltage to be carried out when core/yoke is completely restacked and all connections are ready.

5.1.4.10 Conductor-enamel test for checking of cracks, leakage and pin holes.

5.1.4.11 Conductor flexibility test.

5.1.4.12 Heat shrink test for enamelled wire.

5.1.4.13 Certification of all test results.

5.1.5 **Checks before drying process**

5.1.5.1 Check conditions of insulation on the conductor and between the windings.

5.1.5.2 Check insulation distance between high voltage connection cables and earth and other live parts.
5.1.5.3 Check insulation distance between low voltage connections and earth and other parts.
5.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.
5.1.5.5 Check for proper cleanliness and absence of dust etc.
5.1.5.6 Certification of all test results.

5.1.6 **Checks during drying process**
5.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.
5.1.6.2 Check for completeness of drying by measuring IR and tan delta.
5.1.6.3 Certification of all test results.

5.1.7 **Assembled Reactor**
5.1.7.1 Check completed reactor against approved out line drawing provision for all fittings, finish level etc.
5.1.7.2 Jacking test on all the assembled reactors.
5.1.7.3 Dye penetration test shall be carried out after Jacking tests.
5.1.8 **Bought Out Items**

The makes of all bought out items shall be subject to Employer's approval.

5.1.8.1 The Contractor shall also prepare a comprehensive inspection and testing programme for all bought out/sub-contracted items and shall submit the same to the Employer for approval. Such programme shall include the following.

(a) Buchholz relay
(b) Axles and wheels/Trolley for transportation.
(c) Winding temperature indicators for local and remote mounting
(d) Oil temperature indicators for local and remote mounting
(e) Bushings
(f) Bushing current transformer
(g) Marshalling box
(h) Radiators
(i) Pressure relief device

The above list is not exhaustive and the Contractor shall also include all other bought out items in his programme.

5.2 **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated. The contractor shall bear all additional costs related to tests which are not

possible to carry out at his own works. The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below.

Test on Shunt Reactor		
No.	**Item**	**Test Category**
1.	Measurement of winding resistance	Routine
2	Reactance and loss measurement (Measured in Cold state and Hot state on temp. rise tested unit & Measured in Cold state for other units)	Routine
3	Measurement of insulation resistance & Polarization Index	Routine
4	Measurement of insulation power factor and capacitance between winding and earth	Routine
5	Measurement of insulation power factor and capacitance of bushings	Routine
6	Lightning impulse test	Routine
7	Switching impulse test	Routine
8	Separate source voltage withstand test	Routine
9	Lightning impulse test on Neutral	Routine
10	Induced over voltage test with Partial Discharge measurement	Routine
11	Gas-in-oil analysis	Routine
12	Oil leakage test on Reactor tank	Routine
13	Appearance, construction and dimension check	Routine
14	Frequency response analysis (Soft copy of test report in sfra format to be submitted to site along with O & M manual)	Routine
15	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
16	Tank vacuum test	Routine
17	Tank pressure test	Routine
18	Vibration & stress measurement	Routine
19	Core assembly dielectric and earthing continuity test	Routine
20	Temperature rise test	*Type
21	Measurement of harmonic content of current (Measured in Cold state)	*Type
22	Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)	*Type
23	Knee point voltage measurement of reactor (Measured in Cold state)	*Type
24	Measurement of zero-sequence reactance (For	*Type

	three phase shunt reactor only)	
	Test on NGR	
No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2	Measurement of impedance by V/I	Routine
3	Measurement of insulation resistance	Routine
4	Measurement of Capacitance & Tan delta of bushing	Routine
5	Lightning impulse test	Routine
6	Separate source voltage withstand test	Routine
7	Isolation Test	Routine
8	Oil leakage test	Routine
9	Appearance, construction and dimension check	Routine
10	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
11	Tank vacuum test	Routine
12	Tank pressure test	Routine

All tests shall be done in line with IEC: 60076 and as per ñAnnexure-Aò Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the manufacturer. *Type test shall be carried out at first unit manufactured against the LOA/NOA at each manufacturing plant.

5.2.1 Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

5.2.2 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

5.2.3 Void

5.2.4 Void

5.2.5 Void

5.2.6 Void

5.2.7 Type Tests on fittings:

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the clause no. 9.2 of the Section ï GTR. The list of fittings and the type test requirement is:

1) Bushing (Type Test as IEC: 60137, including snap back test)
2) Buchholz relay (Type Test as per IS: 3637 and IP-55 Test on terminal box)

3) Control cabinet (IP-55 test)

4) Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in reactor tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released. The terminal box / boxes of PRD should conform to degree of protection as per IP-55 of IEC 60529.

5) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

6) Air Cell (Flexible air separator) ï Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016.

7) OTI & WTI ï Switch setting & operation, switch differential, switch rating.

8)

5.2.8 Pre-Shipment Checks at Manufacturer's Works

5.2.8.1 Check for interchangeability of components of similar reactors for mounting dimensions.

5.2.8.2 Check for proper packing and preservation of accessories like radiators, bushings dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.2.8.3 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.2.8.4 Gas tightness test to confirm tightness.

5.2.8.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.2.8.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the reactor tank. Dew point of dry air / nitrogen at the time of reactor despatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

5.2.8.7 Functioning of impact recorder(s) at their works before installing on the tank.

5.3 Inspection and Testing at Site

The Contractor/Manufacturer shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below and in the document No. D-2-01-03- 01-01 (or latest revision) (Pre commissioning Procedures and Formats for substation bay equipment), which will be available in the respective sites and shall be referred by the contractor. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Testing of oil sample at site shall be carried out as per Cl 3.4 above

5.3.1 Receipt and Storage Checks

5.3.1.1 Check and record condition of each package, visible part of the reactors etc. for any damage.

5.3.1.2 Check and record the gas pressure in the reactor tank as well as in the cylinder. Measure and record the dew point of dry air /nitrogen in the transformer tank.

5.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check for condition of core and winding in general.

5.3.1.4 Check and record reading of impact recorders at receipt and verify the allowable limits as per manufacturer's recommendation.

5.3.2 Installation Checks

5.3.2.1 Check the whole assembly for tightness, general appearance & winding healthiness etc.

5.3.2.2 Oil leakage test

5.3.2.3 Visual check for Leakage on bushing before erection.

5.3.2.4 Measurement of capacitance and tan delta of the bushings before fixing/connecting to the reactor. Contractor shall furnish these values for site reference.

