SYRIAN ARAB REPUBLIC
MINISTRY OF ELECTRICITY
PUBLIC ESTABLISHMENT
FOR TRANSMISSION AND DISTREBUTION
OF ELECTRICITY (PETDE)

TENDER No. /2025

SPECIFIC REQUIREMENTS AND SPECIFICATION FOR CALLING OF OFFERS FOR AUTO TRANSFORMERS (400/230/20)KV 300 MVA AND EARTHING TRANSFORMERS (20/0.4) KV 400 KVA

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1.1- GENERAL AND SCOPE OF SUPPLY:

PETDE asks for External call of offers to have Auto transformers to extend some existing 400KV substation, or to replace some of existing Auto transformers, the bidder shall offer the following:

a Auto Transformers 400/230/20 KV, 300 MVA capacity for each.

b) earthing transformers 20/0.4 KV, 400 KVA capacity for each.

The Auto Transformer should be complete with all-necessary equipment and material, needed to put it into operation, and with one earthing transformer for each Auto transformer. The technical specification details according to attached specifications.

c) Spare Parts as per schedules No: E2.1&E2.2

d) The scope of supply shall include design, manufacturing and testing & training at manufacturers works and drawings, brochures, manuals, instructions for erection operation and maintenance of the required transformers.

Tenderer is requested to fill- in and sign the forms of guarantee schedules.

Any missing data in filling these schedules or in submitting any information or documents requested to prove the offer specification will badly affect the evaluation of the offer during the technical comparison.

1.2- CONTRACTOR RESPONSIBILITY FOR FOUNDATION DESIGN :

Contractor should be responsible for complete civil design of all foundations related to mentioned works that means:

- Transformers and earthing transformers foundations and oil pits under or beside these transformers (if needed) taking in consideration – B.S – or UBC – or Syrian Arabic code last edition.
- All loads should be considered in design including seismic load – and factor of seismic should be according to Syrian Arabic code instructions and Annexes and value of seismic factor varies – 0.2G-0.3G.
- Design should be done for various allowable bearing capacities of soil that is :
  - $1 kg/cm^2$
  - $2 kg/cm^2$
  - $3 kg/cm^2$
- Contractor should submit all detailed calculation sheets and civil drawings to PETDE for approval and all safety factors should be included in the calculation's standard and requirements.
- Contractor should submit bill of quantities for all items of civil works – detailed reinforcing steel tables.
- Contractor must submit to PETDE all documents (drawings-calculation- bill of quantities ...etc on CD (compact disk) 3 copies in addition to three copies of printed papers.
- The minimum compressive strength of concrete should be 210kg/cm2 with cement ratio not less than 350 kg/m3.

- Quality of reinforcement –fy =4200 kg/cm2 .
- The contractor shall be entirely responsible for the design of the works and stability and sufficiency of the works .
- Lean concrete not less than 10 cm with cement ratio 200kg cement/m3 concrete (projection-10-cm in all directions).
- Rail according to din-S49-).
- Rails Gauge – 1676- mm .
- Rails centre to centre -1743- mm.
- Four rails for positioning transformer starting from inside of the transformer foundation till end of the road with foundations needed, and all required facilities, foundations…needed for the transformer are the designer responsibility such as (Tifour foundations – Jacks foundations –Earthing ……..and not limited to).
- Design for any needed R.C cable trenches with detailed drawings .

1.3- STANDARDS AND NORMS :

All equipment shall be designed, manufactured and tested at works and on site in conformity with the lasted applicable IEC standards.
Whenever IEC standards have been issued, Tenders shall state the available applicable standards or norms to be followed in the design, manufacture and testing of such equipment and shall enclose an English copy of them.
Tender documents shall include a list covering all standards and norms to be applied for manufacture for each equipment, instruction, installation and testing.
The Tenderer shall also specify the testing procedure to be carried out, keeping in mind that the testing procedures in these specifications are stated only as a minimum.

1.4- SITE CONDITIONS:

The climatic conditions of the site are subtropical.
The tropical climate prevails in summer and temperate climate in winter

-maximum ambient temperature	: +45 °C
-minimum ambient temperature	: -5 °C for indoor equipment
	: -10 °C for outdoor equipment
-maximum wind velocity	: 35 m/s
-prevailing wind direction	: north-west
-relative air humidity, maximum	: 50-60%
-Altitude	: <1000m

1.5- TESTS:

Unless otherwise specified or approved by PETDE, all equipment shall be tested according to the IEC standards. The tests described in the different sections of this book are given as a minimum and are not restrictive. If some type tests have been already affected by an independent testing authority the type test certificates shall be enclosed with the tender.
The Contractor shall provide the PETDE with a schedule of proposed tests to be carried out together with three copies in English of all testing standards and procedures at least two months prior to the testing date so that the PETDE representative may witness the test. The Contractor shall make as many tests as, in the opinion of PETDE, can be made together.
PETDE will delegate engineers for each part in the suppliers country to witness the tests at work.
All instruments to be used for testing shall be calibrated by a recognized and approved laboratory. The test certificates shall bear the details of calibration.
The acceptance of the Contractors tender including his design, drawings and specifications shall not bind the PETDE accept any of the contract works or equipment until they shall have passed the tests prescribed and have been approved by the PETDE in writing.
In case of failure any test the Contractor shall not be entitled to any extra payment or extension of time.
The expenses of all tests and all apparatus, instruments and connections required for the tests shall be born by the contractor and shall be included in the prices.
Three copies of the Contractor's records of all tests shall be furnished to PETDE.

1.6- DIAGRAM AND DRAWINGS TO BE SUBMITTED WITH THE TENDER:

Complete sets of detailed dimensions drawings and catalogues for transformers and accessories as well as layout and sections for foundation shall be submitted with the tender as a part of the tender documents.

1.7- DRAWINGS TO BE SUBMITTED BY CONTRACTOR FOR APPROVAL:

The contractor should submit to the PETDE for approval detailed design and relevant drawings of the various part of transformer and equipment together with the calculations justifying their use as soon as possible after elaboration of the contract and in any way not later than one month from coming into force of the contract.
PETDE approval of said drawings should be obtained before starting the manufacture of any part of the equipment. In any case, the manufacture of any part shall be at the sole risk and expense of the contractor if it is executed before receipt the PETDE approval.

The Contractor shall supply during the execution of the works such further drawings and/or samples as may be required from time to time from the PETDE.
As built drawings should be submitted at most one month before provisional acceptance certificate.

1.8- COPIES OF CONTRACT DOCUMENTS :

The Contractor shall submit in English to the PETDE:

a- Duplicate of approval samples.

b- 15 complete sets of final drawings (paper print copies), maintenance, and operating instruction schedules giving at least full particulars of the following:

c- Dimensions - Power, type, etc.., of transformers and their equipment supplied under this contract.

-4 sets of complete maintenance and operation instructions for all parts of the transformers.

-4 sets of all catalogue and pamphlets mental parts of the transformers.

1.9- REJECTION OF MATERIALS AND/OR EQUIPMENT AND THEIR REPLACEMENT:

If during inspection, tests at work or at site carried by or supervised by the PETDE, any material or equipment proved defective or not manufactured according to the specification agreed upon, the PETDE shall have the right to reject such material or equipment if not convinced that it can be satisfactory repaired. In such case the Contractor shall be obliged to replace the defective material or equipment without being entitled to any extra payment whatsoever or to any extension of the time of completion.

1.10- GENERAL REQUIREMENTS:

1-Contractor is requested to submit ISO certificate for manufacturing of the equipment.

2-Contractor is requested to offer his experience for manufacturing 400/230 kV transformers and equipment.

3-Contractor is requested to enclose in his technical offer schedules for transformers and equipment and spare part without prices and addition to that with prices which will be enclosed with financial offer.

