NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)

TRANSMISSION DIRECTORATE

GRID OPERATION DEPARTMENT

BID DOCUMENT (ICB)

VOLUME –II OF III

(GENERAL TECHNICAL SPECIFICATIONS, TECHNICAL DATA SHEET)

SUPPLY, DELIVERY, INSTALLATION, TESTING AND COMMISSIONING OF 220/132KV, 2X315MVA TRANSFORMERS AT DHALKEBAR SUBSTATION

TENDER NO: GOD/2073/074-21

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SECTION-I, PART-1

GENERAL TECHNICAL SPECIFICATION

1.0 GENERAL SCOPE OF WORK:

Supply, Delivery, Installation, Testing and Commissioning of 2 nos. of 220/132kV, 315MVA Auto Transformers at Dhalkebar Substation.

Background:

A.1 The NEA wishes to invite the Bid for Supply, Delivery, Installation, Testing and Commissioning of 2 nos. of 220/132kV, 315MVA Auto Transformers at Dhalkebar Substation replacing the existing 160MVA Transformers.

A.2 The Equipment supplied shall confirm, in all respects to the high standards of Engineering design and workmanship and be capable of performing in continuous commercial operation in a manner acceptable to the owner who can interpret the meaning of specifications and shall have the power to reject any work or material, which in his judgment are not in full accordance therewith.

Scope of work:

The scope of work under this Tender covers, as per specification as mentioned in the Technical Proposal. Any Omission in the Specification for the items that are necessary for the completion of the work shall be clearly mentioned in the Technical proposal by the Bidder. **If the Bidder fails to mention the omission, it will be assumed that any minor items not present in the specification or price schedule but necessary for the completion of the work were included in the quoted price by the Bidder. The Bidder in such case, will not be liable for any claims.**

Supply & Commissioning Works

Package I

1.1 Design, Manufacture, Supply, Delivery, Installation, Testing and Commissioning of 220/132kV, 315MVA Auto Transformers with OLTC, RTCC facility, complete with all accessories as specified 2 Sets

1.2 600V control cable and power cable recquired to complete the scope of work as specified. 1 Lot

1.3 Supply, Delivery, Installation, Testing and Commissioning of miscellaneous materials, grounding materials etc.

1.4 All accessories and auxiliary equipment required for the successful operation.

1.5 Spare Parts as per the Bill of Quantity

Operational Requirement

1.6 Dimensions and colors of the new equipment should be as per the existing equipments.

1.7 All control signals and indications facilities of the existing equipments shall be properly provided in the panels.

1.8 The new system shall be suitably and properly integrated with the existing system for proper functioning.

Note:
The bidder shall make necessary site visits to familiarize with the condition of the road and existing bridges and culverts. The existing bridges may require temporary supports or strengthening works to transport the 315MVA Transformer. The bidder is fully responsible for that strengthening works and the cost of such reinforcement work shall be included in the transportation part of the transformer.

Civil Works / Steel Structure

1.9 The scope of works includes all the civil work such as supply of new structures, construction of new foundations for all equipments as specified.

1.10 Clearing and striping, Site grading, Leveling, Crushed Rock Surfacing for Switchyard, Exploration Works like Laboratory Test, Soil Test, Resistivity Test and construction of new Cable Trench, Duct Bank, Conduit, Hand Hole, Cable Tray etc.

1.11 Steel Structure for post, beam and equipment supporting frame complete with bolts, nuts and all accessories.

Testing & Commissioning

Testing and Commissioning of Auto Transformer as per the Specification should be performed to the satisfaction of the Owner.

All the work mentioned above is to be done in such a way that the shutdown period should be minimum. So, the Bidder is required to submit the proposal regarding the work methodology.

GENERAL REQUIREMENTS:

1.1 Wiring

Wiring shall be done in accordance with the following general requirement:

1.1.1 All wiring shall be done in general purpose 600V PVC Copper wire complying with IEC. The Wire size shall not be less than 2.5Sq.mm for control circuit and 4Sq.mm for Power circuit. All wire cores shall be multi-stranded and flexible.

1.1.2 Wires should be neatly bunched and adequately supported so as to prevent sagging and strain on termination.

1.1.3 Joints and splices in wiring will not be acceptable.

1.1.4 All termination shall be made with compression type connectors. Wires shall not be spliced or tapped between terminal points.

1.1.5 Not more than two wires should be connected to any terminal points. If required, numbers of terminals shall be jumped together to provide additional wiring points.

1.1.6 Wiring leads and cable cores shall be permanently marked at both ends with an approved type of marking device having black letters and numbers impressed on white background.

1.2 Cable Termination

Marshaling box shall be designed to facilitate cable entry from bottom. Removable plates shall be furnished with compression type cable glands to make entry dust proof and no weight is transferred to the terminal. The glands shall be suitable for terminating Cable Armor.

Sufficient space shall be provided to avoid sharp bending and for easy connection. A minimum space of 200 mm from the gland plate to the nearest terminal block should be provided.

1.3 Terminal Blocks

1.3.1 Multi-way Terminal Blocks complete with screws, nuts, washers and marking strips for terminal identification shall be furnished for terminating the internal wiring and outgoing cables.

1.3.2 Control Terminals shall be Washer head screw type, each suitable for connection of at-least two numbers of copper conductor cables of requisite cross section at each end through compression type (solder less) lugs. Screw type terminal with screw directly impinging on conductor or any other type of terminal, which does not accept compression type lugs, are not acceptable. The successful Bidder shall have to take prior approval of the terminals to be used in the Block from the Owner.

1.3.3 Each Terminal shall be marked with designations obtained from schematic diagrams. At-least 20 % spare Terminals shall be provided in the Terminal Blocks.

1.3.4 **Terminal blocks to be used with the Current Transformer secondary wiring**, both at the panels and cubicles, shall be provided with the shorting links with facility to open circuit or short circuit the CT secondary.

1.4 Painting Works

1.4.1 All sheet steel works shall be phosphated in accordance with the following procedure and in according with IEC.

1.4.2 Oil, Grease, Dirt shall be thoroughly cleaned by emulsion cleaner.

1.4.3 Pickling with dilute acid followed by washing with running water, rinse with slightly alkaline hot water and drying shall remove rust and Scales.

1.4.4 After Phosphating, thorough rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and even drying.

1.4.5 The Phosphate coating shall be sealed by the application of Two Coats of staving type Zinc Chromate primer. The first coat may be "flash dried" while the second coat shall be staved.

1.4.6 After application of the Primer, Two coats of finishing synthetic Enamel Paint shall be applied, each coat followed by staving. Touch up shall be applied after completion of Tests. The color for the finishing paint shall be light Grey or as approved by the Owner.

1.4.7 The Final finished thickness of paint film on steel shall not be less than 100 microns.

1.4.8 Finished painted surface shall present aesthetically pleasing appearance from runs and drips.

1.4.9 A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation.

2.0 CODES & STANDARDS

2.1 All Equipments supplied under this Contract Shall confirm to or be of Higher quality than the latest applicable standard as per relevant IEC.

2.2 If the Specification contained in this Contract conflict in any way with the reference Standards, the Specification shall take precedence. If there are conflicts between different specified standards covering the same materials or equipment, the standard, which will provide the highest quality and most suitable application, as determined by the Employer shall prevail.

2.3 The Contractor may propose alternative standard or equipment, which shall be equal to those specified. If the Contractor for any reason proposes alternatives to or deviations from the above standards, the Contractor shall state the exact nature of the change, the reason for making the change and shall submit with relevant Specifications of the Equipment in the original Language, and in case that these are written in languages other than English, the English version shall be attached and shall govern.

3.0 CONDITIONS OF SERVICE

3.1 All Plants and Equipments supplied under this Contract shall be suitable for the following Site and System Conditions.

3.1.1 System Electrical parameters

For 220kV Equipments:

Rated Service Voltage	: 220kV
Highest System Voltage	: 245kV
Impulse Voltage Withstand Level	: 1050kV
Power Frequency Withstand Voltage	: 395kV
Number of Phases	: 3
Frequency	: 50Hz

For 132kV Equipments:

Rated Service Voltage	: 132kV
Highest System Voltage	: 145kV
Impulse Voltage Withstand Level	: 650kV
Power Frequency Withstand Voltage	: 275kV
Number of Phases	: 3

Frequency : 50Hz

3.1.2 Climatic Conditions

3.1.2.1 All Plants and Equipment supplied under the Contract shall be entirely suitable for the Climatic Conditions prevailing at Site.

The Seismic Factor is 0.15g.

Atmospheric pollution is Moderate.

Maximum ambient Shade Temperature	: 45 °C
Minimum Ambient Shade Temperature	: 0 °C
Annual Average Temperature	: 32 °C
Maximum Wind Velocity for design purpose	: 34.4m/sec
Rainfall	: 1500mm/annum
Relative Humidity	
Maximum	: 100 %
Minimum	: 20 %
Altitude	: 138m from MSL(Approx)
Atmospheric Pollution	: Moderate

The Information provided in this Clause is given solely for the General Assistance of the Bidder and neither responsibility for it will be accepted nor will any claim based on this clause be considered.

The Bidder is advised to survey the sites covered under this Contract to acquaint with the Site Conditions.

4.1 The Contractor shall be responsible for surveying, boring, geological and subsoil conditional for all foundation, and for the precise location of the substation in the Project.

4.2 All Necessary soil tests, wherever necessary, to determine the Earth Resistively. The Design of the Ground Grid and all foundations shall be performed by the contractor at the Substation Site.

4.3 The Contractor shall locate and record on the construction drawings, all interfacing utility lines or other obstruction. Damage to existing equipment and the Contractor at his own expense shall repair structures.

5.0 DRAWINGS, INSTRUCTION AND MAINTENANCE MANUALS (As Applicable)

The Contractor shall submit Detailed Drawings, Instruction and Maintenance manuals and parts list with recommended stock quantities for the equipment furnished, prepare and submit detailed engineering, Design and Construction drawings pertaining to all mechanical and Electrical Equipment and Installations in the substation. The Drawings / Manual submitted by the Contractor should also be in the form of digitized form (Compact Disk). The Drawings to be furnished by the Contractor shall include, but not be limited to the following:

5.1 Single Line and Three Lines Diagram.

5.2 Schematic electrical diagram of substations including interconnection with existing system

5.3 Layout of equipment in control room.

5.4 Plan and elevation of switchyards

5.5 Structural Erection and Fabrication Details, wherever necessary.

5.6 Substation Grounding Calculations, Plans, Elevation and Details, wherever necessary.

5.7 Detailed Cable Schedule list and cable summary, specifying cable identification number, routing and length of the cable for the Substation.

5.8 Details of relay and control panel. Switchgear and Panel front and rear elevation drawings showing dimension and identification of each device and complete name plate schedule.

5.9 Control & Protection Schemes. Calculation and co-ordination for selecting Operation of Protective Relays.

5.10 Instruction Book, spare Parts' lists, Materials lists and any other documents pertaining to the Substation and required for Construction, Operation, Maintenance and Repair.

The successful Bidder will be required, at the time of signing of the Contract; to supply additional copies of the above drawings as may be selected by the Employer. These drawings, together with such drawings originally issued with the Tender documents will then form part of the Contract Document and be signed both by the Employer and the Contractor for identification purposes.

a. Prior to commencement of the work, the Contractor shall submit detailed design drawings and data to the Employer for approval. Should the Employer direct that modifications be made in order to satisfy the requirements of the Specifications, the Contractor shall submit revised drawings for approval. Alteration in the Contract price shall not be allowed by reason of the drawings modifications.

b. The Contractor shall prepare and furnish to the Employer such drawings, calculations, and data on materials and equipment (hereinafter in this provision called data) as are required for the proper control and completion of the work, including but not limited to those drawings, data and calculations specifically required elsewhere in the Technical Specifications.

c. The Metric System shall be used and notations shall be in English. Drawings, calculations, and data shall be furnished as specified. All drawings and data will be subjected to review by the Employer for conformity with the Technical Specification and Contract Drawings and upon meeting review requirements shall become the property of the Employer.

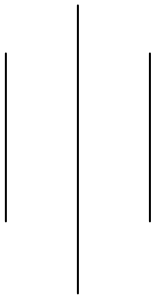
d. The Contractor shall submit detailed drawings, instruction and maintenance books, and parts lists with recommended stock quantities for the equipment furnished, prepare and submit detailed engineering design and construction drawings pertaining to all mechanical and electrical equipment and installations in the substation. The drawings to be furnished by the Contractor shall include, but not be limited to the following:

6.0 The Contractor shall provide Spare parts and Tools for the substation as specified in this Specification.

Furnish qualified supervision and construction personnel for the Installation, Testing, Commissioning and Final system testing and checking out of the equipment listed above and details in the Price Schedule. The testing and commissioning of the equipment should be in the supervision of the manufacturer's representative and should guarantee the test performed. The work shall be performed in close cooperation and collaboration with the Employer / Engineer.

Coordination of the substation work with the Installation of others shall be the responsibility of the Contractor. The Employer / Engineer will furnish the information needed to coordinate the substation work with the other work.

SECTION-I, PART-2



TECHNICAL SPECIFICATION

(AUTO TRANSFORMER)

SECTION-1 PART-2
AUTO TRANSFORMER

1.0 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 Transportation

The Contractor shall dispatch the transformer filled with oil or in an atmosphere of nitrogen or dry air. 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. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

Transformer shall also be fitted with at least one Electronic impact recorder (on returnable basis) during transportation to measure the magnitude and duration of the 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 dispatch 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. In the unlikely event of impact recorder output not available at site, the equipment shall be thoroughly internally inspected by the manufacturer’s representative before erection at site to ensure healthiness of the equipment. Contractor shall mount Vehicle tracking system (GPRS/ GPS/ GSM based) to track the exact position of the vehicle on which the equipment is being loaded for transportation in order to ensure traceability and safety during transportation.

2.0 Performance

2.1 The transformers shall be used for bi-directional flow of rated power.

2.2 Transformers shall be capable of operating under natural cooled condition up to the full/Specified load. Transformers shall be fitted with coolers, capable of dissipating total losses at continuous maximum rating.

2.3 The transformers shall be capable of being operated, without danger, on any tapping at the rated MVA with voltage variation of ± 10% corresponding to the voltage of the tapping.

2.4 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.

2.5 DGA of oil shall be periodically monitored by the Employer and the interpretation of DGA results will be as per IEC - 60599.

2.6 Radio Interference and Noise Level

2.6.1 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

2.6.2 The noise level of transformer, when energized at normal voltage and frequency with cooler equipments in operation shall not exceed, when measured under standard conditions, the values specified at relevant clause.

2.7 The transformers shall be capable of being loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

2.8 The transformer and all its accessories including CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 secs. The short circuit level of the HV & LV System to which the subject transformers will be connected is 40 kA for 1 sec (sym, rms, 3 phase fault) on 220kV, 31.5 kA (sym, rms,3 phase fault on 132 kV), 25kA (sym rms 3 phase fault on 33kV) and 25kA (sym rms 3 phase fault on 11kV).

2.9 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

2.10 Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110% for continuous operation
125% for 1 - minute
140% for 5 - seconds

2.11 **Design review**

The transformers 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 transformer 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 transformer, 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 finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under scope of this specification.

The design review shall be conducted generally following the "Guidelines for conducting design reviews for transformers 100 MVA and 123kV and above" prepared by Cigre SC 12 Working Group 12.22.

