Nepal Electricity Authority

(A Government of Nepal Undertaking)

Transmission Directorate

NEPAL INDIA ELECTRICITY TRANSMISSION AND TRADE PROJECT

Bidding Document
for
Procurement of Plant Design, Supply and Installation of Power Transformer and Reactor for Hetauda & Inaruwa Substations

Single Stage – International Competitive Bidding Procedure

Volume II of III

Issued on:	…….…….
Issued to:	……..
Invitation for Bids No.:	NIETTP/G/ICB-5/TRANS
ICB No.:	NIETTP/G/ICB-5/TRANS
Employer:	Nepal Electricity Authority
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January, 2020

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PROJECT SPECIFICATION REQUIREMENT

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Chapter 1- Project Specification Requirement (PSR)

1.0 GENERAL

1.1 Nepal Electricity Authority is implementing the Hetauda-Dhalkebar-Inaruwa 400kV Transmission Line as a part of the Nepal India Electricity Transmission and Trade Project (NIETTP) which includes the following components:

a) Hetauda-Dhalkebar-Inaruwa 400kV Transmission Line New 220/132/33 kV Substation at Inaruwa

b) 220kV (New) Substation and extension of 132kV substation at Dhalkebar & Hetauda**.**

As part of the above project 285 Km long 400 kV D/C Transmission Line is currently under construction, 2X160 MVA, 220/132 kV Autotransformers at Dhalkebar and 2x160MVA, 220/132kV Autotransformers each at Hetauda & Inaruwa Substations are to be installed. One number of 132/11 kV, 10 MVA power transformer is also to be installed at Hetauda. Further 2x63MVA, 220/33kV Transformers and 25MVAR, 1x132kV Reactor is to be installed at Inaruwa substation. **Power Grid Corporation of India Limited (PGCIL) has been appointed as an Owners Engineer to assist Employer for the execution of works under the Contract. The responsibilities of Owner's Engineer include review of detail design, drawings and other technical documents submitted by the Contractor, supervision during construction, quality assurance, assistance in Factory acceptance testing of major materials, supervision of testing and commissioning of the substations and various contract/project management activities.**

1.2 Associated Transmission System:

The following transmission system is envisaged under the project: -

Transmission lines

1. Hetauda – Dhalkebar 400 kV D/C Lines: 131 km (along with OPGW)
2. Dhalkebar – Inaruwa 400 kV D/C Lines: 154 km (along with OPGW)
3. Muzaffarpur – Dhalkebar 400kV D/C Lines: 140 km (along with OPGW)

   (Part of line i.e. 100 km in India to be constructed by CPTC and balance 40 km in Nepal to be constructed by PTCN)

Besides, following transmission lines are being constructed by NEA under other system strengthening/generation linked schemes: -

1. LILO of 132kV Duhabi- Lahan D/C Lines at Inaruwa Substation
2. Inaruwa- Koshi Corridor 220 kV D/C lines:110 km

3. Hetauda – Bharatpur 220kV D/C Lines: 72 km

Substations

1. Construction of 400/220/132/33kV (New) Substation at Inaruwa.
2. Construction of 400/220kV (New) Substation and extension of 132kV Substation at Dhalkebar & Hetauda substations.

2.0 SCOPE

TRANSFORMER & REACTOR PACKAGE:

The scope of this package covers the following power transformers & Bus Reactor along with tools & testing equipment, all fittings, accessories and marshalling box etc. for each power transformer as per technical specifications.

i) 2 nos. 220/132/33 kV, 160 MVA, 3-Phase Power Transformer for Hetauda substation and 1 nos. 132/11 kV, 10 MVA, 3-Phase Power Transformer for Hetauda substation

iii) 2 nos. 220/132/33 kV, 160 MVA, 3-Phase Power Transformer and 2 nos. 220/33 kV, 63 MVA, 3-Phase Transformer for Inaruwa substation.

iv) 1 no. 145 kV, 25MVAR, 3-Phase Bus Reactor at Inaruwa substation and spare parts for Siemens Make Bus Reactor.

The detailed scope of works is brought out in the subsequent clauses of this Chapter.

2.1 Design, engineering, manufacture, testing at manufacturer's works, transportation, unloading and delivery at site including insurance & storage, erection, testing and commissioning at site, complete in all respect for the above mentioned power transformers and transportation of 1 no. 145 kV, 25MVAR, 3-Phase Bus Reactor stored at Dhalkebar substation to Inaruwa substation, including insurance & storage, loading, unloading, erection, testing and commissioning at site, complete in all respect.

2.2 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies, other contractors and project management.

2.3 The scope includes training of Employer's manpower and testing & commissioning as specified in the Schedules of Rates and Prices.

2.4 The scope includes supply of transformer bushing end terminal connectors suitable for 220kV single Moose ACSR Conductor, 132kV Twin Moose ACSR Conductor, 33kV Twin AAC Bull Conductor and bus reactor bushing end terminal connectors suitable for 145kV single Moose ACSR Conductor and Supply of Testing & maintenance equipment as specified in Schedules of Rates and Prices.

2.5 Design of transformers/Reactor and its associated electrical and mechanical auxiliaries systems includes designs and drawings and relevant documents as required for detailed engineering are covered under the scope of the Contractor.

2.6 The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the Transformers for all the stages from the manufacturer's work to site.

The conditions of roads, capacity of bridges, culverts etc. in the route shall also be assessed by the bidders. The scope of any necessary modification/ extension/ improvement to existing road, bridges, culverts etc. shall be included in the scope of the bidder. The contractor shall carry out the route survey along with the transporter and submit the detail proposal and methodology for transportation of transformers and reactor for approval of Employer within three months from the date of award.

2.7 In Chapter 2 GTR – Transformer & Reactor and other Technical specifications, the term "Purchaser" and/or "Owner" may be read as "Employer".

3.0 SPECIFIC EXCLUSIONS FROM THE SCOPE

The following items are specifically excluded from the scope of this specification:

a) Overhead connection from HV, IV & LV bushings of the Transformers and Bus Reactor to substation equipment.

b) Supply, laying and termination of cables along with necessary accessories from common marshalling box of transformer to RTCC panels which is to be located in switchyard panel room at Inaruwa Substation & in Auxiliary Building at Hetauda Substation.

c) Supply, laying and termination of cables along with necessary accessories from common marshalling box of transformer/Bus reactor to BCU & protection panels and ACDB/DCDB.

d) Earthing connection of Transformers and Bus Reactor to Employer's earthmat and earth electrode.

e) Foundations of Transformers along with jacking pad and pylon supports, rail track and fire resistant wall between Transformers. **However, contractor shall provide all design and drawing of foundations for construction by substation contractor including soil investigation as per requirements.**

f) Foundations of Bus Reactor along with jacking pad and pylon supports, rail track and fire resistant wall between Reactor and capacitor bank.

g) Fire protection system i.e. Hydrant System and High Velocity Water Spray System for Transformers and Bus Reactor.

h) Cable trenches along with covers, road/rail crossings, sump pits etc.

4.0 PHYSICAL AND OTHER PARAMETERS

4.1 **Location of the Substation** – All three substations (Hetauda, Dhalkebar & Inaruwa) of Nepal Electricity Authority are located near East – West Highway Road. For the purpose of transportation of goods, border entry points (with India) are Jogbani for Inaruwa S/S, and Raxaul for Hetauda.

4.2 **Meteorological data : -**

a) Altitude above sea level:

i) Hetauda – 474m, ii) Dhalkebar – 137m iii) Inaruwa – 81m

b) Ambient Air Temperature:

i) Hetauda – 36.5ºC (max)/7.2ºC (min)
ii) Janakpur– 37.4ºC (max)/ 7.7ºC (min) Near Dhalkebar
iii) Biratnagar-35.6ºC (max)/ 8.2ºC (min) Near Inaruwa

c) Average Humidity (in %) :

i) Hetauda – 94.62(max), 53.5(min) ii) Janakpur (near Dhalkebar) – 86.28max), 33.06(min) iii) Biratnagar (near Inaruwa) – 96.72(max), 43.58(min)

d) The substation locations are lying in the wind speed zone 47 m/s.

However, for design purposes, ambient temperature should be considered as 50 degree centigrade and altitude less than 1000m.

5.0 SCHEDULE OF QUANTITIES

The requirement of various items/equipment is indicated in the Schedules of Rates and Prices.

The bill of quantity of major equipment/items/works which are payable on unit rate is indicated in the Schedules of Rates and Prices. Wherever the quantities of items/works are not indicated, the bidder is required to estimate the quantity and incorporate their price in respective Schedules of Rates and Prices.

Bidder should include all such items in the Schedules of Rates and Prices which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning shall be included in the bid price and shall be provided at no extra cost to Employer.

6.0 ORDER OF PREFERENCES OF DIFFERENT CHAPTERS OF TECHNICAL SPECIFICATION

For the purpose of present scope of work, technical specification shall consist of following parts and they should be read in conjunction with each other.

Chapter 1	---	Project Specification Requirement (PSR)
Chapter 2	---	General Technical Requirement (GTR)
Chapter 3	---	220kV Class Specifications for Transformers
Chapter 4	---	145kV Class Specifications for Reactor
Chapter 5	---	Transformer Oil Filtration Plant
Chapter 6	---	Civil Works
Chapter 7	---	Technical Data Sheet (Guaranteed Technical Particulars)

In case of any discrepancy between Chapter 1- PSR, Chapter 2-GTR and other technical specifications on scope of works, Chapter 1- PSR shall prevail over all other Chapters.

In case of any discrepancy between Chapter 2-GTR and individual Chapters for various equipments, requirement of individual equipment Chapter shall prevail.

7.0 APPROVAL OF DRAWINGS/DESIGN DOCUMENTS

Employer shall be responsible for final approval of all drawings and documents. In order to facilitate approval process, contractor shall submit all drawings and documents to Consultant (in 2 sets) & Employer (in 3 sets). Employer shall forward consolidated comments/approval to the contractor.

8.0 TRAINING TO EMPLOYER'S PERSONNEL (at Manufacturer's Works)

Contractor shall provide necessary training to Employer's personnel in the field of design, engineering, operation & maintenance of equipments as per Schedules of Rates and Prices. The Contractor shall include in the training charges Employer trainees' lodging, local transportation, training materials, to and fro economy class air ticket from Nepal to place of training and payment of **USD 100** per Diem allowances per trainee per day for the duration of training.

CHAPTER 2 - GENERAL TECHNICAL REQUIREMENT (GTR)

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1.0 FOREWORD

1.1 The provisions under this Chapter are intended to supplement general requirements for the materials, equipments and services covered under other Chapters of tender documents and is not exclusive. However, in case of conflict between the requirements specified in this Chapter and requirements specified under other Chapters, the requirements specified under respective Chapters shall prevail.

2.0 GENERAL REQUIREMENT

2.1 The bidders shall submit the technical requirements, data and information as per the technical data sheets provided in the bid documents.

2.2 The bidders shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification. An indicative list of such drawings and documents for transformer and reactor are enclosed in **Annexure-A**.

2.3 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to the Employer. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification and the catalogues or the bid, if not clearly brought out in the specific requisite schedule, will not be considered as valid deviation.

2.4 Wherever a material or article is specified or defined by the name of a particular brand, Manufacturer or Vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.

2.5 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the equipment unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal.

3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of bid opening) of standard specified under **Annexure-B** of this Chapter, unless specifically mentioned in the specification.

3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.

3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific **IEC/CIGRE/IEEE/NEMA**.

3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under **Annexure B** / individual Chapters for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out in additional information schedule along with English language version of such standard. The equipment conforming to standards other than specified under **Annexure B** / individual Chapters for various equipments shall be subject to Employer's approval.

3.7 The bidder shall clearly indicate in his bid the specific standards in accordance with which the works will be carried out.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 All equipment shall perform satisfactorily under various electrical, electromechanical and meteorological conditions of the site of installation.

4.2 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

4.3 The equipment shall also comply to the following:

a) To facilitate erection of equipment, all items to be assembled at site shall be "match marked".

b) All piping, if any between equipment control cabinet/ operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

4.4 EHV equipments and system shall be designed to meet the following major technical parameters as brought out hereunder.

4.4.1 System Parameter

Sl. No.	Description of parameters	220 KV System	132 KV System	33 KV System	11 KV System
1.	System operating voltage	220KV	132KV	33KV	11KV
2.	Maximum system operating voltage (rms),Um	245KV	145KV	36KV	12KV
3.	Rated frequency	50Hz	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3	3
5.	Rated Insulation levels				
i)	Full wave impulse withstand voltage(1.2/50 micro sec.)	1050KVp	650KVp	170KVp	75KVp
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	-	-	-	-
iii)	One minute power frequency dry and wet withstand voltage (rms)	460KV	275KV	70KV	28KV
6.	Corona extinction voltage	156KV	105KV	-	-

7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 508kV rms for 765kV, 320KV rms for 400KV system and 156KV rms for 220KV system & 92 KV rms for 132KV system	1000 micro-volt	500 micro-volt	-	-
8.	Minimum creepage distance	25 mm/KV (6125 mm)	25 mm/KV (3625 mm)	25 mm/KV (900 mm)	25 mm/KV (265 mm)
9.a	Min. clearances in air for Transformer & Reactor				
i.	Phase to phase	2300 mm (for BIL-950 kVp)	1220 mm (for BIL-550 kVp)	350 mm (for BIL-170 kVp)	
ii.	Phase to earth	1800 mm (for BIL-950 kVp)	1050 mm (for BIL-550 kVp)	320mm (for BIL-170 kVp)	
9.b	Min. clearances in air for other switchyard equipments				
i)	Phase to phase	2100 mm	1300 mm	320 mm	127 mm
ii)	Phase to earth	2100 mm	1300 mm	320 mm	127 mm
iii)	Sectional clearances	5000 mm	4000 mm	3000 mm	
10.	Rated short circuit current for 1 sec. duration	40 kA	31.5 kA	25 kA	25 kA
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed

Note : The insulation and RIV levels of the equipments shall be as per values given in the respective chapter of the equipments.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The engineering data shall be furnished by the Contractor in accordance with the Schedule for each set of equipment as specified in the Technical Specifications.

5.2 The list of drawings/documents which are to be submitted to the Employer shall be discussed and finalized by the Employer at the time of award.

The Contractor shall necessarily submit all the drawings/ documents unless anything is waived.

5.3 Drawings

5.3.1 All drawings submitted by the Contractor including those submitted at the time of bid shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Each drawing submitted by the Contractor shall be clearly marked with the name of the Employer, the unit designation, the specifications title, the specification number and the name of the Project. If standard catalogue pages are submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in metric units.

5.3.3 Further work by the Contractor shall be in strict accordance with these drawings and no deviation shall be permitted without the written approval of the Employer, if so required.

5.4 The review of these data by the Employer will cover only general conformance of the data to the specifications and documents, interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Employer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

5.5 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor's risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Employer. Approval of Contractor's drawing or work by the Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.6 All engineering data submitted by the Contractor after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

5.7 Approval Procedure

The scheduled dates for the submission of the drawings as well as for, any data/information to be furnished by the Employer would be discussed and finalised at the time of award. The following schedule shall be followed generally for approval and for providing final documentation.

i)	Approval/comments/ by Employer on initial submission	As per agreed schedule
ii)	Resubmission (whenever required) time).	Within 4 (four) weeks from date of comments including both ways postal
iii)	Approval or comments of resubmission.	Within 4 weeks of receipt

iv)	Furnishing of distribution copies in bound volume (5 copies per substation and one copy for Corporate office of Employer)	3 weeks from the date of final approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one copy per substation plus one copy for corporate office of Employer)	3 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (4 copies per substation and two copies for corporate office of Employer)	As per agreed schedule
(vii)	Visual Compact Disk (VCD) highlighting installation and maintenance techniques/ requirements of transformer & reactor (one per substation plus one for corporate office of Employer)	-do-
(viii)	As built drawings on CD/optical Disc (Two sets per substation plus one set for corporate office of Employer)	On completion of entire works

NOTE :

(1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Employer or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

(2) The drawings which are required to be referred frequently during execution should be submitted on cloth lined paper or Laminated Sheets. The list of such drawings shall be finalised with the Contractor at the time of Award.

(3) All major drawings should be submitted in Auto Cad Version 2004 or better.

(4) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(5) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer.

(6) The Contractor shall furnish to the Employer catalogues of spare parts.

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 Incase where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, leveling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

6.1.7 All oil, grease and other consumables used in the Works/ Equipment shall be purchased in Nepal unless the Contractor has any special requirement for the

specific application of a type of oil or grease not available in Nepal. In such is the case he shall declare in the proposal, where such oil or grease is available. He shall help Employer in establishing equivalent Nepal make and Nepal Contractor. The same shall be applicable to other consumables too.

6.1.8 A cast iron or welded steel base plate shall be provided for all rotating equipment which are to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of design with pads for anchoring the units, shall have a raised up all around and shall have threaded in air connections, if so required.

6.2 **Provisions for Exposure to Hot and Humid climate**

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 **Space Heaters**

6.2.1.1 The heaters shall be suitable for continuous operation at 230 V AC supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.1.3 Suitable anti condensation heaters with the provision of thermostat shall be provided.

6.2.2 FUNGI STATIC VARNISH

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

6.2.3 Ventilation opening

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds and suitable provision shall be made so as to avoid any communication of air / dust with any part in the enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc.

6.2.4 Degree of Protection

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall provide degree of protection as detailed here under:

a) Installed out door: IP- 55

b) Installed indoor in air conditioned area: IP-31

c) Installed in covered area: IP-52

d) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.

The degree of protection shall be in accordance with IEC-947 (Part-I)/ IEC 529. Type test report for degree of protection test, on each type of the box shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IEC requirement.

6.3.2 All such nameplates, instruction plates, rating plates of transformers & reactors shall be English.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. which will be required to put the equipment covered under the scope of the specifications, into successful Operation, shall be furnished by the Contractor unless specifically excluded under the exclusions in these specifications and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall note that the equipment offered by him in the bid only shall be accepted for supply. However, the Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Employer & contractor agree upon any such changes, the specification shall be modified accordingly.

7.2 If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Employer. The names of agencies shall be intimated to the successful bidders.

7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Employer (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Corporate Office of Employer, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-contractor's

premises or at the Employer's site or at any other place of Work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the contractor and finalised after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award of contract and finally accepted by Employer after discussion. However, in case detailed valid programme approved by Employer for the equipment already exist, same would be followed till its validity. A quality assurance programme of the contractor shall generally cover the following:

(a) His organisation structure for the management and implementation of the proposed quality assurance programme:

(b) Documentation control system;

(c) Qualification data for bidder's key personnel;

(d) The procedure for purchases of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

(e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;

(f) Control of non-conforming items and system for corrective actions;

(g) Inspection and test procedure both for manufacture and field activities.

(h) Control of calibration and testing of measuring instruments and field activities;

(i) System for indication and appraisal of inspection status;

(j) System for quality audits;

(k) System for authorising release of manufactured product to the Employer.

(l) System for maintenance of records;

(m) System for handling storage and delivery; and

(n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

8.2 Quality Assurance Documents

The contractor would be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of equipment/material

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 All equipment being supplied shall conform to type tests including additional type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective Chapters. Employer reserves the right to witness any or all the tests. The Contractor shall intimate the Employer the detailed program about the tests atleast three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

9.2 The reports for all type tests and additional type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited

laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accredition body of the country where laboratory is located) or witnessed by the representative(s) of Employer or Utility/third party.

In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

9.3 The Employer intends to repeat the type tests and additional type tests on transformers & reactor for which test charges shall be payable as per provision of contract. The price of conducting type tests and additional type tests shall be included in Bid price and break up of these shall be given in the relevant schedule of Schedules of Rates and Prices. These Type test charges would be considered in bid evaluation. In case Bidder does not indicate charges for any of the type tests or does not mention the name of any test in the schedules of Schedules of Rates and Prices, it will be presumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to be rejected.

9.4 The Employer, his duly authorized representative and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times free access to the Contractor's/sub-vendors premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Contractor shall obtain for the Engineer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. Inspection may be made at any stage of manufacture, despatch or at site at the option of the Employer and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.

9.5 The Contractor shall give the Employer /Inspector thirty (30) days written notice of any material being ready for joint testing including contractor and Employer. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer /inspector, unless witnessing of the tests is virtually waived, will attend such tests within thirty (30) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.

9.6 The Employer or Inspector shall, within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer /Inspector giving reasons therein, that no modifications are necessary to comply with the Contract.

9.7 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Employer /Inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Engineer/Inspector. Failure of the Employer /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the

certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Employer.

9.8 In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer /Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer /Inspector or to his authorised representative to accomplish testing.

9.9 The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract.

9.10 The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

9.11 The Employer reserves the right for getting any field tests not specified in respective Chapters of the technical specification conducted on the completely assembled equipment at site. The testing equipments for these tests shall be provided by the Employer.

10. TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Employer will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be provided by the Contractor, free of cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3 The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment. However necessary fee shall be reimbursed by Employer on production of requisite documents.