4-Vacuum on load tap changer for all Power transformers are requested, and the tenderer shall provide in his offer a reference for the manufacturer of OLTC.

5-The manufacturer of the OLTC must have an international field experience.

6-The OLTC and all equipment related to the OLTC shall be manufactured by MR company (Germany made) & supplied by the original OLTC manufacturer from west Europe countries , License Products etc. are not acceptable .

7-The radiators of the Auto transformer shall be tank mounted , connected directly to the tank .

8- The existing power supply system for protection system in the substations is 220VDC (nominal).

9- Oil handling and test equipment in vol.3 item 27.18 isn't required .

10- The Power and Earthing Transformers shall be of well-known western brand or from qualified manufacturer are working in Syrian Grid and have been effective and obtained well received and have well reputation to work in Syrian Grid.

Please note that the western brand manufactured in Developing economies country is accepted.

Otherwise, power Transformers from other manufacturer need to be qualified.

PETDE will have the right to request type tests (short circuit and load tests) from the contracting firm.

The manufacturer of OLTC should be MR Germany origin, other manufacturer subject to rejected >

11- Firefighting equipment in Vol.3 item 27.17 isn't required .

12- Sound level for power transformer 400/230/20 kv without coolers should be <=70 d B.

13- Fixed loss at 75 C and nominal ratio at OFAF(C.M.R)rating <= 65kw.

14- Load loss at 75 C and nominal ratio 400/230 kv (HV/LV) at OFAF(C.M.R)rating <= 375kw.

1.11- Bidder and Manufacturer Qualifications:

Bidders should submit the following qualification documents for the manufacturer firms:

- Manufacturers' experience in designing and manufacturing of Power and Earthing Transformer for similar voltage level and rated power (activities and years of experience).
- Manufacturers' quality certificates (ISO).
- Manufacturers' annual production capacity.
- Manufacturers' quality assurance.
- Manufacturers' quality assurance plan.
- Certificates and test reports (short circuit and load tests) for similar types (voltage levels and rated power) from international independent laboratories.

  only valid certificates and test reports from one of the following :

  (KEMA, KEMA-KEUR, DEKRA or KINECTRICS) labs will be accepted.
- Key customers for the manufacturers of Power and earthing transformers during last five years including addresses and contact details.

Requirements for the manufacturer:

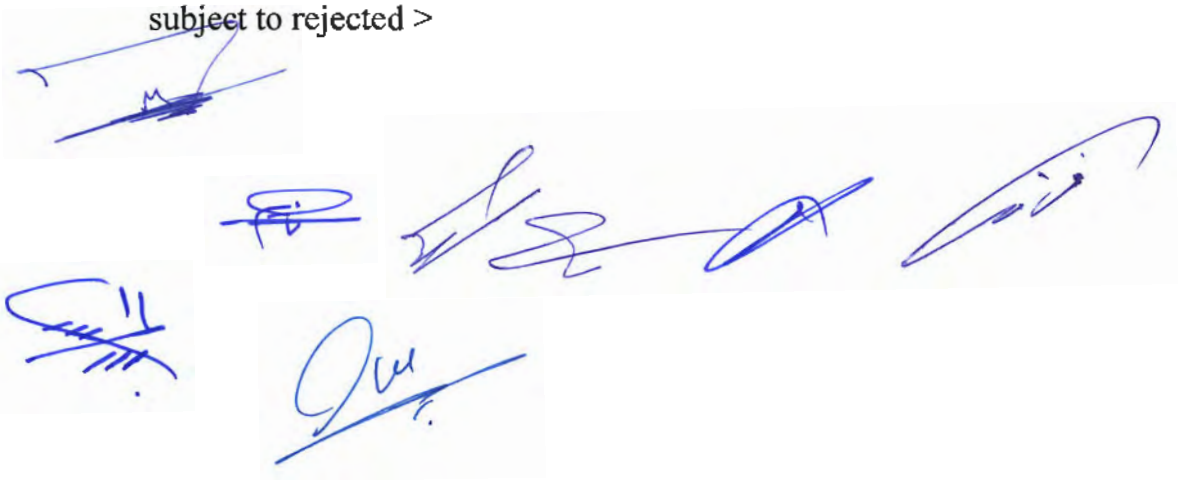
The Power and Earthing Transformers shall be of well-known western brand or from qualified manufacturer are working in Syrian Grid and have been effective and obtained well received and have well reputation to work in Syrian Grid.

Please note that the western brand manufactured in Developing economies country is accepted.

Otherwise, power Transformers from other manufacturer need to be qualified.

PETDE will have the right to request type tests (short circuit and load tests) from the contracting firm.

The manufacturer of OLTC should be MR Germany origin, other manufacturer subject to rejected >



27. - TRANSFORMERS AND REACTORS

27.1 - General

Transformers and reactors shall comply with IEC 76, IEC 289 and with the requirements of this specification.

All windings of the transformers shall be capable of withstanding short circuit for the periods of time specified in IEC 76 when operating on any tapping position, including that corresponding to minimum effective impedance, with the fault current available at the terminals as stated in the Schedules.

Irrespective of the direction of power flow, all transformers shall be capable of operating continuously without injurious heating when delivering the specified winding currents under conditions of continuous operation with voltages higher than tapping voltages, as stated in the Schedules.

The studies indicates that the 400 kV system will be characterised by high Temporary Overvoltages (TOV's). The voltage-time profile of these TOV's is indicated in Schedule D Part I and a typical voltage waveform is included. The design of the transformers and reactors must take into account the presence of such TOV's and the Contractor must guarantee that the life of the transformers and reactors will not be significantly shortened if subjected to overvoltages of the voltage-time characteristic detailed.

The design and manufacture of the transformers, reactors and auxiliary plant shall be such that the noise level is a minimum and that the level of vibration does not adversely affect any clamping or produce excessive stress in any material. Noise levels shall be measured in accordance with IEC 551. The maximum acceptable level is **70 dB**.

If required by PETDE, the transformers shall be subject to vibration tests. The magnitude of vibration of the reactor tanks, coolers and pipework shall be measured by scanning the vibrating surface with calibrated transducers.

The transformers and reactors shall be designed with particular attention to the suppression of harmonic currents, especially the third and fifth, so as to minimise interference with communications circuits.

The transformers shall be designed to ensure that leakage flux does not cause overheating in any part of the transformer.

The transformers shall be designed to operate satisfactorily in parallel when in the same tap position.

Guaranteed maximum values of no load and load losses and auxiliary loss (input to cooling plant) are as given in the Schedule of Requirements . For the purposes of tender evaluation these losses are capitalized using the rates given in Schedule of Requirements and tenders are assessed on the basis of capital cost and cost of losses. The acceptance, after manufacture, of transformers or reactors yielding losses higher than the guaranteed values shall be governed by either of the following:-

a. Transformers or reactors having component losses in excess of guaranteed values but within the tolerance permitted by IEC 76 Part I shall be accepted subject to full compliance with all technical particulars

and subject to the acceptance by the Contractor of a reduction in the Contract Price equal to the cost of excess losses obtained using the tender evaluation rates given in the Schedule of General Particulars and Guarantees.

b. Transformers and reactors having component losses in excess of guaranteed values and exceeding the tolerance permitted by IEC 76 Part 1 shall be accepted at the discretion of the Employer subject to the acceptance by the Contractor of a reduction in the Contract Price equal to the cost of excess losses obtained using the tender evaluation rates given in the Schedule of General Particulars and Guarantees.

c. The values to evaluate the capitalization of losses for PETDE will be :
fixed losses EURO € 5500 / KW and load losses EURO € 2000/ KW these figures will also be used to evaluate any penalty acc . to sections a & b .

d. During tests if the fixed losses or load losses exceed the guaranteed value (which is a fixed value without any tolerances), the contractor will pay penalties of three (3) times for each kW exceeded value as shown above.
e. Note: Fixed losses should be ≤65 kW and load losses should be ≤375 kW for transformers without fans and pumps consumption.