The manufacturer shall provide all necessary information and calculations during design review to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

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:

1.	Core and magnetic design
2.	Winding and tapping design
3.	Short-circuit withstand capability
4.	Thermal design including review of localized potentially hot area.
5.	Cooling design
6.	Overload capability
7.	Eddy current losses
8.	Seismic design, as applicable
9.	Insulation co-ordination
10.	Tank and accessories
10.1	Bushings and barrier design
10.2	Tap changers
10.3	Protective devices
10.4	Radiators
10.5	Oil and oil preservation system
11.	Corrosion protection
12.	Electrical and physical Interfaces with substation
13.	Earthing
14.	Processing and assembly
15.	Testing capabilities
16.	Inspection and test plan
17.	Transport and storage
18.	Sensitivity of design to specified parameters
19.	Acoustic Noise
20.	Spares, inter-changeability and standardization
21.	Maintainability

3.0 Construction Details

The features and construction details of each power transformer shall be in accordance with the requirement 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.

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 of 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 transformer shall have conventional type tank. In case the joint is welded it shall be provided with flanges 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) Lifting lugs suitable for lifting the equipment complete with oil.

(b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic 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 transformer 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 rollers.

3.1.1.7 The base of each tank shall be so designed that it shall be possible to move the complete transformer 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 transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given below. The paint should not fade during drying process. The paint should be able to withstand temperature up to 120 deg. C .The detailed painting procedure shall also be submitted along with the bid which shall be finalized before award of the contract.

	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer	Epoxy high build Micaceous	Aliphatic polyureth ane (PU)	Minimum 155µm	RAL 7035

tank, oil storage tank etc. (external surfaces)		(30-40µm)	iron oxide (HB MIO) (75µm)	(Minimum 50µm)		
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil resistant, non-corrosive varnish or paint or epoxy	--	--	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)**	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aesthetically matching to tank
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish	--	--	--	--
Control cabinet / marshalling box/RTCC	Seven tank process as per IEC	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat	Minimum 80µm	RAL 7035 shade for exterior and interior

Note: * Indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.
** **Radiator hot dip galvanized may also acceptable**.

3.1.1.9 "A fall protection plate shall be provided and suitably located on the tank cover of each transformer. A Uni-Hoist (or equivalent) type fall arrest mounting pad shall be provided and suitably located on the tank cover of high voltage transformers."
"A permanent fixed metal ladder, with a padlock able access barrier, shall be provided for access to the top of all high voltage transformers. The ladder shall not be sloped."

3.1.2 **Tank Cover**

3.1.2.1 The tank cover shall be designed to prevent retention of rain 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 one adequately sized inspection openings shall be provided in the transformers for easy access to bushings and earth connections. The inspection covers shall not

weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

3.1.2.3 The tank covers 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. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

3.1.2.6 Tank hotspot

The maximum temperature on any metal part shall not exceed 130 deg. Celsius.

3.1.2.7 Currents flowing in tank cover and bushing turrets

To allow for the effect of possible induced and capacitive surge current, good electrical connection shall be maintained between the tank and turrets.

3.1.2.8 The transformer shall be provided with pipe flange of suitable diameter with bolted blanking plate, gasket and shall be fitted at the highest point of the transformer tank for maintaining vacuum in the tank.

3.1.3 Axles and Wheels

3.1.3.1 The transformer shall be mounted on rollers, as per manufacturer's standard practice.

3.1.3.2 The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.

3.1.3.3 The rail track gauge shall be 1676 mm.

3.1.4 Foundation and Anti Earthquake Clamping Device

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

3.1.5 Conservator & Oil Preservation System

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 potential free contacts.

3.1.5.2 OLTC 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 with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100degC. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil. The Calculation shall be submitted during design review.

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 transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or 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 radiused elbows shall be used.

3.1.5.3.5 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer 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.

3.1.5.4.2 The temperature of oil is likely to rise upto 100 deg C during operation. As such air cell used shall be suitable for operating continuously at 100 deg 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. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, the recommended replacement intervals and the supplier.

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 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 two breathers (of identical size) shall be connected in series for main tank conservator and two breathers (of identical size) shall be connected in series for OLTC tank conservator.

3.1.5.6 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 equipment. The device shall operate at a static pressure less than the hydraulic test pressure of the transformer 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 pipes and directed away from the transformer/other equipment and this shall be prevented from spraying on the tank. 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.

3.1.5.7 Buchholz Relay

A double float/reed type Buchholz relay shall be provided. Any gas evolved in the transformer 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 transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. Buchholz relay shall be type tested as per international standards. Buchholz relay and its terminal box shall conform to IP 55 degree of protection.

3.1.5.8 Temperature Indicators

The Temperature Indicators should be from the manufacturer: AB KHILSTROM Sweden or equivalent

3.1.5.8.1 Oil Temperature Indicator (OTI)

All transformers shall be provided with a 150 mm (approx.) dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read atleast every 2 deg C. Accuracy of OTI shall be ± 3.0 deg C or better. The setting of alarm and tripping contacts shall be adjustable at site.

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.

3.1.5.8.2 Winding Temperature Indicator (WTI)

A device for measuring the hot spot temperature of each winding shall be provided (HV and LV). It shall comprise the following :

i) Temperature sensing element.

ii) Image coil.

iii) Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet.

iv) 150 mm (approx) dia local indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts; besides that required for control of cooling equipment if any, one for high winding temperature alarm and one for trip. Temperature indicator dials 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 – 110degC
Trip - 120degC

vii) In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

a) Signal transmitter for each winding

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) standard or equivalent. 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 the functions shall be provided.

b) Remote winding temperature indicator

It 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 cooler control cabinet and remote WTI control circuit, shall be in the scope of Contractor. Only one RWTI with a selector switch shall be provided for all the windings (HV and LV).

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 6 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 6 mm galvanised steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

3.2 **Core**

3.2.1 The core shall be constructed from prime quality, non-ageing, cold rolled, super grain oriented, silicon steel laminations.

3.2.2 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. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

3.2.3 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.

3.2.4 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

3.2.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

3.2.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

3.2.7 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

3.2.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

3.2.9 The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.

In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

A drawing furnishing the details of the internal earthing design shall be included in the manual.

The bidder shall offer the CORE for inspection and approval by the purchaser during the manufacturing stage. Bidder's call notice for this purpose shall be accompanied with the following documents, as applicable, as a proof towards use of **PRIME CORE MATERIALS**.

i. Invoice of the supplier

ii. Mill's Test Certificates

iii. Packing List

iv. Bill of Lading

v. Bill of Entry certificate by the Customs

Core Materials shall be directly purchased either from the manufacturer or through their accredited marketing organization of repute and not through any agent. However, if the proof provided is considered sufficient by the Owner the core inspection can be waived.

3.3 Windings

3.3.1 The Contractor shall ensure that windings of all transformers 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 transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service.

3.3.4 Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

3.3.5 The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

3.3.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize 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 dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and only thereafter be brought up to the specified parameter by circulation within the transformer.

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.)- 40degC
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	IEC 60156 or ASTM D1298	(Min.) 50 kV(new unfiltered

	(breakdown voltage)		oil) / 70 kV (after treatment)
6.	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	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 –cm, (Min.) for records only.
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 (Max.)
C1.	Performance		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	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.)135degC
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 : 5 ppm (max.)
3. Tan-delta at 90 °C : 0.0025 (max)
4. Interfacial tension : More than 0.004 N/m

ii) Prior to energisation at site oil shall be tested for following properties &acceptance norms as per below generally in line with IEC 60422:

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
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: 500hour 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 Consultant.

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 parameters as mentioned in serial no. 1 to 5 of clause 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, 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.

3.5 **Terminal Arrangements**

3.5.1 Bushings

3.5.1.1 The electrical and mechanical characteristics of bushings shall be in accordance with IEC 60137/ DIN 42530.

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.
36 kV and below	Solid porcelain or oil communicating type. Dimensions of 36 kV bushing shall conform to IEC

3.5.1.3 Oil Filled condenser type bushing shall be provided with at least the following fittings:

(a) Oil level gauge.

(b) Tap for capacitance and 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 lamination, cavities and other flaws or imperfections 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 turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

3.5.1.9 No arcing horns shall be provided on the bushings.

3.5.1.10 Suitable insulating cap (preferably of porcelain) shall be provided on the terminal of Bushing of tertiary winding to avoid accidental external short circuit.

3.5.1.11 Installation procedures for the various voltage class bushings shall be clearly brought out in the Instruction manual.

3.5.2 Terminal Marking

The terminal marking and their physical position shall be as per IEC: 60076.

3.5.3 Neutral Earthing Arrangement

3.5.3.1 The neutral terminals of transformer 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 6 mm galvanised steel flats connected to Employer's grounding mat.

3.6 Cooling Equipment and its Control

3.6.1 Cooling Equipment

3.6.1.1 The cooler shall be designed using sufficient number of tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

3.6.1.2 Tank mounted radiators shall have its cooling fans , shut off valves at the top and bottom of suitable size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

3.6.1.3 Required number of standby fans of approximately 20% capacity shall also be provided with radiators.

3.6.1.4 Cooling fans shall be directly mounted on radiator. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

3.6.1.5 Cooling fans motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IEC. Each cooling fan motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55.

3.6.1.6 The cooler and its accessories shall preferably be hot dip galvanised or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

3.6.1.7 Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section can be drained independently.

3.6.2 Cooling Equipment Control (ONAN/ONAF COOLING)

3.6.2.1 Automatic operation control of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

3.6.2.2 Suitable manual control facility for cooler fans shall be provided.

3.6.2.3 Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans manually.

3.6.2.4 Indicating Devices

Following lamp indications shall be provided in cooler control cabinet:

a) Control Supply failure.

b) Cooling fan failure.

c) Common thermal overload trip

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet.

3.6.5 Cooling Equipment Control

3.6.5.1 Automatic operation control of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic change over of cooler control over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

3.6.5.2 Suitable manual control facility for cooler fans and oil pumps shall be provided.

3.6.5.4 Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually.

3.6.5.5 Indicating Devices

Following lamp indications shall be provided in cooler control cabinet:

a) Control Supply failure.

b) Cooling fan failure for each bank.

c) Cooling pump failure for each pump.

d) Common thermal overload trip

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet.

3.6.6 **Valves**

3.6.6.1 All valves shall be of gun metal or of cast steel/cast iron. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

3.6.6.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

3.6.6.3 Each valve shall be provided with the indicator to show clearly the position of the valve.

3.6.6.4 All valves flanges shall have machined faces.

3.6.6.5 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

3.6.6.6 The oil sampling point for main tank shall 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.

3.6.6.7 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage

3.6.6.8 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 with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to international standards. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to International Standards followed by two coats of fully glossy finishing paint.

3.6.6.9 All hardware used shall be cadmium plated/electro galvanised steel.

3.6.6.10 For estimation purpose of spares one set of valves would mean one valve of each type used in Transformer.

3.7 Tap Changing Equipment

Each transformer shall be provided with On Load Tap changing equipment.

3.7.1 On Load Tap Changing Gear (OLTC)

The on-load tap-changer (OLTC) to be equipped on the power transformers and associated control equipment shall be from MR Germany or ABB Sweden. Since majority of transformers use this make.

OLTC shall be motor operated for local as well as remote operation. An external handle shall be provided for local manual operation. This handle shall be suitable for operation by a man standing at ground level

3.7.1.1 Each three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load and without producing phase displacement.

3.7.1.2 The requirements of on load tap changing equipment are given here below:

a) The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer.

b) The contacts shall be accessible for inspection without lowering oil level in the main tank and the contact tips shall be replaceable.

c) The Bidder shall indicate the safeguards in order to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer. Necessary tools and tackles shall be furnished for maintenance of OLTC gear.

d) The diverter switch or arcing switch oil chamber shall have oil filling and drain plug, oil sampling valve, relief vent and level glass. It shall also be fitted with a oil surge relay the outlet of which shall be connected to a separate conservator tank.

e) The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of ancillary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment.

f) Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

g) Local OLTC control cabinet shall be mounted on the tank in accessible position. It should be adequately ventilated and provided with anti-condensation metal clad heaters. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.

h) Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command. Subsequent tap changes shall be initiated only by a new or repeat command.

i) On load tap changer shall be equipped with a time delayed INCOMPLETE STEP alarm consisting of a normally open contact which closes, if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.

j) The selsyn units or approved equivalents shall be installed in the local OLTC control cabinet to provide tap position indication for the transformer .The Bidder shall also provide a set of instruments for tap position indication in the control room. Complete mounting details shall be included in the approved diagram.

k) Transformer on load tap shall be equipped with a fixed resistor network capable of providing discrete voltage steps for input to the supervisory system.

l) Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the circuit of the operating motor. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition.

m) Limit switches may be connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated.

n) Thermal device or other means shall be provided to protect the motor and control circuit. All relays, switches, fuses etc. shall be mounted in the local OLTC control cabinet and shall be clearly marked for the purpose of identification.

o) A permanently legible lubrication chart if required shall be fitted within the local OLTC control cabinet.

p) Any 'DROP DOWN' tanks associated with the tap changing apparatus shall be fitted with guide rod to control the movements during lifting or lowering.

q) “A counter of at least six digit shall be fitted to the tap changing equipment to indicate the number of operations completed and shall have no provision for resetting. These high quality counters shall be suitable for at least 1 million operation and shall be supported by a type test certificate”.

r) All relays and operating devices shall operate correctly at any voltage between the limits specified.

s) It shall not be possible to operate the electric drive when the manual operating gear is in use.

t) It shall not be possible for any two controls to be in operation at the same time.

u) The equipment shall be suitable for supervisory control and indication with make before break multi-way switch, having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches which may be required for remote tap position indication.

v) Operation from the local or remote control switch shall cause one tap movement only until the control switch is returned to the off position between successive operations.

w) All electrical control switches and the local operating gear shall be clearly labelled in a suitable manner to indicate the direction of tap changing.

x) Transfer of source in the event of failure of one AC supply shall not affect the tap changer.

3.7.1.3 OLTC Control of Three Phase Transformers

Each three phase transformer shall be suitable for local and remote control. The control feature shall provide the following:

3.7.1.3.1 Local Electrical Control

(a) 'Local-remote' selector switch mounted in the local OLTC control cabinet shall switch control of all load tap changers as followings:

i) When the selector switch is in 'local' position, it shall be possible to operate the 'raise-lower' control switches specified in clause 3.9.3.1(b) below. Remote control of the raise-lower functions shall be prevented.

ii) When the selector switch is in 'remote' position the local OLTC control cabinet mounted 'raise-lower' switch specified in clause 3.9.3.1(b) below shall be in-operative. Remote control of the raise/lower function shall be possible from the remote control panel. The 'local-remote' selector switch shall have at least two spare contacts per position which are closed in that position but open in the other position.

(b) A 'raise-lower' control switch/push button shall be provided in the local OLTC control cabinet. This switch shall be operative only when 'local remote' selector switch is in 'local' position.

(c) An OFF-ON tap changer control switch shall be provided in the local OLTC control cabinet of the transformer. The tap changer shall be in-operative in the OFF position. Also the OFF-ON switch shall have atleast one spare contact per position which is closed in that position but open in the other position.

3.7.1.3.2 Manual Control

The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

a) Mechanical tap position indicator which shall be clearly visible from near the transformer.

b) A mechanical operation counter.

c) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

d) The manual control considered as back up to the motor operated load tap changer control shall be interlocked with the motor to block motor start-up during manual operation. The manual operating mechanism shall be labelled to show the direction of operation for raising the HV terminal voltage and vice-versa.

3.7.1.3.3 Remote Electrical Group Control

The OLTC control scheme offered shall have provision of remote electrical group control during the parallel operation of transformer. This is in addition to independent control of OLTC:

i) A four position selector switch having Master, Follower, Independent and Off position shall be provided in the remote OLTC control panel for each transformer. This shall be wired to enable operator to select operation of OLTC in either Master, Follower or Independent mode.

ii) Out of step relays with timer contacts shall also be provided to give alarm and indication in case tap position in all the transformers under group control are not in same position.

iii) Master Position

If the selector switch is in Master position, it shall be possible to control the OLTC units in the follower mode by operating the controls of the master unit. Independent operation of the units under Follower mode shall have to be prevented. However the units under independent mode will be controlled independently.

iv) Follower Position

If the selector switch is in Follower mode, control of OLTC shall be possible only from panel of the Master unit.

v) Independent Position

In this position of Selector Switch, Control of OLTC of individual unit shall only be possible.