5.3.2.5 Measure and record the dew point of nitrogen in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall for part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

5.3.2.6 **Oil filling**

5.3.2.6.1 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

5.3.2.6.2 The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the reactor tank and should be less than 1mbar.

5.3.2.6.3 Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the reactor is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete reactor. For this purpose the reactor shall first be drained to expose all insulation material.

5.3.2.6.4 The minimum safe level of oil filling (if different from the Buchholz level) to which the reactor shall be oil filled under vacuum, shall be indicated in the manual.

5.3.2.6.5 The Ultra High Vacuum type oil treatment plant of suitable capacity (preferably 4500 to 6000 litres per hour) suitable for treatment of oil in EHV class reactor shall be used in order to achieve properties of treated oil. The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow :

(i) Removal of moisture from 100 ppm to 3 ppm (max.)

(ii) Removal of dissolved gas content from 10% by Vol. To 0.1% by vol.

(iii) Improvement of dielectric strength break down voltage from 20 to 70 KV

(iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.

(v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.

(vi) Processing temperature shall be automatically controlled and have a adjustable range from 40°C to 80°C

5.3.3 **Commissioning Checks**

5.3.3.1 Check the colour of silicagel breather.

5.3.3.2 Check the oil level in the breather housing, conservator tank, cooling system, condenser bushing etc.

5.3.3.3 Check the bushings for conformity of connection to the line etc.

5.3.3.4 Check for correct operation of all protection devices and alarms.

i) Buchholz relay

ii) Excessive winding temperature

iii) Excessive oil temperature

iv) Low oil level indication

5.3.3.5 Check for adequate protection of electric circuit supplying the accessories.

5.3.3.6 Insulation resistance measurement for :

i) Control wiring

ii) Main winding

iii) Bushing current transformer

5.3.3.7 2 kV/minute test between bushing CT terminal and earth.

5.3.3.8 Check for cleanliness of the reactor and the surrounding.

5.3.3.9 Measure vibration and noise level

5.3.3.10 DGA of oil sample just before commissioning and after 24 hours of commissioning.

5.3.3.11 Capacitance and tan delta measurement of winding & bushing.

5.3.3.12 Frequency Response Analysis (FRA) at site by using owner's equipment which shall be provided free of cost.

5.3.3.13 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

6 **Technical Parameters**

6.1 The parameters pertaining to the shunt reactor and neutral grounding reactor furnished under this specification are listed below:

6.1.1	**Shunt Reactor**	**50 / 63 / 80 / 125 MVAR**
6.1.1.1	Rated Voltage	420kV (1.0pu)
6.1.1.2	Applicable Standard	IEC60076-6
6.1.1.3	System Fault level	40kA
6.1.1.4	Connection	Star with neutral brought out

6.1.1.5 Insulation level (for winding)

(a) Lightning impulse :1.2/50 µSec withstand voltage: 1300 kVp

(b) Switching surge impulse: 20/200/500 µSec voltage: 1050 kVp

6.1.1.6 Maximum temp rise over an ambient temp of 50 deg C and at 420kV voltage

(a) of winding measured by resistance method 45 deg C

(b) of top oil measured thermometer 40 deg C

(c) The temperature of the hottest spot shall be as per relevant standards.

6.1.1.7 Cooling System Natural Oil circulation (ONAN**)**

6.1.1.8 Insulation level of neutral

(a) Impulse withstand voltage: 550 kVp

(b) Power frequency voltage: 230 kV(rms)

(c) Whether neutral is to be brought out Yes (through 145kV class oil filled condenser bushings).

6.1.1.9 Ratio of zero sequence reactance between 0.9 & 1.0. to positive reactance (X0/X1)

6.1.1.10 Range of constant impedance Upto 1.5 pu voltage (the bidder shall furnish complete saturation characteristics of the Reactors upto 2.5 pu Voltage

6.1.1.11 Tolerance on current 0 to +5%

6.1.1.12 Harmonic content in phase current The crest value of the third harmonic component in phase current not to exceed 3% of the crest value of fundamental when reactor is energized at rated voltage with sinusoidal wave form.

6.1.1.13 Permissible current unbalance among - + 2% different phases.

6.1.1.14 Minimum clearance in air

Rated voltage	Phase to phase	Phase to ground
420 kV	4000mm	3500mm

145 kV	1220mm	1050mm

6.1.1.15 Noise level at rated voltage and frequency : 80 dB

6.1.1.16 **Bushing**	**Line side**	**Neutral side**
(a) Rated voltage	420 kV	145 kV
(b) Creepage distance (total)	10,500 mm	3625 mm
(c) Mounting	Tank cover	Tank cover
(d) 1.2/50 microsec. Lightning impulse withstand voltage (kVp)	1425	650
(e) Switching impulse (250/2500 micro seconds) withstand voltage (kVp)	1050	-
(f) One minute power frequency with stand voltage (kV rms)	630	270
(g) Rated current (A)	800	800

6.1.1.17 Vibration and stress level at rated voltage and frequency : Not more than 200 microns peak to peak Average vibrations shall not exceed 60 microns peak to peak. Tank stresses shall not exceed 2.0kg/sq.mm at any point on the tank.

6.1.1.18 Maximum Partial Discharge : 100 pico columb (PD) level at 1.5 pu

6.1.2 **Neutral Grounding Reactor**

6.1.2.1 Rated voltage from insulation strength considerations	145kV
6.1.2.2 Rated frequency	50Hz
6.1.2.3 No. of phases	One
6.1.2.4 Type	Outdoor
6.1.2.5 Insulation	Graded
6.1.2.6 Max. continuous current	10A (rms)
6.1.2.7 Rated short time current (10secs.)	60A (rms)

6.1.2.8 Rated impedance at rated short time current: 600 to 2500 ohm (This is an indicative value, actual value will be confirmed during detailed engineering)

6.1.2.9

Bushings	**Line side**	**Ground side**
(i) Rated voltage	145kV	24kV
(ii) Creepage distance (total)	3625mm	600mm
(iii) Mounting	Tank cover	Tank cover
(iv) Lightning impulse (1.2/50 microsec) withstand voltage (kVp)	650	125

(v) Power frequency withstand voltage (kVrms)	275	50
6.1.2.10 Connection	Between neutral of shunt reactor and ground	
6.1.2.11 Insulation level for winding	**Line side**	**Ground side**
(i) Lighting impulse (1.2/50 microsec) withstand voltage (kVp)	550	95
(ii) One minute power frequency withstand voltage (kVrms)	230	38
6.1.2.12 Max. temperature rise over ambient temperature of 50øC at rated voltage		
(i) of winding measured by resistance	50øC	
(ii) of top oil measured by thermometer	45øC	
6.1.2.13 Cooling system	Natural oil cooling (ONAN)	
6.1.2.14 Cooling medium	Mineral oil	
6.1.2.15 Whether neutral is to be brought	Yes.(Through 24kV class out porcelain bushing)	