27.2 - Tertiary windings

The tertiary winding of the transformer is required for the purpose of suppressing harmonics and of providing a connection for reactive (capacitive and inductive) compensation equipment and a connection to an earthing transformer to provide an earth and an auxiliary supply.

The winding shall be capable of withstanding the forces to which it is subjected under all conditions, particularly the forces due to a short circuit between termioals or between any terminal and earth, with full voltage maintained on all other windings intended for connection to external sources of supply and allowing for any feed back through windings connected to rotating machines.

Suitable surge arresters are to be provided to protect the winding against overvoltage. If the winding is connected by cable the surge arresters shall be mounted in the disconnecting chamber.

27.3 - Magnetic circuits

Particular care shall be taken to secure even mechanical pressure over the whole of the core laminations. Each lamination shall be insulated with a material that will not deteriorate under pressure and the action of hot oil.

Where the magnetic circuit is divided into packets tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between packets.

The transformer core shall be free from overfluxing liable to cause damage or to cause maloperation of the protection equipment when operating under the continuous overvoltage condition specified in the Schedules. Under this steady overvoltage condition the maximum flux density must not exceed 1.9 tesla and the magnetising current must not exceed 1 per cent of the rated load current at normal rated voltage.

The cores, framework, clamping arrangements and general structure of the reactors shall be capable of withstanding any shocks to which they may be subjected during transport, installation and service. Adequate provision shall be made to prevent movement of internal parts of the reactor relative to the tank, to support the core structure in the tank and to carry the weight of the core and windings when suspended.

Structural members shall be made of steel.

27.4 - Windings

Winding insulation and all non-metallic material used in winding stacks shall be so treated that no further shrinkage shall take place after assembly.

Coils shall be constructed to avoid abrasion of the insulation, (eg on transposed conductors), allowing for the expansion and contraction set up by changes of temperature or the vibration encountered during normal operation. The insulation on the conductors between turns shall be of paper.

The windings shall be designed to reduce to a minimum the out-of-balance forces inherent in the transformer. Tappings shall be arranged at such positions on the windings as will preserve, as far as possible, electro-magnetic balance at all voltage ratios.

Tappings shall not be brought out from the inside of a coil nor from intermediate turns.

The windings and connections shall be braced to withstand shocks which may occur during transport or due to switching or other transient conditions during service.

Where the yoke supporting channels are adapted for taking up shrinkage in the windings, the arrangement shall be such as to throw a minimum amount of stress on any core bolt insulation.

If the winding is built up of sections or disc coils, separated by spacers, the clamping arrangements shall be such that equal pressure is applied to all columns of spacers. All such spacers shall be securely located and shall be of suitable material.

27.5 - Internal earthing arrangements

All metal parts of the transformers and reactors with the exception of the individual core laminations, core bolts and associated individual side plates shall be maintained at some fixed potential.

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link with a captive bolt and nut, accessibly placed beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection, and taken from the extreme edge of the top yoke in close proximity to the bridging pieces. Alternatively the core earth connection may be brought out through a bushing for earthing to the outside of the tank, in close proximity to the main yoke clamping structure earth point.

Where coil clamping rings are of metal at earth potential each ring shall be connected to the adjacent core clamping structure on the same side of the transformer or reactor as the main earth connection.

The main yoke clamping structures shall be connected to the tank body by a copper strip located at the top of the tank. If there is no metal-to-metal contact between the top and bottom clamping structure, the latter shall be earthed.

Core clamping structures having an insulated sectional construction shall be provided with a separate link for each individual section.

All earthing connections with the exception of those from the individual coil clamping rings shall have a cross-sectional area of not less than 80 mm^2. Connections inserted between laminations shall have a cross-sectional area of not less than 20 mm^2.

27.6 - Tanks

Transformer and reactor tanks shall be of welded steel and designed to allow the complete transformer or reactor, when arranged for transport, to be lifted by crane and transported without overstraining any joints and without causing subsequent leakage of oil. Each tank shall be provided with a minimum of four jacking lugs, to enable the transformer or reactor, complete with all tank mounted accessories and filled with oil, to be raised or lowered by jacks. The jacking points shall be not less than 300 mm above base level for transport masses up to 10 tonnes and not less than 700 mm for greater transport masses. Facilities shall also be provided to enable the transformer or reactor to be hauled or slewed in any direction.

The base of each tank shall be so designed that it will be possible to move the complete transformer or reactor in any direction without injury on rollers, provided with adaptable roller bearing pads. The rollers must be arranged so that they can be turned through an angle of 90 degrees when the transformer is jacked-up clear of the rail

The gauges must be as follows:

- Rails according to din – S49
- Rails – Gauge – 1676 – mm.
- Rails centre to centre – 1743 – mm.
- Four rails for positioning transformer starting from inside of the transformer foundation till end of the road with foundations needed, and all required facilities, foundation .. needed for the transformer are the designer responsibility such as (Tifour foundations – Jacks foundation- Earthing ... and not limited to).

Precautions shall be taken to prevent corrosion between the base or underbase of tanks of aluminium alloy construction and the concrete plinth on which they are finally positioned.

The main tank body, tap changing compartments, radiators and coolers, shall each be capable of withstanding, when empty of oil, the vacuum test level as specified by IEC. The plate thickness for the tank side shall be a minimum of 8 mm.

Tank stiffeners and mounting brackets shall be continuously welded to the tank.

Wherever possible, the transformer or reactor tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas to the main expansion pipe. The vent pipes shall have a minimum inside diameter of 20 mm and, if necessary, shall be protected against mechanical damage.

All joints other than those which may have to be broken shall be welded. Caulking of defective welded joints will not be permitted. Such defective joints may be re-welded subject to the written approval of PETDE.

Tank covers shall not permanently distort when lifted. Inspection openings of ample size shall be provided to give easy access to bushings, for changing ratio or winding connections, and for testing the earth connections. Inspection covers shall be provided with lifting handles. The tank cover shall be fitted with a

thermometer pocket, with captive screwed cap, located in the position of maximum oil temperature at continuous maximum rating.

It must be possible to remove any bushing without removing the tank cover.

A pressure relief device of sufficient size capable of functioning without electrical power, shall be provided for the rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment, but it shall be capable of maintaining the oil tightness of the transformer or reactor under all conditions of normal service. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer or reactor tanks and shall be designed to prevent further oil flow from the transformer or reactor following its operation. In the event that the device is a spring operated valve type it shall be provided with one set of normally open contacts which will be used for tripping purposes.

The relief device shall be mounted on the main tank and if mounted on the cover it shall be fitted with a skirt projecting inside the tank to prevent an accumulation of gas within the device.

Terminals shall be provided close to each corner at the base of the tank for earthing purposes.

The following plates shall be fixed to the tank at an approximate height of 1.75 m above the ground level:-

a. A rating plate bearing the data specified in IEC 76 or IEC 289.

b. A diagram plate on which the transformer tapping voltages in kilovolts shall also be indicated for each tap, together with the transformer impedances at minimum and maximum voltage ratios and for the principal tapping.

c. A property plate of approved design and wording.

d. A title plate.

e. A valve location plate showing the location and function of all valves, drain and air release plugs and oil sampling devices.

27.7 - **Bushings**

All bushings shall comply with the requirements of IEC 137 and the associated barrel porcelains shall comply with IEC 233 together with the requirements of this Specification. Provision shall be made for the fitting of arcing horns.