3.7.1.5 The control circuits shall comply with following conditions:

3.7.1.5.1 An interlock to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

3.7.1.5.2 Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.

3.7.1.5.2.3 "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.

3.7.1.5.2.4 An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

3.7.1.5.2.5 An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

3.7.1.5.2.6 Tap change in progress indication shall be provided by means of an indicating lamp at the Employer's control panel. Necessary contacts for this and for remote tap position indicator at Employer's control panel shall be provided by the Bidder.

3.7.1.5.2.7 Protective apparatus, considered essential by the Bidder according to specialities of the gear.

3.7.2 Local OLTC Control Cabinet, Cooler Control Cabinet and Remote Tap Changer Control Panel

3.7.2.1 Each three phase transformer unit shall be provided with local OLTC control cabinet, cooler control cabinet and RTCC panel.

3.7.2.2 Cabinets and Panels shall be tank mounted, provided with suitable lifting arrangement and have sloping roof.

3.7.2.3 A space heater, and cubicle lighting with ON-OFF switch shall be provided in each panel.

3.7.3 Necessary shorting of terminals shall be done at the cooler control cabinet, local OLTC cabinet and remote OLTC panel. All the CT secondary terminals in the cooler control cabinet shall have provision for short circuiting to avoid CT open circuit while it is not in use.

3.7.4 Cooler Control Cabinet

3.7.4.1 The cooler control cabinet shall have all necessary devices meant for cooler control and local temp indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet. All the necessary terminals for remote connection to Employer's panel shall be wired upto the cooler control cabinet.

3.7.4.2 The cooler control cabinet shall have two (2) sections. One section shall have the control equipment exclusively meant for cooler control. The other section shall house the temperature indicators, aux. CTs and the terminal boards meant for termination of various alarm and trip contacts as well as various bushing CT secondary. Alternatively the two sections may be provided as two separate panels depending on the standard practice of the Bidder.

3.7.4.3 The temperature indicators shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

3.7.5 Local OLTC Control Cabinet

The Local OLTC control cabinet shall house all necessary devices meant for OLTC control and indication. It shall be complete with the following:

i) A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor.

ii) Cubicle light with door switch.

iii) Space heaters to prevent condensation of moisture.

iv) Locking arrangement for hinged door of cabinet.

v) Cable terminal glands for power and control cables to the OLTC gear.

3.7.6 Remote Tap Changer Control Panel.

3.7.6.1 The Contractor shall supply a Remote Tap Changer Control (RTCC) panel suitable for remote operation of On load tap changing gear.

3.7.6.2 The RTCC panel shall house actuating switch for electrical raise/lower control, tap position indicator, signal lamps for "Tap change in progress" and "Tap changer out of step", and all other auxiliary devices for remote electrical control of the OLTC. For tap position indicator, the dual output type OLTC transducer shall be provided in the RTCC panel. One of the outputs of this transducer shall be used for local indication of tap position in RTCC panel and other output (0-10 mA or 4-20 mA) shall be used for RTUs/automation system.

3.7.6.3 The RTCC panel shall be located in Employer's control room /Air conditioned switchyard panel room.

3.8 Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit

3.8.1 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet for OLTC and cooler control and power circuit.

3.8.2 All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch housed in the cooler control cabinet for on load tap changer control and cooler circuits.

Design features of the transfer switch shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.

b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.

c) Indication to be provided at cooler control cabinet for failure of normal source and for transfer to standby source and also for failure to transfer.

d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.

e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

3.8.3 Power Supply for OLTC Circuits

a) AC feeder shall be brought to the local OLTC control cabinet by the Contractor after suitable selection at cooler control cabinet for which description is given in 3.10.2 above, for control power circuit of OLTC.

b) The Contractor shall derive AC power for OLTC control circuitry from the AC feeder as mentioned above by using appropriately rated dry type transformers. If the control circuit is operated by DC supply, then suitable main and standby converters shall be provided by the Contractor to be operated from AC power source.

3.8.4 Power Supply for Cooler Circuits

3.8.4.1 Control and power supplies are to be given for Cooler circuits after the selection as mentioned above.

3.8.4.2 The Contractor shall derive AC power for Cooler Control Circuitry by using appropriately rated dry type transformer in case of using supply voltage different from the Employer's auxiliary supply. If the control circuit is operated by DC supply then suitable main and standby convertors shall be provided by the Contractor, to be operated from AC power source.

3.8.5 Necessary isolating switches and MCBs/MCCBs shall be provided at suitable points as per Employer's approved scheme**.**

4 Fittings

4.1 The following fittings shall be provided with each three phase transformer covered in this specification.

4.1.1 Conservator for main tank with oil filling hole and cap, air cell, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating silicagel breather.

4.1.2 Pressure relief devices with alarm/trip contacts.

4.1.3 Buchholz relay double float/reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts.

4.1.4 Air release plug.

4.1.5 Inspection openings and covers.

4.1.6 Bushing with metal parts and gaskets to suit the termination arrangement.

4.1.7 Winding temperature indicators for local and remote mounting. One remote winding temperature indicator with a four point selector switch shall be provided for the three windings for three phase unit to have selection of any of the three windings.

4.1.8 Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.

4.1.9 Protected type mercury or alcohol in glass thermometer.

4.1.10 Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

4.1.11 Rating and diagram plates on transformers and auxiliary apparatus.

4.1.12 Flanged bi-directional wheels/Trolley for movement

4.1.13 Cooler cabinet.

4.1.14 Off load / On load tap changing gear.

4.1.15 Cooling equipment

4.1.16 Bushing current transformers.

4.1.17 Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

4.1.18 Terminal marking plates.

4.1.19 Valves schedule plates.

4.1.20 Oil temperature indicator for local and remote mounting

.

4.1.21 Oil flow indicator

4.1.22 Marshalling box/Common Marshalling box

4.1.23 Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.

4.1.24 Terminal clamp & connector

4.1.25 The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

4.1.26 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.

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 Clause 5.1. 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 Check for flatness.

5.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexibles.

5.1.1.4 Welder's qualification and weld procedure.

5.1.1.5 Testing of electrodes for quality of base materials and coatings.

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 :

i) Oil insoluble varnish.

ii) Zinc chromate paint.

iii) Finished coat.

5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90 deg C 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 NDT.

5.1.1.11 Leakage test of the conservator.

5.1.1.12 Certification of all test results.

5.1.2 Core

5.1.2.1 Sample testing of core materials for checking specific loss, bend properties, magnetization characteristics and thickness.

5.1.2.2 Check on the quality of varnish if used on the stampings :

i) Measurement of thickness and hardness of varnish on stampings.

ii) Solvent resistance test to check that varnish does not react in hot oil.

iii) Check over all quality of varnish by sampling to 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 of stampings. Corners of the sheet are to be part.

5.1.2.6 Visual and dimensional check during assembly stage.

5.1.2.7 Check for interlaminar insulation between core sectors before and after pressing.

5.1.2.8 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.

5.1.2.9 High voltage test (2 kV for one minute) between core and clamps.

5.1.2.10 Certification of all test results.

5.1.3 **Insulation Material**

5.1.3.1. Sample check for physical properties of materials.

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 Dimension 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 and dimensional checks on conductor for scratches, dent marks etc.

5.1.4.3 Sample check on insulating paper for pH value, bursting strength and 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 with conductor.

5.1.4.6 Check and ensure that physical condition of all materials taken for windings 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 voltage ratio 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 anameled wire.

5.1.4.13 Certification of all test results.

5.1.5 **Checks Before Drying Process**

5.1.5.1 Check condition of insulation on the conductor and between the windings.

5.1.5.2 Check insulation distance between high voltage connections, cables and earth and other live parts.

5.1.5.3 Check insulating distances 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 periodic monitoring of IR and Tan delta.

5.1.6.3 Certification of all test results.

5.1.7 **Assembled Transformer**

5.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.

5.1.7.2 Test to check effective shielding of the tank.

5.1.7.3 Jacking test with oil on all the assembled transformers.

5.1.7.4 Dye penetration test shall be carried out after the jacking test.

5.1.8 **Bought Out Items**

5.1.8.1 The makes of all major bought out items shall be subject to Employer's approval.

5.1.8.2 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 components:

a) Buchholz Relay.

b) Axles and wheels.

c) Winding temperature indicators for local and remote mounting.

d) Oil temperature indicators.

e) Bushings.

f) Bushing current transformers.

g) Cooler cabinet.

h) ON Load / Off Load Tap change gear.

i) Oil pumps.

j) Terminal connectors.

k) Pressure relief device relay

l) Cables used for interconnecting Turret CT, equipment relays (exposed), with marshalling box.

The above list is not exhaustive and the Contractor shall also include other bought out items in his programme.

5.1.9 **Pre-Shipment Checks at Manufacturer's Works**

5.1.9.1 Check for interchangeability of components of similar transformers for mounting dimensions.

5.1.9.2 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.1.9.3 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.1.9.4 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.1.9.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.1.9.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer dispatch 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.

5.1.9.7 Functioning of impact recorder(s) at their works before installing on the tank.

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 in. The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works. Procedure for some of tests is given at annexure-I.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below.

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity & Vector group test	Routine
4.	No-load loss and current measurement	Routine
5.	Impedance voltage and load loss measurement	Routine
6.	Measurement of insulation resistance & Polarization Index	Routine
7.	Measurement of insulation power factor and capacitance between winding and earth	Routine
8.	Measurement of insulation power factor and capacitance of bushings	Routine
9.	Lightning impulse test	Routine
10a	Short duration induced AC withstand Test (ACSD) with PD measurement	Routine
11.	Separate source voltage withstand test	Routine
12.	On-load tap changer test (Ten complete cycle before LV test)	Routine
13.	Gas-in-oil analysis	Routine
14.	Core assembly dielectric and earthing continuity test	Routine
15.	Oil leakage test on transformer tank	Routine
16.	Appearance, construction and dimension check	Routine
17.	Magnetic balance test	Routine
18.	Measurement of no load current & Short circuit impedance with 400 V, 50 Hz AC.	Routine
19.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
20.	Tank vacuum test	Routine
21.	Tank pressure test	Routine
22.	Frequency response analysis (Soft copy of test report in sfra format to be	Routine

	submitted to site along with O & M manual)	
23.	Temperature rise test	*Type
24.	Measurement of harmonic level in no load current	*Type
25.	Measurement of acoustic noise level	*Type
26.	Measurement of Zero seq. reactance	*Type
27.	Measurement of power taken by fans and oil pumps	*Type

All tests shall be done in line with IEC: 60076 and as per "Annexure-A". 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 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% at ambient temperature.

5.2.2 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% at ambient temperature.

5.2.3 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. 9.0 of the Chapter2 – GTR. The list of fittings and the type test requirement is:

1. Bushing (Type Test as per IEC: 60137, including snap back/seismic test)

2. Buchholz relay (Type Test as per IEC and IP-55 Test on terminal box)

3. OLTC (Temperature Rise of contact, Short circuit current test, Mechanical test and Dielectric Test as per IEC: 60214 and IP-55 test on driving mechanism box).

4. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 degree of protection for terminal box.

5. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.

6. Cooler Control cabinet (IP-55 test)

7. 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 transformer tank pressure test above.. 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.

8. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

9. OTI & WTI – Switch setting & operation, switch differential, switch rating.

5.2.4 **Pre-Shipment Checks at Manufacturer's Works**

5.2.5 Check for interchangeability of components of similar transformers for mounting dimensions.

5.2.6 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.2.7 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.2.8 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.2.9 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.2.10 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer 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.

5.3 **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. Pre commissioning Procedures and Formats for equipments shall be contractor's responsibility to draw up and carry out such a programme.

5.3.1 **Receipt and Storage Checks**

5.3.1.1 Check and record condition of each package, visible parts of the transformer etc. for any damage.

5.3.1.2 Check and record the gas pressure in the transformer tank as well as in the gas 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 conditions of core and winding in general.

5.3.2 **Installation Checks**

5.3.2.1 Inspection and performance testing of accessories like tap changers etc.

5.3.2.2 (i) Check the direction of rotation of fans .

(ii) Check the bearing lubrication.

5.3.2.3 Check whole assembly for tightness, general appearance etc.

5.3.2.4 Oil leakage test

5.3.2.5 Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

5.3.2.6 Leakage test on bushing before erection.

5.3.2.7 Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form 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.

5.3.2.8 **Oil filling.**

5.3.2.8.1 Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70 deg C.

5.3.2.8.2 The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

5.3.2.8.3 Vacuum shall not be broken until the transformer 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 transformer. For this purpose the transformer shall first be drained to expose all insulation material.

5.3.2.8.4 The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

5.3.2.8.5 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

5.3.3 **Commissioning Checks**

5.3.3.1 Check the colour of silicagel in silicagel breather.

5.3.3.2 Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

5.3.3.3 Check the bushing for conformity of connection to the lines 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 flow.

(v) Low oil level indication.

(vi) Fan and pump failure protection.

5.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.

5.3.3.6 Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

(i) Control wiring.

(ii) Main windings.

5.3.3.7 Check for cleanliness of the transformer and the surroundings.

5.3.3.8 Continuously observe the transformer operation at no load for 24 hours.

Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

5.3.3.9 Phase out and vector group test.

5.3.3.10 Ratio test on all taps.

5.3.3.11 Magnetising current test.

5.3.3.12 Capacitance and Tan delta measurement of winding and bushing.

5.3.3.13 DGA of oil just before commissioning and after 24 hours energisation at site.

5.3.3.14 Frequency response analysis (FRA) at site by the equipment to be provided by the bidder.

5.3.3.15 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

6.0 Technical Parameters

6.1 Technical Parameters: 315MVA, 220/132 kV three phase Autotransformer.

6.1.1 Rating- H.V. / L.V (MVA) : 315 / 315

(Tertiary) : Not Applicable

6.1.2 Applicable standard : IEC-60076

6.1.3 Cooling : ONAN /ONAF

6.1.4 Rating at different cooling : 60%/100%

6.1.5 Type of Transformer : Constant ohmic Impedance type

6.1.6 Voltage ratio : 220/132 kV

6.1.7 Frequency : 50 Hz

6.1.8 Phases : Three

6.1.9 Impedance

i) HV-LV impedance at 75degC: (IEC Tol. Applicable)

- Max. Voltage tap : ……%
- Principal tap : ……%
- Min. Voltage tap : ……%

6.1.10 Service : Outdoor

6.1.11 Duty : Continuous

6.1.12 Overload capacity : As per IEC-60076-7

6.1.13 Temperature rise over 50degC Ambient Temp.

Of top oil measured by thermometer : 50degC

Of winding measured by resistance : 55degC
Method

6.1.14 Max. design ambient temp. : 50degC

6.1.15 Windings		H.V.	L.V.
i)	System Fault level (kA) :	40	31.5
ii)	1.2/50 micro sec. impulse withstand voltage kVp :	1050	650

iii)	Rated short duration induced: or separate source AC withstand voltage (kVrms)		395	275
iv)	Winding connection	:	Star	Star
v)	Neutral	:	Solidly grounded	
vi)	Insulation	:	Graded	Graded

6.1.16 Vector Group (three phase bank) : ------ YN aO ------

6.1.17 Tap Changer

i) Tap range Tap changer shall be located on the 132 kV side of the series winding for achieving –10% to +10% of HV variation in the step of 1.25%. It shall be of constant flux voltage variation type as per cl. 5.2 of IEC 60076 part-I.

ii) Tap control - Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.