11.0 PACKAGING & PROTECTION

11.1 All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of

supply, to facilitate the Employer to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes should be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharf age and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Employer takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. High tensile steel nuts & bolts and spring washers shall be electro galvanized to service condition 4. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to equivalent international standards.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

13.3 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the Employer. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

13.4 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.

13.5 Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or

in storage and erection of the equipment at Site. Any demurrage, wharf age and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

13.6 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Employer in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Employer, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.7 Where material / equipment is unloaded by Employer before the Contractor arrives at site or even when he is at site, Employer by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.

13.8 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which require indoor storage.

13.9 The words 'erection' and 'installation' used in the specification are synonymous.

13.10 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.11 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.4.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.12 Equipment Bases

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

14.0 SPECIAL TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles for the erection, assembly, dis-assembly and maintenance of the equipment which are proprietary in nature. However, these tools and tackles shall be separately, packed and brought on to Site.

15.0 AUXILIARY SUPPLY

15.1 The sub-station auxiliary supply is normally met through a system having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under.

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase /Wire	Neutral connection
400V	+/- 10%	50 +/- 5%	3/	Solidly 4 WireEarthed.
230V	+/- 10%	50 +/- 5%	1/	Solidly 2 WireEarthed.

Combined variation of voltage and frequency shall be limited to +/- 10%.

16.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

16.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-439 and the clauses given below:

16.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of sheet steel or aluminum enclosure and shall be dust, water and vermin proof. Sheet steel used shall be atleast 2.0 mm thick cold rolled or 2.5 mm hot rolled. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

16.3 Cabinet/boxes shall be free standing floor mounting type, wall mounting type or pedestal mounting type as per requirements. A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

16.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/ cracked during the operation of the equipment.

16.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved quality plan. The quality of gasket shall be such that it does not get damaged/ cracked during the ten years of operation of the equipment or its major overhaul whichever is earlier. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion and to make a tight seal. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

16.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate projecting at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

16.7 A 230V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

16.8 For illumination of a 20 Watts fluorescent tube or 15 watts CFL shall be provided. The switching of the fittings shall be controlled by the door switch.

16.9 All control switches shall be of rotary switch type and Toggle/piano switches shall not be accepted.

16.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

16.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

16.12 a) The following routine tests alongwith the routine tests shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 including application of, 2.5 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

17.0 SUPPORT STRUCTURE

17.1 The support structures to be supplied by the contractor for the tertiary arrangement should be hot dip galvanised with minimum 610 gram/sq.m net of zinc.

17.2 Support structure shall meet the following mandatory requirements:

17.3 The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

18.0 TERMINAL BLOCKS AND WIRING

18.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles will be made through terminal blocks.

18.2 Terminal blocks shall be 650 V grade and have continuous rating to carry the maximum expected current on the terminals. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. The terminal blocks shall be non-disconnecting stud type equivalent to Elmex type CATM4, Phoenix (cage clamp type), Wago or equivalent.

18.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

18.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

18.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

18.6 The terminal blocks shall be of extensible design.

18.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

18.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

18.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

a)	All circuits except CT circuits	Minimum of two of 2.5 sq mm copper flexible.
b)	All CT circuits	Minimum of 4 nos. of 2.5 sq mm copper flexible.

18.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.

18.11 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge overvoltges either transferred through the equipment or due to transients induced from the EHV circuits.

18.12 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment

19.0 LAMPS AND SOCKETS

19.1 Lamps

All incandescent lamps shall use a socket base as per IS-1258, except in the case of signal lamps.

19.2 Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard plugs. They shall be switched sockets with shutters.

19.3 Hand Lamp:

A 230 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

19.4 Switches and Fuses:

19.4.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

19.4.2 All fuses shall be of HRC cartridge type mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

20.0 Bushings, Hollow Column Insulators, Support Insulators:

20.1 Bushings shall be manufactured and tested in accordance with IEC:60137 while hollow column insulators shall be manufactured and tested in accordance with IEC

233. The support insulators shall be manufactured and tested as per IEC 168 and IEC 273. The insulators shall also conform to IEC 815 as applicable.

The bidder may also offer composite silicon rubber insulator, conforming to IEC-1109.

20.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

20.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

20.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

20.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

20.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

20.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

20.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with International Standards. The type test reports shall be submitted for approval.

Annexure –A

INDICATIVE LIST OF DRAWINGS FOR TRANSFORMER & REACTOR

1. Outline General Arrangement (OGA)drawing of transformer & reactor
   a) Plan
   b) Elevation
   c) End View
   d) Neutral formation of three phase bank

   List of all accessories with detailed weights, dimensions, clearances, spacing of wheels in direction, center of gravity, location of cooler etc.

2. Foundation Plan showing reaction at points of support, clamping arrangement & location of jacking pads.
3. Technical Data requirement sheet of transformer & reactor
4. Over fluxing withstand duration curve
5. Schematic wiring and diagram of cooling arrangement along with write up on scheme
6. Schematic wiring and diagram of OLTC along with write up on scheme
7. Mounting Arrangement and wiring diagram of remote WTI along with write up
8. Bushing Drawing showing electrical and mechanical characteristics
   a) HV Bushing
   b) LV Bushing
   c) Neutral bushing
9. Outline and General Arrangement of Cooler Control Cabinet
10. Cooler Control cabinet schematic and wiring diagram
11. Magnetisation Characteristics of bushing CTs
12. Hysteresis Characteristics of iron core
13. Rating and Diagram Plate
14. Overall Transport dimension Drawing of transformer & reactor
15. Drawing showing typical sectional view of the windings with details of insulation, cooling circuit method of cooling and core construction etc.
16. Oil Flow Diagram
17. Valve Schedule Plate drawing
18. Twin Bi-directional Roller
19. Connection Diag.of all protective devices to marshalling box showing physical location
20. List of spares
21. Technical Literature on all fittings and accessories.
22. Calculation to support short circuit withstand capacity of transformer & reactor
23. Calculation of hot spot temperature
24. Value of air core reactance with a typical write-up of calculation
25. Oil sampling Bottle details
26. Typical heating and cooling curves
27. OGA of RTCC panel
28. **RTCC panel schematic and wiring diagram**
29. **Outline and General Arrangement drawing of Common Marshalling Box**
30. **Schematic wiring and diagram of Common Marshalling Box**
31. **OGA of Ladder for transformer & Reactor**
32. **Transformer oil storage tank drawing**
33. **33 KV Neutral CT drawing and technical data sheet**
34. Customer inspection schedule
35. Test procedure of transformer & reactor
36. Type test Reports of transformer & reactor
37. O & M manual of transformer & reactor

ANNEXURE - B

LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

IEC-60 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 66	-	Environmental Test
IEC-117	-	Graphical Symbols
IEC-156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-270,	-	Partial Discharge Measurements.
IEC-376 Hexafluoride	-	Specification and Acceptance of New Sulphur
IEC-437	-	Radio Interference Test on High Voltage Insulators.
IEC-506,	-	Switching Impulse Tests on High Voltage Insulators.
IEC-507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-6094	-	Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniques for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements

CSA-Z299.4-1979h - Inspection Program Requirements

TRANSFORMERS & REACTORS

IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests – External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide
IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044	Current transformers
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear
IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by

	Enclosures
IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG ,Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)

Clamps & connectors

NEMA-CC1	-	Electric Power connectors for sub station
NEMA-CC 3	-	Connectors for Use between aluminium or aluminum-Copper Overhead Conductors

Wires and cables

ASTMD-2863	-	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IEC-96 (part 0 to p4)	-	Radio Frequency cables.
IEC-183	-	Guide to the Selection of High Voltage Cables.
IEC-189 (P1 to P7)	-	Low frequency cables and wires with PVC insulation and PVC sheath.
IEC-227 (P1 to P7)	-	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.
IEC-228	-	Conductors of insulated cables
IEC-230	-	Impulse tests on cables and their accessories.
IEC-287 (P1 to P3)	-	Calculation of the continuous current rating of cables (100% load factor).
IEC-304	-	Standard colours for insulation for low-frequency cables and wires.
IEC-331	-	Fire resisting characteristics of Electric cables.
IEC-332 (P1 to P3)	-	Tests on electric cables under fire conditions.
IEC-502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	-	Tests on gases evolved during combustion of electric cables.
Galvanizing		
ASTM-A-123	-	Specification for zinc (Hot Galvanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.
ASTM-A-121-77	-	Zinc-coated (Galvanized) steel barbed wire
Painting		
ANSI-Z551	-	Gray finishes for industrial apparatus and equipment
SSPEC	-	Steel structure painting council
HORIZONTAL CENTRIFUGAL PUMPS		
API-610	-	Centrifugal pumps for general services
	-	Hydraulic Institutes Standards
BS:599	-	Methods of testing pumps
PTC-8.2	-	Power Test Codes - Centrifugal pumps

CHAPTER 3 – 220kV CLASS SPECIFICATION FOR TRANSFORMERS
(Transformer up to 220 kV class)

Table of Content

1. General

1.1. This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2. The transformers shall in general have constant ohmic impedance between HV and IV on all taps. However, in case of parallel operation with the existing transformer,

i) The percentage impedance, vector group, OLTC connection and range etc. of the transformer is to be matched with that of the existing transformer.

ii) Necessary provision is to be kept in the transformer control scheme for parallel operation with the existing OLTC control scheme having provision of Master/Follower/Independent /Off operation etc.

iii) External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances

1.3. Matching of physical orientation, mounting rail gauge etc. shall be done to facilitate inter-changeability.

2. Transportation

2.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

2.2. The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the contractor.

2.3. The inland transportation of the Transformer shall be on trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the Transformer for tracking the Transformer during transit.

2.4. All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

2.5. The Contractor shall dispatch the transformer filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. A

dry air pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. Generally, the duration of the storage of transformer at site with dry air, shall preferably be limited to three months, after which the Transformer shall be processed as per the recommendation of manufacturer if not filled with oil. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.

In case turret, having insulation assembly, is transported separately then positive dry air pressure shall be ensured.

2.6. Transformer shall also be fitted with Electronic impact recorders (on returnable basis) at least 1 number for 220 kV and below class Transformers during transportation to measure the magnitude and duration of the impact in all three directions. The mounting location of impact recorder shall be finalised during detailed engineering. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed"3g" for 50mSec (20Hz) or as per contractor standard, whichever is lower.

3. Performance

3.1. The transformers shall be used for bi-directional flow of rated power. The major technical parameters of single phase and three phase transformer units are defined at **Annexure – A.**

3.2. Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as ONAF up to specified load and then as OFAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg C. Transformers fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140deg C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

3.3. The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. In general, oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers. The manufacturer shall ensure that there is no electrostatic charging tendency in the design.

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

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

3.5.1. Tank hotspot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

3.6. The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, 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 2 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

220kV system	- 40 kA for 1 sec (sym, rms, 3 phase fault)
132kV system	- 31.5 kA for 1 sec (sym, rms, 3 phase fault)
33kV system	- 25 kA for 1 sec (sym, rms, 3 phase fault)
11kV system	- 25 kA for 1 sec (sym, rms, 3 phase fault)

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e. $Z_s = 0$).

3.7. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.

The transformer shall be designed to withstand for short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

3.8. 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 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.

3.9. Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

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

3.10. **Tertiary Windings (if applicable as per Annexure - A)**

The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching and shall be suitable for connection to LT Transformer for auxiliary supply. All the windings shall be capable of withstanding the stresses which may be caused by such switching.

The Tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

3.11. **Radio Interference and Noise Level**

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

The noise level of transformer, when energised at normal voltage and frequency with fans and pumps running shall not exceed the values specified at **Annexure - A**, when measured under standard conditions.

3.12. **Dynamic Short Circuit Test requirement**

3.12.1. **For 220 kV Class Transformer:**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 220 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 220 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 220 kV class transformers shall be carried out based on design of short circuit tested 220 kV or above voltage class transformer.

4. Measurable Defects

The following shall constitute as Measureable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

5. Design review

5.1. The transformer 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. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure – E**.

5.2. Design reviews shall be conducted by Purchaser or an appointed consultant during the procurement process for transformers; however the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

The design review will commence after placement of award and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope. It shall be conducted generally following the "Guidelines for conducting design reviews for transformers - Guidelines for conducting design reviews for power transformers working group A2.36 Task Force 2 (Replaces TB 204).

5.3. The manufacturer shall provide all necessary information and calculations 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.

5.4. **The validity of Type tests (except dynamic short circuit test) of Transformer shall be 5 years as on the date of NOA,** provided that offered transformer is of same design as that of type tested transformer and active materials like – CRGO, copper conductor and insulation material are of same or better grade with respect to type tested unit. Failing which, type testing of transformer shall be carried out by the contractor at his own cost. Further, type test report of Transformer from the same manufacturing plant shall only be acceptable. With regard to Validity of Dynamic short circuit test, refer clause 3.12 above.

6. Construction Details

The construction details and features of transformer shall be in accordance with the requirement stated hereunder. .

6.1. Tank

6.1.1. Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062.

6.1.2. All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS 9595. After fabrication 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/IS 10801.

6.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

6.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint 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 at the joint.

6.1.5. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

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 at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

6.1.6. The tank shall be designed in such a way that it can be mounted either on the plinth directly or on rollers, as per manufacturer's standard practice.

6.1.7. 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 damage when using plates or rails.

6.2. Tank Cover

6.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the Buchholz relay.

6.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

6.2.3. The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets (for OTI, WTI & RTDs including two spare pockets) shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

6.2.4. 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.

6.2.5. To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

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

6.2.7. **Gas venting** - The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

6.3. **Gasket for tank & cover**

All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints shall preferably of O-ring and groove type. The Gaskets / O-Ring in contact with oil shall be Nitrile rubber or any other better approved quality.

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.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

6.4. **Roller Assembly and Anti Earthquake Clamping Device**

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. The rail track gauge shall be 1676 mm. In case rail is not required for smaller rating Transformers, arrangement of unidirectional roller mounted on channel shall be provided and channel shall be locked with the plinth suitably.

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

6.5. **Conservator**

6.5.1. Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

6.5.2. 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 top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

6.5.3. The conservator shall be fitted with 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 as applicable.

6.5.4. Conservator shall be positioned so as not to obstruct any electrical connection to transformer.

6.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

6.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110ºC during operation. As such air cell used shall be suitable for operating continuously at this temperature.

6.5.7. 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, and the recommended replacement intervals.

6.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

6.5.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long life characteristics shall be preferred.

6.5.10. OLTC shall have conventional type conservator (without aircell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

6.6. **Piping works for conservator**

6.6.1. Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

6.6.2. 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. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle not less than 5 degrees. The. feed pipe diameter for the main conservator shall be not less than 80mm. The Gas-venting pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

6.6.3. A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

6.6.4. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

6.7. Dehydrating Silicagel Filter Breather

Conservator of Main Tank and OLTC shall be fitted with a dehydrating silicagel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such 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 crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.
f) To minimise the ingress of moisture, two in series of identical size shall be connected to OLTC Conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.

6.8. Pressure Relief Device

Adequate number of pressure relief devices (at least 2 numbers) shall be provided at suitable locations preferably close to bushing turret/ cover. These shall have opening diameter of at least 100 mm for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (**with plug & socket type arrangement)**

per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

6.9. **Sudden Pressure Relay**

One number of Sudden Pressure relay with alarm/trip contacts **(Terminal connection plug & socket type arrangement**) shall be provided on tank of transformer. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay

6.10. **Buchholz Relay**

Two numbers double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the Transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Transformer shall be collected 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 tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

6.11. **Oil Temperature Indicator (OTI)**

All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be ± 3.0 deg C or better or better for a temperature of 100 deg C. The setting of alarm and tripping contacts shall be adjustable at site.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

Temperature transducer with Pt100 sensor

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC panel / BCU for further transfer data to SCADA through IEC 61850 compliant communications.

6.12. **Winding Temperature Indicator (WTI)**

All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of WTI shall be ± 3.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IEC 61850 compliant communications.

6.13. The temperature indicators (OTI & WTI) 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.

6.14. **Earthing Terminals**

6.14.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

6.14.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

6.14.3. Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

6.14.4. Each transformer unit should have provision for earthing and connected to grounding mat when not in service. For this purpose, neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

HV & IV Terminals shall also be earthed through neutral by flexible copper connection. Contractor shall provide suitable arrangement for the above.

6.15. **Core**

6.15.1. The core shall be constructed from non-ageing, cold rolled high permeability grade (as per BIS / IEC) or better grain oriented silicon steel laminations. Indian transformer manufacturers shall use core material as per above specification with BIS certification.

6.15.2. 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.

6.15.3. 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 10% over voltage and maximum ambient air temperature conditions of 50 deg C. Adequate temperature margin shall be provided to maintain the long life expectancy for this material.

6.15.4. 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.

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

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

6.15.7. 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.

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

6.15.9. The core shall be earthed to the core clamping structure at one point only, through a removable external link of minimum size of 80 sq. mm copper suitably located and protected to facilitate testing after installation of the transformer. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the outside of tank cover.

6.15.10. 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.

6.16. **Windings**

6.16.1. The Contractor shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

6.16.2. The conductors shall be of electrolytic grade copper free from scales and burrs.

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

6.16.4. 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.

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

6.16.6. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

6.16.7. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

6.16.8. The barrier insulation including spacers shall be made from high- density pre-compressed pressboard (1.1 gm/cc minimum for load bearing and 1 gm/cc minimum for non-load bearing) to minimize dimensional changes.

6.16.9. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

6.16.10. Wherever required, electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit.

6.16.11. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

6.16.12. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

6.16.13. The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

6.17. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

6.18. **Winding terminations into bushings**

6.18.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

6.18.2. The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

6.18.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

6.18.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

6.18.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

7. Paint system and procedures

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – F**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

8. Unused inhibited Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified at **Annexure – G**, while tested at oil supplier's premises. The

contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – G**, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and thereafter be brought up to the specified parameter by circulation within the transformer. The Unused inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at **Annexure – G**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Inhibited oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil (in line with IEC 60076-3) which shall be supplied at site and shall meet parameters as per specification.

8.1. **Particles in the oil**

The particle analysis shall be carried out in an oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17 - "Effect of particles on transformer dielectric strength".

8.2. **Moisture content in the solid insulation**

Dummy insulation test block (2 Nos.) shall be inserted in the active part of Transformer at factory and same shall be used to detect the volume of moisture content. Manufacturer to ensure that moisture content in the dummy insulation test block is less than 0.5% after drying process of solid insulation. Out of two dummy blocks, one block shall be used during manufacturing stage and another one shall be sent with Transformer at site. Before application of vacuum and oil filling, the 2nd dummy block shall be used for DP Test (Degree of polymerisation).

To review the moisture content in the active part insulation at site during erection, Dew Point method shall be applied.

8.3. **Oil filling**

8.3.1. Procedures for site drying, oil purification, oil filling etc. shall be done as per EMPLOYER Field Quality Plan (FQP).

8.3.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point 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.

8.3.3. Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relay.

8.3.4. 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.

8.3.5. The Ultra High Vacuum type oil treatment plant (on returnable basis) of adequate capacity (**generally 6000** litres per hour and above) suitable for treatment of oil in EHV class Transformer shall be used. The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
vi) Processing temperature shall be automatically controlled and have an adjustable range from 40ºC to 80ºC.

The above oil treatment plant (Filtration unit) shall be arranged by the bidder at his own cost.

8.3.6. **Transportation of Oil**

The insulating oil for the Transformer shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in Transformer due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case before contract closing. However, the spare oil shall be delivered in non-returnable drums.

9. Bushings

9.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

9.2. Bushing for voltage of 52 kV and above shall be RIP bushing with composite polymer insulator. 36 kV and below voltage class bushing shall be solid porcelain or oil communicating type.

9.3. RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

9.4. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

9.5. Bushings of identical rating shall be interchangeable to optimise the requirement of spares. Mounting dimensions of bushing shall be as per drawing mentioned at **Annexure – D**.

9.6. 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.

9.7. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587**.** The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

9.8. Clamps and fittings shall be of hot dip galvanised/stainless steel.

9.9. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

9.10. No arcing horns shall be provided on the bushings.

9.11. RIP Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct

contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

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

9.13. Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

9.14. If the bushing Tan delta goes beyond 0.005 or increase is more than 0.001 within the warrantee period w.r.t. pre-commissioning values, the contractor shall arrange to replace the defective bushing by new one. No temperature correction factor shall be applicable for tan delta.

10. Neutral Formation and Earthing Arrangement

10.1. For 3-Phase Unit

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase 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 12 mm galvanised steel flats connected to Employer's grounding mat.

11. Cooling Equipment and its Control

11.1. Cooling Equipment for Radiator Bank

11.1.1. The cooler shall be designed using radiator banks or tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

11.1.2. In case of separately mounted radiator bank arrangement, the main tank shall have provision such that cooler banks can be placed on either side of the main tank without the need of any extra member/pipe maintaining the electrical clearances.

11.1.3. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1 mm. Each radiator bank shall be provided with the following accessories:

(a) Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
(b) Top and bottom shut off valve
(c) Drain Valve and sampling valve
(d) Top and bottom oil filling valves
(e) Air release plug
(f) Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised steel flats.
(g) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(h) Lifting lugs

11.1.4. Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.