Transformer bushings for 66 kV and above shall be either of the oil impregnated paper or resin impregnated type. When filled with transformer oil there shall be no connection with the oil in the transformer and an oil gauge shall be provided. The visible oil levels in the gauge shall correspond to average oil temperatures from the minimum ambient stated in the Schedules to plus 90°C. The oil levels at 15°C and 35°C shall be marked. Connections from the main windings to bushings shall be flexible and shall be such that undue mechanical stresses are not imposed on them during assembly on site.

Bushings shall be mounted on the tank in such a manner that external connection can be made free of all obstacles. Neutral bushings shall be mounted in position from which a connection can be made to a neutral current

transformer mounted on a bracket secured to the tank. The current transformer will be supplied by the switchgear manufacturer but provision shall be made on the tank for mounting to PETDE`s requirements.

Where a direct connection to gas insulated switchgear is made by bus duct, an SF_6/oil bushing is required which shall be supplied under this Contract. The bushing shall have a double barrier between the SF_6 and the oil. The transformer shall be provided with fixings for the GIS bus duct.

27.8 - Conservator vessels, oil level gauges and breathers

Each conservator shall have a filling cap, an adequate sump and be so designed that it can be completely drained by means of a drain valve. One end of the conservator shall have a removable end cover, complete with integral lugs for lifting purposes and secured by nut and bolt fixings, to permit internal cleaning of the conservator.

An oil level gauge shall be provided for each conservator. The indicated minimum oil level shall occur when the feed pipe to the main tank is covered with not less than 12 mm depth of oil. The indicated oil level range shall correspond to average oil temperatures from the minimum ambient stated in the Schedules to plus 90 C. The oil levels at 15 C and 35 C shall be marked on the gauge. The oil level gauge shall incorporate alarm contacts which close when the oil level falls below a predetermined level.

Taps or valves shall not be fitted to oil gauges.

The main oil feed pipe from the conservator vessel to the transformer shall be connected to the highest point of the tank and shall be arranged at a rising angle towards the conservator of from 3 to 7 degrees to the horizontal. A valve shall be provided at the conservator to cut off the oil to the transformer.

Whether or not the oil is in direct contact with air or gas the air outlet from each conservator vessel shall be connected to a dehumidifying breather, which shall be mounted at approximately 1.4 m above ground level. This breather should be at least one size larger than would be fitted for use in a temperate climate.

Where a conservator vessel contains two compartments, one for oil in the main tank and the other for the oil associated with the current making and breaking contacts of the tap change equipment, there shall be no communication between the two compartments in respect of the oil and air spaces. Each compartment shall be provided with the fittings detailed in the preceding paragraphs as if it were a separate conservator vessel.

27.9 - Valves

Valves shall be of the fully sealing full-way type and shall be opened by turning counter-clockwise when facing the handwheel. They shall be suitable for working between the minimum ambient and the maximum oil temperatures stated in the Schedules.

Padlocks shall be provided for locking all valves other than individual radiator valves in the "open" and "closed" positions. Valves shall be provided with an indicator readily visible from ground level, to show clearly the position of the valve.

All valve handwheels shall be fitted with nameplates which shall be chromium plated brass not less than 3 mm thick with the engraving filed with enamel. All valves shall be fitted with spoked handwheels, the spokes and rims of which shall be smooth and where necessary, for appearance, shall be chromium plated.

All valves opening to atmosphere shall be fitted with blanking plates.

Each transformer and reactor tank shall be fitted with the following:-

a. One 100 mm valve at the top and one 100 mm valve at the bottom of the tank mounted diagonally opposite each other, for connection to oil circulating and oil filtering equipment. The lower valve shall also function as a drain valve.

b. An oil sampling device at the top and bottom of the main tank.

c. All parts containing oil, and liable to trap air during filling, shall be fitted with a flanged type air release plug at their highest points.

27.10 - Cooling plant

Transformers shall have ONAN/ONAF/OFAF cooling and facilities shall be provided at the marshalling kiosk or cubicle for the selection of AUTOMATIC or MANUAL control of the cooling plant motors.

Reactors shall be ONAN cooled.

Transformers shall be fitted with two cooling banks each capable of dissipating 50 per cent of the losses at continuous maximum rating. Transformers shall be capable of remaining in operation at full load for 20 minutes in event of failure of the cooling fans and for 10 minutes in the event of failure of the oil circulating pump without the calculated winding hot spot temperature exceeding 150°C. Failure of one fan in each group of fans shall not reduce the continuous maximum rating of the transformer.

Radiators and coolers shall be designed so that all painted surfaces can be readily cleaned and subsequently painted in position.

Radiators should be erected at the transformer tank.

Plugs shall be fitted at the top and bottom of each radiator for filling and draining.

Mal-operation of gas and oil actuated relays shall not occur on starting or stopping of forced-oil circulation.

The oil circuit of all coolers shall be provided with the following as appropriate to tank mounted or separate bank coolers:-

a. A valve at each point of connection to the transformer or reactor tank.

b. A valve in the main oil connection at the bottom of each cooler.

c. Loose blanking plates to permit the blanking off of the main oil connection to the top of each cooler.

d. A 100 mm oil filtering valve at the top and bottom of each cooler, the bottom valve shall also function as a drain valve.

e. A thermometer pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each cooler.

f. Visual oil flow indicators in the pipework adjacent to the coolers. In the event that this will affect circuit access to oil flow under ONAN conditions a differential pressure gauge of approved design and manufacture may be connected across the pumps, as an alternative.

The material of the tube plates and tubes shall be such that corrosion shall not take place due to galvanic action.

Drain plugs shall be provided in order that each section of pipework can be drained independently.

Each forced oil cooler shall be provided with a fully weatherproof motor driven oil pump. The motor shall be of the submersible type. It shall be possible to remove the pump and motor from the oil circuit without having to lower the level of the oil in the transformer or coolers.

Where forced air cooling is provided it shall be possible to remove the fan, complete with its motor and supporting structure without disturbing or dismantling the cooler framework or pipework.

Wire mesh guards galvanized after manufacture shall be provided to prevent accidental contact with the fan blades. Metal guards shall also be provided over all other moving parts. The guards shall be designed such that neither the blades nor other moving parts can be touched by a Standard Test Finger to IEC 529.

27.11 - Cooler control

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this contract for automatic starting and stopping from contacts on the winding temperature indicating devices. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totalling more than 15 kW simultaneously either manually of automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts which may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors shall be included in the contract.

Two independent sources of power shall be made available to ensure loss of cooling capacity for a single contingency is not greater than 50 per cent.

27.12 - Voltage control

Equipment shall be provided for varying the turns ratio without producing phase displacement.

All leads and connections to fixed and moving contact assemblies and between the transformer and the voltage control device shall be supported and adequately braced to withstand the short circuit current for which the associated transformer is designed.

Equipment for varying the effective turns ratio when the transformer is dead shall consist of tap-changing switches located inside the tank under oil and rigidly attached to the core structure as near as possible to the tapped coils.

The switches shall be operated mechanically from the outside of the tank; the arrangement shall be such that it can be operated with the transformer out of its tank. The design shall be such as to prevent the ingress of moisture into, or the leakage of oil from the tank. Means shall be provided to ensure that the operating mechanism can be locked only when the switches are making full contact. Padlocks shall be provided and the tap change equipment shall be suitable for padlocking in any switch position.

Off circuit tapping switches shall be provided with mechanical end stops which prevent movement beyond an end position.

Equipment for varying the effective turns ratio on-load shall consist of tap changing gear arranged for local hand and electrical operation and remote electrical operation. It shall also be so designed that it may be easily adapted to operate by automatic control.