6.1.18 Bushing	:	HV	LV	Neutral
i) Rated voltage (kV)	:	245	145	36
ii) 1.2/50 micro sec. lightning impulse withstand voltage (kVp).	:	1050	650	170
iii) One minute power frequency withstand voltage kV (rms)	:	505	305	77
iv) Minimum total creepage distances (mm)	:	6125	3625	900
v) Mounting	:	Tank	Tank	Tank

6.1.19 Maximum partial discharge level At 1.5 pu : 100 pico-coulomb

6.1.20 Noise level : 75 dB (ONAN & ONAF)

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 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 for Bushing CT**

7.5.1 Current Transformer Parameters (On each phase) for 3-ph, 315 MVA Auto Transformers

		HV Side	LV side	Neutral side
(a)	Ratio			
	Core - 1	To be finalized during Drawing Approval		
	Core - 2	To be finalized during Drawing Approval		
(b)	Minimum knee point Voltage and accuracy class:			
	Core - 1	600V Class PS	600V Class PS	600V Class PS
	Core - 2	0.5 class 15VA ISF ≤5	0.5 class 15VA ISF ≤5	-
(c)	Maximum CT Resistance			
	Core - 1	1.5 ohms	1.5 ohms	1.5 ohms
	Core - 2	-	-	-
(d)	Application			
	Core - 1 (Near the wdg)	Restricted earth fault	Restricted earth fault	Restricted earth fault
	Core-2	Metering	Metering	-
(e)	Maximum magnetisation current (at knee point voltage)			
	Core-1	100 mA	100 mA	100 mA
	Core–2	-	-	-

Annexure -A

All tests shall be carried out as per IEC: 60076 on transformer.

1) Magnetic Circuit Test

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

2) Tank Tests

(i) Oil Leakage Test

All tanks and oil filled compartments shall be tested for oil tightness by being 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 applying a pressure equal to the normal pressure plus 35 kN/Sq.m (5 psi) measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

(ii) Vacuum Test

All transformer tank of each size 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 plate 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

All transformer 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 to the normal pressure plus 35 KN/m2 whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

3) 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.

4) Temp. Rise Test (as per IEC 60076)

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as IEC: 60567 and results will be interpreted as per IEC -61181. The DGA results shall generally conform to IEC/IEEE guidelines.

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps of the transformer and shall recommend the combination that results in highest temperature rise for the test.

6) 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. The list of fittings and the type test requirement is:

a. Bushing (Type Test as per IEC: 60137)
b. Buchholz relay (Type Test and IP-55 Test on terminal box)
c. Marshalling box (IP-55 test)
d. 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 transformer 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.

e. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
f. Air Cell (Flexible air separator) –Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
g. OTI & WTI – Switch setting & operation, switch differential, switch rating.

7) Inspection and Testing at Site

The Contractor/Manufacturer shall supervise testing & commissioning at site. Testing & commissioning shall be carried out by the owner (MOEP-2). Contractor shall submit a detailed procedure for Testing & Commissioning at site including receipt, storage & installation checks as mentioned below.

a) Receipt and Storage Checks

- Check and record condition of each package, visible parts of the transformer etc. for any damage.
- Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

- Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
- Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

b) Installation Checks

- Check whole assembly for tightness, general appearance etc.
- Oil leakage test
- Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- Leakage check on bushing before erection.
- Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form 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.

c) Oil filling

Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.

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 transformer tank and should be less than 1mbar.

Vacuum shall not be broken until the transformer 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 transformer. For this purpose the transformer shall first be drained to expose all insulation material.

The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

d) Commissioning Checks

- Check the colour of silicagel in silicagel breather.
- Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- Check the bushing for conformity of connection to the lines etc,
- Check for correct operation of all protection devices and alarms:

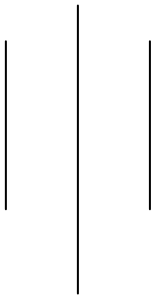
(i) Buchholz relay.
(ii) Excessive winding temperature.
(iii) Excessive oil temperature.
(iv) Low oil level indication.

- Check for the adequate protection on the electric circuit supplying the accessories.
- Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

(i) Control wiring.
(ii) Main windings.

- Check for cleanliness of the transformer and the surroundings.
- Continuously observe the transformer operation at no load for 24 hours.
- Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.
- Phase out and vector group test.
- Ratio test on all taps.
- Magnetising current test.
- Capacitance and Tan delta measurement of winding and bushing.
- DGA of oil just before commissioning and after 24 hours energisation at site.

SECTION-I, PART-3



TECHNICAL SPECIFICATION

(SPECIFICATION OF CABLES)

SECTION I, PART 3

SPECIFICATION OF CABLES

1 GENERAL

This specification covers the design, manufacture, factory test, supply, delivery, installation, field-testing and commissioning of all Power, Control, Communication and Instrumentation cables required for the entire project.

2 DESIGN REQUIREMENTS

11 kV Power Cable (Not Applicable)

a) General

The rated voltage of the power cables shall be 19/33(36) kV.

The power cable shall be cross-linked polyethylene insulated, screened and steel tape armoured.

b) Conductor

Conductor for power cable shall consist of stranded annealed copper wires. They shall comply with IEC Publication.

c) Cable Rating

The minimum current rating for the cable and conditions of installation shall be as follows:

The fault current for 1 sec. shall not be less than *15* kA.

The cable shall be single core 400sq. mm. per Phase.

d) Anti-Termite Covering

Anti-termite protection shall be applied to the cable and shall be black PVC suitable for the operating temperature of cable and shall meet the requirements of IEC standard.

e) Outer Covering

The outer covering of the cable shall be extruded, continuous black PVC suitable for the operating temperature of cable and shall meet the requirements of IEC standard.

f) Cable Drum

Cable drum shall be non- returnable and made of steel suitably protected against corrosion.

g) Outdoor and Indoor Termination

33 kV cable terminations shall be of the heat-shrinkable type / pre-moulded push on type. Terminations for cable shall be provided in sufficient quantities for complete installations of all feeders of the substations. The cost of all necessary termination kits shall be included in the price of the cables.

h) Jointing Accessories

Cables shall be installed in maximum possible lengths and straight-through jointing shall not be permitted without the prior written approval of the Employer.

i) Voltage Identification

The plastic covering shall be embossed with the name of the manufacturer, number of conductors, the cross sections, type of insulation followed by:

Electric cable - (Corresponding) volts

j) Phase Identification

Phase identification for either triplex or multi-core conductor cable shall be in accordance with the following:

Phase A (R) : Red
Phase B (Y) : Yellow
Phase C (B) : Blue

600 Volt Power Cable

a) General

The low voltage cables shall be 600 V grade polyethylene insulated and PVC sheathed. Low voltage AC power systems will be solidly grounded neutral with phase to phase voltage level of 400 V and phase to neutral voltage of 230V AC system and the DC system with 110V. The size of the single core conductor shall not be less than 2.5 sq. mm for lighting and 4 sq. mm for power. The main (incomer) cable to AC distribution panel shall be three & half (3.5) core and not less than 120 sq. mm.

b) Conductor

Conductor shall consist of stranded annealed copper wires. They shall comply with IEC publication. The cable is intended for use at normal conductor operating temperatures not exceeding 75 degree C.

c) Insulation

The electrically and thermally stable polyethylene insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

d) Current Rating

The Contractor shall state the maximum continuous current rating and conditions of installation for low voltage power cables.

e) Jacket

The cable core assembly shall be covered with a flame-retardative and moisture resistant PVC jacket, which is free stripping from the insulation. The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

f) Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

g) Identification

1) Each cable shall have a printed legend on the overall jacket with the manufacturer's name, voltage class, the number and size of conductors, type of insulation.

2) The colors for core identification and color sequence shall be in accordance with follows
   - Single-core : Black
   - Twin : Red and black
   - Three-core : Red, yellow and blue
   - Four-core : Red, yellow, blue and black

Control and Instrumentation Cable

a) General

All control and instrumentation cable shall be 600 V grade as per IEC standard, multi conductor, color-coded, PVC insulated armored cable. Each multicore cable shall have not less than 20 percent or 2 spare cores, whichever is the greater.

b) Conductor

Copper conductor shall be stranded circular non-compacted cross-section of minimum 2.5 sq.mm. The Contractor shall calculate the load of CT core considering all connected loads and submit to the employer for approval. In case of CT burden constrain, CT circuit cable cross sectional area shall be increased. In this case the Contractor shall supply and install the cable required cross-section area without any additional cost to the Employer.

c) Insulation

The electrically and thermally stable PVC insulation shall be extruded onto the conductor so as to prevent contamination and voids in the insulation.

d) Assembly

1) Multicore connductor cables shall be assembled in accordance with applicable IEC standards.

2) A flame-retardative binder tape may be used underneath the overall jacket of multi-conductor cables, if required, to achieve the desired flame retardative characteristics. Tapes, if used, shall be non-hygroscopic.

e) Jacket

1) The cable core assembly shall be covered with a flame retardative and resistant jacket, which is free stripping from the insulation.

2) The overall jacket shall be clean, dry, and free of grease and shall be suitable for ink or paint application.

3) Cable jacketing and the interstices within the jacket shall be free of water. Evidence of water shall be the ground for rejection of the cable.

f) Anti- Termite Covering

Anti-termite protection shall be applied to the cable and shall consist of either a non-magnetic metallic barrier or layer of nylon sheathing.

g) Identification

Each cable shall have a printed legend on the overall jacket, with the manufacturer's name, voltage class, the number and size of conductors, and a unique number or code indicating the production run or batch. The identification shall remain legible for the life of the cable.

2.4. SPECIAL REQUIREMENTS

Small cut piece lengths of cables will not be accepted. Cables up to 500 meters in length or as approved by Employer shall be of one length shipped in a drum of adequate size. For higher quantities, multiple lengths/drums may be shipped subject to the approval of Employer.

2.5 DRAWINGS, DATA & MANUALS

The following information shall be furnished along with the bid.

a) Manufacturer's leaflets giving constructional details, dimensions and characteristics of different cables.

b) Current rating of cables including derating factor due to grouping, ambient temperature and type of various installation.

2.6 TESTS

2.6.1 Routine and Design Tests

Power cable shall be subjected to following routine tests. As far as practical, the procedure of IEC shall be followed:

a) Measurement of the electrical resistance of conductor
b) Partial discharge test
c) Voltage test

The power cable design tests shall include following:

a) Partial discharge test
b) Bending test, followed by a partial discharge test
c) Tan delta measurement
d) Heating cycle test, followed by a partial discharge test
e) Impulse test, followed by voltage test
f) Voltage test for 4 hours.

The Bidder shall submit copy of design test report from recognized testing laboratory for the offered power cable along with the bid.

2.6.2 Field Tests

After installation at Site, cables shall be subjected but not limited to the following tests:

a) Measurement of insulation resistance
b) *DC dielectric test*

2.7 PERFORMANCE GUARANTEE

The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/replace the defect/defective part at no extra cost to the Employer and without delaying the commissioning schedule.

SECTION I, PART 4

SPECIFICATION OF GROUNDING SYSTEM

SECTION I, PART 4

GROUNDING SYSTEM

1. GENERAL

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below.

The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

2. GROUNDING INSTALLATION FEATURES

The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation. All exposed ground conductors runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean contact surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit system, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc. shall be by pressure type or bolting type connectors.

2.3 All lap, cross and tee connections between two grounding conductors shall be made by thermo-welding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer.

2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

2.5 The maximum size of each grid of grounding mat shall not exceed *4X4* meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary. *(The new grounding shall be bonded with existing grounding network.)*

3 GROUNDING CONDUCTOR

3.1 Main Ground Grid

The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of minimum 25 x 4 mm copper flat conductor cable or minimum 100 sq. mm stranded copper wire.

3.2 Ground Electrodes

The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. These shall be driven into ground and connected to the main ground grid.

3.3 Risers

The risers shall consist of copper conductor of adequate size (but not less than 100 sq. mm.) connected at one end to the main ground mat and at the other end to the equipment.

4 DESIGN REQUIREMENTS

4.1 *The Contractor shall measure the soil resistivity in presence of the Employer. Based on the resistivity the contractor shall* calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of less than 1.0 (One) Ohm.

4.2 The Contractor shall calculate the cross-section considering the maximum fault level of 25 kA.

4.3 The Contractor shall submit the details of calculations of the grounding system for the Employer's approval.

5 TESTS

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance can not be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.

6 LIGHTNING PROTECTION

The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by an overhead lightning shield system of galvanized steel wire of 7/3.35 mm, which shall be connected to the main grounding grid by steel conductor of 7/3.35 mm. The design of the lightning protection system shall be subject to the approval of the Employer.

7 DRAWINGS

After award of the Contract, the Contractor shall furnish the grounding layout drawing with dimensions showing the location of grounding grids, electrodes, test link chambers and risers, backed up by necessary calculations for Employer's approval. The work shall have to be started at site only after getting approval from the Employer. If alteration is required for any work done before getting Employer's approval, the same shall have to be done by the Contractor at no extra cost to the Employer.

APPENDIX 4

STATION GROUNDING SYSTEM

DESCRIPTION	UNIT	REQD.
1. Main ground grid conductor material		Copper
2. Main ground grid conductor size	Sq.mm	≥ 100
3. Cross section of riser conductors	sq mm	≥ 100
4. Ground electrodes		
- Material		Copper clad steel
- Diameter	mm	16
- Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	≤ 1

PART 5
MISCELLANEOUS MATERIAL

PART 5
MISCELLANEOUS MATERIAL

1 GENERAL

This specification covers the design, fabrication, properly packing for transportation, delivery, installation, testing and putting into efficient and trouble-free operation of the bus materials, insulators and miscellaneous items complete with all accessories.

2 TECHNICAL REQUIREMENTS

2.1 Insulators

a) General

All types of insulators shall satisfactorily withstand the specified climatic and service conditions. The strength of insulators as given by the electro-mechanical tests shall be such that the factor of safety when supporting their maximum working loads shall be not less than two and a half.

Design shall be such that stresses due to expansion and contraction in any part of the insulators and fittings do not lead to development of defects.

All insulators, whether cylindrical post or string shall have plain shed profiles.

Damaged insulators shall be replaced at no costs to the Employer.

b) Materials

Porcelain insulators shall be in accordance with IEC standards, where applicable. Porcelain shall be sound, free from defects and thoroughly vitrified and the glazed.

Porcelain glaze shall be smooth, hard, of uniform shade of brown and shall completely cover all exposed parts of the insulators. Outdoor insulator fittings shall remain unaffected by atmospheric conditions producing weathering, acids, alkalis, dust and rapid changes in temperature that may be experienced under working conditions.

Suspension and tension insulators shall comprise porcelain units with ball and socket fittings.

Retaining pins or locking devices for insulating units shall be of phosphor bronze or other approved material, and shall effectively prevent accidental separation of the units.

Unless otherwise approved, the individual units of both the suspension and tension insulator sets shall be identical and interchangeable.

c) Number of discs

-	132 kV :	11 Nos (minimum)	per set
-	33 kV:	3 Nos (minimum)	per set

d) Marking

Each insulator shall have marked on it the manufacturer's name or trademark, the year of manufacture and the manufacturer's reference mark. Tension and suspension insulators shall also be marked with the guaranteed electromechanical strength. Marks shall be legible and indelible.

e) Post insulator

Post insulator shall be cylindrical type, solid core porcelain, single stacked, provided in accordance with following requirements:

	Type A	Type B	Type C
- Rated voltage	145 kV	72.5 kV	36 kV
- Nominal voltage	132 kV	66 kV	33 kV
- Impulse withstand voltage	650 kV	325 kV	170 kV
- Color	Brown	Brown	Brown

Test shall be divided into three groups in accordance with IEC 168.

f) Standard particulars of insulator units

Insulator units shall comply with the following requirements. (IEC 305)

1)	Porcelain disc diameter	254 mm
2)	Unit spacing	146 mm
3)	Creepage distance	292 mm
4)	Electro mechanical failing load	12,000 kg
5)	Dry power frequency withstand Voltage	70 kV
6)	Wet power frequency withstand Voltage	40 kV
7)	Dry impulse withstand voltage	120 kV
8)	Puncture voltage	120 kV

Dimension and tolerances of ball and socket coupling shall comply with IEC Publications 120, and the internal height of the socket shall also comply with the requirements of IEC Publication 372-1 (1977)

2.2 Bus Conductor and Fittings

The bus-bar system to be adopted shall be as follows:

- For132 kV it shall be of double bus-bar type with single breaker connecting system.