6.1.2.16 Method of grounding Solidly connected between neutral of shunt reactor and earth.

7.0 **Bushing Current Transformer**

7.1 Current transformers shall comply with IEC-60185.

7.2 It shall be possible to remove the turret mounted current transformers from the reactor tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

7.3 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core. 7.4 Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

7.5 **Technical Parameters**

7.5.1 Current Transformer Parameter for 420 kV Shunt Reactor (on each phase connection) & Neutral Grounding Reactor.

	Shunt Reactor		**Neutral Reactor**	
	Line Side	**Neutral side**	**Common Neutral side**	**Earth side**
	(In each Phase)			
7.5.1.1 Ratio				
Core 1	200/1A	200/1A	200/1A	200/1A
Core 2	200/1A	--		

Core 3	200/1A	2000-1000-500/1A			
Code 4	200/1A	-do-			

7.5.1.2 Minimum knee point voltage or burden and accuracy class

Core 1	200V Class PS	200V Class PS	200V Class PS	200V Class PS
Core 2	200V Class PS	Suitable for WTI being supplied		
Core 3	200V Class PS	1000-500 250V Class PS		
Core 4	10VA Class 1.0	-do-		

7.5.1.3 Maximum CT Resistance

Core 1	1 ohm	1 ohm	1 ohm	1 ohm
Core 2	1 ohm	--		
Core 3	1 ohm	10-5-2.5 ohm		
Core 4	--	-do-		

7.5.1.4 Application

Core 1	Reactor Differential	Reactor Differential	Restricted Earth Fault	Restricted Earth Fault
Core 2	Restricited Earth fault	Temp. indicator (On one phase only)	--	--
Core 3	Reactor Backup	Line Protection (Main-I)/ Tzone differential Protn./spare		
Core 4	Metering	Line Protection (Main-II)/ Tzone differential Protn./spare		

7.6 Note:

7.6.1 The arrangement of current transformers on shunt reactor and NGR shall be furnished for necessary action.

7.6.2 The secondary excitation current of class PS shall not be more than 4% of rated secondary current at 25% of knee point voltage.

7.6.3 Accuracy class PS as per IEC 60044.

7.6.4. Class (for the relevant protection and duties) as per IEC 60185.

7.6.5 For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor and/or NGR.

8.0 **SURGE ARRESTER**

8.1. General

The surge arresters shall conform in general to IEC-60099-1 or IEC-60099- 4 except to the extent explicitly modified in the specification.

8.1.1 The bidder shall offer surge arresters of gapless type without any series or shunt gap.

8.1.2 Arresters shall be hermetically sealed units, of self supporting construction, suitable for mounting on structures.

8.2 Duty Requirements

8.2.1 The surge arresters shall be of heavy duty station class type. It shall be physically located between the neutral of 420kV shunt reactor (brought out at 145kV class bushing) and neutral grounding reactor and shall be electrically in parallel with the latter.

8.2.2 The surge arresters shall be capable of discharging over voltage occurring during switching of unloaded transformers and reactors.

8.2.3 Surge arresters shall be capable of spark over on severe switching surges and multiple strokes.

8.2.4 The surge arresters shall be able to withstand wind load calculated at 195 kg/sq.m.

8.2.5 The gapless arrester, if provided, shall meet following additional requirements.

8.2.5.1 It shall be fully stabilized thermally to give a life expectancy of 100 years under site conditions and shall take care of the effect of direct solar radiation.

8.2.5.2 The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

8.3 Constructional Features

The features and constructional details of surge arresters shall be in accordance with requirement stipulated hereunder:

8.3.1 **Gapless Type Surge Arrester**

8.3.1.1 The non linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent electrical and mechanical properties even after repeated operations.

8.3.1.2 The surge arresters shall be fitted with pressure relief devices and arc diverting parts suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure.

8.3.1.3 The arresters shall incorporate anti-contamination feature to prevent arrester failure consequent to uneven voltage gradient across the stack in the event of contamination of the arrester porcelain.

8.3.1.4 Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

8.3.1.5 Outer insulator shall be porcelain used shall be homogenous, free from laminations, cavities and other flaws or imperfection that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Glazing of porcelain shall be of uniform brown colour, free from blisters, burrs and other similar defects. Porcelain housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester.

8.3.1.6 The end fittings shall be made of non-magnetic and corrosion proof material.

8.3.1.7 The name plate shall conform to the requirement of IEC incorporating the year of manufacture.

8.3.1.8 The arrester shall be supplied with suitable support structure either of tubular GI pipe or lattice steel galvanised.

8.3.1.9 The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block to be furnished. Metalised coating thickness for reduced resistance between adjacent discs to be furnished along with procedure for checking the same. Details of thermal stability test for uniform current distribution of current on individual disc to be furnished.

8.3.3 **Fittings and Accessories**

8.3.3.1 Each arrester shall be complete with insulating base, support structure and terminal connector. The height of the support structure shall not be less than 2500 mm. The structure would be made of galvanized steel generally conforming to IS:802. The surge arrester can also be mounted on the neutral grounding reactor in lieu of separate support structure.

8.3.3.2 Self contained discharge counter, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation, shall be provided for each unit. The counter shall be visible through an inspection window from ground level. The counter terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends.

8.3.3.3 Suitable milliammeter on each arrester with appropriate connections shall be supplied to measure the resistor grading leakage current. The push buttons shall be mounted such that it can be operated from ground level.

8.3.3.4 Discharge counter and milliammeter shall be suitable for mounting on support structure of the arrester.

8.3.3.5 Grading/Corona rings shall be provided on each complete arrester unit as required for proper stress distribution.

8.4 Tests

8.4.1 The surge arresters shall conform to type tests and shall be subjected to routine tests as per IEC-60099.1/IEC-60099.4.

8.4.2 Surge arrester shall be subjected to additional acceptance tests.

(i) Construction check (visual check)

(ii) Measurement of insulation resistance by 1kV megger.