11.2. If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators shall be provided to record temperature during temperature rise test.

11.2.1. One number standby fan shall be provided with each radiator bank.

11.2.2. Cooling fans shall not be directly mounted on radiator. It may cause undue vibration. These shall be located so as to prevent ingress of rain water. 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.

11.2.3. Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

11.2.4. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.

11.2.5. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

11.2.6. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325 / IEC 60034. Each cooling fan and oil pump 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 as per IS: 4691/ IEC 60034-5.

11.2.7. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

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

11.3. **Cooling Equipment Control for Radiator banks**

11.3.1. Automatic operation control of fans/pumps 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 over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

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

11.3.3. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

11.3.4. In addition to the traditional starting of fan and pump by winding & oil temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds. Furthermore, a one-week timer is required to check the healthiness of the cooling system on a routine basis for one hour at a time.

11.3.5. Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan failure for each bank
f) Cooling pump failure for each pump
g) 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 and for single ph. unit connection shall be extended further to CMB.

11.3.6. The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature 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/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

11.3.7. All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box (in case of 1-Ph unit) or Marshalling Box (3-Ph unit).

11.3.8. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Details of station auxiliary power supply are mentioned in GTR.

11.4. Auxiliary Power Supply for OLTC, Cooler Control and Power Circuit

11.4.1. For Three Phase Transformer

11.4.1.1. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided by the Purchaser at cooler control cabinet / Marshalling Box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the cooler control cabinet / Marshalling.

11.4.1.2. For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor

Box etc. (as applicable), shall be provided by contractor in cooler control cabinet/ Marshalling.

11.4.1.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the contractor. Further any special cable (if required) from MB to Owner's Control Panels/Digital RTCC panels is also in the scope of the contractor.

11.4.2. **Design features of the transfer scheme** 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/Individual Marshalling Box/Common Marshalling Box 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.

11.5. **Valves**

11.5.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

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

11.5.3. Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.

11.5.4. All valves flanges shall have machined faces. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

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

11.5.6. The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

11.5.7. Valves or other suitable means shall be provided to fix various on line condition monitoring systems to facilitate continuous monitoring. The location & size of the same shall be finalised during detail design review.

11.5.8. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank.

b) A valve which shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

c) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. Glass window for visual inspection similar to Buchholz glass inspection window shall be provided for physical checking of status of valve. It shall have IP 67 class degree of protection. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset.

11.5.9. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

11.5.10. All hardware used shall be hot dip galvanised / stainless steel.

12. Cabling

12.1. All interconnecting control and power cables between various parts of Transformers like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc as required shall be considered included in the scope of supply.

13. Tap Changing Equipment

Each transformer shall be provided with Off load tap / On Load Tap changing equipment as specified elsewhere.

13.1. Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energised, shall be fitted.

13.2. ON Load Tap Changing (OLTC) Equipment (Vacuum or Oil type)

13.2.1. **Main OLTC Gear Mechanism**

13.2.1.1. Each single / 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.

13.2.1.2. OLTC shall be motor operated suitable for local as well as remote operation. 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 auxiliary 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. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

13.2.1.3. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

13.2.1.4. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank.

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

13.2.2. **Local OLTC Control Cabinet (Drive Mechanism Box)**

Each transformer unit of OLTC gear shall have following features:

13.2.2.1. OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

13.2.2.2. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting.
- Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
- The manual control considered as back up to the motor operated on 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 voltage and vice-versa.

- 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.

13.2.2.3. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

13.2.2.4. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

13.2.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in Section - GTR. In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

13.2.2.6. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.

13.2.2.7. Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

13.2.2.8. OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.

13.2.2.9. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/ Digital RTCC/SCADA etc. shall be

executed. The remote-local selector switch shall be having at-least two spare contacts per position.

13.2.2.10. Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch position
f. OLTC upper/lower limits reached

13.2.2.11. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification.

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

13.3. **Digital RTCC Panel**

13.3.1. The digital RTCC relay shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC.

13.3.2. For new substation, the contractor shall provide Digital RTCC panel consisting of 4 Nos. Digital RTCC relays. Further, one spare Digital RTCC relay shall also be provided in the same panel. Each digital RTCC relay shall be used to control 1 bank of transformers (i.e. 3 Nos. 1-Phase units or 1 No. 3-Phase unit),

For existing substations, the requirement of digital RTCC panel and relays are specified in Section-Project Specific Requirements/BPS. However, bidders are advised to get clarified about the availability of existing RTCC schemes /Digital RTCC relays to finalise matching digital RTCC relays requirements. The Digital RTCC relays envisaged for existing transformers shall be integrated for parallel operations. All required cables for the same shall be included in the scope.

13.3.3. Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

13.3.4. The RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ Off mode selection features for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

13.3.5. **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

13.3.6. **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

13.3.7. **Master / Follower/ Independent/ Off mode**

Master / Follower parallel operation is required with Group simultaneous feature in Digital RTCC relay. Master-follower scheme implies that controlled decision shall be taken by the Master and control actions (Raise/Lower tap position) shall be executed simultaneously by Master & Follower units. Same logic needs to be implemented in digital RTCC relays.

Master Position: If the digital RTCC relay is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the digital RTCC relay is in Follower position, control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected.

Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

13.3.8. **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers / 3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

13.3.9. Digital RTCC relays shall communicate with SCADA using IEC 61850 through FO port to monitor, parameterise & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC- 61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate up to

distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder.

13.3.10. The Digital RTCC relay shall have additional programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

13.3.11. The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

13.3.12. Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local / Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm
g. OLTC Tap position indications for transformer units
a. Independent-combined-remote selector switch positions of CMB (In case of single phase transformer)
b. 415V, AC Mail Supply Fail.
c. 415V, AC Standby Supply Fail

13.3.13. In case of parallel operation or 1-Phase Transformer unit banks, OLTC out of step alarm shall be generated in the digital RTCC relay for discrepancy in the tap positions.

14. SCADA Integration

All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) etc. provided for individual transformer unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in IMB or CMB by the contractor. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) upto IMB (for 3-Ph unit) or CMB (for 1-Ph unit) shall be in the scope of contractor. All cable from RTCC to DM shall also be in the scope of contractor. Further, any special cable between IMB (for 3-Ph unit) or CMB (for 1-Ph unit) to switchyard panel room/control room shall be in the scope of contractor.

However, fiber optic cable, power cable, control cables, as applicable, between IMB (for 3-Ph unit) or CMB (for 1-Ph unit) to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant

equipment with Substation Automation System shall be under the scope of sub-station contractor.

15. Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Junction Box / Outdoor cubicle and Digital RTCC Panel

15.1. Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box, Digital RTCC panel (as applicable) shall be provided.

15.2. The cooler control cabinet / individual marshalling box, Junction box and all other outdoor cubicles (**except OLTC Drive Mechanism box**) shall be made of stainless steel sheet of minimum thickness of 1.6 mm. Digital RTCC panel shall be made of CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure – F**.

15.3. The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

15.4. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400 or equivalent International standard.

15.5. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

15.6. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

16. Current Transformer

16.1. Current transformers shall comply with IEC-61869-1 and 61869-2.

16.2. It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

16.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

16.4. For 1-Phase Transformer, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of transformer and shall be located in the neutral conductor connecting common neutral point with earth.

16.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – H.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

16.6. Secondary resistance and magnetising current characteristics of PX class (protection) (as per IEC) CT of same rating shall be similar. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

17. Hand Tools (if specified in BPS)

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 used - 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), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied.

18. Test Kit (if specified in BPS)

BDV Kit as per Annexure-I of specification
Portable DGA Kit as per Annexure-I of specification

19. Fittings & accessories

The following fittings & accessories shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the transformer are deemed to be included.

a. Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge, prismatic oil level gauge and dehydrating silicagel filter breather with flexible connection pipes to be used during replacement of any silicagel breather

b. Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and dehydrating breather

c. Pressure relief devices

d. 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 / trip contacts.

e. Air release plug

f. Inspection openings and covers

g. Bushing of each type with metal parts and gaskets to suit the termination arrangement

h. Winding & Oil temperature indicators

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

j. Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator as applicable

k. Rating and diagram plates (in English) on transformers and auxiliary apparatus

l. Roller Assembly (as per clause 6.4)

m. On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable

n. Cooling equipment

o. Bushing current transformers, Neutral CT (if applicable)

p. Oil flow indicators (if applicable)

q. Terminal marking plates

r. Valves schedule plate

s. Bottom oil sampling valve, Drain valves, Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank and Transformer tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valve for on line DGA, valves for Drying out system, Flow sensitive conservator Isolation valve, Valve for UHF sensors, valves for NIFPS system (if applicable) etc.

t. Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition

u. Suitable Platform for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from transformer top.

v. Haulage lugs

w. Neutral bus connection arrangement (3-Phase Transformer)

x. Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral, HV & IV terminals as per clause 6.14.4.

y. On line insulating oil drying system(if specified in BPS) as per **Annexure-K**

z. Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment (if specified in BPS) as per **Annexure-J**

aa. Nitrogen Injection Type Fire Prevention & Extinguishing System (if specified in BPS) as per **Annexure – L**

bb. Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB (as per clause 14). All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

20. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation. All accessories and components of transformer shall be purchased from approved soured of purchaser. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP) by purchaser.

20.1. 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.

The contractor shall carry out type & routine tests as per "**Annexure-B & Annexure-C".** All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-C".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

20.2. Type Tests on fittings:

Following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with drawing of the equipment / fittings as per the Section – GTR.

1) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)
2) Buchholz relay
3) OTI & WTI
4) Pressure Relief device Test (including IP 55 test in terminal box)
5) Sudden Pressure Relay Test (including IP 55 test in terminal box)
6) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
7) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016 or equivalent international standard.
8) Marshalling & common marshalling box and other outdoor cubicle (IP-55 test)

9) RTCC (IP-43)

20.3. **Pre-Shipment Checks at Manufacturer's Works**

20.3.1. Check for inter-changeability of components of similar transformers for mounting dimensions.

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

20.3.3. Ensure following setting of impact recorder at the time of installation with Transformer unit before despatch from factory:

1g: Start recording
2g: Warning
3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 5g to 10g.

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

20.3.5. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

20.4. **Inspection and Testing at Site**

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

20.5. **Receipt and Storage Checks**

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

20.5.2. Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

20.5.3. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

20.5.4. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

20.6. **Installation Checks**

20.6.1. Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.

20.6.2. Check the direction of rotation of fans and pumps and Check the bearing lubrication.

20.6.3. Check whole assembly for tightness, general appearance etc.

20.6.4. Oil leakage test

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

20.6.6. Leakage check on bushing before erection.

20.6.7. Measure and record the dew point of gas in the main tank before assembly.

20.7. **Commissioning Checks**

20.7.1. Check the colour of silicagel in silicagel breather.

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

20.7.3. Check the bushing for conformity of connection to the lines etc.,

20.7.4. Check for correct operation of all protection devices and alarms/trip :

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

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

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

i) Control wiring
ii) Cooling system motor and control
iii) Main windings
iv) Tap changer motor and control

20.7.7. Check for cleanliness of the transformer and the surroundings

20.7.8. 2 kV for 1 minute test between bushing CT terminal and earth.

20.7.9. Phase out and vector group test

20.7.10. Ratio test on all taps

20.7.11. Magnetising current test

20.7.12. Capacitance and Tan delta measurement of winding and bushing

20.7.13. Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

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

20.7.15. 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.

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

20.7.17. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures forward to Purchaser for future record.

Annexure – A

1.0 Technical Particulars / Parameters of Transformers (220/132/33 kV 3-Phase Auto Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
1.1	Rated Capacity		
	HV	MVA	160
	IV	MVA	160
	LV (Tertiary: Active Loading)	MVA	5
1.2	Voltage ratio	kV	220/132/33
1.3	Single / Three Phase Design		Three
1.4	Applicable Standard		IEC 60076
1.5	Frequency	Hz	50
1.6	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% / 80%/100%
1.7	Type of Transformer		Constant Ohmic impedance type (Refer Note1)
1.8	HV-IV Impedance at 75 Deg C		
i)	Max. Voltage tap	%	10.3
ii)	Principal tap	%	12.5
iii)	Min. Voltage tap	%	15.4
iv)	Tolerance on Impedance	%	As per IEC
1.9	Service		OUTDOOR
1.10	Duty		CONTINUOUS
1.11	Overload Capacity		IEC 60076-7
1.12	Temperature rise over 50 deg C Ambient Temp		
i)	Top oil measured by thermometer	^{o}C	50
ii)	Average winding measured by resistance method	^{o}C	55
1.13	Windings		
i)	System Fault level		
	HV	kA	40
	IV	kA	31.5
	LV	kA	25
ii)	Lightning Impulse withstand Voltage		
	HV	kVp	950
	IV	kVp	650
	LV	kVp	250
	Neutral	kVp	95
iii)	Switching Impulse withstand Voltage		
	HV	kVp	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	395
	IV	kVrms	275
	LV	kVrms	95
	Neutral	kVrms	38
v)	Neutral Grounding		Solidly grounded

vi)	Insulation		
	HV		GRADED
	IV		GRADED
	LV		UNIFORM
vii)	Tertiary Connection		DELTA
viii)	Tan delta of winding	%	<0.5%
1.14	Vector Group (3 –ph) (unless specified differently elsewhere)		YNa0d11
1.15	Tap Changer		OLTC
i)	Tap Range & No. of steps		–5% to +10% of HV variation in the step of 1.25%, 12 Steps
ii)	Location of Tap changer		On the 132 kV side of the series winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
1.16	Bushings		
i)	Rated voltage		
	HV	kV	245
	IV	kV	145
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	800
	IV	A	1250
	LV	A	800
	Neutral	A	1000
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	650
	LV	kVp	250
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	IV	kVrms	305
	LV	kVrms	105
	Neutral	kVrms	77
vi)	Minimum total creepage distances		
	HV	mm	6125
	IV	mm	3625
	LV	mm	1300
	Neutral	mm	900
vii)	Tan delta of bushing		

	HV	%	<0.4%
	IV	%	<0.4%
	LV	%	<0.4%
	Neutral	%	-
viii)	Max Partial discharge level at U_m		
	HV	pC	10
	IV	pC	10
	LV	pC	10
1.17	Max Partial discharge level at 1.5Um/√3	pC	100
1.18	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	75

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

2.0 Technical Particulars / Parameters of Transformers (220/33 kV 3-Phase Power Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
2.1	Rated Capacity		
	HV	MVA	63
	LV	MVA	63
2.2	Voltage ratio (HV/LV)	kV	220/33
2.3	Single / Three Phase Design		Three
2.4	Applicable Standard		IEC 60076
2.5	Frequency	Hz	50
2.6	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% / 80%/100%
2.7	Type of Transformer		Constant Ohmic impedance type (Refer Note1)
2.8	HV-LV Impedance at 75 Deg C		
i)	Max. Voltage tap	%	10.3
ii)	Principal tap	%	12.5
iii)	Min. Voltage tap	%	15.4
iv)	Tolerance on Impedance	%	As per IEC
2.9	Service		OUTDOOR
2.10	Duty		CONTINUOUS
2.11	Overload Capacity		IEC 60076-7
2.12	Temperature rise over 50 deg C Ambient Temp		
i)	Top oil measured by thermometer	^{o}C	50
ii)	Average winding measured by resistance method	^{o}C	55
2.13	Windings		
i)	System Fault level		
	HV	kA	40
	LV	kA	31.5
ii)	Lightning Impulse withstand Voltage		
	HV	kVp	950
	LV	kVp	170
	Neutral HV	kVp	95
	Neutral LV	kVp	170
iii)	Switching Impulse withstand Voltage		
	HV	kVp	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	395
	LV	kVrms	70
	Neutral HV	kVrms	38
	Neutral LV	kVrms	70

v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		GRADED
	LV		UNIFORM
vii)	Tan delta of winding	%	<0.5
2.14	Vector Group (3–ph) (unless specified differently elsewhere)		YNyn0
2.15	Tap Changer		OLTC
i)	Tap Range & No. of steps		–5% to +10% of HV variation in the step of 1.25%, 12 Steps
ii)	Location of Tap changer		On Neutral side of 220kV winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
2.16	Bushings		
i)	Rated voltage		
	HV	kV	245
	LV	kV	36
	Neutral HV & Neutral LV	kV	36
ii)	Rated current (Min.)		
	HV	A	800
	LV	A	2000
	Neutral HV	A	2000
	Neutral LV	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	LV	kVp	170
	Neutral HV & Neutral LV	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	LV	kVrms	77
	Neutral HV & Neutral LV	kVrms	77
vi)	Minimum total creepage distances		
	HV	mm	6125
	LV	mm	900
	Neutral HV & Neutral LV	mm	900
vii)	Tan delta of bushing		
	HV	%	<0.5%
	Neutral HV & Neutral LV	%	-
viii)	Max Partial discharge level at U_m		
	HV	pC	10

2.17	Max Partial discharge level at 1.5Um/√3	pC	100
2.18	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	75

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Bushing shall be measured at ambient temperature between 20ºC to 90ºC. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

3.0 Technical Particulars / Parameters of Transformers (132/11 kV, 3-Phase Power Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
3.1	Rated Capacity		
	HV	MVA	10
	LV	MVA	10
3.2	Voltage ratio (HV/LV) Line to line	kV	132/11
3.3	Single / Three Phase Design		3 (THREE)
3.4	Applicable Standard		IEC 60076
3.5	Frequency	Hz	50
3.6	Cooling		ONAN/ONAF
3.7	Rating at different cooling	%	60/100
3.8	Type of Transformer		Constant Ohmic impedance type (Refer note 1)
3.9	HV-LV Impedance at 75 Deg C		
i)	Max. Voltage tap	%	8.26
ii)	Principal tap	%	10
iii)	Min. Voltage tap	%	12.34
iv)	Tolerance on Impedance	%	As per IEC
3.10	Service		OUTDOOR
3.11	Duty		CONTINUOUS
3.12	Overload Capacity		IEC 60076-7
3.13	Temperature rise over 50deg C Ambient Temp		
i)	Top oil measured by thermometer	^{O}C	50
ii)	Average winding measured by resistance method	^{O}C	55
3.14	Windings		
i)	System Fault level		
	HV	kA	31.5
	LV	kA	25
	Neutral	kA	-
ii)	Lightning Impulse withstand Voltage		
	HV	kV_p	650
	LV	kV_p	75
	HV Neutral	kV_p	95
	LV Neutral	kV_p	75
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	540

iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	275
	LV	kV_{rms}	28
	HV Neutral	kV_{rms}	38
	LV Neutral	kV_{rms}	28
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		GRADED
	LV		UNIFORM
vii)	Tan delta of winding	%	<0.5%
3.15	Vector Group (3 –ph) (unless specified differently elsewhere)		YNynO
3.16	Tap Changer		OLTC
i)	Tap Range & No. of steps		–15% to +5% of HV variation in the step of 1.25%, 16 stpes
ii)	Location of Tap changer		On Neutral side of 132 kV winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.
3.17	Bushings		
i)	Rated voltage		
	HV	kV	145
	LV	kV	12
	Neutral	kV	12
ii)	Rated current (Min.)		
	HV	A	800
	LV	A	1000
	Neutral	A	1000
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	95
	HV Neutral	kVp	170
	LV Neutral	kVp	95
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	305
	LV	kVrms	38
	HV Neutral	kVrms	77
	LV Neutral	kVrms	38

v)	Minimum total creepage distances		
	HV	mm	3625
	LV	mm	300
	HV Neutral	mm	900
	LV Neutral	mm	300
vi)	Tan delta of bushing		
	HV	%	<0.5
vii)	Max Partial discharge level at U_m		
	HV	pC	10
3.18	Max Partial discharge level at 1.5Um/√3	pC	100
3.19	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	70

Notes:

5. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

6. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

7. Tan delta of Bushing shall be measured at ambient temperature between 20°C to 90°C. No temperature correction factor shall be applied.

8. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

Annexure -B

Test Plan

No.	Test	U_m ≤ 170kV	U_m >170kV
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	No-load loss and current measurement	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
6.	Impedance and load loss measurement	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
9.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
10.	Induced voltage withstand test (IVW)	Routine	-
11.	Applied voltage test (AV)	Routine	Routine
12.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
13.	On-load tap changer test(Ten complete cycle before LV test)	Routine	Routine
14.	Gas-in-oil analysis	Routine	Routine
15.	Core assembly dielectric and earthing continuity test	Routine	Routine
16.	Oil leakage test on transformer tank	Routine	Routine
17.	Appearance, construction and dimension check	Routine	Routine
18.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
19.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
20	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
21.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine	Routine
22.	Tank vacuum test	Routine	Routine
23.	Tank pressure test	Routine	Routine
24.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
25.	Switching impulse test for the line terminal (SI)	Type	Routine
26	Line terminal AC withstand voltage test (LTAC)	Routine	Type
27.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Type	Type
28.	Lightning impulse test for the neutral terminals (LIN)	Type	Type
29.	Temperature rise test	Type	Type
30.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type	Type
31.	Measurement of harmonic level in no load current	Type	Type
32.	Measurement of acoustic noise level	Type	Type
33.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type	Type
34.	Dynamic Short circuit withstand test (If specified in BPS)	Type	Type

Annexure - C

Test Procedures

General

Tests shall be carried out as per following procedure. However, IEC 60076 shall be followed in general for other tests. Manufacturer shall offer the transformer unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) assembled.

1. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

2. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 h, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

3. No-load loss and current measurement

As per IEC 60076-1:2011 clause 11.5

4. Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open-circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps).

5. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the

performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). For such type of transformer test may be carried out with the following sequence:

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank. Raise the oil temperature 20-25 deg C above ambient. Stop power input and pumps for 6 minutes and observe cooling down trend. Restart pumps and observe increased cooling trend due to forced oil flow.

6. Temp. Rise Test as per IEC: 60076

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer.

3-Winding Loss = HV (Max MVA) + IV(Max MVA) + LV (Max MVA).

The Contractor before carrying out such test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a “finger print” for the units to be tested only with short term heat run test.

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

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. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

i. Test conditions for temperature rise test:

- This test shall be generally carried out in accordance with IEC 60076-2
- For each cooling combination with cooler bank, tests shall be done on the maximum current tap for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.
- The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.
- DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

ii. Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

iii. General:

- Purchaser's order number and transformer site designation.
- Manufacturer's name and transformer serial number.
- Rating of transformer
- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75° C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.

iv. Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30 minute intervals:

- time
- Voltage between phases

- Current in each phase and total power
- Power in each phase and total power
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting of the test then after every four hours till the temperature stabilised and finally during temperature stabilised for each rating (ONAN/ONAF/OFAF or ONAN/ONAF1/ONAF2).

- **Notes:**

The probes may be left in position provided the reliability and integrity of unit will not be jeopardized during its long life expectancy.

v. Winding temperature rise test

- Record the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half-hourly readings of the quantities as for the top oil temperature rise test.
- Provide a table of readings, after shut-down of power, giving the following information ;

  a) Time after shut- down:
  b) Time increment:
  c) Winding resistance: At least 20 minutes reading
  d) Resistance increment:
- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

7. Dielectric Tests

Following Test shall be performed in the sequence given below as per IEC 60076-3:2013 clause 7.2.3 shall be followed:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Induced voltage test with partial discharge measurement (IVPD)

8. Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse

The voltage shall be applied on the phase for which transferred surge shall be measured in the same phase of tertiary (i.e. if voltage is applied on 1W, the transferred surge shall be measured at 3W terminal). The above process shall be repeated for the remaining HV & IV terminals.

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap. However, applied voltage shall be selected such a way that induced voltage at other winding should not go more than the SI limit of that winding.

Following tests shall be carried out with applying 50% to 80% of rated Impulse & Switching impulse (upto 60% for IV to limit the max. limit of HV SI level) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

For each tap position, atleast 2 nos. shots (one at approx. 50% and other at approx. 80%) shall be applied and measured values shall be extrapolated to 100%. Measured and extrapolated values shall be recorded.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

3-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
1	FW	1U	1V, 1W, 2U, 2V, 2W, N, 3V & 3W	-	3U
2	FW	1V	1U, 1W, 2U, 2V, 2W, N, 3U & 3W	-	3V
3	FW	1W	1U, 1V, 2U, 2V, 2W, N, 3V & 3U	-	3W
4	FW	2U	1U, 1V, 1W, 2V, 2W, N, 3V & 3W	-	3U
5	FW	2V	1U, 1V, 1W, 2U, 2W, N, 3U & 3W	-	3V
6	FW	2W	1U, 1V, 1W, 2U, 2V, N, 3V & 3U	-	3W

Transformer with non-linear element in the winding
Voltage shall be applied progressively to check at which point the surge arrestor is actuated. This measured voltage shall be the value of transfer surge for that particular connection and tap position.

Acceptance criteria
Transfer surge at Tertiary should not exceed the rated impulse level of that winding. The extrapolated values measured at 50% and 80% as stated above shall be approximately matched.

9. Chopped wave & full wave lightning impulse test for the line terminals (LIC & LI) and Switching impulse test

Chopped wave lightning impulse and Switching impulse test shall be performed at normal and extreme taps on Unit-1, Unit-2 and Unit-3 respectively for 1-Ph unit, otherwise R ph,

Y Ph and B Ph respectively for 3-Ph unit. All the parameters as per IEC shall be mentioned in the report.

10. Measurement of power taken by fans and oil pumps (100 % cooler bank)

Losses of each fan and pumps shall be measured at rated voltage and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, Applied voltage, measured current, frequency and make shall be furnished in the test report.

11. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii. Vacuum Test

All transformer tanks 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)**
Up to 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 tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

12. Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation. Type

tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

13. Routine test on bushings shall be done as per IEC 60137

Annexure –D

Reference Drawings

The list of drawings indicated below forms a part of this specification.

Sr. No	Drawing Description	Drawing No.
i)	Standard dimensions for RIP Condenser bushings (Lower portion)	0000-T-E-A-001 R02
ii)	Typical arrangement of transformer with regulating winding at the end of the series winding.	000S3-YE4-014
iii)	Conceptual drawing for optical fiber sensor	C/ENGG/STD/ optical fiber sensor/AT-SR, REV 0
iv)	Conceptual drawing for showing power and control cable for operation of 3-Ph Transformer	C/ENGG/STD/CABLE/TR REV01

Annexure–E

Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto $1.7U_m$
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localised potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
33.	Conductor insulation paper details
34.	Location of Optical temperature sensors
35.	The design of all current connections
36.	Location & size of the Valves

Annexure – F

Painting Procedure

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	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 aestheticall y matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40µm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80µm / for powder coated minimum 100µm	RAL 7035 shade for exterior and Glossy white for interior
Control cabinet / Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – G

Unused inhibited Insulating Oil Parameters

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s
1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm2/s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm2/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 (breakdown voltage)	IEC 60156	(Min.)50 kV(new unfiltered 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.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max.Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B	**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 sulphur content	BS 2000 part 373 or ISO 14596 or ASTM D 2622 or ISO 20847	0.05 % (Max.) (before oxidation test)
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.)
C	**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.	Oxidation stability	ASTM D2112 (a)	220 Minutes (Min.)
D	**Health, safety and environment (HSE)**		
1.	Flash point	ISO 2719	(Min.)135deg C
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		More than 0.04 N/m
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)	IS: 1866 / IEC 60422	70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*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.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
	* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of the Employer.		

1.0 Technical Parameters of Current Transformers (for 160MVA, 220/132kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)		
	HV Side	**IV Side**	**Neutral Side**
(a) Ratio			
CORE 1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	600V, PX / PS	600V, PX / PS	600V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	0.2S Class 15VA ISF ≤ 5	-
(c) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	100 mA	100 mA
CORE 2	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

2.0 Technical Parameters of Current Transformer (for 63 MVA 220/33kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
(a) Ratio				
CORE 1	600/1	1600/1	1600/1	1600/1
CORE 2	200/1	-	1600/1	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	1600V, PX / PS	1600V, PX / PS	1600V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	-	0.2S Class 15VA ISF ≤ 5	-
(c) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-	-
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering			-
(e) Maximum magnetization current (at knee point voltage)				
CORE 1	100mA	100 mA	100 mA	100 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

3.0 Technical Parameters of Current Transformer (for 10 MVA 132/11kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
(f) Ratio				
CORE 1	100/1	200/1	800/1	800/1
CORE 2	200/1	-	800/1	-
(g) Minimum knee point voltage or burden and accuracy class				
CORE 1	400V, PX / PS	400V, PX / PS	800V, PX / PS	800V, PX / PS
CORE 2	0.2S Class 10VA ISF ≤ 5	-	0.2S Class 10VA ISF ≤ 5	-
(h) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-	-
(i) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering			-
(j) Maximum magnetization current (at knee point voltage)				
CORE 1	100mA	100 mA	100 mA	100 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

ANNEXURE - I

Technical Specification of Oil BDV Test Set (Applicable as per BPS)

Item	Specification
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Transformer oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Employer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

Technical Specification of Portable Dissolved Gas Analysis of Oil (Applicable as per BPS)

S.No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104-2008 and IEC 60599-2007.
02	Detection of Gases	All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO & CO2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47-clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.
05	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store at least 15000 records
06	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.
07	Operating Temperature, Relative humidity	01. Temperature 0-50 Deg. C 02. 85% non-condensing

	& Dimensions	03. Portable
08	Warranty	The entire test set up shall be covered on warranty for a period of 5 year from the last date of complete commissioning and taking over the test set up. If the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc of kit for repair at test lab/works.
09	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
10	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - J

Online Dissolved Gas (Multi-gas) and Moisture Analyser (Applicable as per BPS)

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
H_2O	2 – 100 % RS should have facility for measuremen of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 ^{0}C ambient temperature and EMI

and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty.

1.7. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable) shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) upto warrantee period shall be included in the scope of supply

1.8. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.9. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.10. Software for fault indication and fault diagnostics shall include following: Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.11. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),

iii) Software Manual and

iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

1.12. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

ANNEXURE - K

On-line insulating oil drying system (Cartridge type) (if specified in BPS)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each Transformer shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

v. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vi. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - L

Nitrogen Injection Type Fire Prevention & Extinguishing System

1.1 Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults resulting from arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

Electrical isolation of transformer shall be an essential pre-condition for activating the system.

1.2 Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

1.2.1 Prevention of transformer from explosion and fire

To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

1.2.2 Prevention of transformer from fire

In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

1.3 Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil

ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank

iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.

There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

1.4 Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from NEA.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box:-

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer/ Reactor
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

1.5 Details of Supply of System Equipments and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:

- Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
- Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit
- Mechanical release device for oil drain and nitrogen release
- Limit switches for monitoring of the systems
- Panel lighting
- Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
- Back up pressure switch to operate nitrogen gas valve
- Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

1.6 Under Ground Oil Storage Tank

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **Annexure – F**. The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalised during detailed engineering.

1.7 Installation and pre-commissioning test

After installation the system pre-commissioning tests shall be carried out jointly with the Owner's representative before the system is put in service.

1.8 NIFPS based on alternate proven technology shall also be acceptable.

ANNEXURE - M

Oil sampling bottles (Applicable as per BPS)

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Transformers and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week. An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

Oil Syringe (Applicable as per BPS)

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

ANNEXURE - N

Oil Storage Tank (Applicable as per BPS)

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS: 803 or other internationally acceptable standards. Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100ºC.

2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

5. The following accessories shall also form part of supply along with each Oil storage tank.

5.1 Four numbers of 50NB suitable rubber hoses for Transformer oil application up to temperature of 100ºC, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

5.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

5.3 One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

5.4 The painting of oil storage tank and its control panel shall be as per technical specification.

5.5 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

---------- X ----------

CHAPTER 4 - 145kV CLASS SPECIFICATIONS FOR REACTOR

Table of Content

1 General

1.1 This specification covers design, engineering, manufacture, testing at manufacturer's works, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2 Type of Reactor

1.2.1 The shunt reactor shall be of either gapped core type or magnetically shielded air core type construction.

1.2.2 The impedance ratio (X0/X1) specified shall be achieved by any one of the following methods:

1.2.2.1 Adopting single phase construction in separate tanks.

1.2.2.2 Adopting 5 limb core construction.

1.2.3 In case of coreless construction following requirements are stipulated.

1.2.3.1 A magnetic shield shall be provided around the coreless coils.

1.2.3.2 Non-magnetic material sheet shall form the central core to minimize the vibrations.

1.3 Reference Drawing

1.3.1 The list of drawings included: None.

ii.

1.4 Transportation

The Contractor shall despatch the reactor 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. Reactor 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 despatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be down loaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks the contractor shall communicate the interpretation of the data. 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 Shunt Reactors will be connected to the 132kV transmission system for reactive load compensation and shall be capable of controlling the over voltage occurring in the system. Typical line parameters of 132kVTransmission Lines are given below:

Line	Positive sequence impedance ohms/ckt/km	Zero sequence impedance ohms/ckt/km	Susceptance mhos/ckt/km Positive sequence	Susceptance mhos/ckt/km Zero sequence
132kV Line	0.1622+j0.3861	0.4056+j1.6222	2.9270 x 10-6	-

2.2 Shunt Reactors shall be capable of operating continuously at a voltage 10% higher than their rated voltage without exceeding hot spot temperature of 140 deg C at any part of the reactor.

2.3 Temperature rise shall be guaranteed when shunt reactor is operating at rated voltage.

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

2.5 Design review

The Reactors shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc so that the reactor(s) provide long life with least maintenance.

Design reviews shall be conducted by Owner or an appointed Consultant at different stages of the procurement process for Reactors, however the entire responsibility of design shall be with the manufacturer.

Owner may visit to the manufacturers works to inspect design, manufacturing and test facilities.

The design review will commence after placement of award with successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the reactor(s) under scope of this specification.

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

The manufacturer will be required to demonstrate the use of adequate safety margin for thermal, mechanical, dielectric and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

The scope of such a design review shall at least include the following:

1.	Core and magnetic design
2.	Winding and lead design
3.	Thermal design including review of localised potentially hot area.
4.	Cooling design
5.	Overload capability
6.	Eddy current losses
7.	Seismic design, as applicable
8.	Insulation co-ordination
9.	Tank and accessories
9.1	Bushings and barrier design
9.2	Radiators
9.3	Sensors and protective devices – its location, fitment, securing and level of redundancy
9.4	Oil and oil preservation system
10.	Corrosion protection of metallic surface and aesthetics
11.	Electrical and physical Interfaces with substation
12.	Earthing
13.	Processing and assembly
14.	Testing capabilities
15.	Inspection and test plan
16.	Transport and storage

17.	Sensitivity of design to specified parameters
18.	Acoustic Noise
19	Vibration and Tank stress
20	Spares, inter-changeability and standardization
21.	Maintainability

3 Construction Details

The feature and construction of the reactors shall be in accordance with the requirements stated hereunder.

3.1 Tank and Tank Accessories

3.1.1 Tank

3.1.1.1 Tank shall preferably be of welded construction and fabricated from tested quality low carbon steel of adequate thickness.

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/Equivalent international standard.

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 reactor 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) Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete reactor when filled with oil without structural damage to any part of the reactor. The factor of safety at any one point shall not be less than 2. The lifting lugs shall be so arranged and located as to be accessible for use when the reactor is loaded on the transport vehicle.

(b) A minimum of four jacking pads in accessible position to enable the reactor complete with oil, to be raised or lowered using mechanical/hydraulic screw jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least

half of the total mass of the reactor filled with oil allowing in addition for maximum possible mis-alignment of the jacking force to the centre of the working surface.

(c) Suitable haulage holes shall be provided.

(d) Sufficient No. of man holes of suitable size shall be provided.

3.1.1.6 The base of each tank shall be so designed that it shall be possible to move the complete reactor unit by skidding in any direction without injury when using plates or rails.

3.1.1.7 Paint system and procedures

3.1.1.8 The painting details for reactor main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given below. The 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 tank, oil storage tank etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75μm)	Aliphatic polyurethane (PU) (Minimum 50μm)	Minimum 155μm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil resistant, non-corrosive varnish or paint or epoxy	--	--	Minimum 30μm	Glossy white for paint

Radiator (external surfaces)	Chemical / Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy base Zinc primer (30-40μm)	PU paint (Minimum 50μm)	Minimum 100μm	Matching shade of tank/ different shade aesthetically matching to tank
Radiator and pipes upto 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish /Paint and flushing with transformer oil	--	--	--	--
Control cabinet / Marshalling box	Seven tank process as per IEC/equivalent	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat	Minimum 80μm	RAL 7035 shade for exterior and Glossy White for interior

Note: * indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

3.1.1 Tank Cover

3.1.2.1 The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

3.1.2.2 At least two adequately sized inspection openings, one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25kg. Handles shall be provided on the inspection cover to facilitate lifting.

3.1.2.3 The tank cover shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

3.1.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

3.1.2.5 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over compression. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

Details of all gasket joints shall be submitted for approval.

3.1.2.6 Current flowing in tank cover and bushing turrets.

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

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

3.1.3 Axles and Wheels

3.1.3.1 The shunt reactor shall be mounted on concrete plinth foundation directly.

3.1.3.2 One complete set of flanged bi-directional wheels and axles shall be provided for each sub-station. This set of wheels and axles shall be suitable for fixing to the under carriage of shunt reactor to facilitate its movement on rail track. Bidder can supply one set of trolleys in place of wheel assembly rollers for movement of reactor per sub-station for plinth mounted reactor

3.1.3.3 The rail track gauge shall be 1676 mm.

3.1.4 Foundation and Anti Earthquake clamping Device

To prevent reactor movement during earthquake, suitable clamping device shall be provided for fixing the reactor 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 electrically insulated alarm contacts. Magnetic oil level gauge shall be type tested. Magnetic oil level gauge and its terminal box shall conform to IP 55 degree of protection.

3.1.5.2 Conservator tank and pipe work

3.1.5.2.1 Conservator tank shall have adequate capacity between highest and lowest visible-levels to meet the requirements of expansion of total cold oil

volume in the shunt reactor and cooling equipment from minimum ambient temperature to 100 deg C.

3.1.5.2.2 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.

3.1.5.2.3 Conservator shall be positioned so as not to obstruct any electrical connection to reactor. Pipe work shall not obstruct the opening of inspection or manhole covers.

3.1.5.2.4 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radius elbows shall be used.

3.1.5.2.5 The feed pipe to the reactor tank shall enter the reactor cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the reactor side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.

3.1.5.2.6 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.

3.1.5.3 **Oil Preservation Equipment**

The requirements of air cell type oil sealing system are given below.

3.1.5.3.1 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth air cell.

3.1.5.3.2 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 least at 100 deg C.

3.1.5.3.3 Air cell of conservator shall be able to withstand the vacuum during installation/ maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator.

3.1.5.3.4 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

3.1.5.4 **Dehydrating Filter Breather**

Conservator shall be fitted with a dehydrating filter breather. It shall be so designed that:

a) Passage of air is through a dust filter and silicagel.

b) Silicagel is isolated from atmosphere by an oil seal.

c) Moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.

d) Breather is mounted not more than 1200 mm above rail top level.

e) To minimise the ingress of moisture following shall be provided.

Two breathers (of identical size) shall be connected in series for conservator of shunt reactor.

3.1.6 Pressure Relief Device

Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall operate at a static pressure less than the hydraulic test pressure of reactor tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipe and directed away from reactor/other equipment and this shall be prevented from spraying on the tank. The terminal box/boxes of PRD should conform to degree of protection as per IP-55 of IEC- 60529. Following routine tests shall be conducted on PRD

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact test
e) Dielectric test

3.1.7 Buchholz Relay

A double float, reed type Buchholz relay shall be provided. All gases evolved in the reactor shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper/stainless steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the reactor in service. The device shall be provided with two electrically independent contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

3.1.8 Temperature Indicators

3.1.8.1 Oil Temperature Indicator (OTI)

All Shunt reactors shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts.

The maximum reading pointer and resetting device for the thermometer shall be mounted in the marshalling box. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be $\pm$ 3 deg C or better.

The setting of alarm and tripping contacts shall be adjustable at site and typical values are as given below which will be reviewed during detailed engineering based on manufacturer's recommendation.

Alarm – 90degC
Trip – 105degC

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

a) Temperature transducer with Pt100 sensor

Dual output 4-20mA temperature transducer with Pt100 sensor with duplex platinum RTD of 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 IEC 60751-2 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.

b) Remote oil temperature indicator

It shall be suitable for flush mounting on Employer's/RTCC panel and shall operate on 4-20mA input available from the above transducer..

Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four point selector switch shall be provided

3.1.8.2 Winding Temperature Indicator (WTI)

A device for measuring the hot spot temperature of winding shall be provided on shunt reactors only. It shall comprise the following:

(i) Temperature sensing element

(ii) Image coil

(iii) Auxiliary current transformers if required to match the image coil shall be furnished and mounted in the marshalling box.

(iv) 150 mm dia local indicating instrument with maximum reading pointer mounted in marshalling box and with two adjustable, electrical independent, ungrounded contacts, one for high winding temperature alarm and one for trip. Temperature indicator dial shall have linear gradations to clearly read at least every 2 deg C.

(v) Calibration device.

(vi) Accuracy of WTI shall be ± 3 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	100degC
Trip	110degC

(vii) In addition to the above, the following shall be provided for remote indication of winding temperature for each reactor.

(a) Temperature transducer with Pt100 sensor

Dual output 4-20mA temperature transducer with Pt100 sensor with duplex platinum RTD of 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 IEC 60751-2 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.