- For 33 kV it shall be of single bus-bar type with single breaker connecting system. The bus-bar system shall be designed in such a way that at least one bay in each end can be extended in future without major construction.

a) General

Busbars and electrical connections in outdoor substations shall be in accordance with IEC, BS, ASTM or equivalent national standards in respect of current rating and material analysis.

Bus conductor to be supplied shall be aluminum tube for 132 kV and 33 kV. For connection purpose aluminum conductor steel reinforced may be used, if required. Minimum size and material of each bus shall be as following:

	Bus	Material	Min. Size
-	33 kV Main	*Al-Tube*	*100mm*
-	33 kV Branch	*Al-Tube*	*75mm*

The 33 kV bus-bars shall be designed for the following conditions:

	Current Carrying Capacity	Fault Level
Main bus-bar -	*1600 A*	25 kA
Branch bus-bar -	*800 A*	25kA

The Contractor shall submit detailed calculation for approval.

Materials used for busbars and connections shall be stressed not to more than two-fifths of their elastic limit. Provision shall be made for expansion and contraction with variation in conductor temperature and busbars shall be arranged so that they may be readily extended in length with a minimum of disturbance to existing equipment.

Busbars shall be in continuous lengths between supports. Connectors shall be of approved type, and if necessary type tested. Connections dependent upon site welding techniques will not be permitted.

Busbars and connections shall be so arranged and supported that under no circumstances, including short circuit conditions, the clearances between live metal and earth, or between other conductors, cross the safe limit.

b) Strain Bus and Fittings

The conductor shall be aluminum conductor; steel reinforced (ACSR)*"BEAR"* (Overall cross sectional area of 326 sq. mm.).

The conductor shall be constructed of hard-drawn aluminum and zinc-coated steel wires which have the mechanical and electrical properties in accordance with the latest revisions of ASTM or equivalent.

The direction of lay of the outer layer shall be right-hand. The direction of lay shall be reversed in successive layers; continuous layer shall in all cases have opposite lay.

The external form and surface of the finished conductor shall be uniformly cylindrical upon completion of manufacture and shall remain so when erected in place on the line.

The surface of the conductor shall be free from points, sharp edges, abrasions or other departures from smoothness or uniformity that would tend to increase radio interference and corona loss. When the conductor is subjected to tensions up to 50 percent of its rated ultimate strength, the conductor surface shall not depart from its general cylindrical form, nor shall any of the strands move relative to each other in such a way as to get squeezed out of place and disturb the longitudinal smoothness of the conductor. Strands of a section of "popped" cable shall not protrude more than 1/2 of their diameter of a strand. The conductor shall be capable of withstanding the normal handling necessary for manufacture and erection, such as, reeling, unreeling, and pulling through stringing sheaves under sufficient tension to keep the conductor off the ground, etc., without being deformed from the cylindrical form that causes to increase radio interference and corona loss.

The make-up and lay of wires shall be such as to produce a conductor essentially free from a tendency to untwist or spring when cut. The steel wires shall be preformed or post-formed so that when the conductor is cut and the aluminum wires are stripped away from the core as required for splicing, the steel wires can be readily regrouped and easily held in place with one hand to allow a splicing sleeve to be slipped over the steel core wire at the cut end of the conductor.

This forming of the core is required and shall be done in a manner which will not in any way scratch, scrape, remove or otherwise damage the zinc coating of the steel core wires, individually or collectively.

The conductor shall be free from excessive amounts of die grease, metal particles and dirt. The Bidder shall describe in complete detail the method, which he proposes to use to clean the conductor in normal production. The effectiveness of the cleaning process shall be subject to verification.

Where dissimilar metals are in contact, approved means shall be provided to prevent electro-chemical action and corrosion. Unless otherwise approved, joints and surfaces of copper or copper alloy fittings shall be tinned.

Suspension and tension conductor clamps shall be of approved types and shall be as light as possible. Those for aluminum conductor shall preferably be compression type. Suspension and tension clamps shall be designed to avoid any possibility of deforming the stranded conductor and separating the individual strands.

Tension conductor clamps shall not permit slipping of or damage to, or failure of the complete conductor or any part thereof, at a load less than 95 per cent of the ultimate strength of the conductor.

Clamps and fittings made of steel or malleable iron shall be galvanized. All bolts and nuts shall be as specified and shall be locked in an approved manner.

c) Tubular Bus and Fittings

Tubular bus shall be made of first melting aluminum alloy, cold rolled or hard-drawn and assembled using corona free fittings. The bus–bar shall be designed and manufactured in such a way to dampen any vibration.

The tubular bus conductor shall be designed to withstand mechanical forces due to short circuit currents; and its temperature when carrying full load current shall not exceed 75 degree C. A safety factor of 2 for normal working loads and 1.5 with short circuit currents shall be used. Vibration of bus shall be checked for the design wind conditions.

The tubular bus shall include a small drain hole in any low section. Where joints are required they shall be of the thin leaf type. They are required at all potheads and as required on bus bars. Bus supports for main tubular buses shall include rigid fixed conductor clamp with slide fit on adjacent supports.

All bus support clamps shall be cast of first melting aluminum alloy. Each clamp shall be adjustable for alignment with insulator and furnished with four galvanized steel mounting bolts.

- Bolted type clamps shall be furnished with first melting alloy and, bolts, nuts and washers shall be finished with an anodic coating and lubricated. The clamps for tubing shall have dimensions and sections suitable for splicing two pieces of tubing in the clamp.

- Flexible elements of expansion bus support clamps shall be laminated aluminum strap, which has current capacity equivalent to the tube.

Terminal connectors for aluminum shall be of first melting cast aluminum alloy. All terminal pads shall be furnished with stainless steel bolts, nuts and Belliville washers.

The bolted type terminal connectors shall be a multigrip type terminal and furnished with first melting aluminum alloy with bolts, nuts and washers finished with anionic coating and lubricated.

Bolted type connectors shall be furnished with first melting aluminum alloy with bolts, nuts and washers finished with anionic coating and lubricated.

Angle-connectors:

All angle connectors shall be of streamlined, bolted type and made of first melting cast aluminum alloy. Tap element sockets shall be deep enough to allow for error in cut-off.

- Couplers: All couplers shall be of bolted type and made of first melting cast aluminum alloy.

- Corona Bells: All corona bells shall be streamline internal type and cast of first melting aluminum alloy.

The Contractor shall submit calculations regarding selection of the size of the bus material for approval.

d) Overhead ground wire

Overhead shield wire shall be galvanized steel wire, stranded with a minimum cross sectional area of 61.7 sq mm and shall comply with BS 183.

Earthwires shall be greased as for conductors and the outer strands shall have a right hand lay.

Each completed shield wire shall be bare and shall be composed of the specified number of strands.

The nominal diameter of individual wires shall have a variation of not more than plus or minus one and one-half (1.5) percent.

Joints or splices may be made in the individual wires prior to drawings to final size or in the finished wire composing the strand. Such joints shall have protection to corrosion equivalent to that of the finished wire itself and shall not decrease the strength of the finished strand below the specified minimum breaking strength. Joints in the individual wires in the finished strand shall be separated by at least 15.2 meters.

All strands in the wire shall lay naturally in their true position in the completed cable, shall tend to remain in position when the cable is cut at any point, and shall permit restraining by hand after being forcibly raveled at the end of the cable. The strand shall be free from imperfections and consistent with good commercial practice with a carefully controlled finish completely free from any dirt, loose metal particles, nicks, scratches, abrasions or deformities of any nature.

Each item of material to be furnished by the Contractor shall be accompanied by the manufacturer's routine factory test certificates/reports.

3 TESTS

3.1 Insulators

The insulators shall be tested in accordance with IEC standards. Certified copies of the tests shall be submitted for approval to the Employer.

a) Design tests

- Power frequency wet withstand voltage test
- Critical - impulse flashover test
- Impulse withstand test
- Radio-interference voltage test
- Compression strength test
- Thermal shock test

b) Quality conformance tests

- Visual and dimensional test
- Porosity test
- Galvanizing test
- Cantilever strength test
- Torsional strength test
- Tensile strength test

c) Routine tests

- Flashover test
- Tension tests

3.2 Bus Materials

Following shop tests shall be performed by the manufacturer on the bus material. The Contractor shall submit such test reports to the Employer for approval before dispatch.

a) Aluminum Tube

- General inspection
- Chemical composition of aluminum alloy
- Conductivity measurement of aluminum tube
- Dimension and weight measurement
- Certified report of aluminum alloy from the original manufacturer

b) Bus Support Clamp and Connector

- General inspection
- Dimension measurement
- Chemical composition of aluminum alloy
- Certified report of aluminum alloy from the original manufacturer

c) Connectors for Stranded Conductor

- General inspection
- Measurement of dimensions
- Compression tests
- Certified report of aluminum alloy from the original manufacturer

d) Miscellaneous Hardware

- General inspection
- Measurement of dimensions
- Tension test
- Galvanizing test

4 PACKAGING AND MARKING

4.1 Insulator

a) Packaging

The insulators shall be packed in strong wooden boxes with a waterproof lining. These boxes shall provide adequate protection against salt spray, chemical attack and damage that might be encountered in transportation and rough handling during loading, transportation to job site, unloading to temporary storage, ocean transportation, etc.

b) Marking

In addition to marks required for shipping purposes, each crate and pallet shall be marked with shipper's identity, Employer's name and address and quantity and type of contents etc. Also, the gross, tare and net weights in kilograms shall be stenciled on each pallet.

4.2 Bus Materials

a) Packing

The conductor shall be furnished on non-returnable wooden reels, and shall be properly protected to prevent displacement, chafing, distortion, damage from corrosive atmosphere or other damage to the conductor, which might be encountered in shipping, storage for handling, etc. Each layer of conductor shall be separated from the adjacent layer in such a manner as to prevent abrasion or other damage during handling and shipping.

The non-returnable reels shall be made of strong materials suitably strengthened for ocean transport and treated to withstand rotting or any type of damages due to ocean atmosphere. The reels shall be capable of withstanding all stresses due to braking and string operations. The Employer will accept the use of returnable reels, but any additional costs in disposing such reels shall be the responsibility of the Contractor.

b) Marking

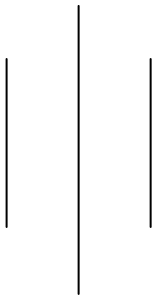
In addition to marks required for shipping purposes, each reel-head shall be stenciled to show serial number, type of conductor, length of conductor in meters, the gross, tare, and net weights in kilograms. Each reel shall also be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the conductor on the reel. Those reels from which test samples were taken shall be marked "TESTED" with length of sample conductor removed and removal included in the markings.

5 GUARANTEE

5.1 Any defects in materials or workmanship or other failure to meet requirements of these specifications, which are disclosed prior to the Operational Acceptance Certificate by the Employer, be corrected entirely (including removal and replacement) at the expense of the Contractor.

5.2.1 Any latent defects not disclosed before date of the Operational Acceptance Certificate but disclosed within Defects Liability Period shall be corrected promptly by and at the expense of the Contractor.

SECTION-I, PART-6



TECHNICAL SPECIFICATION

(CIVIL WORKS)

SECTION I, PART-6

CIVIL WORKS

1. GENERAL

This specification covers the general requirements for Design, Manufacture, Test, Supply and Construction of Civil works necessary for the erection of a Equipment at the various substations.

The Contractor shall perform the works to meet the requirements of this Specification, the attached drawings and the relevant Articles in these Contract Documents.

2. STANDARD AND REFERENCES.

All equipment, materials, fabrication and tests under these Specifications shall conform to the latest applicable standards, manuals and Specifications contained in the following list or to equivalent applicable standards, manuals and Specifications established and approved in the country of manufacturer, and approved as equal by Employer.

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standard Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
JIS	Japanese Industrial Standards
DIN	Dueches Industries Norms

Any details not specifically covered by these standards and Specifications shall be subject to approval of Employer. In the event of contradictory requirements between the standards and these Specification requirements, the terms of the Specifications shall apply.

Unless specifically mentioned reference to standards and specifications or to equipment and materials of the particular manufacture shall be considered as followed by "or equivalent". The Contractor may propose equivalent specifications, materials or equipment, which shall be equal in every respect to that specified. If the Contractor for any reason proposes equivalents to or, deviates from, the above standard, the Contractor shall state the exact nature of the change and shall submit complete specifications of the materials, as well as copies of pertinent standards, for the approval of Employer and decision of Employer in the matter of quality will be the final.

3. SCOPE OF WORKS.

3.1 Site Installation. All offices, housing facilities, plants and equipment, temporary structures and works, temporary construction and access road and everything else which will be used or needed for the performance of the Works shall be considered part of the Contract.

3.2 Existing Drain and Fence shall be shifted to new location as required. The existing Fence shall be dismantled and re erected at new location. If new material is to be used the prices shall be included in the price schedule.

4. DESIGN OF CIVIL WORK.

The Contractor shall perform detailed design for each structure and on the basis of the design criteria and codes or regulations of international standards.

Prior to proceeding with the design work, design conditions or design values that shall include other allowable stress safety factor, load conditions, and applicable standards shall be approved by Employer.

The Contractor shall submit to Employer for approval the Contractor's drawing, structural and other calculation sheets, bill of materials, construction method and schedule for the construction of civil works.

In case modification of detailed design of civil work is required, the Contractor shall promptly inform Employer and shall submit modified drawings to Employer for approval.

No separate or direct payment will be made to the Contractor for design works. All costs incurred in connections therewith shall be included in the unit/lump sum bid prices for the construction of various structures, foundations, etc.

5 FOUNDATIONS AND CONCRETE WORK.

5.1 Foundation Works

5.1.1 General Requirement.

The design of the foundation for all the substation steel structures, electro-mechanical equipment's, control building to be constructed shall be the responsibility of the Contractor. All designs and details shall be subject to approval of Employer. Approval of designs by Employer in no way relieves the Contractor of responsibility for an inadequate foundation design.

Where new transformers are to replace existing transformers, the Contractor shall investigate the technical feasibility of using the existing foundations for the new transformers. In case, the existing foundations are not suitable, the Contractor shall remove them from site.

Design loads

Foundations shall be actual working loads applied to the foundations by the equipment and structures. The foundations shall be designed to resist all vertical and lateral forces, uplift forces and overturning moments with a minimum factor of safety of 1.5.

Bearing loads

The Contractor shall use an allowable soil bearing pressure of 1.0kg/sq.cm for the design of the foundation for the purpose of bidding, but this is only reference value. After award of Contract, the Contractor shall carry out detail soil test and detail design of foundation based on the soil test result. There may be variation in the volume of work in final design compared to the bidding design, for which the Contractor will not get any extra payment.

Uplift and overturning loads

The uplift and overturning resistance of concrete spread footings shall be assumed as the weight of a volume of earth in the form of an inverted frustum of a cone or pyramid. The cone or pyramid height shall be 30 cm less than the depth from finish grade to the top of the concrete mat, the base area shall be the top area of the mat and the top area shall be determined by the intersection of planes starting at the mat edges and sloping outward at a 20 degree cone angle from the vertical and the horizontal plane 30 cm below finish grade.