The tap changing switches and mechanism shall be mounted in an accessible position in oil tanks or compartments and shall be supported from the main tank or its base. It is preferable that examination and repair of both selector and diverter switches including their associated equipment should be carried out without lowering the oil level in the main tank. However, other designs of tap-changer which involve lowering the oil level in the transformer tank may be accepted with the agreement of PETDE.

It shall not be possible for the oil in those compartments of the tap change equipment which contain contacts used for making and breaking current, to mix with the oil in the main transformer or with the oil in the compartments containing contacts not used for making or breaking current. A drain valve shall be provided.

The oil in those compartments of the main tap-change apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a pipe connection from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay.

Each compartment in which the oil is not maintained under conservator head shall be provided with an oil gauge.

Any enclosed compartment not oil filled shall be adequately ventilated and designed to prevent the ingress of vermin. All contactors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation.

Tap changing shall be prevented when the transformer is carrying a load above a predetermined maximum or when on short circuit.

Limit switches shall be provided to prevent over-running of the mechanism and shall be directly connected in the circuit of the operating motor. Limit switches may be connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated.

A mechanical stop or other approved device shall be provided to prevent over-running of the mechanism under any condition within resulting damage.

Thermal devices or other approved means shall be provided to protect the motor and control circuits. Switches for the initiation of a tap change shall bear the inscription "Raise Tap Number". as applicable.

Tripping contacts associated with any thermal device used for the protection of tap changing equipment shall be suitable for making and breaking 150 VA at 0.35 power factor, between the limits of 30 and 250 volts ac or breaking 150 VA and making 500 VA between the limits of 110 and 250 volts dc.

A device shall be fitted to the tap changing meehanism to indicate the number of operations completed by the equipment.

A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.

The terminals of the operating motor shall be clearly and permanently inscribed with numbers corresponding to those on the leads a7ttached thereto.

Equipment for local and remote electrical and local hand operation shall comply with the following conditions:-

a. It shall not be possible to operate the electric drive when the hand operating gear is in use.

b. It shall not be possible for any two electrical control points to be in operation at the same time.

c. Each step movement shall require separate initiation at the control point.

d. All electrical control switches and the local operation gear shall be clearly labelled in an approved manner to indicate the direction of tap changing.

e. The local control switches shall be housed in the marshalling kiosk.

The equipment shall be arranged so as to ensure that when a step movement has been commenced it shall be completed independently of the operation of the control relays or switches. If a failure of the auxiliary supply during a tap change, or any other contingency, would result in that movement not being completed. means shall be provided to safeguard the transformer and its auxiliary equipment.

Apparatus shall be provided:-

f. To give indication mechanically at the transformer and electrically at the remote control point of the tapping in use. The indicator at the transformer shall show the number of tapping in use and the indicator at the remote control point shall show clearly the actual voltage ratio in kilovolts and the tap number representing this ratio. The numbers shall range from 1 upwards.

g. To give indication at the remote control point that a tap change is in progress by means of an illuminated lamp and alarm buzzer. If the tap change is not completed in its specified time the buzzer shall continue to sound until switched off by hand but the lamp shall remain illuminated until the tap change is completed.

h. To give indication at the remote control point by means of an approved illuminated indicator and the buzzer alarm as described in g. above when the units of a group of transformers arranged to operate in parallel are operating at different ratios.

If specified in the Schedules on-load tap changing equipment shall be suitable for supervisory control and indication and a separate multi-way switch, having one fixed contact for each tap position, shall be provided for this purpose and wired to the marshalling kiosk or cabinet. Unless otherwise specified all other components of the supervisory gear will be supplied under a separate contract.

Where the on-load tap changing equipment is fully automatic, and automatic voltage control relay (AVC) shall be provided. The relay shall be responsive to variation in the measured voltage and cause the necessary tap change to be made to restore the voltage to the desired level within pre-determined limits.

The reference voltage shall be taken from the lower voltage side of the power transformer. The measured voltages will be derived from voltage transformers, supplied under a separate contract, having secondary windings rated at 110 volts phase-to-phase and having an accuracy not inferior to Class 1. The relay shall have a nominal voltage rating to unit.

The relay setting voltage, expressed as a percentage of the relay nominal voltage shall be adjustable over a range of not less than 10 per cent of nominal.

The relay sensitivity band relative to the setting voltage shall be adjustable from not more than 1.5 times to not less than 2.5 times the percentage equivalent of one tap change step.

Settings for relay operating time shall be adjustable. For definite time relays, the setting range shall be from 10 s to 120 s and the timing device shall be of the "slow resetting" type. Relays having time dependent characteristics shall have a range of adjustments allowing a delay of up to at least 120 s for a voltage deviation 1 per cent greater than the sensitivity setting and not more than 10 s for a deviation of 5 times sensitivity or 10 per cent voltage, whichever is the greater.

The relay shall be insensitive to frequency variation between the limits of 47 Hz and 51 Hz and shall incorporate an undervoltage blocking facility to render the control inoperative if the reference voltage falls to 80 per cent of nominal value with automatic restoration of control when the reference voltage rises to 85 per cent of nominal value.

The relay setting voltage must be capable of adjustment from a remote/supervisory location.

On-load tap change transformers provided with fully automatic control and required to operate in parallel as a group shall be provided with means to ensure proportionate sharing of watts and VARs.

A scheme intended to maintain step-by-step operation to within one tap difference at all times of parallel operation shall be provided. Operation with more than one tap difference between any two transformers shall automatically be prevented and an "out-of-step" alarm signal transmitted to the control point(s).

Control equipment supplied under this contract shall include all alarm, indication and repeat relays necessary to identity faulted equipment. Each relay shall have not less than two electrically separated normally open contacts, one of which is fleeting and the other non-fleeting. The fleeting contact shall reset (open) when the relay is de-energized. The non-fleeting contact shall be wired to a terminal strip.

All equipment shall be suitable for operation within the limits 85 per cent - 110 per cent of the auxiliary voltage supply.

On each transformer the voltage transformer supply to the voltage regulating relay shall be monitored for partial or complete failure. If the circuit breaker controlling the lower voltage side of the transformer is open or when the tap changer is on other than automatic control then any alarm or indication should be made inoperative.

Requirement for remote adjustment (supervisory/telecontrol) of the AVC setting voltage will be defined in accordance with the particular scheme. Relays equipped to accept electrical signals to control the actual set point (eg drive stepping motors to alter rheostat position or input digital signal to reset level detector etc) shall be capable of set point adjustment in steps not exceeding 1 per cent.

For relays having a manually adjusted setting, means shall be provided to allow remote adjustment via interposing relays having contacts available to enable the effective setting to be altered by altering the measured voltage (eg by switching resistors in the relay input measuring circuit).

27.13 - Disconnecting and sealing end chambers

Where cables for 11 kV and above are terminated in a cable box, an oil filled disconnecting chamber with removable links shall be provided for testing purposes. The disconnecting chamber shall be capable of withstanding on site the cable high voltage test level in accordance with IEC 55 and BS 141 as appropriate. During the test the links in the disconnecting chamber will be withdrawn and the transformer or reactor windings earthed. A barrier shall be provided on both sides of the disconnecting chamber to prevent ingress of the oil used for filling the chamber into the cable box or tank.

Where sealing end chambers are provided, the disconnecting chamber may be omitted and the facilities for testing shall be provided in the sealing end chamber itself; a barrier shall be provided between the sealing end chamber and the main tank.

Disconnecting and sealing end chambers shall be suitable for oil filling.

Provision shall be made to allow for the expansion of the filling medium and drain plugs of ample size shall be provided for enabling the filling medium to be removed.

The disconnecting or sealing end chambers shall have a removable cover and the design of the chambers shall be such that ample clearances are provided to enable either the transformer or reactor or each cable to be subjected separately to high voltage tests. The disconnecting links shall be flexible or flexibly attached at one end.