(b) Remote winding temperature indicator

It shall be suitable for flush mounting on Employer's/RTCC panel and shall operate on 4-20mA input available from the above transducer. Only one RWTI with a four point selector switch shall be provided for all the three windings (HV, IV and LV). Drawing showing the mounting details of RWTI shall be submitted to the purchaser within two months from the date of award of the contract. Any special cable required for shielding purpose, for connection between Marshalling box and remote WTI control circuit, shall be in the scope of Contractor. Drawing

showing the mounting details of RWTI shall be submitted to the Purchaser

3.1.9 **Earthing Terminals**

3.1.9.1 Two (2) earthing pads (each complete with two (2) nos. holes, M 10 bolts, plain and spring washers) suitable for connection to 50 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 50 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 In case of gapped core construction the following requirements are stipulated.

3.2.1.1 The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented, silicon steel laminations.

3.2.1.2 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

3.2.1.3 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV rms for 1 minute.

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

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

3.2.1.6 When bell type tank construction is offered, suitable projecting guides shall be provided on core assembly to facilitate removal of tank.

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

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

3.2.1.9 Adequate lifting lugs as required shall be provided to enable lifting of the core and winding.

3.3 Windings

3.3.1 The Contractor shall ensure that windings of reactors are made in dust proof and conditioned atmosphere.

3.3.2 The conductors shall be of electrolytic grade copper, free from scales and burrs.

3.3.3 The insulation of windings and connections shall be free from insulating components which are liable to soften, ooze out, shrink or collapse shall and be non-catalytic and chemically inactive in oil during service.

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

3.3.5 Coil shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

3.3.6 The conductors shall be transposed at sufficient intervals in order to minimise eddy currents and to equalise the distribution of currents and temperature along the winding.

3.4 Unused inhibited Insulating Oil

3.4.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer/reactor and only thereafter be brought up to the specified parameter by circulation within the transformer/reactor.

The insulating oil for the transformer shall be delivered at site not before 90 days from the date of commissioning, which shall be informed by the owner.

Sl. No.	Property	Test Method	Limits
A1.	Function		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s
1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm2/s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or	(Max.)1800 mm2/s

		ASTM D7042	
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 (breakdown voltage)	IEC 60156 or ASTM D1298	(Min.) 50 kV(new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM 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 or ASTM D129	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	IEC 61125 (method c) Test duration 500 hour IEC 60247	 Max 0.3 mg KOH/g Max 0.05 % Max 0.05

	factor (tan delta) at 90degC		
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 : 05 ppm (max.)
3. Tan-delta at 90 °C : Less than 0.0025
4. Interfacial tension : More than 0.04 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 NEA/authorised representative.

3.4.3 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameter as mentioned below

a) Break Down voltage (BDV) : 70 kV (min.)
b) Moisture content : 10 ppm (max.)

c) Tan-delta at 90 °C : 0.01 (max.)
d) Resistivity at 90 °C : 6 X 10 ^12 ohm-cm (min.)
e) Interfacial tension : 0.035 N/m (min.)

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. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN cooled reactors, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

3.4.4 Sufficient quantity of oil necessary for maintaining required oil level in tank, radiator and conservator etc. till completion of warranty period shall be supplied.

3.5 Terminal Arrangement

3.5.1 Bushings

3.5.1.1 The electrical and mechanical characteristics of bushings shall be in accordance with relevant IEC. Bushing must have been type tested successfully as per IEC 60137.

3.5.1.2 Bushing for various voltage rating shall be as follows

52 kV and above	Hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator. Mounting dimensions of bushing shall be as per drawing No.0000-T-E-A-001 R02.
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 bushings shall be provided with atleast the following fittings:

(a) Oil level gauge

(b) Tap for capacitance/tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable

3.5.1.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

3.5.1.5 Bushings of identical rating shall be interchangeable.

3.5.1.6 Porcelain used in bushing manufacture shall be homogenous, free from laminations cavities and other flaws or imperfection that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

3.5.1.7 Clamps and fittings shall be of hot dip galvanised steel.

3.5.1.8 Bushing turret shall be provided with vent pipe, to route any gas collection through the buchholz relay.

3.5.1.9 No arcing horns shall be provided on bushings.

3.5.1.10 Spare Bushing shall be specially packed suitable for long storage.

3.6 **Terminal Marking**

The terminal marking and their physical position shall be in accordance with IEC 60076.

3.7 **Neutral Earthing Arrangement**

3.7.1 The neutral of the shunt reactor shall be grounded directly.

3.7.2 The neutral terminals of Reactors shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 50 x 6 mm galvanised steel flats connected to Employer's grounding mat.

3.8 **Cooling Equipment**

3.8.1 Oil immersed with natural cooling (ONAN)

3.8.1.1 The radiator bank of the shunt reactor may be tank mounted.

3.8.1.2 Radiators shall be made from pressed steel.

3.8.1.3 Each radiator bank shall be provided with the following accessories:

(a) Top and bottom shut off valve

(b) Drain Valve and sampling valve

(c) Air release plug

(d) Two grounding terminals for termination of two (2) Nos. 50 x 6 mm galvanised steel flats.

(e) Thermometer pockets with captive screw caps at cooler inlet and outlet.

(f) Lifting lugs

3.8.1.4 Radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches.

3.8.1.5 Expansion joint, if required, shall be provided on top and bottom cooler pipe connection.

3.8.1.6 The radiator shall preferably be hot dip galvanised or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

3.8.2 **Valves**

3.8.2.1 All valves 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.

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

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

3.8.2.4 All valve flanges shall have machined faces.

3.8.2.5 All valves in oil line shall be suitable for continuous operation with shunt reactor oil at 115 deg C.

3.8.2.6 The oil sampling point for main tank should have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

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

3.8.2.8 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. All valve shall be painted with a shade (preferably red or yellow distinct and

different from of main tank surface and as per the painting system and procedure specified in clause no 3.1.1.9.

3.8.2.9 All hardware used shall be cadmium plated/electro-galvanised.

3.8.2.10 For estimation purpose of spares one set of valves mean one valve of each type used in Reactor.

3.9 Marshalling Box

3.9.1 A sheet steel marshalling box of a suitable construction shall be provided for the reactor ancillary apparatus and this shall be vermin, dust & weather proof. All the terminals for remote indication shall be wired upto the marshalling box from the reactor accessories. Necessary shorting of CT secondary terminals shall be done at the marshalling box.

3.9.2 The marshalling box shall be tank mounted type. Suitable anti-vibration pads shall be provided so that vibration from tank is not transferred to the marshalling box. The marshalling box shall have sloping roof. It shall have double hinged doors and shall be provided with locking arrangement. The exterior and interior painting shall be in accordance with painting clause no 3.1.1.9.

3.9.3 All doors, removable covers and plates shall be gasketed all round with neoprene gaskets. Louvers shall have screens and filters. The screens shall be of fine wire mesh made of brass and GI wire.

3.9.4 The marshalling box shall accommodate the following :

(a) Temperature indicator for winding and oil,

(b) Terminal blocks and gland plates for incoming and outgoing cables.

3.9.5 The temperature indicator shall be so mounted that the dials are about 1200 mm above ground level. Glass doors of suitable size shall be provided for convenience of reading. A space heater and cubicle lighting with ON-OFF switch shall be provided. It shall be so designed that with the space heater switched on continuously, the temperature inside the marshalling box does not exceed the safe operating limits at the service conditions.

3.9.6 In case of single phase reactor a common Marshalling Box shall be provided and all termination for bushing CTs, PRV, Temperature Indicators, Buchholz relay, MOG, etc. shall be brought out to the common marshalling box by cable to make the scheme suitable for three phase operation. Further, cabling and terminations for spare reactor shall also be provided in each common marshalling box.

4 Fittings

The following fittings shall be provided with each shunt reactor covered under this specification.

4.1 Conservator for reactor main tank with filling hole and cap, drain valve, isolating valve, vent pipe and magnetic oil level gauge with low level alarm contacts.

4.2 Air release devices.

4.3 Dehydrating breather complete with first fill of activated silicagel.

4.4 Inspection openings and covers.

4.5 Rating & diagram plate for reactors and current transformers. These plates shall be of material capable of withstanding continuous outdoor service.

4.6 Terminal marking plate conforming to IEC-60076.

4.7 Two earthing terminals each on shunt reactor tank, radiators & marshalling box, SA structures etc.

4.8 Suitable neutral bus connection.

4.9 Ladder to climb up to the reactor tank cover with suitable locking arrangement to prevent climbing during charged condition.

4.10 Double float/reed type Buchholz relay with alarm and trip contacts.

4.11 Bottom oil sampling valve and drain valves.

4.12 Filter valves at top and bottom.

4.13 Shut off valves on the pipe connection between radiator bank and reactor tank.

4.14 Shut off valves on both sides of Buchholz relay at accessible height.

4.15 Sampling gas collectors for Buchholz relay at accessible height.

4.16 Four jacking pads.

4.17 Lifting lugs or eyes for the cover.

4.18 Suitable terminal connectors on bushings

4.19 Under carriage with provision for flanged bidirectional wheels, set of flanged bi-directional wheels, set of flanged bidirectional rollers/trolley for transportation.

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

4.21 Pressure relief devices with alarm/trip contacts.

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

4.23 Winding temperature indicators for local and remote mounting.

4.24 Oil temperature indicator for local and remote mounting.

4.25 Protected type mercury or alcohol in glass thermometer.

4.26 Marshalling box.

4.27 Haulage lugs.

4.28 Bushing CT

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

4.30 One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes as used in the reactor one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one) shall be supplied per Substation.

4.31 Suitable galvanized iron tray for cabling on main tank for better aesthetics.

5 Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Employer is given under Cl.5.1 below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation.

5.1 **Inspection**

5.1.1 **Tank and Conservator**

5.1.1.1 Certification of chemical analysis and material tests of plates.

5.1.1.2 Checks for flatness

5.1.1.3 Electrical interconnection of top and bottom tank by braided tin flexible

5.1.1.4 Welder's qualification and weld procedure.

5.1.1.5 Testing of electrodes for quality of base materials.

5.1.1.6 Inspection of major weld preparation.

5.1.1.7 Crack detection of major strength weld seams by dye penetration test.

5.1.1.8 Measurement of film thickness of

(a) Oil insoluble varnish

(b) Zinc chromate paint

(c) Light grey paint

5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90ø and further dimensional check.

5.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to non destructive test (NDT).

5.1.1.11 Leakage test of conservator.

5.1.1.12 Certification of all test results.

5.1.2 **Core**

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

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

(a) Measurement of thickness and hardness of varnish on stampings.

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

(c) Check over all quality of varnish on stamping, ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.

5.1.2.3 Check on the amount of burrs.

5.1.2.4 Bow check on stampings.

5.1.2.5 Check for the overlapping stampings. Corners of the sheets are to be apart.

5.1.2.6 Visual and dimensional check during assembly stage.

5.1.2.7 Check for interlaminar insulation between core sections after pressing.

5.1.2.8 Visual and dimensional check for straightness and roundness of core.

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

5.1.2.10 Check of pressure during dimensional stabilisation of winding/core assembly.

5.1.2.11 Certification of all test results.

5.1.3 **Insulation Material**

5.1.3.1 Sample check for physical properties of material.

5.1.3.2 Check for dielectric strength.

5.1.3.3 Visual and dimensional checks.

5.1.3.4 Check for the reaction of hot oil on insulating materials.

5.1.3.5 Dimensions stability test at high temperature for insulating material.

5.1.3.6 Tracking resistance test on insulating material.

5.1.3.7 Certification of all test results.

5.1.4 **Winding**

5.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.

5.1.4.2 Visual dimensional checks on conductor for scratches, dent marks etc.

5.1.4.3 Sample check on insulating paper for pH value, electric strength.

5.1.4.4 Check for the reaction of hot oil on insulating paper.

5.1.4.5 Check for the bonding of the insulating paper on conductor.

5.1.4.6 Check and ensure that physical condition of all materials taken for winding is satisfactory and free of dust.

5.1.4.7 Check for absence of short circuit between parallel strands.

5.1.4.8 Check for brazed joints wherever applicable.

5.1.4.9 Measurement of impedance by low voltage to be carried out when core/yoke is completely restacked and all connections are ready.

5.1.4.10 Conductor-enamel test for checking of cracks, leakage and pin holes.

5.1.4.11 Conductor flexibility test.

5.1.4.12 Heat shrink test for enamelled wire.

5.1.4.13 Certification of all test results.

5.1.5 **Checks before drying process**

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

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

5.1.5.3 Check insulation distance between low voltage connections and earth and other parts.

5.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.

5.1.5.5 Check for proper cleanliness and absence of dust etc.

5.1.5.6 Certification of all test results.

5.1.6 **Checks during drying process**

5.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.

5.1.6.2 Check for completeness of drying by measuring IR and tan delta.

5.1.6.3 Certification of all test results.

5.1.7 **Assembled Reactor**

5.1.7.1 Check completed reactor against approved out line drawing provision for all fittings, finish level etc.

5.1.7.2 Test to check effective shielding of tank.

5.1.7.3 Jacking test on all the assembled reactors.

5.1.7.4 Dye penetration test shall be carried out after Jacking tests.

5.1.8 **Bought Out Items**

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

5.1.8.1 The Contractor shall also prepare a comprehensive inspection and testing programme for all bought out/sub-contracted items and shall submit the same to the Employer for approval. Such programme shall include the following.

(a) Buchholz relay

(b) Axles and wheels/Trolley for transportation.

(c) Winding temperature indicators for local and remote mounting

(d) Oil temperature indicators

(e) Bushings

(f) Bushing current transformer

(g) Marshalling box

(h) Radiators

(i) Pressure relief device

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

5.2 Factory Tests

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated.

The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

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

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Reactance and loss measurement	Routine
3.	Measurement of insulation resistance & Polarization index	Routine
4.	Measurement of insulation power factor and capacitance between winding and earth	Routine
5.	Measurement of insulation power factor and capacitance of bushings	Routine
6.	Lightning impulse test	Routine
7.	Separate source voltage withstand test	Routine
8.	Induced over voltage test with Partial Discharge measurement	Routine
9.	Gas-in-oil analysis	Routine
10.	Oil leakage test on Reactor tank	Routine
11.	Appearance, construction and dimension check	Routine
12.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
13.	Tank vacuum test	Routine
14.	Tank pressure test	Routine
15.	Vibration & stress measurement	Routine
16.	Core assembly dielectric and earthing continuity test	Routine
17.	Temperature rise test	*Type
18.	Measurement of harmonic content of current (Measured in Cold state)	*Type
19.	Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)	*Type
20.	Knee point voltage measurement of reactor (Measured in Cold state)	*Type
21.	Lightning impulse test on Neutral	*Type
22.	Measurement of zero-sequence reactance (For three phase shunt reactor only)	*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. No correction factor shall be applied.

5.2.2 .

5.2.3 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% at ambient Temperature. No correction factor shall be applied.

5.2.4 **Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the clause no. 9.2 of the Section – GTR. The list of fittings and the type test requirement is:

1) Bushing (Type Test as IEC: 60137)

2) Buchholz relay (Type Test and protection test IP-55 of IEC 60529 on terminal box)

3) Control cabinet (IP-55 test)

4) Pressure Relief device Test

   The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in reactor tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.
   The terminal box / boxes of PRD should conform to degree of protection as per IP-55 of IEC 60529

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

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

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

5.2.4 Pre-Shipment Checks at Manufacturer's Works

5.2.4.1 Check for interchangeability of components of similar reactors for mounting dimensions.

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

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

5.2.4.4 Gas tightness test to confirm tightness.

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

5.2.4.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the reactor tank. Dew point of dry air / nitrogen at the time of reactor despatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

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

5.3 Inspection and Testing at Site

The Contractor/Manufacturer shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below and in the document No. D-2-01-03-01-01 (or latest revision) (Pre-commissioning Procedures and Formats for substation bay equipment), which will be available in the respective sites and shall be referred by the contractor. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Testing of oil sample at site shall be carried out as per Cl 3.4 above

5.3.1 Receipt and Storage Checks

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

5.3.1.2 Check and record the gas pressure in the reactor tank as well as in the cylinder. Measure and record the dew point of dry air /nitrogen in the reactor tank.

5.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check for condition of core and winding in general.

5.3.1.4 Check and record reading of impact recorders at receipt and verify the allowable limits as per manufacturer's recommendation.

5.3.2 Installation Checks

5.3.2.1 Check the whole assembly for tightness, general appearance & winding healthiness etc.

5.3.2.2 Oil leakage test

5.3.2.3 Visual check for Leakage on bushing before erection.

5.3.2.4 Measurement of capacitance and tan delta of the bushings before fixing/connecting to the reactor. Contractor shall furnish these values for site reference.

5.3.2.5 Measure and record the dew point of nitrogen in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall for part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

5.3.2.6 Oil filling

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

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

5.3.2.6.3 Vacuum shall not be broken until the reactor is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete reactor. For this purpose the reactor shall first be drained to expose all insulation material.

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

5.3.2.6.5 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 breather.

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

5.3.3.3

5.3.3.4 Check the bushings for conformity of connection to the line etc.

5.3.3.5 Check for correct operation of all protection devices and alarms.

i) Buchholz relay

ii) Excessive winding temperature

iii) Excessive oil temperature

iv) Low oil level indication

5.3.3.6 Check for adequate protection of electric circuit supplying the accessories.

5.3.3.7 Insulation resistance measurement for :

i) Control wiring

ii) Main winding

iii) Bushing current transformer

5.3.3.8 2kV/minute test between bushing CT terminal and earth.

5.3.3.9 Check for cleanliness of the reactor and the surrounding.

5.3.3.10 Measure vibration and noise level

5.3.3.11 DGA of oil sample just before commissioning and after 24 hours of commissioning.

5.3.3.12 Capacitance and tan delta measurement of winding & bushing.

5.3.3.13 Frequency Response Analysis (FRA) at site (For 245 kV class Reactor only) by using owner's equipment which shall be provided free of cost.

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

6 Technical Parameters

6.1 Shunt Reactor of 145 kV class 25 MVAR Three phase

6.1.1	Rated Voltage	145kV (1.0pu)
6.1.2	Applicable standard	IEC 60076-6
6.1.3	System Fault level	31.5kA
6.1.4	Connection	Star with neutral brought out
6.1.5	Insulation level (for winding)	
	(a) Lightning impulse 1.2/50 µsec withstand voltage	550 kVp
6.1.6	Maximum temp rise over an ambient temp of 50 deg C and at 145kV voltage	
	(a) of winding measured by resistance method	45 deg C
	(b) of top oil measured thermometer	40 deg C
	(c) The temperature of the hottest spot	Shall be as per relevant standards.
6.1.7	Cooling System	Natural Oil circulation (ONAN)
6.1.8	Insulation level of neutral	
	(a) Impulse withstand voltage	170 kVp

	(b) Power frequency voltage	70 kV (rms)
	(c) Whether neutral is to be brought out	Yes (through 36kV class solid core bushing
6.1.9	Ratio of zero sequence reactance to positive reactance (X0/X1)	between 0.9 & 1.0
6.1.10	Range of constant impedance	Upto 1.4 pu voltage (the bidder shall furnish complete saturation characteristics of the Reactors up to 2.5 pu Voltage
6.1.11	Tolerance on current	0 to +5%
6.1.12	Harmonic content in phase current	The crest value of the third harmonic component in phase current not to exceed 3% of the crest value of fundamental when reactor is energised at rated voltage with sinusoidal wave form
6.1.13	Permissible current unbalance among different phases	± 2%
6.1.14	Minimum clearance in air	

Rated voltage	Phase to phase	Phase to ground
145 kV	1220 mm	1050 mm

6.1.15	Noise level at rated voltage and frequency		: 75 dB	
6.1.16	Bushing		Line side	Neutral side
	(a)	Rated voltage	145 kV	36 kV
	(b)	Creepage distance (total)	3625 mm	900 mm
	(c)	Mounting	Tank cover	Tank cover
	(d)	1.2/50 microsec. Lightning impulse withstand voltage (kVp)	650	170
	(e)	One minute power frequency with stand voltage (kV rms)	305	77
	(f)	Rated current (A)	800	800

6.1.17	Vibration and stress level	Not more than 200 microns peak to peak at rated voltage and frequency Average vibrations shall not exceed 60 microns peak to peak. Tank stresses shall not exceed 2.0kg/sq.mm at any point on the tank.
6.1.18	Maximum Partial Discharge	100 pC (PD) level at 1.5 pu

7.0 Bushing Current Transformer

7.1 Current transformers shall comply with IEC-60185.

7.2 It shall be possible to remove the turret mounted current transformers from the reactor tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

7.3 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.