Unit weights for overturning resistance

The following unit weights shall be used for design:

a) Soil .....1,200kg/m^3

b) Concrete .....1,600kg/m^3

5.1.2 Details.

Detail Calculation. Detail calculations for each type of foundation shall be submitted for approval of Employer. Such details shall show the following requirements:

1. Calculation of loads acting on foundation under different conditions.

2. Calculated safety factor for each type of stability and condition.

3. Maximum stresses in concrete and in steel reinforcement at any critical section.

Line and Grade.

The Contractor shall provide all lines and grades or elevation of the ground at each footing and set the necessary stakes that are required for the work and will be held responsible for their accuracy. Employer may check lines and levels set by the Contractor from time to time, but the responsibility for their accuracy shall rest entirely with the Contractor.

Detail Drawings.

Details of each type of foundation submitted for Employer's approval shall be as shown on the approved design drawings and shall conform to the requirements described hereafter. No change shall be made without the written approval of Employer. The detail drawings shall at least include:

1. Detail dimensions of foundation.

2. Detail of setting dimensions of foundation.

3. Details of placing of all reinforcing steel which shall conform to the Building Code Requirements for Reinforced Concrete (ACI 318) and the Manual of Standard Practice of Detailing Reinforced Concrete Structure (ACI 315) unless otherwise as specified herein.

4. Details of type, size and length of each reinforcing steel including details of bar bending.

6 EARTH WORK

Earth work

Excavation.

Excavation shall conform to the dimensions and elevations as shown on the approved drawings. The general cut slope shall not be steeper than 1: 1.5; however, where the Contractor shall not excavate the slope to satisfy the condition above, temporary supports to the sides of excavations shall be required by means of timbering, sheet piling or shoreing.

When foundations rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation. When subsoil for foundations become mucky on top due to construction operation or any other reason, such subsoil shall be removed and replaced by one or more layers of compacted sand or compacted crushed rock, as directed by Employer.

Excavated materials suitable for use as backfill shall be deposited by the Contractor in storage piles at the area approved by Employer. However, surplus excavated materials shall also be hauled and transported to the disposal area designated by Employer.

Backfill.

The Contractor shall place and compact the backfill materials to the lines, grades and dimensions to be shown on the approved drawings. The materials to be used for backfill, the amount thereof and the manner of depositing the materials shall be approved by Employer.

Payment

No separate or direct payment will be made to the Contractor for earth work in foundations. All costs incurred in connections therewith shall be included in the unit/lump sum bid prices for the construction of various foundations, etc.

7 CONCRETE WORKS

Concrete work shall mean and include all and every concrete work for the civil work. The Contractor shall perform the concrete work in strict conformity to the Specification and as directed by Employer and shall inform Employer at least 24 hours in advance, of the times and places at which he intends to place concrete.

7.1 Composition of Concrete.

General Mix Composition.

The concrete shall be composed of cement, fine aggregate, coarse aggregate, water and admixtures as specified. All materials shall be well mixed and brought to the proper consistency.

The mix proportions shall be as follows:

Minimum compressive strength (28 days)	210 kg/cm^2
Minimum cement content	300 kg/cm^3
Maximum water cement ratio	0.6
Maximum slump	10 cm.

The detailed mix proportion shall be submitted to Employer for approval on the basis of producing concrete having suitable workability, consistency, density, impermeability, durability, and required strength, with concrete compressive strength test records. If 210kg/sq.cm. Strength of 28 days concrete cannot be achieved with the above cement content, more cement shall be used for which the Contractor will not receive any extra payment.

Consistency.

The detailed mix proportions shall be submitted to Employer for approval to secure concrete of the proper consistency and to adjust for any variation in the moisture content or grading of the aggregate as they enter the mixer. Addition of water to compensate for stiffening of the concrete before placing will not be permitted. Uniformity in concrete consistency from batch to batch will be required.

Lean Concrete.

Lean concrete of minimum 5 cm. thickness shall be used under all foundations with the ratio of cement: fine aggregate: coarse aggregate equal to 1:3:5 (by volume)

7.2 Cement

Quality. The Contractor shall furnish normal Portland cement in fifty (50) kg net weight sacks.

The cement for the civil work shall conform to the requirements of "Portland cement, Type I" designated in ASTM C150.Where conditions require the use of high sulphate resistance cement, cement conforming to the requirements of ASTM CISO Type V shall be used without any cost to Employer.

7.3 Coarse Aggregate

Quantity.

Coarse aggregate shall conform to the requirements of ASTM C 33 and shall be either natural gravel or manufactured coarse aggregate. Coarse aggregate shall consist of well-shaped clean, hard, dense, durable rock fragments and shall not contain wood chips and any other impurities.

Grading.

Coarse aggregate shall be graded for each maximum size within the standard limits specified as follows:

Percentage passing by weight

Designation of size in inch (Sieves with square openings)	inch	2 inch	1-1/2 inch	1 inch	3/4 inch	3/8	No.4
40 mm		100	90to	20to	0to	0to	
(1-1/2 to 3/4 inch)			100	55	15	5	
20 mm	-	-	100	90to	20to	0to	
(3/4 inch to No.4)					100	55	10

7.4 Fine Aggregate.

Quality.

Fine aggregate shall conform to the requirements of ASTM C33 and shall be natural sand or manufactured sand. It shall consist of clean, hard, dense and durable rock particles, free from injurious amounts of dust, silt, stone powder, pieces of thin stone, alkali, organic matter and other impurities.

Grading.

The fine aggregate as batched shall be well graded, and when tested shall conform to the following limits:

Sieve size	Percentage passing by weight
9.51mm (3/8 inch)	100
4.76 mm (No.4)	95 to 100
2.38 mm (No.8)	80 to 100
1.19 mm (No.16)	50 to 85
595 micron (No.30)	25 to 60
297 micron (No.50)	10 to 30
149 micron (No.100)	2 to 10

7.5 Admixture.

The Contractor shall use admixture, if required, listed below in order to improve the quality of concrete or mortar such as workability and finishability and water tightness.

Air-entraining agent	- ASTM C260
Water-reducing and set retarding agent	- ASTM C494
Plasticizer	

The cost of the material and all costs incidental to their use shall be included in the unit price bid in the Price Schedule for concrete in which the materials are used.

7.6 Batching and Mixing.

The Contractor shall provide equipment and shall maintain and operate the equipment to produce the required quality of concrete.

When any mixer produces unsatisfactory results, Employer may direct the Contractor to increase the mixing time or repair the mixing blades, and the Contractor shall promptly carry out the directions of Employer.

The order of feeding the materials into the mixer shall be subject to approval of Employer. If concrete is to be mixed by hand, it shall be subject to approval of Employer.

7.7 Placing of Concrete.

General Conditions.

Prior to placing concrete, the Contractor shall submit to Employer for approval the mixed proportion, the characteristics of each materials of concrete, the concrete placing schedule, placing equipment, and method of execution of work. No concrete shall be placed until all formwork, treatment of surface, placing of reinforcement and other parts to be embedded have been inspected and approved by Employer.

Placing of concrete shall not be permitted under the following conditions, unless specifically approved by Employer.

1. When it rains.

2. When illumination is imperfect for night work.

3. When Employer orders to stop.

Preparation for Placing.

Treatment of foundation surfaces. All surfaces of foundation upon or against which the concrete is to be placed shall be cleaned and moistened thoroughly before the placing. When concrete is placed upon or against earth foundations, the Contractor shall, in accordance with the direction of Employer, remove all objectionable substances such as standing water, flowing water, fragments of wood.

Treatment of surfaces of construction joints. Prior to placing the concrete upon or against the hardened concrete, the surface of the construction joints shall be cleaned, moistened and removed of all laitance, defectable or loose concrete, and unsound foreign materials.

Transporting and Conveying.

The concrete which has elapsed more than 60 minutes after being discharged from the mixer and/or in which slump loss exceeds 3.0 cm as it is delivered to the site for placing shall be disposed of at the place designated by Employer. All such wasted concrete shall be borne to the Contractor's account. Concrete shall be placed with a vertical drop not greater than 1.0 m except where suitable equipment is provided to prevent segregation or where specifically authorized.

Concrete which has segregated during transportation shall be remixed. Retempering of concrete shall not be permitted.

Placing.

After the surface of unformed construction joint has been cleaned and the placing of concrete has been approved by Employer in accordance with the provisions of the preceding sub-Articles, surface of unformed construction joint shall be covered with a layer of mortar approximately 1.5 cm thick. The Contractor shall place concrete upon the fresh mortar before it begins to set. The mortar shall be of richer cement content than concrete without coarse aggregate. The cost of the mortar shall be included in the bid unit price for the foundation lot.

Concrete shall be deposited in all cases, as nearly as practicable, directly in its final position and shall not be caused to flow such that will permit lateral movement or cause segregation of the coarse aggregate, mortar or water from the concrete mass.

Consolidation.

Immediately after placing, every layer of concrete shall be consolidated to the maximum practicable density so that it closes snugly against all surfaces of reinforcement bars and embedded fixtures and against all corners of the forms. Consolidation of concrete shall be by electric or pneumatic power-driven, immersion-type vibrators or other approved means.

7.8 **Concrete Construction Tolerance**.

Variation in alignment, grade and dimension of the structures from the established alignment, grade and dimensions shall be remedied or removed and replaced by the Contractor at his own expense.

7.9 **Repair of Concrete**.

The Contractor shall repair at his own expense the imperfections of concrete surfaces and the irregularities which do not meet the specified dimensions. Repairing work shall be performed and completed within 24 hours after the removal of forms, in accordance with the direction of Employer.

7.10 **Curing.**

Prior to placing concrete, the Contractor shall obtain Employer's approval in respect of the method to protect and cure concrete and the facilities he proposes to use. After concrete has been placed, it shall be protected and cured strictly in accordance with the method approved by Employer.

All costs for the curing of concrete shall be included in the unit price bid for foundation lot.

7.11 Forms.

General Conditions.

Forms shall be used, wherever necessary, to confine and shape the concrete to the required lines, and as directed by Employer. Forms shall have sufficient strength to withstand the pressure resulting from placing and vibrating of the concrete, and shall be maintained rigidly in positions. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Each form shall be so prepared that each section may be removed individually without injuring the concrete.

The costs of all labor and materials for forms and for any necessary treatment of coating of forms shall be included in the unit price bid for foundation lot, for which the forms are to be used. No separate payment will be made for form.

Removal of Forms.

Forms shall not be removed without the approval of Employer. As a rule, the forms shall be removed at the following minimum times after concrete has been placed.

Side form of column and wall	2 days
Supporting form of floors and beam	28 days

7.12 Grouting

Grouting for seating structural steel members and equipment on foundations shall be non-shrink (not-setting) Portland cement mortar grout, or a suitable commercially available grout, at the Contractor's option. Grouting shall be done under pressure by means of an expanding agent or by means of a static head. Proportioning and mixing of grout shall conform to the following:

(a) Mortar grout containing aluminum powder as an expansive agent mixture of 1 part cement and 2 parts sand, by weight, with a water-cement ratio not exceeding 0.55. The quantity of aluminum powder used shall be approximately 0.005 percent of the weight of cement, the actual quantity to be determined from tests with materials to be used, and at the temperature and under the conditions of placement. Aluminum powder shall be blended with cement in proportions of one part powder to 50 parts cement, by weight, and the blend shall be sprinkled over the dry batch. After all ingredients are added, the batch shall be mixed for 3 minutes. Grout which has not been placed within 45 minutes shall be wasted.

(b) In lieu of use of an expansive agent, settlement shall be reduced by extending the mixing period or by delaying final mixture to minimize the interval between time of placement and initial set and placement the understatic header pressure. The mortar grout shall be a mixture of one part cement and 2.5 parts sand, with a minimum necessary to enable placement.

Payment:

No separate or direct payment will be made to the Contractor for Grouting. All cost incurred in connection therewith shall be included in the unit sum bid price for the construction of the various foundation types.

7.13 Tests.

The Contractor shall make all necessary tests for determining the mixed proportions of each type of concrete, including tests of aggregates, so as to produce the concrete specified in Item 14.7.1.

In order to control the quality of concrete to be placed, the Contractor shall perform the following field tests:

Slump Test.

A slump test will be made from each of the first three batches mixed each day. An additional slump test will be made for each additional 40 cubic meters of concrete placed in any one day. Slump will be determined in accordance with ASTM C 143.

Compression Test.

Three sets of three concrete compression test cylinders will be made each day when concrete is placed or as directed by Employer. One set of each group will be tested at an age of 7 days and the other set will be tested at an age of 28 days. The third set will be an extra set to be tested only if needed. If the compressive strength indicates a compressive strength of less than 210 kg/sq.cm. Employer will determine what remedial measures are necessary and the Contractor shall perform the remedial measures at his own expense.

Concrete test cubes/cylinders will be made, cured, and stored in accordance with ASTM C31. Concrete cubes/cylinders will be tested in accordance with ASTM C39.

No separate or direct payment will be made to the Contractor for tests. All costs for the tests shall be included in the unit bid price for the construction of various foundation types.

7.14 **Measurement for payment.**

Measurement for payment for the Contract item, "Concrete Foundation" shall be on the basis of the actual unit/lump sum of each type of foundation constructed by the Contractor.

a) Performing detail foundation designs and preparation of construction drawing including bar-bending schedule.

b) Supplying and transporting all foundation materials to job site.

c) Excavating, dewatering, form works, providing 10cm thick soiling layer providing 5cm thick (1M3M6) lean concrete layer, form works and backfilling for the foundations and all other related operations.

8 STEEL REINFORCEMENT.

The Contractor shall place all the reinforcement bars in the concrete structures as shown on the approved drawings and as directed by Employer. The reinforcement bars shall be furnished by the Contractor.

Quality.

The reinforcement bars used for the concrete structure shall be torsteel reinforcing bars and dimensions, shapes, tensile strength, yield point, elongation and other properties, shall conform to BS 1144 or equivalent.

Placing.

Reinforcement bars shall be accurately placed and special care shall be exercised to prevent the reinforcement bars from being displaced during the placement of concrete. Intersecting points and splices of the reinforcement bars shall be fixed by using suitable clips or annealed wires, the diameter of which shall be no less than No.16 gauge. The reinforcement bars in

structures shall be placed and supported by use of concrete blocks, metal spacers, metal hangers or other satisfactory devices to ensure required coverage between the reinforcement bars and the surface of concrete. Drawings of bar lists shall be submitted for approval. The cost of binding wires, cutting and placing of steel bars shall be included in the unit price bid for foundation lot.

Payment

No separate or direct payment will be made to the Contractor for Concrete Reinforcing Steel in foundations. All costs incurred in connection therewith shall be included in the unit bid price for the construction of the various foundation types.

9. SUBSTATION STEEL STRUCTURES

9.1 General Requirements.

The Contractor shall assume full responsibility for design and details of the steel structures and for their satisfactory performance. All designs and details shall be subject to approval of Employer. Employer shall have the right to instruct the Contractor to make any changes to conform to the Contract Document. Elevations of all structures shall be compatible with the existing structures.

No omissions or ambiguities on the drawings or in these Specification will relieve the Contractor from furnishing first class materials and workmanship. Should any inaccuracies be found the Contractor shall notify Employer and any further work done before these discrepancies are corrected will be at the Contractor's risk.

9.2 Materials.

The materials shall conform to the following requirements:

Item	Description	Unit	Minimum Value
1.	Tensile and Yield strength The quality of steel used for support members and bolts.		
1.1	Mild steel (a) Tensile strength	kg/mm^2	24
	(b) Yield strength	kg/mm^2	14
1.2	High strength steel (a) Tensile strength	kg/mm^2	36
	(b) Yield strength	kg/mm^2	20

9.3 Design of Steel Structures.

Design Methods.

The stress analysis shall be conducted by the force diagram method for all type of steel structures. Any computer programs to be employed, shall be prepared or approved by a recognized institute and be submitted to Employer.

Loading Conditions.

In additions to dynamic loads imposed by equipment, steelwork shall be design to withstand simultaneously wind and other loads as follows:

Design Load.

a. Wind Load.