The oil level in disconnecting or sealing end chambers shall be maintained from the main conservator tank by means of a connection to the highest point of the chamber and this connection shall be controlled by a valve.

An earthing terminal shall be provided in each disconnecting or sealing end chamber to which the connections from the transformer or reactor winding can be earthed during cable testing.

Terminals shall be marked in a clear and permanent manner.

27.14 - Temperature indicating devices, alarms and gas and oil actuated relays

27.14.1 - Temperature indicating devices and alarms. Oil temperature indicating devices shall be fitted with alarm and trip contacts.

Winding temperature indicating devices shall indicate the temperature of the hottest spot of the winding and shall have a load-temperature characteristic approximating to that of the main winding. Alarm and trip contracts shall be provided.

Alarm contacts of oil and winding temperature indicating devices shall be adjustable over a range of 60°C to 110°C and trip contacts adjustable over a range of 80°C to 150°C. Alarm and trip contacts shall be suitable for making and breaking 150 VA at 0.35 power factor, between the limits of 30 and 250 volts dc or breaking 150 VA and making 500 VA between the limits of 110 and 250 volts dc.

For transformers having or being suitable for mixed or forced cooled ratings whether the forced cooling is to be supplied initially or at a later date, an additional contacts shall be provided to automatically control the forced cooling plant.

Temperature indicating devices shall incorporate a dial and a pointer indicator and a separate pointer to register the maximum temperature reached.

The capillary connected sensing bulbs of temperature indicators shall be positioned in separate oil-tight pockets arranged in the top oil.

Where winding temperature indicators are specified they shall be associated with arc resistance only. In the case of auto-transformers there shall be separate indicators for the series and common windings.

The winding temperature indicating devices shall be so designed that it shall be possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment. The working parts of the instruments shall be made visible by the provision of cut-away dials and glass fronted covers.

The characteristics of the winding temperature indicating devices shall be forwarded to the PFUP for approval prior to the delivery of the transformers and shall also be included in the operating and maintenance instructions.

All temperature indicators shall be housed in the marshalling kiosk or cabinet and shall be mounted so that they will not be affected by vibration.

27.14.2 - Gas and oil actuated relays. Gas and oil actuated relays shall be fitted to each transformer and reactor and to each tap selector compartment. They shall have alarm contacts which close on collection of gas or at low oil level and tripping contacts which close following an oil surge.

The normally open, electrically separate, alarm and tripping contacts shall not be exposed to oil.

The relays shall be fitted in the expansion pipe connecting the transformer or reactor tank to the conservator.

Each relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

A 5.0 mm inside diameter pipe shall be connected to the gas release cock of the relay and brought down to a point approximately 1.4 m above ground level where it shall be terminated by a cock.

27.14.3 - Oil flow indicators. Forced oil cooled transformers shall be provided with a visual oil flow indicator in each outlet pipe connection from the coolers. These indicators shall incorporate contacts which close under conditions of no oil flow.

27.15 - Topping up with oil and drying out on site

If oil is to be added to a transformer or reactor at Site prior to commissioning, the oil in the transformer or reactor shall first be tested for dielectric strength and water content and each container of make up oil shall be similarly tested. All tests shall be witnessed by the Resident Engineer or his representative.

Should it be found necessary to resort to oil treatment before a transformer or reactor is commissioned, the Contractor shall submit to PETDE, in writing, a full description of the process to be adopted, the equipment to be used and a statement of the precautions being taken to prevent fire or explosion.

Should a transformer or reactor arrive on Site without positive pressure of gas in the tank, it shall be dried out on Site at the Contractor's expense.

Clear instructions, in English shall be included in the Maintenance Instructions regarding any special precautionary measures, which must be taken before vacuum treatment can be carried out. Any special equipment necessary to enable the transformer or reactor to withstand vacuum treatment shall be provided with each transformer or reactor. The maximum vacuum which the complete transformer or reactor, filled with oil can safely withstand without any special precautionary measures being taken shall be stated in the Maintenance Instructions.

27.16 - Earthing/auxiliary transformers

When specified each earthing transformer shall be of the oil immersed ONAN type suitable for outdoor installation and shall have an interconnected star winding which will be directly connected to the tertiary windings of the main transformer and an auxiliary star connected winding arranged to give a three-phase 4-wire supply, via a switch fuse unit.

The neutral point of the interconnected star winding of each earthing transformer shall be brought out of the tank through a bushing insulator similar to those on the phase terminals. This point may be isolated or may be connected to earth either directly or through an impedance in order to provide an earthing point for the neutral of the lower voltage system.

Earthing transformers shall be capable of withstanding for a period of 3 seconds the application of normal three-phase line voltage to the line terminal and the neutral terminal connected solidly to earth.

The interconnected star winding of each earthing transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for thirty seconds without injurious heating an earth fault current not less than the value given in the Schedules.

The auxiliary winding of each earthing transformer shall have an IEC continuous rating equal to that stated in the Schedules.

Earthing and auxiliary transformers shall be provided with the following fittings:-

a. One thermometer pocket with captive cap.

b. Dehumidifying breather.

c. Filter valve and combined filter and drain valve.

d. A sampling device at the bottom of the tank.

e. Conservator vessel with removable end cover and prismatic oil gauge.

f. Double float gas oil actuated relay.

The earthing transformers shall comply with the provisions of this Specification relating to the main transformers wherever these are applicable.

27.17 - Fire fighting equipment

Transformers and reactor fire fighting systems shall be supplied where specified . The contractor should where necessary make allowance for the addition of pipes, nozzles etc around the transformer and be prepared to provide details and co-ordinate designs with the fire fighting equipment supplier.

27.18 - Oil handling and test equipment

The oil processing plant is required to remove solid matter, dissolved gases and moisture from the oil.

The oil treatment plant should be able to achieve a standard of oil purity similar to that specified by the transformer manufacturer for the first filling, and the rate of flow shall be suitable for filling the transformers in this specification but have a minimum value of 9000 litres/hour.

The flow rate shall be variable, but when adjusted it should be steady, continuous and automatic in operation. The degasifier and the filter shall be able to operate together or independently.

The pumps shall be rated suitably for the treatment of the required quantities of oil at ground level and to deliver oil into the highest part of the oil system of the transformers specified herein.

The plant should be complete with vacuum pump, air cleaning set, cooling unit, suitable rubber hoses for use with oil and all other necessary accessories.

The plant shall be mounted on a weatherproof trailer suitable for movement about the site on its own wheels.

The plant will be used:

a. For routine oil processing of transformer oil in tap changers and small low voltage transformers.

b. To process oil in the high voltage transformers specified in this document. or other similar transformers.

c. To create, under special conditions, a high vacuum in the tank of the high voltage transformers supplied under this contract, or similar transformers. It is not expected that the vacuum pumps should have the capacity necessary for a complete transformer dry-out, but rather that they should be able to degas the empty tank or the space above the lowered oil level in the tank and then maintain a high vacuum whilst oil is pumped into the space.

Separate mobile vacuum panels should have a capacity of 60 m^3/hr and be complete with the required hoses.

The transformer oil dissolved gas extractor should comply with ASTM 3612 and be suitable for use with a sample of oil up to 50 ml. The following equipment should be provided as a minimum.

a. PTFE tubing.

b. Degassing flask.

c. Absolute pressure gauge.

d. Vacuum pump.

e. Vacuum glass wear.

f. High vacuum valves or stopcocks.

g. Reservoir of mercury.

h. All other neeessary accessories.

The oil insulation set should be portable, provide an output of 90 kV, be fully automatic and complete with test vessels.

The transformer oil power factor test set is for measuring of electric losses, power faster (tan _) of insulating oil according to ASTMD-924 and should comply with VDE 0370. The equipment should be complete with.

a. Liquid electrodes.

b. Mobilisation set.

c. All other neeessary accessories.