7.4 Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

7.5 Technical Parameters

7.5.1 Current Transformer Parameters for 145 kV Shunt Reactor (on each phase connection)

Line side

		Core 1	**Core 2**	**Core 3**
(i)	Ratio	200/1A	200/1A	200/1A
(ii)	Accuracy class	PS	PS	PS
(iii)	Minimum knee point voltage(volts)	200	200	200
(iv)	Maximum secondary resistance (ohms)	1.0	1.0	1.0
(v)	Exciting current(max.) at 50V	60mA	60mA	60mA

(vi)	Function	Differential protection(High impedance)	Restricted Earth fault protection	Backup impedance protection

Neutral side

		Core 4	**Core 5**	**Core 6**	**Core CW**
(i)	Ratio	200/1A	200/1A	200/1A	Suitable for WTI
(ii)	Accuracy class	1.0	PS	PS	Suitable for WTI
(iii)	Minimum knee point voltage(volts)	-	200	200	Suitable for WTI
(iv)	Maximum secondary resistance (ohms)	-	1.0	1.0	-
(v)	Exciting current(max.) at 50V	-	60mA	60mA	-
(vi)	Burden(VA)	10	-	-	Suitable for WTI
(vii)	Instrument security factor (max.)	20	-	-	Suitable for WTI
(viii)	Function	Metering	Restricted Earth fault protection	Differential protection(High impedance)	Winding temp. indication (on one phase only)

7.5.2 The arrangement of current transformers on shunt reactor shall be as per drawing no. 0000-000-T-E-J-001 ,Rev-0

7.6.0 Notes:

a) Magnetisation characteristics of core 1 and core 6 should be identical up to 200V to the extent possible.

b) Magnetisation characteristics of core 2, core 5 and core NCI should be identical upto 200V to the extent possible.

7.6.1 Accuracy class PS as per IEC -60044.

7.6.2 Class (for the relevant protection and duties) as per IEC- 60185.

7.6.3 For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor.

8.0 OIL SAMPLING BOTTLE

8.1 Oil sampling bottles shall be suitable for collecting oil samples from transformers and shunt reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

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

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

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

8.4.1 An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of 01 meter length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

9.0 Oil Syringe

The glass syringe and three way stop cock valve shall meet the following specification

Dimensions	The tentative dimensions are given below	
	Volume	50 ml ± 1.5 %
	Piston outside diameter	27.45 ± 0.20 mm
	Barrel Diameter (OD)	32.35 ± 0.55 mm
	Barrel Diameter (OD)	44.00 ± 0.75 mm
	Barrel Diameter (OD)	34.05 ± 0.65 mm
	Length (L)	178.00 mm ± 0.50 mm
	Increment	2.0 ml
General	The syringe shall be made from Heat resistant borosilicate Glass	
	The material and construction should be resistant to	

	breakage from shock and sudden temperature changes
	Reinforced at luer lock tip Centre and barrel base.
	The cylinder-Plunger fit is leak proof and shall meet the requirement of IEC-60567.
	Plunger shall be individually ground and fitted to barrel for smooth movement with no back flow.
	Barrel rim should be flat on both sides tom prevent rolling and should be wide enough for convenient finger tip grip.
	The syringe shall be custom fit and uniquely numbered for matching.
	The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.
Three way Valve	Shall be made of 100% Nylon.
	Two female ports and one male port.
	Two female ports shall be designed to accept luer lock fitting.

1. Core assembly dielectric and earthing continuity tests

The insulation of the magnetic circuit, and between the magnetic circuit and the core clamping structure, including core-bolts, bands and/or buckles shall withstand the application of a test voltage of either 2kV AC or 3kV DC for 60 seconds.

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2. Tank Tests

i) Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC:60296 at the ambient temperature and subjected to a pressure equal to normal tank pressure plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii) Vacuum Tests

Shunt reactor tank shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/sq.m absolute (25 torr) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below:

Horizontal length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
above 3000	19.0

iii) Pressure Test

Shunt reactor tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or normal pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of the flat plate after the excess pressure has been released shall not exceed the figures specified above for vacuum test.

3. Temp. Rise Test as per IEC: 60076

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test.

The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The test shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours.

4. Routine tests on Bushings: Routine test on bushings shall be done as per IEC 60137.

CHAPTER 5 – TRANSFORMER OIL FILTRATION PLANT

1.1 Performance Requirement

1.1.1 The Ultra High Vacuum type oil treatment plant of capacity of 10KLPH (Kilo litre per hour) shall be mobile and shall be suitable for treatment of new oil and reconditioning of used oil in EHV class transformer, shunt reactor and other oil filled equipment in order to achieve properties of treated oil within specified limits at the rated capacity.

1.1.2 The plant shall be capable of treatment of new oil (as per IEC 296/IS:335) and reconditioning of used oil (as per IS:1865/IEC:422 for oil in-service) at rated capacity on single pass basis as follows:

(i) Removal of moisture from 100 ppm to 3 ppm (max.)

(ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.

(iii) Improvement of dielectric strength break down voltage from 20 KV to 70 KV (min).

(iv) Vacuum level of degassing chamber at rated flow and at final stage :- not more than 0.15 torr (0.2 m bar) max.

(Degassing chambers of different degree of vacuum should have sufficient surface areas to achieve the final parameters. A detailed justification as to how end parameters shall be met with detailed calculations and test reports in support of the same shall be submitted along with the offer.

(v) Filtering capacity: Max. particle size less than 0.5 micron in the filtered oil.

(vi) Processing temperature :- 40º C to 60ºC (Maximum allowed temp. in oil to prevent oxidation (when oil is at atmospheric pressure) :- 60ºC)

1.1.3 Bidder is to furnish along with the bid detailed calculation to establish the sizing and capability of the vacuum pumping system with respect to moisture and gas removal as above.

1.1.4 Bidder is to submit along with the bid test reports, test methodology to prove the capability of the plant offered.

1.1.5 The plant shall also have two independent vacuum pumping systems one for evacuating the transformer for vacuum filling of oil in transformer and the other for degassing chamber. The blank off vacuum of each pumping system shall be 10^{3} torr or less.

1.1.6 The plant shall be provided with control and indication panel with full automation.

1.1.7 The plant shall be fitted with hoses for connection of oil lines and vacuum lines to transformers and reactors. Hoses shall have leakage rate of 10^{2} torr-ltr/sec. (max.)

1.1.8 The Ultra High Vacuum Type oil purification plant shall be complete with oil pumps for drawing oil for transformers and reactors, oil heater (max. heating rate = 2.0W/cm²) of adequate rating, suitable filter or centrifuge as required to ensure oil quality, degasifier complete with vacuum pumps, oil extraction pump etc. of adequate capacity such that throughout from the purification plant is of guaranteed purity.

1.1.9 The plant shall also be suitable for cleaning and degassing of the oil stored in the storage tanks.

1.1.10 All equipments required as above shall be mounted on a tow-able road worthy trailer unit with 4 nos. pneumatic tyres. The equipment shall be suitable for outdoor use.

1.2 Design & Construction

The features and construction details of 10KLPH mobile outdoor type oil filtration & purification plant shall be in accordance with the requirements stated hereunder.

1.2.1 **Oil Pump** (Inlet Side)

1.2.1.1 Two (2) nos. electrically driven oil pumps with one (1) working and one (1) standby shall be provided. Selection switch is to be provided for selection of either of pumps. The pumps shall be single stage positive displacement gear type. Suitable mechanical seals shall be provided to ensure vacuum tightness. A built-in pressure relief valve to re-circulate the oil to suction side in case of accidental pressure rise shall be provided. Suction lift of the pump shall be at least 5 meters of transformer oil at atmospheric pressure & temperature. A separate by pass valve is provided across the gear pump so that the flow rate through the filter can be adjusted as required. The pump should be controlled by **frequency drive**. This should help to set the flow rate of filter plant from 8000-10000 LPH for 10KLPH machine.

1.2.1.2 The pumps shall be provided with an interlock with delay such that if there is no oil flow of 30 sec. through the heater, the pump shall trip automatically and also if the pump is not operating the heater will not be energized.

1.2.2 Magnetic Strainer

The plant shall be provided with suitable magnetic strainer with wire mesh to filter all particles of sizes above 0.5 mm and all magnetic particles. The strainer shall be installed at the suction of the oil pump described above.

1.2.3 Heater

a) An oil heater for heating up inlet oil shall be provided at the discharge side of the oil pump.
b) The oil heater vessel shall be of mild steel welded construction & insulated with glass/mineral wool.
c) The vessel shall be constructed for ultra high vacuum & pressure application.
d) Electric heater shall be provided inside the heater vessel to heat up oil from lowest ambient temperature to temperature required for filtration/degasification operation in single pass. The heater shall also be rated for heating the inlet oil from lowest ambient temperature at 70°C in single pass during filling up of transformers. Two separate temperature settings with thermostatic controllers shall be provided for this purpose.

e) The heating shall be indirect type and specific heat load shall not exceed 2.0 watt/cm² in order to avoid local overheating.
f) The total heating capacity shall be divided into three independent thermostatically controlled heating stages evenly balancing the three phases of power supply. The control switches and knobs shall be housed on a control panel.
g) An additional preset temper proof safety thermostat set at the highest temperature shall be provided on the heater to put off the heater and give audio and visual alarm to take care of accidental overheating.
h) The heater body shall be so designed as to allow replacement of heating elements without draining of oil. Suitable pressure relief valve, vent and drain valves & two (2) dial type temperature gauges at inlet & outlet of heater shall be provided.

1.2.4 Filter

a) Cartridge filter as may be required to ensure maximum particle size to less than 0.5 micron in the filtered oil shall be provided.

b) The filter body shall be fabricated of mild steel & designed for leak tightness at full vacuum & high pressures. The oil will flow from dirty oil chamber to clean oil chamber through filter elements.

c) Cartridge type element used shall be suitable for transformer oil in service and submicronic filtration, the media shall be non hygroscopic and of high dirt holding capacity.

d) The filter elements shall be easily removable for replacement when required. Compound gauge to indicate pressure across the filter, vent and drain with valves & other necessary accessories shall be mounted on the filter for each operation.

1.2.5 External Solenoid Operated valves

Two valves should be provided at the inlet and outlet of the plant. The moment inlet and outlet pumps are switched on these valves open thus making way for oil to pass. In case of power failure, oil from the transformer will not enter the plant and vacuum system.

1.2.6 Degassing Chamber

a) The degassing chamber shall be of welded construction and shall be suitable for operation under full vacuum. The fill of rasching rings & trays for distribution shall be designed for efficient distribution of oil over large areas. Incoming transformer oil should be spread over these rings in the form of film and over a longer surface area, thus achieving better degassing and dehumidification.
b) The degassing chamber shall be multistage (minimum 02 stages) type suitable for ensuring the desired oil properties. Arrangement for

condensing back lighter fraction (aromatics) of the insulating oil into the system shall be provided.

c) The degassing channels shall have adequate height to allow long enough free fall for complete degassing. Design shall be such as to minimize foam formation.

d) The degassing chambers shall be provided with suitable level monitor for oil or foam level in the chamber and shall trip the inlet gear pump when the level rises above the designed maximum level in order to prevent foam/oil to enter the vacuum pumping system. The oil inlet pump starts again automatically once the oil level in the degassing chamber falls below the preset oil level.

e) Necessary illuminated sight glass shall be provided through which oil flow through the degasser can be viewed clearly.

f) The degasser shall be provided with vacuum gauges, vacuum breaking valves, main and auxiliary vacuum connections and other necessary accessories.

1.2.7 Vacuum Pumping System

a) The pump shall be provided with a suitable vacuum pumping system for creating adequate high vacuum in the degassing chambers. The pumping system shall consist of suitable combination of Roots Blowers and Rotary vane vacuum pumps with inter-stage condensing units.

b) The roots blowers shall be of reputed make. Suitable built in labyrinth packing system, slinger rings, oil return chambers shall be provided between bearings and working chambers to prevent penetration of lubricating oil to the working chamber. The pumps motor shall be dynamically balanced. The pumps shall be suitable for starting evacuation from atmospheric pressure and shall be applied with necessary overflow valve.

c) The rotary vane vacuum pumps shall be installed after the roots blower. An automatic by pass valve across the roots blower shall permit operation of rotary vane pump alone to operate when so required. The rotary vane pumps are provided with gas ballast valve to prevent contamination of vacuum pump oil with moisture. The vacuum pump shall also be provided with suitable non-return valve device such that in the event of power failure the vacuum in the degassing chamber shall be maintained and the vacuum pump oil is not sucked back into the degassing chamber. A high vacuum safety valve (piston type) to prevent back streaming of oil and air intrusion shall be provided. The pump motors shall be having return stop device.

d) Necessary water cooled condensing units to condense the light faction (aromatics) and return the same to the transformer oil shall be provided to reduce the loss of aromatics. Condensing units shall also be suitable for operation with broken ice for remote location operation where cooling water connection is not available.

1.2.8 Vacuum Pumping system for TRANSFORMER Evacuation

An independent vacuum pumping system shall be provided for evacuating the transformer for oil filling. The vacuum level required for transformer evacuation for oil transfer is about 0.76 torr (1 m bar) for transformer oil heated to 70-80°C. The pumping system shall be identical to that of the degassing vacuum system. **The capacity shall be adequate for evacuation of:**

a) **90KL Tank in one hour from 1 atm to 1mbar**. (**For 10KLPH machine**)

The vacuum systems for degasser and transformer evacuation shall be inter connected in such a way that it shall be possible to use either or both the systems for any of the purpose. A reinforced hose of 10 mts. length should be provided. The hoses must be for vacuum leakage rate of 10^{2} torr-litre/sec.

1.2.9 Oil Extraction Pump

Suitable pumping system shall be provided for extracting oil from degasser under vacuum and supplying to transformer/reactor etc., at discharge pressure of 1.5 kg/cm² at the outlet hose nozzle of the plant, the pump shall be either glandless centrifugal type with canned motors or a combination of gear pump and centrifugal pump with mechanical seals suitable for extracting oil from high vacuum degassing chamber. The oil extraction pump shall be located at a suitable level below the degasser chamber so as to ensure adequate suction head for the pump. The pump shall be supplied with double check valve assembly and solenoid operated non return valve. In order to stop reverse flow of oil in case of power failure, the pumping system shall preferably be self priming type alternatively priming device with safety interlock to protect pump against dry running shall be provided. Sampling valves shall be provided at the discharge of extraction pump for testing of oil properties. A recirculation line with valves shall be provided to re-circulate a part of the purified oil to the inlet point if necessary during operation. The pump should be controlled by **frequency drive**. This should help to set the flow rate of filter pant from 8000-10000 LPH for 10KLPH machine

1.2.10 Hoses For Transformer Oil, Vacuum, Air And Water

a) Separate reinforced rubber hoses shall be provided for each operation for oil suction, oil discharge, transformer vacuum connection and cooling water supply and return. The hoses shall be at least 15 meter long each and shall be complete with hose quick connect couplers for connection to installations under operation.

b) Hose pipes for oil service shall be suitable for transformer oil application upto temperature of 100° C, full vacuum and pressure upto 2.5 kg/cm². All oil hoses shall be built up around an earthed core or have built in earthed conductor to avoid static electricity accumulation. Inlet and outlet nozzles

of purification plant and corresponding hoses shall be of 50 NB/40 NB size respectively in order to avoid error in connecting.

c) Vacuum hoses shall be of braided nitrile rubber suitable for full vacuum without collapsing and kinking. The vacuum hoses shall be transparent construction such that accidental oil flow can be easily detected.

1.2.11 Oil sampling valve: Suitable valve shall be provided for taking sample during filtration.

1.2.12 Material of construction and painting

a) Oil heater, filter vessel, degasser shall be of mild steel construction. The internal and external surfaces including oil heater, filter vessel, degasifier and structural steel work to be painted shall be shot or sand blasted to remove all rust and scale of foreign adhering matter or grease. All steel surface in contact with insulating oil shall be painted with two coats of heat resistant oil insoluble, insulating varnish.
b) All internal paints steel surfaces shall be given a primary coat of zinc chromate, second coat of oil and weather resistant varnish of a color distinct from primary and final two coats of glossy oil and weather resisting paint.
c) All paints shall be carefully selected to withstand heat and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
d) Bolts & Nuts: All bolts and nuts exposed to weather shall be hot dip galvanized/cadmium plated and passivated /zinc plated and passivated.
e) Material of construction for vacuum pumps air compressor, air drying plant, air receiver shall be steel of suitable grade.
f) All piping and equipment carrying transformer oil shall be insulated with glass wool/mineral wool insulation.

1.3 Instrumentation and Control

1.3.1 Following minimum instruments shall be provided on the oil purification plant:

a) Compound gauge at oil pump discharge
b) Compound gauge at filter inlet.
c) Compound Gauge at filter outlet
d) Pressure Gauge at discharge pump outlet
e) Pressure Gauge at degasifier
f) Vacuum Gauge at transformer evacuation line
g) Vacuum Gauge in between roots, vacuum pump and rotary vane vacuum pump.
h) Panel mounted vacuum indicators at degasser
i) Panel mounted vacuum indicators at transformer evacuating line.
j) Separate fine vacuum gauge for measurement of vacuum for transformer evacuation system and oil line degassing chamber evacuation system should be provided. This vacuum gauge should be electronic type having

range from 0.01 torr to 20 torr and should be of any of these reputed manufacturers' (Wika/ Hasting/ Edwards) make.

k) Oil Filtration Machine should be fitted with on-line moisture in oil-PPM indicator.
l) Sight glass at degassifier
m) Temperature indicator cum controller at heater inlet
n) Temperature indicator cum controller at heater outlet
o) Voltmeter
p) Oil flow meter (Positive displacement type)
q) Ammeter

1.3.2 **Control Panel :**

A centralized electrical panel with auxiliary step down transformer, contractors, back up protection fuses, indicating lamps etc. to be provided with following minimum audio and visual alarms:

a) High temperature at heater outlet
b) High differential pressure across filters
c) Oil pump trip
d) Vacuum pump trip
e) Loss of vacuum in degassing chamber
f) Loss of vacuum in transformer evacuation line
g) No oil flow through heater
h) High oil level in degasser.

All controls and annunciation equipment should be suitable for 240 V AC.

1.3.3 Suitable interlock as described against each equipment shall be provided for safe and trouble free operation.

1.3.4 All instruments, control hardware and alarms shall be mounted on a suitable control panel. A mimic diagram with indication lamps showing on-off status of various equipments shall be provided on the control panel.

1.3.5 The plant shall be fully equipped with adequate instrumentation having provision of manual operation, if required. All necessary control and indicating panel shall be provided.

1.3.6 It shall be possible to use the oil transfer pump for the purpose of loading oil to transformers or reactors from tankers and vice versa by by-passing to purification plant, if required.

1.3.7 There shall be independent vacuum pump for creating and holding the transformer/ reactor winding under vacuum for vacuum drying and filling of winding when required. The vacuum pump shall have capacity to develop and maintain adequate vacuum in the oil space of the 60KL tank within 1 hour time.

1.4 Electrical System:

1.4.1 The plant shall receive 415V, 3 phase, 50 Hz, 4 wire power supply through flexible cable in the distribution panel located on the plant. The incomer of the distribution panel shall be switch fuse unit.

1.4.2 One length of 50 meters of core 1100V grade flexible cable with crimped lugs at one end shall be provided for connection of the unit to the mains. The length of the cable will be covered in a suitable cable drum.

1.4.3 Provision for earthing the plant at the operating locations with earthing terminals for safety shall be provided.

1.4.4 The plant shall be suitably illuminated and ventilated for comfort of operator.

1.5 **Capacity Demonstration:** The supplier has to submit the detailed calculations in support of meeting the desired vacuuming capacity in prescribed time along with their technical offer. The capacity calculations submitted by the supplier shall be evaluated as per below mentioned method:

Pumping Down Time (PDT) = V/S ln (P1/P2)

PDT = 1.2 x (PDT1 + PDT2); Considering 1.2 as service factor

PDT1: V= Volume of Tank to be evacuated (90KL or 60KL),
S= Capacity of Vacuum pump in LPM, P1= 760mm of Hg, P2=50 mm of Hg

PDT2: V= Volume of Tank to be evacuated (90KL or 60KL),
S= Capacity of Roots pump in LPM, P1= 50 mm of Hg, P2=0.76 mm of Hg

If the supplier offers the capacity of vacuum pump and roots pump different than the capacity derived from above mentioned method, it has to demonstrate the machine at his Works for required capacity by achieving desired vacuum within prescribed time and this will be the part of technical evaluation i.e. pre-award demonstration of vacuuming capacity has to be arranged by supplier within 45 days of intimation by the Employer without any financial implication to the Employer.

The supplier, who offers the vacuuming capacity in line with the above method, shall have to demonstrate the machine (Post-Award) at his Works for required capacity by achieving desired vacuum within prescribed time.

The tank required for the demonstration at his Works is to be arranged by the supplier. The supplier who has already successfully demonstrated the desired vacuuming capacity in the region needs not to repeat again.

1.6 **Gaurantee:** Min 01 year from the date of successful & complete commissioning at The Employer sub-station. All the materials, including accessories, cables, components etc. are to be covered under warranty/guaranty period. If any component of the plant needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, transportation of component/plant for repair at works.

1.7 **Commissioning, handing over the Instrument:** Successful bidder will have to commission the plant to the satisfaction of the Employer. The equipment failed during the demo shall be rejected and no repairs are allowed.

1.8 **Training:** Supplier shall have to ensure that the plant is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to the Employer engineers.

1.9 **<u>After Sales Services</u>:** Bidder will have to submit the documentary evidence of having established mechanism in Nepal for "after sales services".