On flat steel surface 121 kg/m^2

For lattice structures 121 kg/m^2 of 1.71 times the projected area of the members of one face of the structure

On line trap, disconnecting switch 50 kg/m^2

On overhead ground wire,
Conductor 75 kg/m^2

On porcelain insulator
Strings and all other section 50 kg/m^2

b. **Human Load.** 240 kg at the center of the beam.

c. **Load due to conductor and weight of equipment and accessories**.

Loads due to the ACSR conductor shall be wind load, dead weight and short circuit forces.

Weight of equipment including insulator string shall be according to actual installation.

Normal Working Condition.

The normal working condition for various loads shall be deemed to work simultaneously. The take-off structure shall be subjected to a vertical uplift of 500 kg. at each supporting point of overhead ground wire and conductor. The tension for conductor and ground wire will be 750 and 350 kg respectively and angle of deviation will be 15^0.

Combination of loads.

The Contractor shall calculate the maximum and minimum stresses at any combinations of loading conditions.

Safety Factors.

The safety factors shall be not less than two (2) times for normal working conditions and 1.5 in combination with short circuit forces.

Design and Ultimate Stress Allowed in Design.

For tensile members of steel structure the design stress shall not exceed the yield point of materials even under test loading condition. For compressive members the design stress shall not exceed the value of the ultimate buckling stress.

Ultimate stress allowed in design shall be as follows :

Members:	
Buckling	As per ASCE Manuals and Reports on Engineering Practice-No. 52.
Tension	less than 1.00 Fy
Bearing	less than 1.80 Fy
Bolts:	
Shear	less than 0.60 Fu
Bearing	less than 1.00 Fu

Where : Fy : Yield point of steel member materials
Fu : Ultimate tensile stress of bolt materials

Limit of Effective Slenderness Ratio.

The effective slenderness ratio (L/r) of members shall meet the following limits:

Leg member, main compression member and ground wire peaks = 120

Other members having computed compressive stresses = 200

Secondary members without computed compressive stresses = 250

Tension member = 350

Where : L : Length of the unsupported panel of member
r : Radius of gyration of members.

In determining the slenderness ratio for various member, suitable provisions shall be taken into consideration for various types of end connections, eccentricity of load transfer in the members etc. The unsupported length "L" shall be considered from centre to centre of intersections or working lines at both ends of members. A single bolt connection shall not be considered as offering restraint against rotation. A multiple bolt connection with minimum two (2) bolts; properly detailed to minimize eccentricities shall be considered to offer partial restraint, if such connection is to a member having adequate strength to resist rotation of joint. Points of intermediate supports shall not be considered as offering full restraint to rotation, if the same is provided only on one flange of the member. For members of double-diagonal web system which are bolted at their point of intersection, max L/r shall be determined from the following criteria:

'L' is the greatest distance from the point of the intersection to either of the end connections and 'r' is the minimum radius of gyration of the member.

'L' is equal to 0.75 times the distance between the end connections and 'r' is the radius of gyration of the member for its axis parallel to the plane of connected leg.

Minimum Thickness and Size of Steel Members.

Minimum thickness and size of steel members of structures shall be as follows:

Calculated members	40x5 mm
All other stressed members and secondary members	not less than L40x4 mm
Gusset plates	not less than 5 mm
Bolts and nuts	M-12 mm

In computing the net section of tension members, the diameter of the bolt holes shall be taken as 3.0 mm greater than the nominal diameter of the bolts. Net section on both straight and zigzag sections across the members shall be as specified in ASCE or BS.

Connections.

a. Bolts. All connections shall be bolted and all stressed members shall be connected by at least one(1) bolt. For structural connections, a maximum of two bolt sizes may be used for each tower type provided the quantity of each size is not less than 20 per cent of the total requirement for the tower and the bolts in any one connection are uniform in size.

b. Splices. The number of splices shall be practically minimum. Splices shall develop the maximum stress in member or seventy (70%) percent of compressive strength of gross section or tensile stress of net section. No credit shall be allowed for bearing on abutting areas.

Design Drawings and Calculation.

The design drawings shall show the following data and information

Scaled line diagram of the steel structures showing all redundant bracing members and their sizes completely dimensioned and proving compliance with all clearance requirements.

All loadings and their manners of application including the determination of wind load (wind load on structure shall be applied at each panel point along the height of the steel structure.)

Calculations showing:

a. Total stresses in each member for each loading case and the critical case.
b. The effective slenderness ratio, calculated stress ratio of maximum total stress to calculated stress for each member and strength of connection.
c. The estimated weight of the complete galvanized steel structures.
d. Size and type of steel for each member and number of bolts required for its connection.
e. The compression and uplift reactions and corresponding horizontal shears at each leg of all steel structures (column and equipment supports) for all loading cases.

9.4 Detailing

Detailing shall be as follows:

General. Steel structure dimensions, framing, member sizes and length, number, size and length of bolts, thickness of each filler, and other necessary details to fabricate each piece shall be shown on the approved detail drawings. No change shall be made without the written approval of Employer.

All web members shall be in one piece where practicable. All double diagonal web system members shall be connected at their point of intersection by at least one bolt.

Step Bolts. Step bolts shall be of 16 mm diameter and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125 mm respectively. Step bolts shall not be used as connection bolts.

The step bolts shall be spaced alternately on the inner gauge line on each face of the angle about 40 cm centers. They shall be furnished for one leg of each steel tower from the base elevation of the steel tower.

Step bolts for lattice single pole or H-frames are not required.

U-Bolts.

U-bolts shall be suitably furnished on steel structures to suspend or terminate insulator strings or ground wire assemblies. Size of U-bolt shall withstand all loads acting on it.

Detail Drawings.

Detail drawings shall be complete with sizes and detail dimensions of all steel structure members. At each joint, there shall be the number, size and length of bolts, number and size of fillers and detail dimensions of gusset plate, if any.

Bill of Material.

Bill of materials shall give the size length and galvanized weight of each member and the total weights of steel structures. It shall also include the number of bolts, nuts and washer per structure.

9.5 Fabrications.

Workmanship.

Workmanship shall be first class throughout. All pieces must be straight, true to detail drawings and free from lamination flaws and other defects. All clipping, backcuts, grindings, bends, holes and etc. must be true to detail drawings and free of burrs.

All identical pieces bearing the same erection number must be exactly interchangeable with each other and interchangeable in their relative position in all towers or structures of which they form a part.

Threads of bolts and nuts shall be cleanly rolled or cut and the face and head of nut shall be truly at right angle to the axis of the bolt.

Cleaning and Galvanizing.

a. Cleaning. After fabrication has been completed and accepted, all materials shall be clear of rust, loose scale, dirt, oil, grease and other foreign substances.

b. Galvanizing. All materials shall be hot-dip galvanized after fabrication and cleaning. Retapping of nuts after galvanizing is not required.

Galvanizing for structural mild steel products shall meet the requirements of ASTM A123. All holes in materials shall be free of excess splinter after galvanizing.

Galvanizing for bolts, nuts, washers, lock nuts, step bolts and similar hardware shall meet requirements of ASTM A153. Excess spelter on bolts, nuts, washers, lockouts , step bolts and similar hardware shall be removed by appropriate means acceptable to Employer.

Finished materials shall be dipped into the solution of dichromate after galvanizing for white rust protection during sea transportation.

c. Uniformity of Coating. The uniformity of coating test shall be made in accordance with ASTM A239. The minimum repetition times for one minute dip in uniformity test shall be as follows :

Steel shapes and plates..... 6
Bolts, nuts and similar hardware.....4

Galvanizing Coating Weight

Description	Thickness	Coating Weight (g/sq.m) Average Value	Coating Weight (g/sq.m) Minimum Value	Uniformity Test Time (1 min./1 time)
Shaped steel	Over 6mm	more than 700	more than 610	more than 6
Steel plates	Under 6mm	more than 610	more than 550	more than 6
Bolts, Nuts & washers etc		more than 470	more than 400	more than 4

d. Straightening after Galvanizing. All plates and shapes which have been warped by the galvanizing process shall be straightened by being rerolled or pressed. The materials shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of Employer, the material has been hardfully bent or warped in the process of galvanizing or fabrication, such defects shall be cause for rejection.

e. Repair of Galvanizing. Materials on which galvanizing has been damaged shall be acid stripped and regalvanized, unless, in the opinion of Employer, the damage is local and can be repaired by zinc spraying or by applying a coating of galvanizing repair compound. Where regalvanizing is required, any member which becomes damaged after having been dipped twice shall be rejected.

f. Shop Assembly. One of each type of steel structure shall be assembled in the shop to such an extent as to insure proper field erection. Reaming of untrue holes will not be permitted. A reasonable amount of drifting will be allowed in assembling. Shop assembled parts shall be dismantled for shipment.

9.6 Shop Test.

The following shop test shall be performed with relevant provisions of the ASTM.

a) General inspection
b) Material tests
c) Assembly test
d) Galvanizing test

The Contractor shall furnish four certified copies of report of all tests to Employer. The cost of all tests and reports shall be borne by the Contractor.

9.7 Payment

Payment for the Contract item, “Steel Structures” will be made at the unit / lump sum price per steel structures type bid therefor in the Price Schedule, which unit/lump sum price shall include full compensation for all costs incurred in furnishing all materials, equipment and labor and all other operations related to steel structure design, fabrication, installation etc.

SECTION - II
TECHNICAL DATA SHEET

Item No. 1: Auto Transformer		**Sheet 1 of 6**
		Offered Data
S.N.	**Bidders/ Description**	**220/132, 315 MVA**
1	Name of manufacturer	
2	Normal full load single phase/three phase output:	
	H.V. Winding (kVA)	
	L.V. Winding (kVA)	
2.1	Temp. Rise as specified in the specification.	
3	Continuous single phase/three phase output under, Site conditions as specified in the specification	
	H.V. Winding (kVA)	
	L.V. Winding (kVA)	
4	Type of cooling and corresponding normal Full load output	
	H.V. Winding (kVA)	
	L.V. Winding (kVA)	
5	Over load capacity starting from Full load and with Temp. as specified in the Specification (kVA)	
6	Normal ratio of transformation	
7	Connection (including vector group reference & Symbol)	
	H. V. Winding	
	L.V. Winding	
8	Type of tap changer	
9	Tapping	
	a) Number	
	b) Range	
	c) Location	
10	Details of Automatic Voltage Regulator	
	(a) Make	
	(b) Model etc.	
	(c) Short description (other)	
11	Type of core construction	
12	i) Temp. rise by resistance of winding (ºC)	
	ii) Temp. rise in oil by thermometer (ºC)	
	iii) Hot spot temp. for which the transformer is designed (ºC)	
13	Limit for hot spot temp. for which the transformer is designed (ºC)	
14	Guaranteed no load loss at rated voltage & rated frequency and 75ºC average winding temperature	
15	Guaranteed load losses at rated current rated voltage, rated frequency and 75 ºC average winding temp. kW (excluding auxiliary losses)	
	for ONAN cooling	
	for ONAF cooling	
	for ODAF cooling	
16	a) Auxiliary losses at rated output – kW	

Item No. 1: Auto Transformer		**Sheet 2 of 6**
		Offered Data
S.N.	**Bidders/ Description**	**220/132, 315 MVA**
	b) Total losses at normal ratio, rated output, rated voltage, rated frequency and maximum attainable temp. at site including auxiliary losses – kW	
	(c) Stray eddy losses as % of total losses	
17	Exciting current power factor (Amp. %)	
	i) At normal voltage & frequency	
	ii) At maximum voltage and normal frequency	
18	Efficiency at 75 ºC Unity P.F.	
	i) On 100% load (%)	
	ii) On 75% load (%)	
	iii) On 50% load (%)	
	iv) On 25% load (%)	
19	Efficiency at 75 ºC 0.8 P.F. (Lag)	
	i) On 100% load (%)	
	ii) On 75% load (%)	
	iii) On 50% load (%)	
	iv) On 25% load (%)	
	v) Load at which maximum efficiency occurs (% of full load)	
20	Maximum efficiency (%)	
21	a) Percentage reactance at rated current and frequency	
	b) Percentage impedance at rated current and frequency at 75 ºC	
	i) Positive sequence	
	ii) Zero sequence	
	c) Range of variation (+,-) offered	
	d) Tolerance applicable if any	
22	Impedance voltage drop at normal ratio at 75ºC expressed as a percentage of normal voltage on full load (%)	
23	Regulation on full load at unity P.F. at 75 ºC expressed as a percentage of normal voltage (%)	
24	Regulation on full load 0.8 P.F. lagging at 75ºC expressed as a percentage in the winding	
25	Maximum current density & c/s area in the winding (Guaranteed and As per SC calculation)	
	i) H.V. (Amp./Sq. cm.)	
	ii) Cross sectional area	
	iii) L.V. (Amp/Sq. cm)	
	iv) Cross sectional area	
26	Maximum flux density in the core	
26.a	Core details	
	i) Material of core lamination	
	ii) Thickness of core plates (mm)	
	iii) Insulation of core lamination	

Item No. 1: Auto Transformer		**Sheet 3 of 6**
		Offered Data
S.N.	**Bidders/ Description**	**220/132, 315 MVA**
	iv) Insulation of core clamping plates	
	v) Press board material & thickness	
	vi) Prime quality grade	
27	Core joints (butt or inter leave)	
28	Type of winding	
	i) H.V.	
	ii) L.V.	
29	Type of radial support	
	i) High Voltage Winding	
	ii) Lower Voltage Winding	
30	Insulation of higher voltage winding	
31	Insulation of lower voltage winding	
32	Thickness of transformer tank plates	
	i) Sides (mm)	
	ii) Bottom (mm)	
	iii) Cover (mm)	
	iv) Radiator (mm)	
33	(A) POWER FREQUENCY WITHSTAND VOLT	
	i) Test voltage for 1 min. P.F. withstand test on live end of high voltage winding (kV rms)	
	ii) Test voltage for 1 min. P.F. withstand test on neutral end of high voltage winding (kV rms)	
	iii) Test voltage for 1 min. P.F. withstand test on live end of low voltage winding (kV rms)	
	(B) IMPULSE TEST	
	i) Test voltage for 1.2/50 micro sec. Full wave withstand test on high voltage winding (kV crest) on	
	ii) Test voltage for 1.2/50 micro sec. Full wave withstand test on low voltage winding (kV crest) on	
34	Inter-turn Insulation	
	i) Extent of end turns reinforcement	
	ii) Extent of reinforcement of turns adjustment to tap	
	iii) Test voltage for 1 min. 50 Hz. Inter-turn insulation test on (i) (kV rms)	
	iv) Test voltage for 1 min. 50 Hz. inter-turn insulation test on (ii) (kV rms)	
	v) Test voltage for 1 min. 50 Hz. inter-turn insulation test on main body of the winding (kV rms)	
35	Type of winding temperature indicator	
36	Maxi continuous ratings	
	i) At 50 C ambient air temp. at site (kVA)	

Item No. 1: Auto Transformer		**Sheet 4 of 6**
		Offered Data
S.N.	**Bidders/ Description**	**220/132, 315 MVA**
	ii) At 40 C ambient air temp. at site (kVA)	
	iii) At 30 C ambient air temp. at site (kVA)	
	iii) At 20 C ambient air temp. at site (kVA)	
37	Details of Air cell	
	Make	
	Type	
	Capacity	
	Size	
38	Width of track gauge (Meters)	
39	Bushing Particulars	
	(a) HV Bushing	
	i) Type of high voltage bushing and creepage distance in mm	
	ii) Rated current	
	iii) STC rating for 3 sec	
	iv) Weight of high voltage bushing in kg	
	v) Quantity of oil in one high voltage bushing Insulator, in litre	
	vi) Dry 1 minute power frequency test voltage value of high voltage bushing in kV	
	vii) Wet 10 second power frequency test voltage value of high voltage bushing in kV	
	viii) Impulse withstand test voltage value with 1.2/50 microsecond full wave of high voltage bushing in kV	
	(b) LV Bushing	
	i) Type of low voltage bushing and creepage distance in mm	
	ii) Rated current	
	iii) STC rating for 3 sec	
	iv) Weight of low voltage bushing in kg	
	v) Quantity of oil in one low voltage bushing Insulator, in litre	
	vi) Dry 1 minute power frequency test voltage value of low voltage bushing in kV	
	vii) Wet 10 second power frequency test voltage value of low voltage bushing in kV	
	viii) Impulse withstand test voltage value with 1.2/50 microsecond full wave of low voltage bushing in kV	
	(c) NEUTRAL Bushing	
	i) Type of low voltage bushing and creepage distance in mm.	
	ii) Rated current	
	iii) Weight of bushing insulator in kg	
	iv) Quantity of oil in one bushing in litres	