All of the above equipment should be suitable for an operating voltage as specified in the schedule of Requirements .

27.19 – Losses and evaluation of losses:

If the transformer has passed the tests prescribed before except that the losses and temperature rise exceed guaranteed limits, the PETDE may accept this transformer in accordance with the penalty set out below:

- If the no load losses or load losses are higher than the guaranteed value by 1/7 (according to IEC 354), PETDE will reject the transformer.
- If the total losses exceed the guaranteed value by 1/10 (according to IEC 354). PETDE will reject the transformer.
- For comparison of tenders, PETDE will evaluate the cost of losses of the transformer and power required for operation of cooling equipment based on the capitalised per kW cost of no load and load losses shown in the table:

No Load Losses	Load Losses	Auxiliary Losses (Fans/Pump)
5500 EURO/kW	2000 EURO/kW	4000 EURO/kW

- The losses used in the evaluation are the losses guaranteed in schedules.
- During transformer tests if the no load losses or load losses exceed the guaranteed value (which is a fixed value without any tolerances), the contractor will pay penalties of three (3) times for each kW exceeded value as shown above.

Note:

-No load losses should be ≤65 kW

-Load losses should be ≤375 kW without fans and pumps consumption.

SCHEDULE H1

1. TRANSFORMERS, REACTORS AND CAPACITORS

1.1- POWER TRANSFORMER 300 MVA WITH ON - LOAD TAP CHANGER

Item	Description		PETDE Requierments	Particulars
1	Outline dimensions (attach sketches)	mm		
2	Net weight of transformar :			
	a) Core / coils	kg		
	b) Tank / fittings	kg		
	c) Oil	kg		
	d) Total (a + b + c)	m.ton		
3	Volume of oil	m3		
4	Shipping dimensions largest package			
	a) Length	m		
	b) Width	m		
	c) Height	m		
5	Shipping Weight of largest piece excluding oil	m.ton		
	Rated voltage ratio	kV		
6	Continuous maximum rating (C . M. R)			
	(HV / LV) OFAF	MVA	300	
7	Continuous tertiary rating OFAF	MVA	60	
8	Type/Vector group (Auto delta tertiary)		3 PH unit / YNaod11	
	Rated frequency	Hz	50	
9	Type of cooling		ONAN / ONAF / OFAF	
10	On – load taps changer :			
	Total range	%	+5 - 15	
	Total No . of steps		21	
	Size of step	%	1	
11	Exiting current			
	a) at rated voltage	%		
	b) at 110 rated voltage	%		
12	Transformer losses (excluding cooling plant)			
	a)Fixed loss at 75 ˚C and normal ratio at OFAF (C.M.R) rating	KW	≤ 65	
	b) Load loss at 75 ˚ C and nominal ratio: 400/230 kV (HV/LV) at OFAF (C.M.R)	KW	≤ 375	
	c) Load loss at 75 ˚C and max. tap 420/230 kV (HV/LV) at OFAF (C.M.R)	KW		
	d) Load loss at 75 ˚C and min. tap 340/230 kV (HV/LV) at OFAF (C.M.R)	KW		

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
	e) Total losses at 75 ˚C and nominal ratio 400/230 kV (HV/LV) at OFAF (C.M.R) Load loss stated above excludes fixed loss	Kw		
13	Tertiary winding :			
	a) phase to phase voltage	kV	20	
	b) Nominal rating	MVA	60	
	c) Short circuit MVA available at teriary			
	Terminals due to specified HV and LV			
	System fault levels.			
14	Type of winding and polarity			
	a) HV windings			
	b) LV windings			
	c) Tertiary windings			
15	-Impedance voltage at 75 ˚ C and normal ratio and		400/230/20	
	a) Between HV and LV windings	%	15 (Base 300 MVA)	
	b) Between HV and tertiary windings	%	(Base 60 MVA)	
	c) Between LV and tertiary windings	%	(Base 60 MVA)	
	-Impedance voltage at 75 ˚ C and max tap and C.M.R		420/230/20	
	a) Between HV and LV windings	%		
	b) Between HV and tertiary windings	%		
	c) Between LV and tertiary windings	%		
	-Impedance voltage at 75 ˚ C and min tap and C.M.R		340/230/20	
	a) Between HV and LV windings	%		
	b) Between HV and tertiary windings	%		
	c) Between LV and tertiary windings	%		
16	Regulation at 75 ˚ c and rated MVA at of normal voltage			
	a) HV windings	%		
	b) LV windings	%		
17	Average winding temperature rise above			
	maximum 45 ˚ C ambient by resistance			
	measurements at C.M.R OFAF	ºC	60	
18	Hottest spot temperature at C.M.R	ºC	115	
19	Load required by transformer air blast coolers	KW		

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
20	Zero sequence impedance under line to ground fault condition at rated MVA and voltage .			
	a) Measured from HV (LV open)	ohms		
	b) Measured from HV (LV short-circuit)	ohms		
	c) Measured from LV (HV open)	ohms		
	d) Measured from LV (HV short-circuit)			
21	Basic insulation withstand voltage kv peak : (1.2 x 50 peac)			
	a) HV winding	kV	1425	
	b) HV bushing	kV	1425	
	c) LV bushing and winding	kV	1050/950	
	d) Neutral bushing and winding	kV	95/95	
	e) Tertiary bushing and winding	kV	125	
	f) Switching surge voltage KV (peak)	kV		
	- HV winding	kV	1050	
	- HV bushing	kV	1175	
22	Power frequency withstand - kv (R.M.S)	kV		
	a) HV winding	kV	610	
	b) LV winding	kV	395	
	c) tertiary winding	kV	50	
	d) HV bushing	kV	630	
	e) LV bushing	kV	460	
	Tertiary bushing	kV	50	
23	No of coolers or cooler units per transformer including spare unit (radiators)	Nos		
24	Air blast coolers on transformer tank (fans) Total number	Nos		
25	Fan /pump motor details:			
	a)Total number	Nos		/
	b) rated power (each)	Kw		/
	c)full load current	A		/
	d) Voltage	V		/
	e) Type			/
	F) Starting current	A		/
26	Efficiency At 0.8 power factor			
	a)At full load			
	b) At ¾ full load			

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
20	Zero sequence impedance under line to ground fault condition at rated MVA and voltage .			
	a) Measured from HV (LV open)	ohms		
	b) Measured from HV (LV short-circuit)	ohms		
	c) Measured from LV (HV open)	ohms		
	d) Measured from LV (HV short-circuit)			
21	Basic insulation withstand voltage kv peak : (1.2 x 50 peac)			
	a) HV winding	kV	1425	
	b) HV bushing	kV	1425	
	c) LV bushing and winding	kV	1050/950	
	d) Neutral bushing and winding	kV	650/550	
	e) Tertiary bushing and winding	kV	125	
	f) Switching surge voltage KV (peak)	kV		
	- HV winding	kV	1050	
	- HV bushing	kV	1175	
22	Power frequency withstand - kv (R.M.S)	kV		
	a) HV winding	kV	570	
	b) LV winding	kV	395	
	c) tertiary winding	kV	50	
	d) HV bushing	kV	630	
	e) LV bushing	kV	460	
	Tertiary bushing	kV	50	
23	No of coolers or cooler units per transformer including spare unit (radiators)	Nos		
24	Air blast coolers on transformer tank (fans) Total number	Nos		
25	Fan /pump motor details:			
	a)Total number	Nos		/
	b) rated power (each)	Kw		/
	c)full load current	A		/
	d) Voltage	V		/
	e) Type			/
	F) Starting current	A		/
26	Efficiency At 0.8 power factor			
	a)At full load			
	b) At ¾ full load			