CHAPTER 6 - CIVIL WORKS

1.0 GENERAL

The intent of specification covers the following:

Design, engineering and drawing of all transformer foundation under present scope of work. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (BS Codes)/IS/equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design and drawings and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA/Consultant.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA/Consultant. All foundations shall be developed by the Contractor as per approved layout. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements. **No extra payment shall be made for design and any other works related to transformer foundations and it is considered to be included in price schedules.**

2.0 GEOTECHNICAL INVESTIGATION

2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the transformer can be designed safely and rationally.
A detailed soil report including field data duly certified by site engineers of NEA/Consultant will be submitted by the Contractor for specific approval of NEA/Consultant. The report shall contain all soil parameters along with recommendation of soil consultant for type of foundation i.e. pile or open type, soil treatment if any etc to be used for the design of civil foundations.
Soil investigation report shall be provided by the employer. However, if further investigation is required, such shall be included in present scope of

work.

2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering transformer areas.

2.3 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for transformers. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the NEA/Consultant. The soil investigation for 132 kV and 33 kV switch yard extension in existing switch yard has not been envisaged. Soil data of 220 kV yard under the present scope shall be referred for the design of foundations in switch yard extension.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/ equivalent International Standards.

2.3.1 Bore Holes

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant international standards/British standards(BS) at the rate of minimum one number bore hole per hectare up to 15meter depth(Minimum) or to refusal which ever occur earlier shall be drilled for new areas (220 kV Yards and 220/132/33 kV yards wherever applicable). In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata is varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 25 m depth from ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every

change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Standard Penetration Test shall be performed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/ equivalent International Standards. or an alternative recognize method as agreed by NEA/Consultant. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

2.3.2 Trial Pits

The Contractor Shall excavate two number trial pits per sub station (New) as and where directed by NEA/Consultant, of Plan area 10 sq.m and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the NEA/Consultant. All Trial Pits shall be re-filled with approved material after the tests are complete and shall be compacted in layers of not more than 500mm.

2.3.3 Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.. Unless otherwise specified at each test location, the test shall be conducted along

two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m upto a distance of 50.0 m.

2.3.4 Plate load test

Plate load test shall be conducted at the location of control room building and Auxiliary building as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standard. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs Settlement shall be kept as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.
Backfilling of the pit shall be carried out as per the directions of the NEA/Consultant**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

2.3.5 Water Sample

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

2.3.6 Back Filling of Bore Holes

On completion of each hole, the Contractor shall backfill all bore holes as

directed by the NEA/Consultant. The backfill material can be the excavated material.

2.3.7 Laboratory Test

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples have reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/ equivalent International Standards.

   The following laboratory tests shall be carried out

   a) Visual and Engineering Classification

   b) Atterberg limits Tests.

   c) Natural moisture content, bulk density and specific gravity.

   d) Grain size distribution analysis.

   e) Swell pressure and free swell index determination.

   f) California bearing ratio.

   g) Consolidated drained test with pore pressure measurement.

   h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.

   i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/ equivalent International Standards including following tests shall also be conducted.
      (i) UCC test.
      (ii) Point load index test.

2.3.8 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and

recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA/consultant. Initially the contractor shall submit draft report and after the draft report is approved, the final report in four (4) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA/Consultant.

The report shall include, but not limited to the following:-

a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.

b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

   Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA/Consultant. The observations and recommendations shall include but not limited to the following:

a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.

b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.

c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.

d) Recommendations regarding slope of excavations and dewatering schemes, if required.

e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.

f) If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.

g) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

3.0 CONTOUR SURVEY, SITE LEVELLING

3.1 CONTOUR SURVEY & SITE LEVELLING:

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level at 05 m x05 m grid interval with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bride/railway platform or government buildings of local authorities. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map with contour interval of 0.5 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi level or gradual slope with the finished ground level as approved by NEA/Consultant during detailed engineering based on highest flood level. The levelling area shall be decided by NEA/Consultant during detailed Engineering stage.

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA/Consultant. The Contractor shall provide all assistance in instruments, materials and personnel to NEA/Consultant for checking the detailed layout and shall be solely

responsible for the correctness of the layout and levels.

3.2 **SCOPE**

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling, supplying and compaction of fill material if required. Cutting/felling of trees and their disposal has not been envisaged under the present scope.

3.3 **GENERAL**

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation & filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA/Consultant for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA/Consultant for approval.

3.4 Filling material shall conform to relevant British standard codes (BS Codes)/ equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

4.0 TRANSFORMERS/REACTOR FOUNDATION, RAIL TRACK/ RAIL CUM ROAD TRACK

The Contractor shall design and prepare drawing for a RCC Rail cum road system integrated with the Transformer/Reactor foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS.

The Contractor shall design a pylon support system for supporting the fire fighting system.

Each Transformer /Reactor including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer/Reactor shall be 20% of the Transformer /Reactor height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200% volume for 220 kV and 130% for 132 kV of total oil in the Transformer /Reactor. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40mmx 5mm placed at 30mm center to center and 25mmx5mm MS flat at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150mm, shall be placed at the formation level and will be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/ equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

4.1 MATERIALS

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in clause 11.0 in the specification.

5.0 FOUNDATION

5.1 GENERAL

1. Work covered under this Clause of the Specification comprises the design and drawing of transformer foundations.

2. Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards. and all the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, a minimum grade of M25 (design Mix) concrete shall be used for all foundations and

structural/load bearing members as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

4. The switchyard foundation's plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.

5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

6. Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of relevant British standard codes (B S Codes)/ equivalent International Standards. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles have been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

5.2 DESIGN

While designing foundations, following may be taken care of :

5.2.1. All foundations shall be of reinforced cement concrete. The design of RCC structures shall be carried out as per relevant BS and minimum grade of concrete shall be M-25 (design Mix). Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the NEA/Consultant.

5.2.2. Limit state method or any other method as per relevant British standard codes (B S Codes)/ equivalent International Standards of design shall be adopted unless specified otherwise in the specification.

5.2.3. For detailing of reinforcement relevant BS followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

5.2.4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (B S Codes)/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS.

5.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant British standard codes (B S Codes)/ equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

5.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

5.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.

5.2.8. RCC columns shall be provided with rigid connection at the base.

5.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

5.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of

substructures of any underground enclosures, earth pressure at rest shall be considered.

5.2.11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.

5.2.12. Following conditions shall be considered for the design of water tank in sumps, trenches and other underground structures:

a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).

b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

5.2.13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.

5.2.14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.

5.2.15. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

5.2.16. The foundations of transformer/reactor shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

5.2.17. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/ equivalent International Standards for two conditions i.e. Normal condition and short

circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor over loads in limit state design also.

6.0 BRITISH STANDARD CODES

Major British standard Codes for civil work have been given in the following list. This list is illustrative but not exhaustive. However, for design and engineering relevant BS codes or equivalent International standards shall be referred by the contractor. Relevant portion of BS codes or equivalent international standards referred by the contractor for the design shall be made available to NEA/Consultant if necessary during detailed engineering stage.

Sr. No.	Standard No.	Title	Year
1	BS 41	Structural steel sections. Specification for hot-rolled sections	2005
2	BS 13771	Methods of test for soils for civil engineering purposes. General requirements and sample preparation	1990
3	BS 4449	Steel for the reinforcement of concrete. Weldable reinf orcing steel. Bar, coil and decoiled product. Specificati on (with A2:2009)	2005
4	BS 4482	Steel fabric for the reinforcement of concrete. Specifica tion	2005
5	BS 4483	Steel fabric for the reinforcement of concrete. Specifica tion	2005
6	BS EN 102102	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties	2006
7	BS EN 100561	Specification for structural steel equal and unequal angles. Dimensions	1999
8	BS EN ISO 80 0001	Quantities and units. General	2013
9	BS 5930	Code of practice for site investigations (with A2:2010)	1999
10	BS EN 199311	Eurocode 3. Design of steel structures. General rules an d rules for buildings	2005
11	NA to BS EN 1 99311	UK National Annex to Eurocode 3. Design of steel stru ctures. General rules and rules for buildings	2008
12	BS EN 199315	Eurocode 3. Design of steel structures. Plated structural elements	2006
13	NA to BS EN 1 99315	UK National Annex to Eurocode 3. Design of steel stru ctures. Plated structural elements	2008
14	BS EN 199318	Eurocode 3. Design of steel structures. Design of joints	2005
15	NA to BS EN 1 99318	UK National Annex to Eurocode 3. Design of steel stru ctures. Design of joints	2008
16	BS 60732	Precast concrete masonry units. Guide for specifying pr ecast concrete masonry units	2008
17	BS 7668	Weldable structural steels. Hot finished structural hollo w sections in weather resistant steels. Specification	2004
18	BS EN 19971	Eurocode 7. Geotechnical design. General rules	2004

19	NA to BS EN 1 9971	UK National Annex to Eurocode 7. Geotechnical desig n. General rules	2007
20	BS EN 19923	Eurocode 2. Design of concrete structures. Liquid retai ning and containing structures	2006
21	BS EN 199211	Eurocode 2. Design of concrete structures. General rule s and rules for buildings	2004
22	NA to BS EN 1 99211	UK National Annex to Eurocode 2. Design of concrete structures. General rules and rules for buildings	2005
23	BS 75334	Pavements constructed with clay, natural stone or conc rete pavers. Code of practice for the construction of pa vements of precast concrete flags or natural stone slabs	2006
24	BS EN 1971	Cement. Composition, specifications and conformity cr iteria for common cements	2011
25	BS 743	Specification for materials for dampproof courses	1970
26	BS 8122	Testing aggregates. Methods for determination of densi ty	1995
27	BS 952-1	Glass for glazing. Classification	1995
28	BS 952-2	Glass for glazing. Terminology for work on glass	1980
29	BS EN 12620	Aggregates for concrete	2013
30	BS 1125	Specification for WC flushing cisterns (including dual f lush cisterns and flush pipes)	1987
31	BS 1188	Specification for ceramic wash basins and pedestals	1974
32	BS 1199 and 1 200	Specifications for building sands from natural sources	1976
33	BS EN 13310	Kitchen sinks. Functional requirements and test method s	2003
34	BS 1245	Pedestrian doorsets and door frames made from steel s heet. Specification	2012
35	BS 1254	Specification for WC seats (plastics)	1981
36	BS 1370	Specification for low heat Portland cement	1979
37	BS EN 1008	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industr y, as mixing water for concrete	2002
38	BS 3505	Specification for unplasticized polyvinyl chloride (PV CU) pressure pipes for cold potable water	1986
39	BS EN 15743	Supersulfated cement. Composition, specifications and conformity criteria	2010
40	BS EN ISO 37 66	Construction drawings. Simplified representation of co ncrete reinforcement	2003
41	BS 8666	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification	2005
42	BS 4514	Unplasticized PVC soil and ventilating pipes of 82.4 m m minimum mean outside diameter, and fittings and ac cessories of 82.4 mm and of other sizes. Specification	2001
43	BS 4551	Mortar. Methods of test for mortar and screed. Chemic al analysis and physical testing (with A2:2013)	2005
44	BS EN 122001	Plastics rainwater piping systems for above ground ext ernal use. Unplasticized poly (vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system	2000
45	BS EN 1462	Brackets for eaves gutters. Requirements and testing	2004

46	BS EN 607	Eaves gutters and fittings made of PVC-U. Definitions, requirements and testing	2004
47	BS 6262	Code of practice for glazing for buildings	1982
48	BS EN 14411	Ceramic tiles. Definitions, classification, characteristic, evaluation of conformity and marking	2012
49	BS 6510	Steel framed windows and glazed doors. Specification	2010
50	BS EN 636	Plywood. Specifications	2012
51	NA to BS EN 1 9923	UK National Annex to Eurocode 2. Design of concrete structures. Liquid retaining and containment structures	2007
52	BS EN 1339	Concrete paving flags. Requirements and test methods	2003
53	BS EN 1340	Concrete kerb units. Requirements and test methods	2003

Chapter 7

Technical Data Sheet (Guaranteed Technical Particulars)

A. Power Transformer

Technical Data Sheet (Guaranteed Technical Particulars)

A. Power Transformer

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 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 (as per IS:6600) 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)			

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
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			
	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 (%)			
	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			

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
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			
	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)			

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
	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			
	Maxi continuous ratings			
	i) At 50 C ambient air temp. at site (KVA)			
	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			

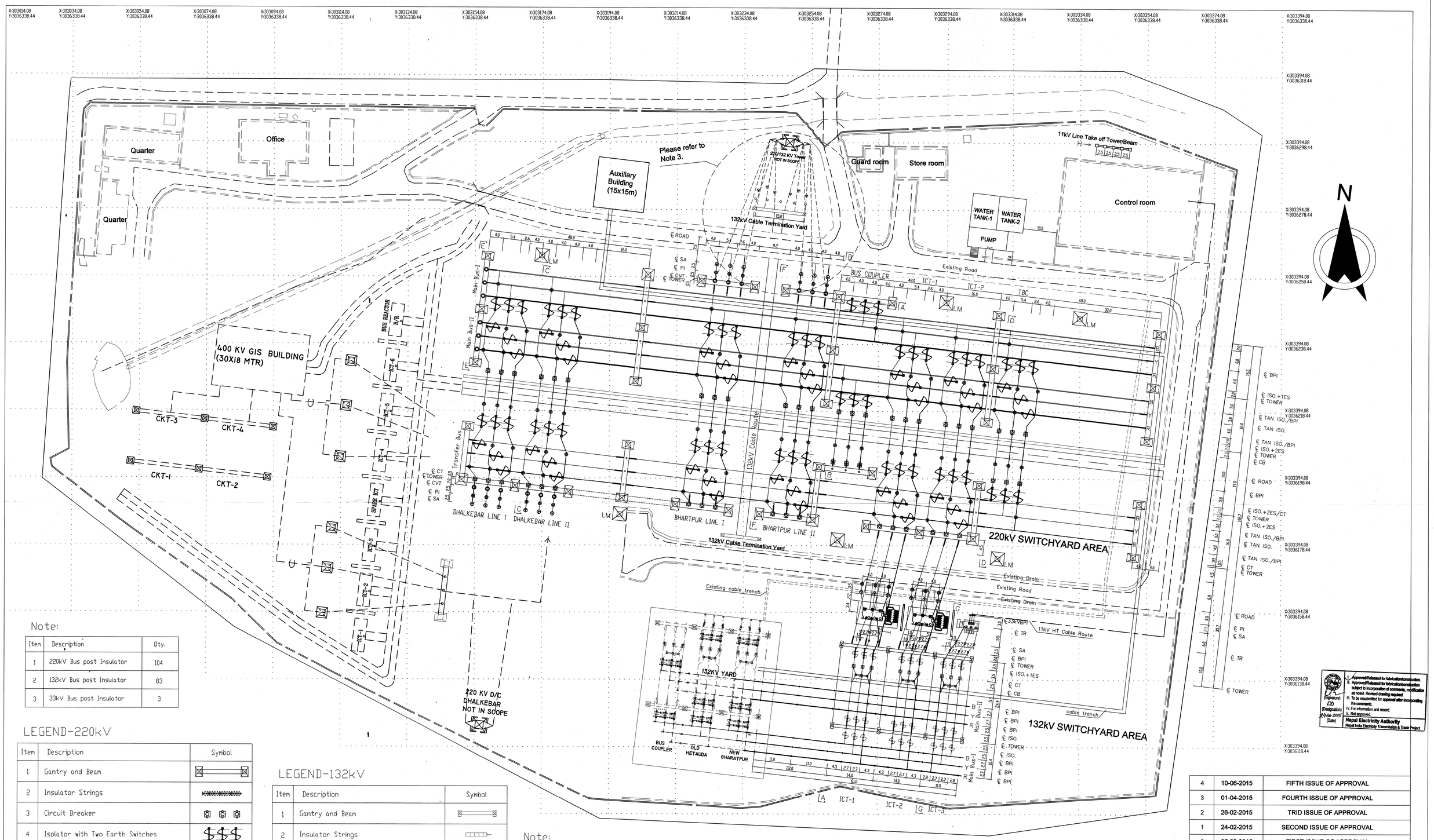
S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
	vi) Dry 1 minute power frequency test voltage value of high voltage bushing in KV			
	vii) Wet 10 second power frequency test voltage value of high voltage bushing in KV			
	viii) Impulse withstand test voltage 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			
	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)			

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
	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			
	d) Time for complete tap change (Sec.)			

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
	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 TAPCHANGING 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			

S.N.	Description	Offered Data		
		220/132/33kV, 160 MVA	220/33kV, 63 MVA	132/11kV, 10 MVA
	xi) Drawing or pamphlet-number of the technical and descriptive particulars of the OLTC, enclosed with the Bid.			

Signed _____
As representative for _____
Address _____
Date_____



Note:

Item	Description	Qty.
1	220kV Bus post Insulator	104
2	132kV Bus post Insulator	83
3	33kV Bus post Insulator	3

LEGEND-220kV

Item	Description	Symbol
1	Gantry and Beam	
2	Insulator Strings	
3	Circuit Breaker	
4	Isolator with Two Earth Switches	
5	Isolator with One Earth Switches	
6	Isolator (Tandem) without Earth Switches	
7	Current Transformer	
8	Capacitor voltage Transformer	
9	Surge Arrester	
10	Bus Post Insulator	

LEGEND-132kV

Item	Description	Symbol
1	Gantry and Beam	
2	Insulator Strings	
3	Circuit Breaker	
4	Isolator with One Earth Switches	
5	Isolator without Earth Switches	
6	Current Transformer	
7	Surge Arrester	
8	Capacitor voltage Transformer	
9	Bus Post Insulator	

Note:

1. All dimensions are in m.
2. The Location of LM showing on this drawing is tentative, and shall be submitted separately. The detailed Drawing will be submitted separately.
3. For Baharatpur D/C Multicircuit Tower, the conductor profile and electrical clearance of dropper to SA and PI shall be submitted separately. The Details of 132kV XLPE Cable termination yard for interconcection of Multicircuit Tower D/C Bharatpur Line I &II from the top tier to 220kV Gantry Beam and the adjointing 220kV foundation (SA,PI,CVT ect.) details shall also be submitted separately.

——— Under present scope
---- Existing/Future

DESIGNATION	NAME	SIGNATURE
DRAWN BY	LUREE	
CHECKED BY	FAN JIANYE	
APPROVED BY	WU LEGUO	

REV	DATE	MODIFICATION
4	10-06-2015	FIFTH ISSUE OF APPROVAL
3	01-04-2015	FOURTH ISSUE OF APPROVAL
2	26-02-2015	TRID ISSUE OF APPROVAL
1	24-02-2015	SECOND ISSUE OF APPROVAL
0	05-02-2015	FIRST ISSUE OF APPROVAL

NEPAL ELECTRICITY AUTHORITY

CENTRAL CHINA POWER GRID INTERNATIONAL ECONOMIC & TRADE CO.,LTD

NIETTP / W / ICB / -2 / SS

HETAUDA SUBSTATION

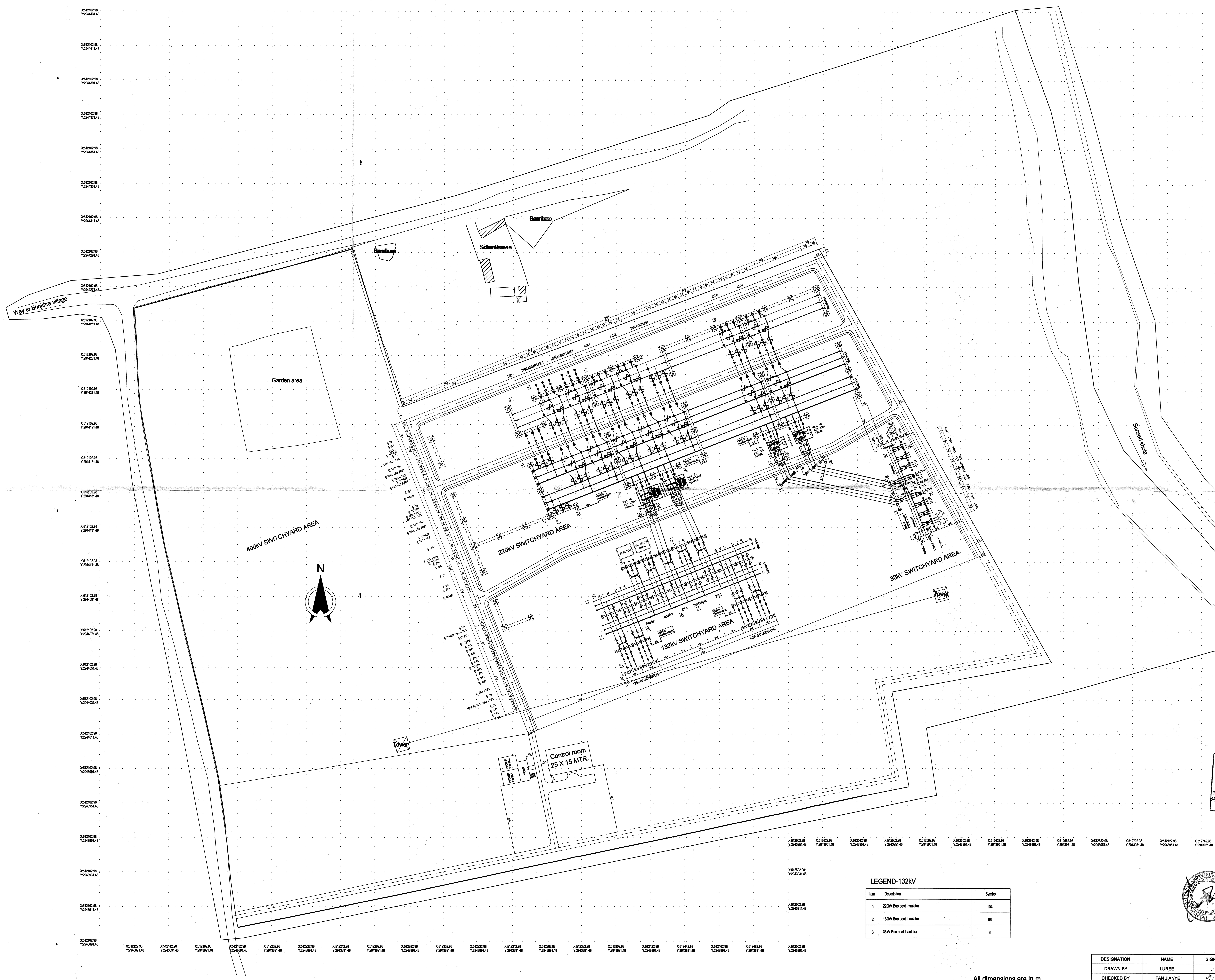
ELECTRICAL LAYOUT PLAN

DRAWING No. HTD-SS-E-01(02)

(Signature) (Designation) 24-06-2015 (Date)

I. Approved/Released for fabrication/construction.
II. Approved/Released for fabrication/construction subject to incorporation of comments, modification as noted. Revised drawing required.
III. To be resubmitted for approval after incorporating the comments.
IV. For information and record.
V. Not approved.