8.5.1 **Gapless Surge Arrester**

8.5.1.2 Rated arrester voltage	120 kV
8.5.1.2 Rated system voltage	145 kV
8.5.1.3 Rated system frequency	50Hz
8.5.1.4 System neutral earthing	Effectively earthed
8.5.1.5 Installation	Outdoor
8.5.1.6 Nominal discharge current	10kA of 8/20 micro sec wave.
8.5.1.7 Class of arrester	10kA heavy duty type
8.5.1.8 Minimum discharge capacity	3.5 kJ/kV (referred to rated voltage)
8.5.1.9 Continuous operating voltage at 50øC	102kV
8.5.1.10 Maximum switching surge residual voltage	280kVp (1kA)
8.5.1.11 Maximum residual voltage at	
(i) 5kA	320kVp
(ii) 10kA nominal discharge current	340kVp
8.5.1.12 Long duration discharge class	2
8.5.1.13 High current short duration test value (4/10microsec. wave)	100kAp
8.5.1.14 Current for pressure relief test	40kArms
8.5.1.15 Low current long duration test value	1000Apeak (2000microsec.)
8.5.1.16 Min. total creepage distance.	3625 mm.
86.1.17 One minute dry power frequency withstand voltage of arrester housing.	275kVrms
8.5.1.18 Impulse withstand voltage of arrester housing with 1.2/50 microsec. wave	+650KVp
8.5.1.19 Pressure relief class	A
8.5.1.20 RIV at 92 kVrms.	Less than 500microvolts
8.5.1.21 Partial discharge at 1.05	Not more than 50pC

	continuous over voltage	
8.5.1.22	Seismic acceleration	0.3 g horizontal.
8.5.1.23	Reference ambient Temperature	50 deg C

9.0 **Oil Storage Tank**

9.1 General

This specification covers supply of oil storage tank.

9.2 Standard

The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS:803 or other internationally acceptable standards.

9.3 Specifications

Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Size of the storage tank shall be as follows:
Diameter : 2.0 meter
Minimum Capacity : As mentioned in BPS The tank shall be designed for storage of oil at a temperature of 100°C.

9.3.1 The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

9.3.2 The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

9.3.3 The tank shall also fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. Bidder shall indicate the engine capacity in horse power to pull one tank completely fitted with oil. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Suitable arrangement shall also be provided to prevent overflow in the tank.

9.3.4 The following accessories shall also form part of supply along with each Oil storage tank.

(i) Four numbers of suitable nominal bore rubber hoses for transformer oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

(ii) Two numbers of suitable nominal bore vacuum hoses, suitable for full vacuum without collapsing and kinking, with couplers and unions each not less than 10 metre long shall also be provided.

(iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with atleast 8 meter cable so as to suitably place the Vacuum gauge at ground level.

9.3.4 The painting of oil storage tank and its control panel shall be as per clause no 3.1.1.8.

9.3.5 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubical with IP-55 enclosure.

10.0 **OIL SAMPLING BOTTLE**

10.1 Oil sampling bottles shall be suitable for collecting oil samples from transformers and shunt reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

10.2 Oil sampling bottles shall be made of stainless steel having a capacity of one litre.

10.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

10.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

10.5 An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of 01 meter length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

Annexure-A (Test Procedures)

1. Core assembly dielectric and earthing continuity tests

The insulation of the magnetic circuit, and between the magnetic circuit and the core clamping structure, including core-bolts, bands and/or buckles shall withstand the application of a test voltage of either 2kV AC or 3kV DC for 60 seconds.

2. Tank Tests

i) Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC:60296 at the ambient temperature and subjected to a pressure equal to normal tank pressure plus 35 kN/sq.m (5 psi) measured at the base of the

tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii) Vacuum Tests

Shunt and neutral grounding reactor tank shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/sq.m absolute (25 torr) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below:

Horizontal length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
above 3000	19.0

iii) Pressure Test

Shunt and neutral grounding reactor tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or normal pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of the flat plate after the excess pressure has been released shall not exceed the figures specified above for vacuum test.

3. Temp. Rise Test as per IEC : 60076

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers/reactors, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181. The test shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours.

4. Routine tests on neutral grounding reactor

In addition to the routine tests listed in the IEC-60076 the volt-current characteristics test shall also be carried out on each neutral grounding reactor preferably atleast upto short time rated current. Calculated value of hot spot temperature shall be furnished by the Contractor. Further, Lighting impulse voltage withstand test and ohmic value measurement shall be carried out.

5. Routine tests on Bushings: Routine test on bushings shall be done as per IEC 60137.

ODISHA POWER TRANSMISSION CORPORATION LTD

TECHNICAL SPECIFICATION

VOLUME-II (PART-I)

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ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION
VOLUME-II (PART-I)

GENERAL

GENERAL CLAUSES

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1. GENERAL CONDITIONS

1.1 Responsibility of the Contractor

The Contractor shall also be responsible for the complete design and engineering, overall co-ordination with internal and external agencies, project management, training of Employerôs manpower, loading, unloading, storage at site, inventory management at site during construction, dismantling, re-erection of installations as per Engg Incharge advice, handling, moving to final destination, obtaining statutory authorityôs clearance for successful erection, and testing and commissioning of the substation.

1.2 Specific exclusions:

The following items of work are specifically excluded from the Contractors scope of work unless otherwise specifically brought out..

I. Substation site selection

II. Land acquisition

1.3 Interfacial point for line termination at substation

The line Contractor shall terminate the transmission line along with insulator hardware and other essential fittings at the substation gantry. The substation Contractor shall provide necessary anchoring plates in co-ordination with the transmission line contractor. The substation Contractor shall be responsible for providing the necessary electrical interconnection from the line conductor to the substation.

1.4 Limit of contract

The scope of work shall also include all work incidental for successful operation and commissioning and handing over of works whether specifically mentioned or not. In general works are to be carried out by the Contractor in accordance with stipulations in Conditions of Contract.

1.5 Quantity variation

The Employer reserves the right to order and delete such works which may be necessary for him within the quantity variation option laid down in the conditions of the contract. This shall include but not be limited to: the manufacture, supply, testing, and delivery to site, erection and commissioning as may be required in accordance with the Conditions of Contract at the prices stated in the Schedules.

The Employer shall be at liberty to order from the Contractor such quantities of the apparatus at any time before the expiration of the maintenance period of the scope of work, provided that such quantities do not exceed the limitation of the Contract Value as defined in the Conditions of Contract. Each separate order for Work at the Option of the Employer shall constitute a section for the purpose of payment and taking over.

The Employer shall also be at liberty to delete from the Contractor such quantities of the apparatus at any time before commencement of supply of works under the detailed scope of work.

1.6 Supply of non specified equipment/service during execution of contract.

The Employer may require the Contractor to supply and install a number of items such as testing and measuring instruments, vehicles, repairing of existing equipment, removal and refurbishment of plant/equipment from one place to another etc., which in the opinion of the Engg Incharge are to the interest of the project execution. These items and services shall not be limited to proprietory goods provided for the project.