Item No. 1: Auto Transformer		Sheet 5 of 6
		Offered Data
S.N.	Bidders/ Description	220/132, 315 MVA
	v) Dry 1 minute power frequency withstand and test voltage value of bushing in kV	
	vi) Wet 10 second power frequency withstand test voltage value of bushing in kV	
	vii) Impulse withstand test voltage with 1.2/50 microsecond fall wave of bushing in kV	
40	Clearance	
	a) Minimum clearance between phase (mtrs.)	
	i) In oil	
	ii) Out of oil	
	b) Minimum clearance of high voltage to earth in oil (mtrs)	
	c) Minimum clearance of high voltage to tank in oil (mtrs)	
41	Net weight of the core (kgs.)	
42	Net weight of copper (kgs.)	
	a) H.V. (kgs.)	
	b) L.V. (kgs.)	
	c) Total (kgs.)	
43	Weight of core and windings	
44	Weight of fittings	
45	Net untanking weight(kgs.)	
46	Weight of tank and cover (kgs.)	
46.1	Tank dimensions	
46.2	Guarantee against leakage for 3 years	
47	Weight of oil in transformer including bushings, conservator and cooling system (kgs.)/Quantity (ltrs.)	
48	Weight of oil in transformer (including bushings) (kgs)	
49	Weight of complete transformer with oil and all fittings (kgs.)	
50	Weight of transformer with all fittings but without oil (kgs.)	
51	Weight of the package to be transported and dimensions	
52	Dimensions of the transformers	
	i) Maximum height upto top of bushings (mtrs.)	
	ii) Overall length (mtrs.)	
	iii) Overall width (mtrs.)	
53	Minimum clear height for lifting core and windings from tank in meters	
54	Details of on load tap changing gear	
	a) Make	
	b) Type	
	c) Rating	
	i) Rated Voltage	
	ii) Rated current	
	iii) Step Voltage	
	iv) STC rating	

Item No. 1: Auto Transformer		**Sheet 6 of 6**
		Offered Data
S.N.	**Bidders/ Description**	**220/132, 315 MVA**
	d) Time for complete tap change (Sec.)	
	e) Diverter selector switch transition time (Cycles)	
	f) Control	
	g) Auxiliary supply details	
	h) Voltage control	
	i) Protection devices	
	j) Value of Maxi. Short circuit current	
	k) Maxi. Impulse withstand test voltage value with 1.2/50 microsecond full wave between switch and ground	
	l) Maxi. Impulse withstand test voltage value with 1.2/50 micro sec. Full wave between the remote terminal and ground with the selector terminal at one end of the range	
	m) Maxi. Power frequency test voltage between switch assembly and range	
	n) Maxi. Impulse withstand test voltage with 1.2/50 micro sec. across the tapping range	
	o) Maxi. Temp. of the tap changer which must not be exceeded during operation :	
	p) Approximate overall weight (kg)	
	q) Approximate overall dimensions (mtrs)	
	r) Approximate overall quantity of oil (kgs.)	
55	No. of operations (approx.) after which the change of oil is necessary :	
56	Any other particulars which need a mention	
57	Cooling calculation shall be submitted	
58	**OIL LOAD TAP CHANGING GEAR**	
	i) Make	
	ii) Type designation	
	iii) Suitable for auto/manual operation (YES / NO)	
	iv) Rated voltage (kV)	
	v) Rated current (Amps)	
	vi) Step voltage (Volts)	
	vii) Number of steps	
	viii) Rated voltage of drive motor (V)	
	ix) List of routine tests to be carried out	
	x) Location of the taps with respect to the terminals of the tapped winding	
	xi) Drawing or pamphlet-number of the technical and descriptive particulars of the OLTC, enclosed with the Bid.	

Signed……As representative for……

Address…….
Date……

ITEM No.2: CONTROL CABLES				**Sheet 1 of 1**
	DESCRIPTION	**UNIT**	***NEA REQ***	**DATA to be Filled**
1	Manufacturer and Country of Origin			
2	Manufacturer's type designation			
3	Type		Armoured	
4	Applicable standard		IEC	
5	***Voltage rating*** Suitable for max. system voltage voltage grade of this cable	 V V	 1000 600/1100	
6	Conductor material	copper		
7	Insulating material		Polyethylene	
8	Overall jacket material		PVC	
9	Fire Retardive	Yes		
10	Mositure Resistant	Yes		
11	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		

Deviations from technical requirements:

Signed…….
As representative for……

Address…….
Date……

ITEM No.3: LV POWER CABLES				**Sheet 1 of 1**
	DESCRIPTION	**UNIT**	***NEA REQ***	**DATA to be Filled**
1	Manufacturer and Country of Origin			
2	Manufacturer's type designation			
3	Type		Armoured	
4	Applicable standard		IEC	
5	***Voltage rating*** Suitable for max. system voltage voltage grade of this cable	 V V	 1000 600/1100	
6	Conductor material	copper		
7	Insulating material		Polyethylene	
8	Overall jacket material		PVC	
9	Fire Retardive	Yes		
10	Mositure Resistant	Yes		
11	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		

Deviations from technical requirements:

Signed……
As representative for……

Address……
Date……

ITEM No.4: GROUNDING SYSTEM				**Sheet 1 of 1**
	DESCRIPTION	**UNIT**	***NEA REQ.***	**DATA to be Filled**
1	Main ground grid conductor material		Copper	
2	Main ground grid conductor size	mm x mm		
3	Depth of Buried Main Ground Conductor	m		
4	Type of Joint above and below Ground level			
5	Material of Risers		Copper	
	Cross section of riser conductors	sq. mm	100	
6	Ground electrode -Material -Diameter -Length	 mm meter	 Copper clad steel 16 as per IEEE 80	
7	Fence Grounding included			
8	Cross Section of Conductor Rise for Fence Grd	Sq.mm		
9	Fence Seperately Grounded by Electrode	Yes/ No	Yes	
10	Calculation for Grounding Grid Length and Conductor Size Furnished	Yes/No	Yes	
11	Earthing system designed for	Ohm	≤1	

Deviations from technical requirements:

Signed…….
As representative for……

Address…….
Date……

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.5: MISCELLANEOUS MATERIALS **Sheet 1 of 2**

	DESCRIPTION	UNIT	*NEA REQ.*	DATA to be Filled
A	**Strain Bus and Fittings**			
1	Manufacturer and Country of Origin			
2	Nominal Sectional Area			
3	Nos. and Size of Wire i. Aluminium ii. Steel			
4	Overall diameter i. Steel Core ii. Complete Conductor			
5	Ultimate Tensile Strength			
6	Continuos Current at 45Deg C			
7	Short Circuit Current, 1sec			
8	Resistance			
9	Weight			
B	**Fittings**			
1	Manufacturer and Country of Origin			
2	Material			
C	*Insulators*			
1	Manufacturer and Country of Origin			
2	Manufacturer's type designation			
3	Applicable standard			
4	Size - Diameter - Height	 mm mm	 254 146	
5	Number of units per string	No.		
6	Combined electrical and mechanical failing load	kg	12000	
7	Creepage distance per unit	mm	292	
8	Impulse withstand voltage	kV	120	
9	Dry power frequency withstand voltage	kV	78	
10	Wet power frequency withstand test	kV	45	
11	Puncture voltage	kV	120	
12	Technical literature submitted	Yes/No		
D	**Post Insulator**	**N/A**		
1	Manufacturer and Country of Origin			
2	Manufacturer's type designation			
3	Applicable standard			
4	Rated system voltage	kV		
5	Maximum rated voltage	kV		
6	Unit size (Diameter)	mm		

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.5: MISCELLANEOUS MATERIALS **Sheet 2 of 2**

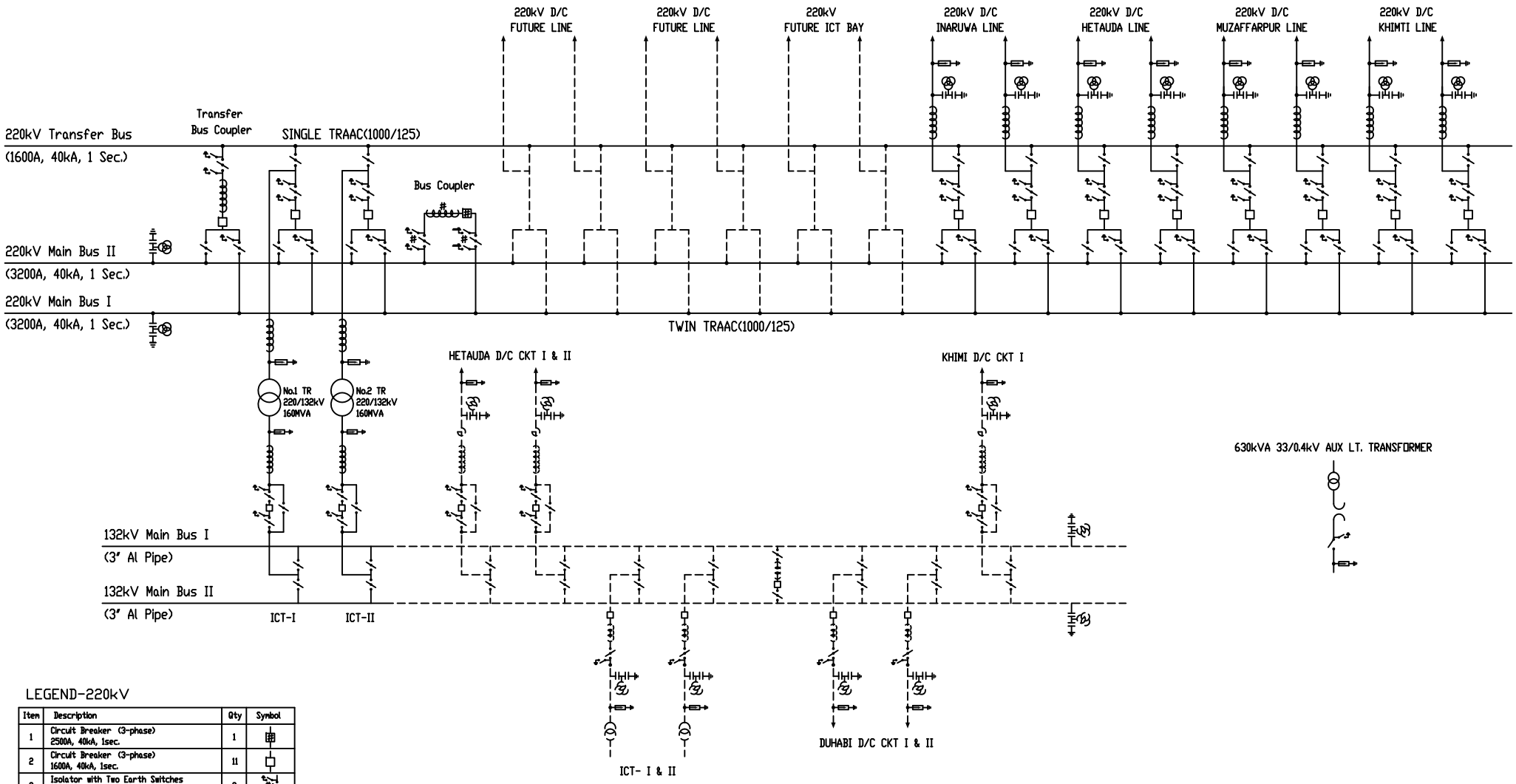
	DESCRIPTION	UNIT	*NEA REQ.*	DATA to be Filled
7	Unit size (Length)	mm		
8	Creepage distance	mm		
9	Insulation level a) Impulse withstand voltage b) Power frequency withstand voltage (1min rms)	 kV kV		
10	Failing load(bending)	kg		
11	Failing load(torsion)	kg-m		
E	**ACSR Conductor**			
1	Manufacturer and Country of Origin			
2	Manufacturer's type designation			
3	Applicable standard			
4	Unit size (Diameter x no of strands)			
5	Overall Cross sectional area			
6	Technical literature submitted	Yes/No	Yes	
F	**Tubular Bus of Aluminium**	**N/A**		
1	Manufacturer and Country of Origin			
2	Nominal Sectional Area			
3	Diameter i. Inner ii. Outer	 mm mm	As per Existing / Specs	
4	Ultimate Tensile Strength			
5	Continuous Current at 45Deg C			
6	Short Circuit Current, 1S			
7	Resistance			
8	Weight			
9	Technical literature submitted	Yes/No	Yes	
G	***Earth Wire***			
1	Manufacturer and Country of Origin			
2	Manufacturer's type designation			
3	Applicable standard			
4	Unit size (Diameter x no of strands)	mm/Nos		
5	Overall Cross sectional area	Sq.mm		
6	Technical literature submitted	Yes/No		

Deviations from technical requirements:

Signed…….
As representative for……

Address…….
Date……

220/132 KV DHALKEBAR SUBSTATION



LEGEND-220kV

Item	Description	Qty	Symbol
1	Circuit Breaker (3-phase) 2500A, 40kA, 1sec.	1	
2	Circuit Breaker (3-phase) 1600A, 40kA, 1sec.	11	
3	Isolator with Two Earth Switches 2500A, 40kA, 1sec. (3-phase)	2	
4	Isolator with Two Earth Switches 1600A, 40kA, 1sec. (3-phase)	11	
5	Isolator with One Earth Switches 1600A, 40kA, 1sec. (3-phase)	11	
6	Isolator (Tandem) without Earth Switches 1600A, 40kA, 1sec. (3-phase)	21	
7	Current Transformer (1-phase) 1600A, 40kA, with 150% Extended Rating	3	
8	Current Transformer (1-phase) 1600A, 40kA, with 120% Extended Rating	33	
9	Capacitor voltage Transformer 5000pf (1-phase)	30	
10	Surge Arrester (1-phase) 216kV	30	

LEGEND-132kV

Item	Description	Qty	Symbol
1	Circuit Breaker (3-phase) 1250A, 31.5kA, 1sec.	2	
2	Isolator with One Earth Switches 1250A, 31.5kA, 1sec. (3-phase)	4	
3	Isolator without Earth Switches 1250A, 31.5kA, 1sec. (3-phase)	6	
4	Current Transformer (1-phase) 800A, 31.5kA, with 120% Extended Rating	6	
5	Surge Arrester (1-phase) 120kV	6	

LEGEND-33kV

Item	Description	Qty	Symbol
1	Auxiliary Transformer 630kVA, 33/0.4kV	1	
2	Isolator with One Earth Switches 1250A, 25kA, 3sec. (3-phase)	1	
3	Horn Gap Fuse (3-phase) 33kV	1	
4	Surge Arrester (1-phase) 30kV	3	

Note:
——— Under present scope
– – – Existing/future

NEPAL ELECTRICITY AUTHORITY

DESIGNATION	NAME	SIGNATURE
DRAWN BY		
CHECKED BY		
APPROVED BY		

DHALKEBAR SUBSTATION
SINGLE LINE DIAGRAM
DRAWING No.