Nepal Electricity Authority
Nepal India Electricity Transmission & Trade Project



LEGEND-220kV

Item	Description	Symbol
1	Gantry and Beam	
2	Insulator Strings	
3	Circuit Breaker	
4	Isolator with Two Earth Switches	
5	Isolator with One Earth Switches	
6	Isolator (Tandem) without Earth Switches	
7	Current Transformer	
8	Capacitor voltage Transformer	
9	Surge Arrester	
10	Bus Post Insulator	

LEGEND-132kV

Item	Description	Symbol
1	Gantry and Beam	
2	Insulator Strings	
3	Circuit Breaker	
4	Isolator with One Earth Switches	
5	Isolator without Earth Switches	
6	Current Transformer	
7	Surge Arrester	
8	Capacitor voltage Transformer	
9	Bus Post Insulator	

LEGEND-33kV

Item	Description	Symbol
1	Gantry and Beam	
2	Insulator Strings	
3	Circuit Breaker(with Current Transformer)	
4	Isolator with One Earth Switches	
5	Isolator without Earth Switches	
6	Surge Arrester	
7	Capacitor voltage Transformer	
8	Horn Gap Fuse	
9	Bus Post Insulator	

I. Approved/Released for fabrication/construction.
II. Approved/Released for fabrication/construction subject to incorporation of comments, modification as noted. Revised drawing required.
III. To be resubmitted for approval after incorporating the comments.
IV. For information and record.
V. Not approved.

(Signature)
PD
(Designation)
24.06.15
(Date)

Nepal Electricity Authority
Nepal India Electricity Transmission & Trade Project

LEGEND-132kV

Item	Description	Symbol
1	220kV Bus post Insulator	104
2	132kV Bus post Insulator	96
3	33kV Bus post Insulator	6

All dimensions are in m.

REV	DATE	MODIFICATION
2	10-06-2015	THIRD ISSUE OF APPROVAL
1	12-05-2015	SECOND ISSUE OF APPROVAL
0	01-02-2015	FIRST ISSUE OF APPROVAL

NEPAL ELECTRICITY AUTHORITY

CENTRAL CHINA POWER GRID
INTERNATIONAL ECONOMIC & TRADE CO.,LTD

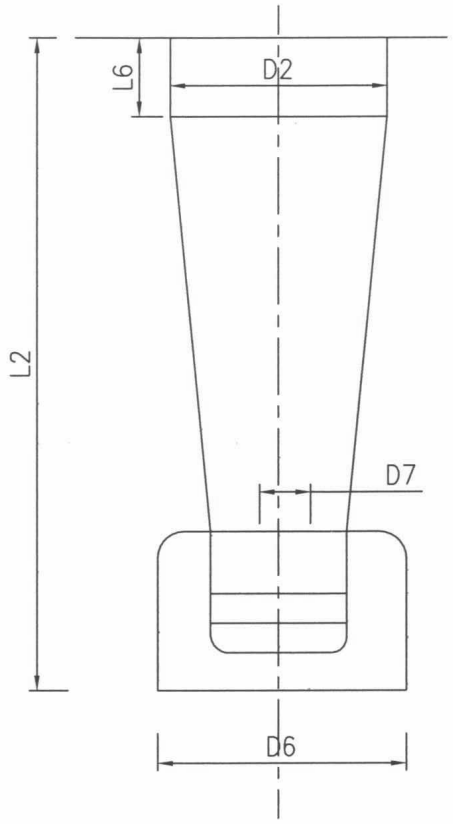
NIETTP / W / ICB / -2 / SS

DESIGNATION	NAME	SIGNATURE
DRAWN BY	LUREE	
CHECKED BY	FAN JIANYE	
APPROVED BY	WU LEGUO	

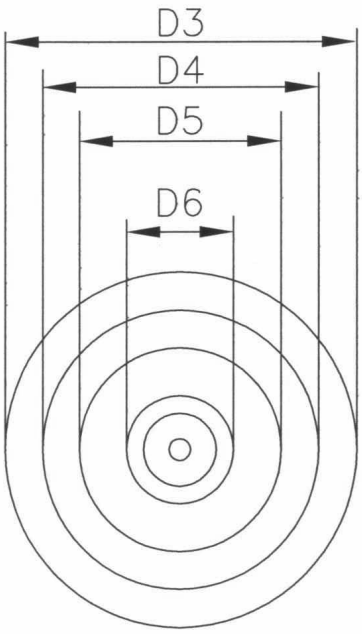
INARUWA SUBSTATION

ELECTRICAL LAYOUT PLAN

DRAWING No. IRW-SS-E-01(02)



VOLTAGE RATING KV	420	245	145	72.5	52
BIL (kV_p)	1425	1050	650	325	250
CREEPAGE (MM) (Min.)	10500	6125	3625	1810	1300
CURRENT RATING (A) (Min.)	800 / 1250	1250 / 2000	800	800	3150
L2±5 (FOR DIFF. VALUES OF L6)	1640	1130 / 1230	600#/800	695	475
L6 (MIN.)	400	300	100#/300	300	100
D2 (Max.)	350	270	165	115	165
D3±2	720	450	335	225	335
D4±1	660	400	290	185	290
D5xN	24x12	20x12	15x12	15x6	15x12
D6 (MAX)	350	270	165	115	115
D7 (Min)	60	48 / –	38	—	—

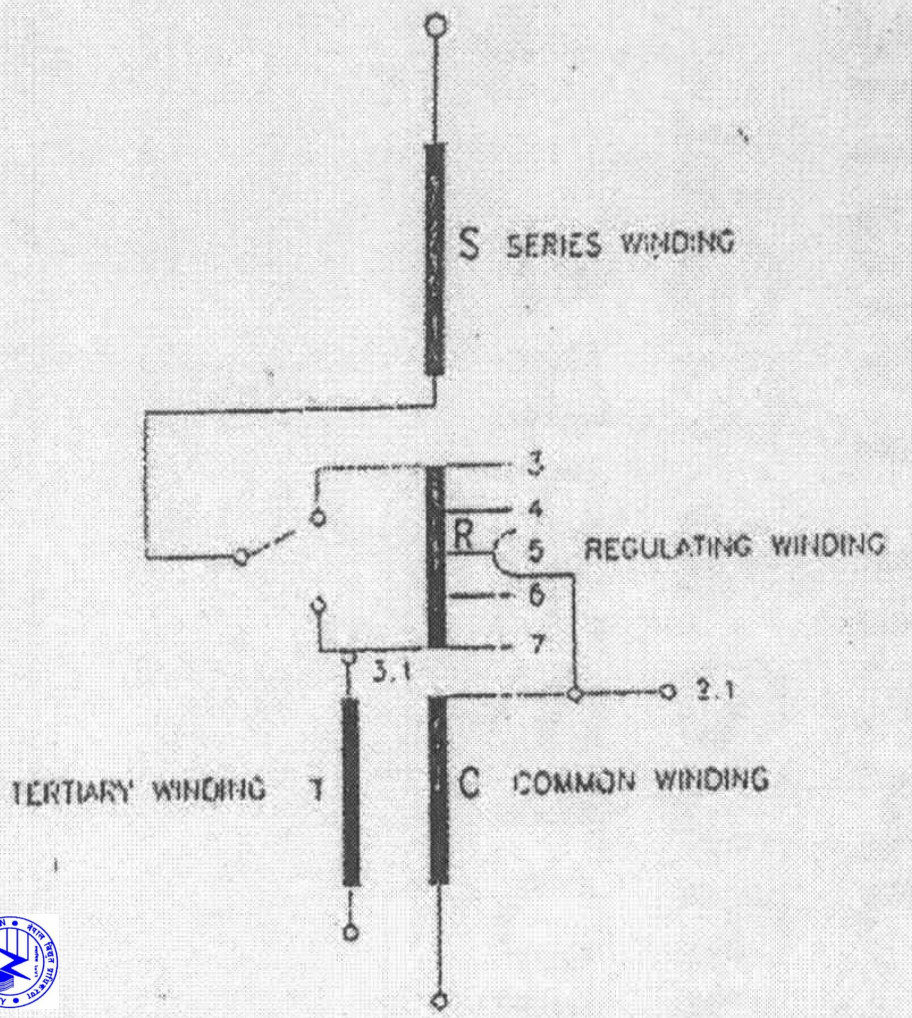


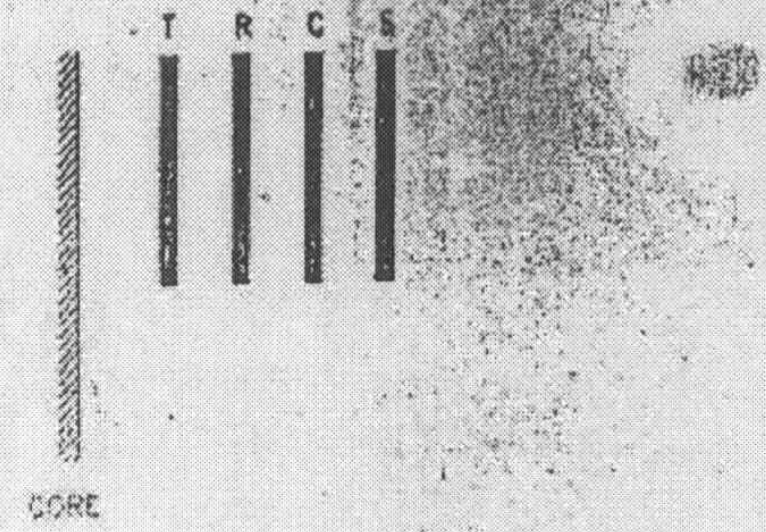
NOTE:

1. ALL DIMENSIONS ARE IN MM
2. NO POSITIVE TOL. WHERE MAX. DIMENSION SPECIFIED AND NO NEG. TOL. WHERE MIN. DIMENSION IS SPECIFIED

APPLICABLE FOR SHUNT REACTOR

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO
			STD. DIMN. FOR RIP CONDENSER BUSHINGS (LOWER PORTION)	000-T-E-A-001-R02



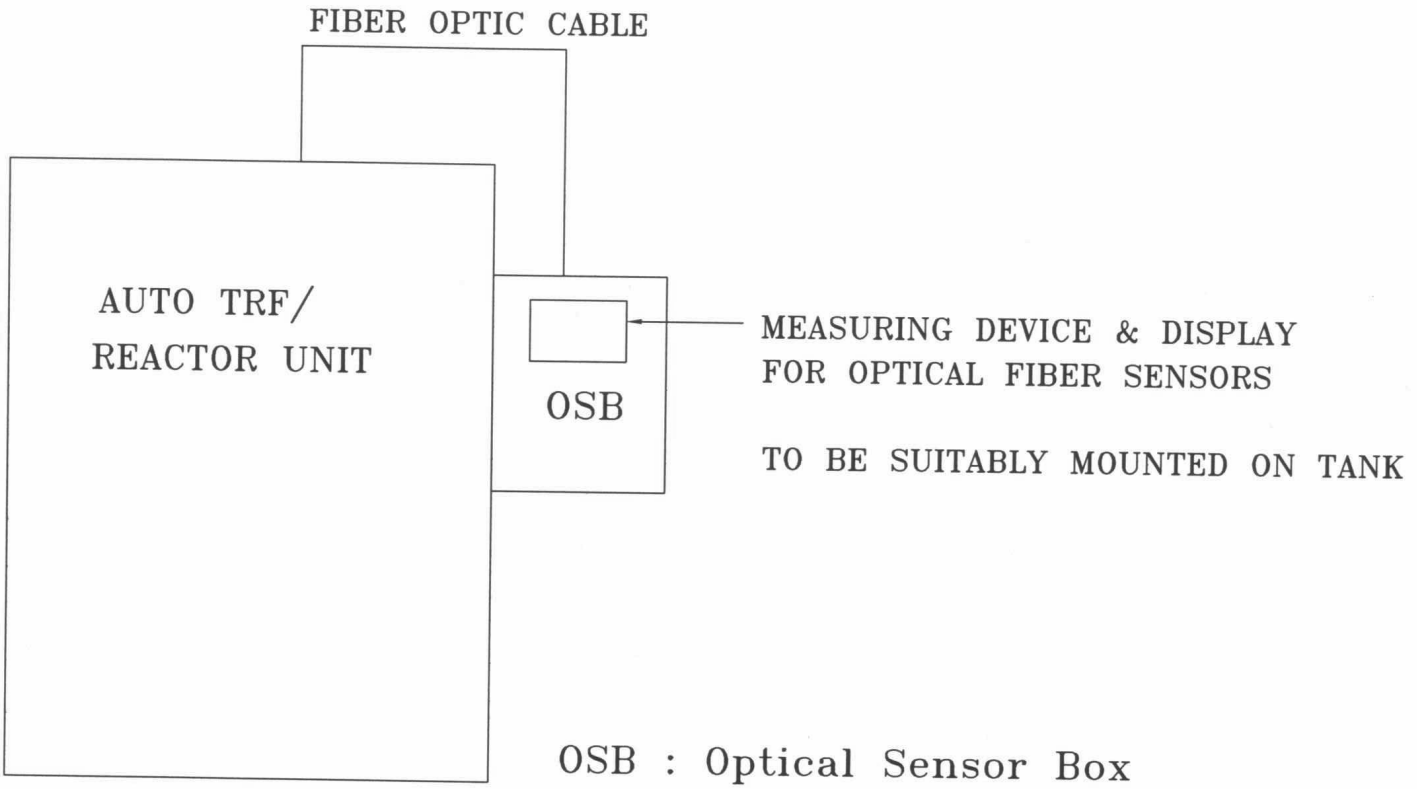


A TYPICAL MARKINGS FOR ONE PHASE OF AUTO TRANSFORMER WITH TAPPED WINDING AT THE END OF SERIES WINDING (COMMON FOR ALL TYPE OF AUTO TRANSFORMER)

B POSITIONING OF REGULATING WINDING WITH RESPECT TO OTHER WINDINGS.

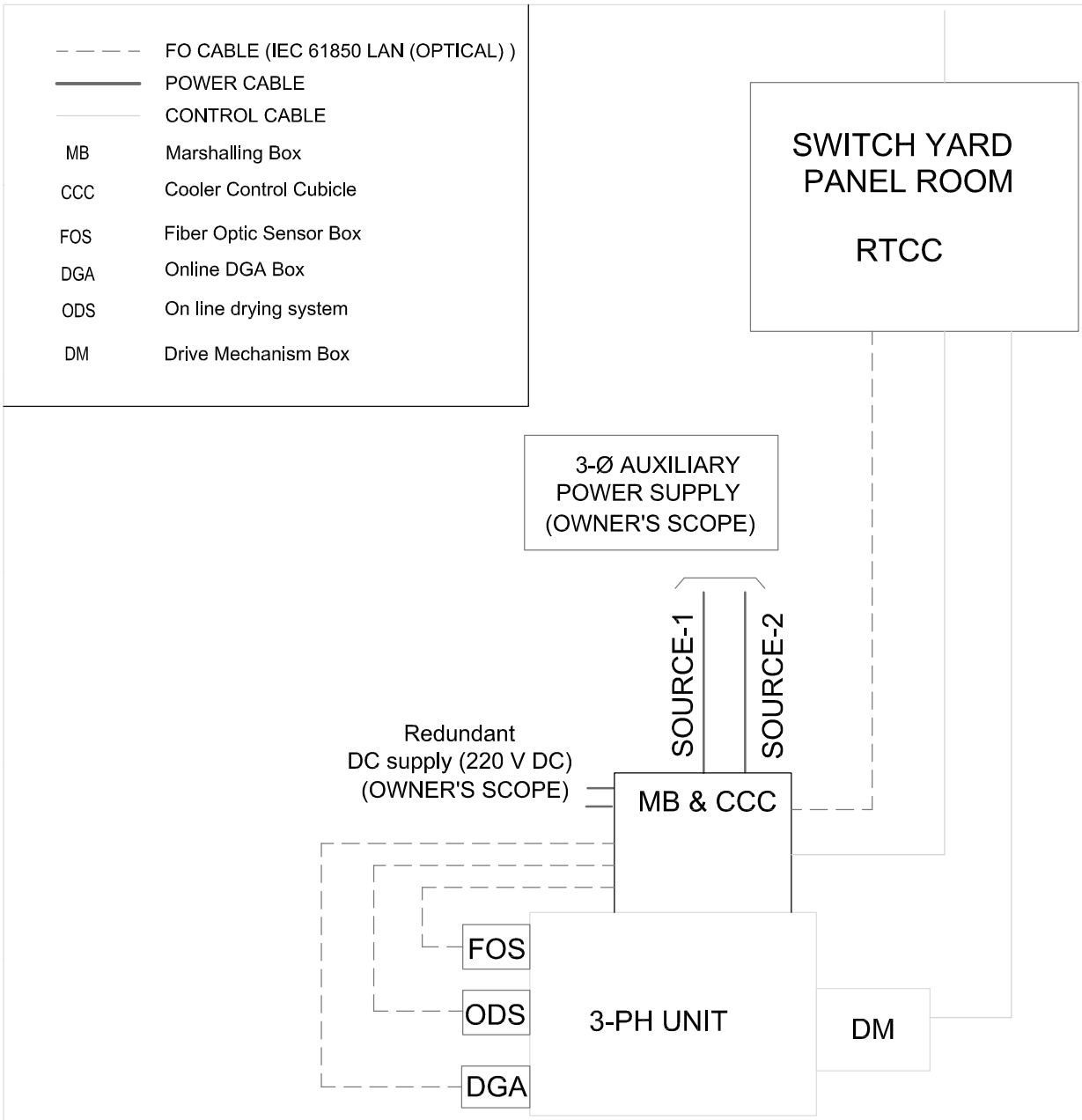
APPLICABLE FOR CONSTANT OHMIC (IMPED) TYPE AUTO TRANSFORMERS ONLY.

REV	DATE	DRN	CHKD	APPD	TITLE	PROJECT	
C	25.1.97				TYPICAL ARRANGEMENT FOR ONE PHASE OF AUTO TRANSFORMER WITH REGULATING WINDING AT THE END OF SERIES WINDING	STANDARDISATION	POWER GRID CORPORATION OF INDIA LIMITED
						DRG. NO. 0053-TE4-014	



OSB : Optical Sensor Box

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO	REV.
			CONCEPTUAL DRG. FOR OPTICAL FIBER SENSOR	C/ENGG/STD/OPICAL FIBER SENSOR/AT–SR	0



NOTE:

1. All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) provided for individual transformer unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in MB by the contractor. The switch shall be powered by redundant DC supply (220V DC). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) upto MB shall be in the scope of contractor.

2. However, fiber optic cable, power cable, control cables, as applicable, between MB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of sub-station contractor.

3. Control, Power, FO and any special cable from online monitoring equipment, DM, Cooler control cubicle to MB shall be supplied by contractor

4. Ethernet switch, LIU, Patch cord etc. shall be provided at MB by contractor

5. All cable from RTCC to MB & DM and any special cable between MB to switchyard panel room/control room shall be supplied by contractor

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO	REV.
			CONCEPTUAL DRG. FOR SHOWING POWER & CONTROL CABLE FOR OPERATION OF 3–PH TRANSFORMER	C/ENGG/STD/CABLE/TR	01