Such supplies and services shall be reimbursed against supply and service invoices for the materials or services actually supplied from the manufacturer or supplier of these items. The bidder shall quote on cost for these items for the earmarked funds in appropriate schedules which shall be considered in bid prices. How ever these costs shall be payable to the Contractor on pro rata basis for the actual amount spent for procurement and availing of the services.

For such items of supply the Contractor shall follow the fair principle of contracting procedure to the satisfaction of Engg Incharge.

2. GENERAL PARTICULARS OF SYSTEM

System description

The following are the general particulars governing the design and working of the complete system of which the Contract Works will eventually form a part:

Electrical energy is generated at a number of thermal and hydro power plants generally located in the North, Central and Southern areas of Orissa State. The system is three phase, 50Hz and power is transmitted at 400kV, 220kV and 132kV to the distribution system, via grid substations, which operate at 33kV, 11kV and 400V. The 400kV and 220kV networks tie into the OPTCL's 400kV and 220kV grid systems operated by OPTCL. The proposed works will increase the interconnection of, and will thus reinforce the 400kV and 220kV networks within Orissa State. The detailed technical parameters of the system are given in the schedules.

Substation description:

OPTCL has adopted the philosophy of installing open terminal air insulated substations. The busbars for 400 KV rigid type and for 220 KV flexible strain type depending upon the choice of the designer considering the overall suitability and economy of the substation to be installed.

Layout arrangement

The Contractor shall study the details of layout arrangements already indicated in the schedules details for the existing substations. The bay width and height of the conductors for these substations shall be achieved by the Contractor in case of extension substations. However the Contractor shall finalise the layout arrangements in case of new substations in line with this Specification with the approval of the Engg Incharge ,which shall be meeting at least the basic minimum electrical clearances as specified in the schedules.

Location and site description

Details of the sub-substation locations, their approach , geography and topography has been provided to the extent possible. The Bidder shall make necessary visit to the substation sites and fully appraise himself before bidding. Deviations on account of inadequate data for substation works shall not be acceptable and the Bid shall not be considered for evaluation in such cases.

Meteorological data

Appropriate meteorological data is given in the schedules.

Soil data

Detailed soil investigations in respect of various substations have not been made. However the general characteristics of the soil are given in the schedules. The Contractor shall investigate the properties of the substations and measure the soil resistivity as part of the scope of work.

Completeness and accuracy of information

The Contractor shall note that the information provided above and in the relevant schedules may not be complete or fully accurate at the time of bidding. For his own interest the Contractor is advised to make site visits and fully satisfy himself regarding site conditions in all respects, and shall be fully responsible for the complete design and engineering of the substations.

3. DRAWINGS ATTACHED WITH TENDER DOCUMENT

The various drawings and schedules provided are a part of the specification and for information purposes only. These are not necessarily binding on the part of the Contractor. Bids shall be prepared by the Bidder based on information provided in the drawings and schedules and that gathered by the Bidder himself.

4. GUARANTEES TECHNICAL PARTICULARS

The Contract Works shall comply with the guaranteed technical particulars specified or quoted in the bid. All plant and apparatus supplied under this Contract shall be to the approval of the Engg Incharge .

All plant and equipment supplied under this contract must have been type tested, have been in manufacture and satisfactory service at identical ratings for at least two years. The bidder shall furnish in his bid the necessary supporting data in specified formats for consideration during bid evaluation. If during evaluation non compliance is identified the successful Contractor shall be bound to supply the equipment from manufacturers complying with the stipulated requirements / OPTCL approval renders.

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees.

The Bidder for his own interest, shall establish the technical responsiveness of his bid, shall provide all data in appropriate technical data sheets, general/ technical information, literature, and pamphlets etc. along with the bid.

5. COMPLIANCE WITH SPECIFICATION

All apparatus should comply with this Specification. Any departures from the requirements of this Specification shall be stated in the relevant Bid Proposal Schedules and will be considered during Bid evaluation. Unless brought out clearly in the technical schedules, it will be presumed that the equipment is deemed to comply with the technical specification.

In the event of there being any inconsistency between the provisions of the conditions of contract and the provisions of this Specification in respect of commercial requirements, the provisions of the conditions of contract shall take precedence for commercial matters and the provisions of this Specification shall take precedence in respect of technical matters.

In case of inconsistency between technical specification & bid proposal sheet, quantities of various items as specified in the bid proposal sheet shall be considered for quoting however the work shall be executed as specified in the technical specification. Only brief description is given in the BPS & the work shall be executed in line with the requirement given in the TS.

The manufacturer and places of manufacture, testing and inspection of the various portions of the Contract Works shall be stated in the relevant Bid Proposal Schedules.

6. TEST AND MAINTENANCE EQUIPMENT

The Contractor shall supply the type and quantity of test and maintenance equipment specified in the Schedules as part of the contract works.

7. SPARES

7.1 General

The Contractor shall provide the mandatory spares detailed in the Schedules. Provide a list of recommended spare parts (optional spares) together with their individual prices, but that will not be considered for evaluation. The Employer may order all or any of the Optional spare parts listed at the time of contract award . Mandatory spares shall be supplied as part of the Works under this

specification. Additional spares(Mandatory) may be ordered at any time during the contract at the rates stated in the Price Schedule.

7.2 Mandatory spares

The Employer has indicated the requirement of mandatory spares as a percentage of the population of main equipment together with proposed storage locations. The quantities shall be determined by the Contractor and indicated in the relevant Bid Price Schedules. These quantities shall be considered for evaluation of the bids.

7.3 Optional spares (shall not be considered for evaluation purpose).

The Contractor may recommend a list of optional spare parts together with the quantity and usage rates for their equipment in the relevant Bid Proposal Schedule. The Engg Incharge shall assess their requirement and place orders.

The spares shall include consumable items sufficient for a plant operational period of five years after commissioning, as well as essential replacement parts to cover the event of a break-down which would affect the availability or safety of the plant. Spares shall be available during the life of the equipment and the Contractor shall give 12 months notice of his, or any sub-contractorôs, intention to cease manufacture of any component used in the equipment.

The Contractor shall ensure that sufficient spare parts and consumable items are available for his own use during commissioning of the plant. Spares ordered by the Employer shall not be used by the Contractor without the written consent of the Engg Incharge and any spares so used by the Contractor during the commissioning of the plant shall be replaced by the Contractor at the Contractorôs expense.

Any spare apparatus, parts and tools shall be subject to the same specification, tests and conditions as similar material supplied under the Scope of Works of the Contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the plant and must be suitably marked and numbered for identification and prepared for storage by greasing or painting to prevent deterioration.

All spare apparatus or materials containing electrical insulation shall be packed and delivered in cases suitable for storing such parts or material over a period of years without deterioration. Such cases shall have affixed to both the underside and topside of the lid a list detailing its contents. The case will remain the property of the Employer.

8 .0 TRAINING

The Contractor will be required to provide suitable training for selected staff both on site and at the Contractor's place of work. Details of the training considered appropriate shall be stated clearly, at the bidding stage, based on the number of trainees specified. The cost of training including all course fees shall be included.

The areas in which it is considered training should be provided, and duration of the training courses, are given in this section. Alternative arrangements, where considered appropriate, should be suggested.

Four categories of training are considered appropriate namely :

I. Hardware maintenance.

II. Operator familiarisation.

III. Software management.

IV. Installation and commissioning techniques.

8.1 Hardware maintenance

Courses for hardware maintenance shall identify techniques for preventative physical maintenance and for identification, isolation and replacement of faulty components. This course shall take place before equipment is delivered to site.

An essential part of the hardware maintenance course shall include highlighting the philosophy of computer based preventive maintenance and identification of the various diagnostic/interrogation facilities available. The Contractor shall supply adequate documented instructions to enable a detailed interrogation and analysis process to be carried out using the diagnostic software facilities. All items of hardware to be supplied shall be covered by the course.

8.2 Operator familiarisation

This course is intended to familiarise the operators with the system and its use in operating and controlling the PLCC network. The course shall ensure that the control room staff are completely familiar with all operational aspects of the equipment. The means of obtaining special data, report logs and all other facilities which would enable the operators to be fully conversant with the system, shall also be incorporated.

It is envisaged that it will be necessary for the Contractor to run operator familiarisation courses each of approximately one week in duration at site for the training of the Employer's staff.

8.3 Software management

This course shall comprise two main areas and shall take place at the Contractor's works before equipment is delivered to site .

I). A FORMAL COURSE ON THE SOFTWARE FOR EPAX ETC. DETAILING THE VARIOUS MODULES USED AND THEIR INTERACTION.

II). A PRACTICAL COURSE ON EDITING THE DATABASE (TO INCORPORATE EXTENSIONS TO THE POWER NETWORKS, INCLUSION OF ADDITIONAL ANALOGUE/DIGITAL SIGNALS FROM EXISTING EQUIPMENT, ETC.) AND GENERATING NEW LOGS, ALPHANUMERIC DISPLAYS, ETC.

It is envisaged that the software management courses shall extend for a period of approximately six weeks.

II.A) Installation and commissioning techniques

The Employer's staff will be present during the installation and commissioning period and it is essential that they be fully involved in any on-site corrections or modifications to hardware and software equipment.

It is envisaged that it will be necessary for the Contractor to run installation and commissioning techniques courses each of approximately one week in duration at site for the training of the Employer's staff.

II.B) Proposals for training and manning

For each course recommended the following information shall be provided:

I. Course name and identification.

II. Short description of the curriculum.

III. Level of competency required for each course.

IV. Date and duration.

V. Maximum number of staff that can attend.

VI. Location.

VII. Other important information.

The times at which the various training courses will take place shall be stated, and fully documented notes shall be available to the Employer not later than two months before the commencement of the course.

All training course notes and documentation shall be in the English language.

An estimate of the total number of the Employer's staff required to run, operate and service the works covered by this Specification shall be given if this is different to the numbers specified.

The prices of the training courses shall be detailed in full such that additions or deletions to personnel or courses can be calculated by the Employer without necessarily having to contact the Contractor. This is particularly important for the 'Software management' courses where prices for formal course days and practical course days shall be individually detailed.

9 .0 ERECTION AT SITE AND ACCOMMODATION

The Contractor shall provide, at his own cost and expense, all labour, plant and material necessary for unloading and erection at the Site and shall be entirely responsible for its efficient and correct operation.

The Contractor shall be responsible for arranging and providing all living accommodation services and amenities required by his employees. He shall also provide suitable office accommodation at each substation site for the sole use by the Engg Incharge (Divisional Engr.) **for new substations only**.

10 .0 SITE CONSTRUCTION SUPPLIES

The Contractor shall provide at his own cost and expense, any site supplies of electrical energy which he may require for supplying power for heavy erection plant, welding plant or other tools and lighting and testing purposes.

All wiring for such tackle and for lighting from the point of supply shall be provided by the Contractor and all such installations shall comply with all appropriate statutory regulations to which the Employer is subject.

Wiring shall be of the best quality double insulated flexible cable, suitably fixed, protected and maintained. All necessary precautions shall be taken to ensure the safety of every person employed or working on the Site and this shall include routine inspection of all temporary installations and portable equipment.

The Engg Incharge or his authorised representative may require the disconnection or alteration of any parts which he may consider dangerous.

As soon as any part or the whole of the Contractorôs installation is no longer required for the carrying out of the works, the Contractor shall disconnect and remove the same to the satisfaction of the Engg Incharge or his authorised representative.

The contractor shall be responsible for arranging construction water at his own cost.

How ever in case water is available at any substation site, Contractor may request Engg Incharge for availing water at one point, which shall be charged to the contractor at prevailing rates for supply of water by Govt. Dept. / Municipal Authorities.

In no case the work shall suffer on account of the Employer not making available the supply of water and electricity for construction purposes.

11 .0 SUPERVISION AND CHECKING OF WORK ON SITE

All work on site included in the Contract scope of works shall be supervised by a sufficient number of qualified representatives of the Contractor.

Before putting any plant or apparatus into operation the Contractor shall satisfy himself as to the correctness of all connections between the plant and apparatus supplied under this and other contracts. The Contractor shall advise the Engg Incharge in writing, giving the period of notice as specified in the General Conditions of Contract, when the plant or apparatus is ready for inspection or energisation.

12 .0 RESPONSIBILITY FOR THE RUNNING OF PLANT BY CONTRACTOR

Until each Section of the Contract Works has been taken over or deemed to have been taken over under the Conditions of Contract, the Contractor shall be entirely responsible for the Contract Works, whether under construction, during tests, or in use for the Employerôs service.

The Contractor shall instruct the Employerôs operating staff in the recommended method of operation of the plant supplied. Such instruction shall commence prior to the commissioning of the plant and shall be followed by practical instruction for a period of up to one month after the plant is taken over by the Employer. During this one month period the Contractor shall provide an engineer, on each site that is taken over, to assist with operation of the plant and to provide on-site training of the Employerôs operating staff. The training schedule and programme for each substation shall be submitted to the Engg Incharge for approval, three months prior to the substationôs planned completion date.

If the Employer shall so require, the Contractor shall provide the services of a skilled engineer acquainted with the running of the plant for any period required by the Employer between commencing of use of any portion of the plant (whether taken over or not) and the expiry of the period of maintenance, the wages for such services being paid by the Employer to the Contractor, except in respect of the carrying out of any work already covered by the Contractorôs obligations under this Contract.

When the Contractor ceases to be obliged to maintain a supervising engineer on the Site under the foregoing provisions of this clause, the Contractor shall, until the expiration of the period of maintenance, make such arrangements as to ensure the attendance on site within 24 hours of being called upon by the Engg Incharge of a competent supervising engineer for the purpose of carrying out any work of maintenance or repair for which the Contractor shall be liable. During such part or parts of the said period as the Engg Incharge shall deem it necessary the said representative shall be continuously available on the Site.

Any work which may be necessary for the Contractor to carry out in pursuance of his obligations under the Conditions of Contract shall be carried out with the minimum of interference to the normal operation of the substation. Work on the Site shall be carried out at such time and during such hours as the Engg Incharge may require.

13 .0 COMPLIANCE WITH REGULATIONS

All apparatus and material supplied, and all work carried out shall comply in all respects with such of the requirements of all Regulations and Acts in force in the country of the Employer as are applicable to the Contract Works and with any other applicable regulations to which the Employer is subject.

The Contractor shall fully inform himself of the requirements of the local Laws, Regulations and rules in-force in the State of Orissa, especially with respect to local employment laws, licensing requirements, electrical safety rules and regulations, building regulations and planning procedures.

The Contractor shall be responsible for applying for all necessary licenses; including Electrical Contractors License, Workmanôs Permits and Certificates of Competency for Supervisors, and local government approvals required for the contract works and for the payment of all necessary fees associated with such licenses and approvals.

Correspondence with the Electrical Inspector shall be conducted through the Engg Incharge (Divisional Engr.), but the Contractor shall provide all necessary information, regarding the contract works, as may be required by the Electrical Inspector.

Additionally the Contractor shall also follow the minimum regulations on safety, employees welfare, industry etc. as stipulated under the relevant Clause of this section.

14 .0 MAINTENANCE AND CLEARING OF SITE

The placing of materials and plant near the erection site prior to their being erected and installed shall be done in a neat, tidy and safe manner. The Contractor shall at his own expense keep the site area allocated to him and also the erection area of the Contract Works reasonably clean and shall remove all waste material as it accumulates and as directed by the Engg Incharge from time to time.

15 .0 INSURANCE

15.1 General

In addition to the conditions covered under the Clause titled insurance in the Special Conditions of Contract, the following provisions will also apply to the portion of works to be done beyond the Suppliers own or his sub-Contractors manufacturing Works.

15.2 Workmen's Compensation Insurance

This insurance shall protect the Contractor against all claims applicable under the Workmenôs Compensation Act, 1948 (Government of India). This policy shall also cover the Contractor against the claims for injury, disability, disease or death of his or his sub-contractor's employees, which for any reason are not covered under the Workmanôs Compensation Act, 1948. The liabilities shall not be less than;

I.	Workmenôsô Compensation	As per statutory provisions
II.	Employee's liability	As per statutory provisions

* According to the Govt. rules.

15.3 Comprehensive auto mobile insurance

This insurance shall be in a such a form to protect the Contractor against all claims for injuries, disability, disease and death to members of public including the Employer's men and damage to the property of others arising from the use of motor vehicles during on or off the Site operations, irrespective of the ownership of such vehicles. The minimum liability covered shall be as herein indicated:

I.	Fatal Injury	:	Rs. 100,000/- each person
II.	Property	:	Rs. 200,000/- each occurrence
III.	Damage	:	Rs. 100,000/- each occurrence

* As per latest prevailing Govt. rules.

15.4 Comprehensive General Liability Insurance

This insurance shall protect the Contractor against all claims arising from injuries, disabilities, disease or death of members or public or damage to property of others, due to any act or omission on the part of the Contractor, its agents, its employees, its representatives and sub-contractors or from riots, strikes and civil commotion.

The hazards to be covered will pertain to all works and areas where the Contractor, its sub-contractors, agents and employees have to perform work pursuant to the Contracts.

The above are only an illustrative list of insurance covers normally required and it will be the responsibility of the Contractor to maintain all necessary insurance coverage to the extent both in time and amount to take care of all its liabilities either direct or indirect, in pursuance of the Contract.

16.0 PROTECTION OF MONUMENTS AND REFERENCE POINTS

The Contractor shall ensure that any finds such as relics, antiques, coins, fossils, etc. which he may come across during the course of performance of his works either during excavation or elsewhere, are properly protected and handed over to the Employer. Similarly, the Contractor shall ensure that the bench marks, reference points, etc. which are marked either with the help of Employer or by the Employer shall not be disturbed in any way during the performance of his works. If any work is to be performed which disturbs such reference points, the same shall be done only after these are transferred to other suitable locations under the direction of the Employer. The Contractor shall provide all necessary materials and assistance for such relocation of reference points etc.

17 .0 WORK AND SAFETY REGULATIONS

The Contractor shall ensure safety of all the workmen, plant and equipment belonging to him or to others, working at the Site. The Contractor shall also provide for all safety notices and safety equipment required by the relevant legislation and deemed necessary by the Engg Incharge .

The Contractor will notify, well in advance to the Engg Incharge, his intention to bring to the Site any container filled with liquid or gaseous fuel, explosive or petroleum substance or such chemicals which may involve hazards. The Engg Incharge shall have the right to prescribe the conditions under which such a container is to be stored, handled and used during the performance of the works and the Contractor shall strictly adhere to and comply with such instructions. The Engg Incharge shall also have the right, at his sole discretion, to inspect any such container or such construction plant and equipment for which materials in the container is required to be used and if in his opinion, its use are not safe, he may forbid their use.

No claim due to such prohibition or towards additional safety provisions called for by him shall be entertained by the Employer.

Further, any such decision of the Engg Incharge shall not, in any way, absolve the Contractor of his responsibilities and in case use of such a container or entry thereof into the Site areas is forbidden by the Engg Incharge the Contractor shall use alternative methods with the approval of the Engg Incharge without any cost implication to the Employer or extension of work schedule.

Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the Contractor shall be responsible for carrying out such provision and/or storage in accordance with the rules and regulations laid down in Petroleum Act 1934, Explosives Act 1948 and amendments thereof, and Petroleum and Carbide of Calcium Manual published by the Chief Inspector of Explosives of India. All such storage shall have prior approval of the Engg Incharge. In case, any approval is necessary from the Chief Inspector (Explosives) or any statutory authorities, the Contractor shall be responsible for obtaining the same.

All equipment used in construction and erection by Contractor shall meet Indian or International Standards and where such standards do not exist, the Contractor shall ensure these to be absolutely safe. All equipment shall be strictly operated and maintained by the Contractor in accordance with manufacturers operation manual and safety instructions and as per any existing Guidelines/Rules in this regard.

Periodical examinations and all tests for all lifting and hoisting equipment and tackle shall be carried out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity (Supply) Act and associated Laws/Rules in force, from time to time. A register of such examinations and tests shall be properly maintained by the Contractor and will be promptly produced as and when desired by Engg Incharge.

The Contractor shall provide suitable safety equipment of prescribed standard to all employees and workmen according to the need, as may be directed by the Engg Incharge who will also have the right to examine such safety equipment to determine itôs suitability, reliability, acceptability and adaptability.

Where explosives are to be used, the same shall be used under the direct control and supervision of an expert, experienced and qualified competent person, strictly in accordance with the Code of Practices/Rules framed under Indian Explosives Act pertaining to handling, storage and use of explosive.

Contractors employing more than 250 workmen whether temporary, casual, probationer, regular or permanent or on contract, shall employ at least one full time officer exclusively as Safety Officer to supervise safety aspects of the equipment and workmen. Such an officer will co-ordinate with the Project Safety officer of the Employer.

The name and address of the Safety Officer of the Contractor will be promptly informed in writing to the Engg Incharge with a copy to the Safety Officer-in-charge before he starts work or immediately after any change of the incumbent is made during currency of the Contract.

In case any accident occurs during the construction, erection or other associated activities undertaken by the Contractor, thereby causing any minor or major or fatal injury to his employees due to any reason whatsoever, it shall be the responsibility of the Contractor to promptly inform the same to the Engg Incharge and also to all the authorities envisaged under the applicable laws.

The Engg Incharge shall have the right at his sole discretion to stop the work, if in his opinion the work is being carried out in such a way as may cause accidents or endanger the safety of the persons and/or equipment. In such cases, the Contractor shall be informed in writing about the nature of hazards and possible injury/accident and he shall remove shortcomings immediately. The Contractor, after stopping the specific work, can if felt necessary appeal against the order of stoppage of work to the Engg Incharge within three days of such stoppage of work and the decision of the Engg Incharge in this respect shall be conclusive.

The Contractor shall not be entitled for any damages or compensation for stoppage of work due to safety reasons and the period of such stoppage of work will not be taken as an extension of time for completion of work, nor will it be the grounds for waiver of any part of suppliers liability for timely completion of the works.

The Contractor shall follow and comply with all Safety Rules, relevant provisions of applicable laws pertaining to the safety of workmen, employees, plant and equipment as may be prescribed from time to time without any demur, protest or contest or reservation. In case of any conflict between statutory requirement and Safety Rules referred above, the most stringent clause shall be applicable.

If the Contractor fails in providing safe working environment as per Safety Rules or continues the works even after being instructed to stop work by the Engg Incharge, the Contractor shall promptly pay to the Employer on demand, compensation at the rate of Rs. 5,000/- per day or part thereof till the instructions are complied with and so certified by the Employer. However, in case of accident taking place causing injury to any individual, the provision contained in subsequent paragraph as here below shall also apply in addition to the compensation mentioned in this paragraph.

If the Contractor does not take all safety precautions and comply with Safety Rules as prescribed by the Engg Incharge or as prescribed under the applicable law, to safeguard equipment, plant and personnel the Contractor shall be responsible for payment of compensation to the Employer as per the schedule given below.

If the Contractor does not prevent hazardous conditions which may cause injury to his own employees, employees of other Contractors, or the Employer or any other person at Site or adjacent thereto, the Contractor shall be responsible for payment of compensation to the Employer as per the following Schedule:

Fatal injury or accident causing death.	Rs. 100,000/- per person	Applicable for injury or death to any person whomsoever.

Major injuries or accident causing 25% or more permanent disability.	Rs. 20,000/- per person	Applicable for injury or death to any person whomsoever.

* As per prevailing Govt. rules.

Permanent disability shall have the same meaning as indicated in Workmen's Compensation Act. The compensation mentioned above shall be in addition to the compensation payable to the workmen/employees under the relevant provisions of the Workmen's Compensation Act and rules framed thereunder or any other applicable law as applicable from time to time. In case the Employer is made to pay such compensation, the Contractor will reimburse the Employer such amount(s) in addition to the compensation indicated above.

18 .0 FOREIGN PERSONNEL

If necessary for the execution of the works, the Contractor shall bring foreign supervisors for the execution of the Contract at his own cost. The Contractor shall submit to the Employer data on all personnel he proposes to bring into India for the performance of the works under the Contract, at least Sixty (60) days prior to their arrival in India. Such data shall include the name of each person, his present address, his assignment and responsibility in connection with the works, and a short resume of his qualifications and experience etc. in relation to the work to be performed by him.

Any person unsuitable and unacceptable to the Employer, shall not be brought to India. Any person brought to India, and found unsuitable or unacceptable to the Employer shall be immediately removed from Site and repatriated. If found necessary, he may be replaced by other personnel acceptable to the Employer.

No person brought to India by the Contractor for the works shall be repatriated without the consent of the Employer in writing, based on a written request from the Supplier for such repatriation giving reasons for such an action to the Employer. The Employer may give permission for such repatriation provided the Employer is satisfied that the progress of work will not suffer due to such repatriation.

The cost of passports, visas and all other travel expenses to and from India, shall be to the Contractor's account. The Employer will not provide any residential accommodation and/or furniture for any of the Contractors personnel including foreign personnel. Contractor shall make his own arrangements for such facilities.

The Contractor and his expatriate personnel shall respect all Indian Acts, Laws, Rules and Regulations and shall not in any way, interfere with Indian political and religious affairs and shall conform to any other rules and regulations which the Government of India, and the Employer may establish on them. The Contractorôs expatriate personnel shall work and live in close co-operation and co-ordination with their co-workers and the community and shall not engage themselves in any other employment either part-time or full-time nor shall they take part in any local politics.

The Employer shall assist the Contractor, to the extent possible, in obtaining necessary certificates and other information needed by the Government agencies.