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
	c) At ½ full load			
	d)At ¼ full load			
27	Sound level			
	a) With coolers	dB	≤ 75	
	b)Without coolers	dB	≤ 70	
28	Radio interference voltage at 15 m-ds			
	Above one microvolt	dB/V		
29	Type and thickness of steel core laminations			
30	Maximum flux density	Weber/		
31	Maximum current density	A/mm2		
32	Thickness of transformer plates:			
	a)Tank cover	mm		
	b) Side	mm		
	c)Bottom	mm		
	d)Air blast coolers plates (radiators)	mm		
33	Limits of tolerance for all guaranteed values			
	a)Lmpedance voltage	-+%		
	b)No load losses	-+%		
	c)Load losses	-+%		
34	a)Winding temperature rise by resistance			
	Above 45 ˚C ambient temperature	℃	≤ 60	
	b)Top oil temperature rise by thermometer			
	Above 45 ˚C ambient temperature	℃	≤ 55	
35	Multiration Bushing current transformer details			
	a)Ratio			
	Primary	A		
	Secondary	A		
	b)Accuracy class			
	c)Rated burden	VA		
	d)Quantity	NOS		
36	Bushing capacitance tap details:			
	a) Ratio secondary tension	V		
	b)Acouracy class			
	c)Rated burden at 50 HZ	W		
	d)Quantity of secondaries			
37	Ability to withstand short circuits and duration			
	a) H.V winding	KA/2sec		
	b) L.V winding	KA/2sec		
	c) Tertiary winding	KA/2sec		

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
	c) At ½ full load			
	d)At ¼ full load			
27	Sound level			
	a) With coolers	dB	≤ 75	
	b)Without coolers	dB	≤ 70	
28	Radio interference voltage at 15 m-ds			
	Above one microvolt	dB/V		
29	Type and thickness of steel core laminations			
30	Maximum flux density	Weber/		
31	Maximum current density	A/mm2		
32	Thickness of transformer plates:			
	a)Tank cover	mm	≥ 28	
	b) Side	mm	≥ 12	
	c)Bottom	mm	≥ 30	
	d)Air blast coolers plates (radiators)	mm	≥ 1.2	
33	Limits of tolerance for all guaranteed values			
	a)Lmpedance voltage	-+%		
	b)No load losses	-+%		
	c)Load losses	-+%		
34	a)Winding temperature rise by resistance			
	Above 45 ˚C ambient temperature	°C	≤ 60	
	b)Top oil temperature rise by thermometer			
	Above 45 ˚C ambient temperature	°C	≤ 55	
35	Multiration Bushing current transformer details			
	a)Ratio			
	Primary	A		
	Secondary	A		
	b)Accuracy class			
	c)Rated burden	VA		
	d)Quantity	NOS		
36	Bushing capacitance tap details:			
	a) Ratio secondary tension	V		
	b)Acouracy class			
	c)Rated burden at 50 HZ	W		
	d)Quantity of secondaries			
37	Ability to withstand short circuits and duration			
	a) H.V winding	KA/2sec		
	b) L.V winding	KA/2sec		
	c) Tertiary winding	KA/2sec		

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
38	Load required by the fans at rated power and ambient air temp :			
	a) 10 °C	KW		
	b) 20 °C	KW		
	c) 35 °C	KW		
	d) 45 °C	KW		
39	Permissible duration of operation at total fail out of the cooling system		After 50 % loading /After 100 % loading	
	a) at no load and L			
	10 °C			
	25 °C			
	35 °C			
	45 °C			
	b) at 50% of rated power and:			
	10 °C			
	25 °C			
	35 °C			
	45 °C			
	c) at 75 % of rated power and :			
	10 °C			
	25 °C			
	35 °C			
	45 °C			
	d) at 100 % rated power and :			
	10 °C			
	25 °C			
	35 °C			
	45 °C			
40	Permissible duration of over loading at '45 C ambient air temperature and at :		After 50 % loading /After 100 % loading	
	a) 10 % overload	min		
	b) 20 % overload	min		
	c) 30 % overload	min		
	d) 40 % overload	min		
	e) 50 % overload	min		

SCHEDULE H1

1.2- STATION SERVICE TRANSFORMER 20/0.4 KV , 400 KVA

Item	Description		PETDE Requierments	Particulars
	Station service transformer combined with earthing transformer:			
1	Outline dimensions (attach sketches)	mm		
2	Net weight of transformer:			
	a)core / coils	kg	/	/
	b)tank / fittings	kg	/	/
	c)oil	kg		
	d)Total (metric tons)			
	e)Volume of oil	M3		
3	Shipping weight (metric tons)			
4	Continuous ONAN rated capacity	kVA	400	
5	Vector group		ZNyn11	
6	Type of cooling		ONAN	
7	Off-circuit taps:			
	a)range on increasing step	%	2	
	b)range on decreasing step	%	2	
	c)size of steps	%	2.5	
8	Primary rated voltage	kV	20	
9	Highest primary voltage	kV	24	
10	Secondary voltage (phase to phase)	V	400	
11	Short time earth fault current (3sec)	A		
12	Impedance	%		
13	Exciting current			
	a)at rated voltage	A		
	b)at 110% rated voltage	A		
14	Transformer losses :	KW		
	(shall be stated as maximum without any tolerance on			
	Fixed loss at 75 °C and normal ratio at ONAN Rating	KW		
	Load loss at 75 °C and normal ratio at ONAN Rating	KW		
	Total loss at 75 °C and normal ratio at ONAN Rating	KW		
	Load loss stated above excludes fixed loss			
15	Type of windings and polarity:			
	a)HV windings			
	-By description and drawings			
	b)LV windings			

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
16	Impedance voltage at 75 ˚C normal ratio and			
	continuous maximum rating (C.M.R)			
	Between HV and LV windings			
	Impedance voltage at 75 ˚C and max .ratio			
	Voltage and C.M.R			
	Between HV and LV windings			
	Impedance voltage at 75 ˚C and max .lower			
	Voltage and C.M.R			
	Between HV and LV windings			
17	Regulation at 75 ˚C and rated MVA at of normal voltage			
	a) at unity power factor			
	b)at 0.8 lagging power factor			
18	Average winding temperature rise above Maximum 45 ˚C ambient by resistance			
	Measurements at ONAN rating	ºC		
19	Hottest spot temperature at C.M.R	ºC		
20	Zero sequence impedance under line to Ground fault condition at rated MVA and Voltage between HV and LV windings	ohm	115	
21	B. I. L – kv peak : (1.2 × 50 μsc)			
	a) HV windings	kv	125	
	b) HV bushing	kv	125	
	c) LV bushing and winding			
	d) Neutral bushing and winding			
22	Power frequency withstand			
	a) HV winding	kv	50	
	b) LV winding	kv		
	c) HV bushing	kv	50	
	d) LV bushing	kv		
23	EFFICIENCY:			
	a) at full load			
	b) at ¾ full load			
	c) at ½ full load			
	d) at ¼ full load			
24	Type of steel core laminations			
25	Maximum flux density	web./cm		
26	Maximum current density	A/mm2		

SCHEDULE H1

Item	Description		PETDE Requierments	Particulars
27	Thickness of transformer plates :			
	a) Tank	mm		
	b) Sides	mm		
	c) Bottom	mm		
	d) Radiator plates	mm		
28	Limits of tolerance for all quarantine values			
	a) Impedance voltage	+ -		
	b) Core loss	+ -		
	c) Load loss	+ -		
29	a)Winding temperature rise by the thermometer above 45 °C ambient temperature	°C	60	
	b) Top oil temperature rise by thermometer			
	Above 45 C ambient temperature	°C	55	
30	Current transformer details		≥ 400 / 1-20 VA C:5P10	

SCHEDULE H1

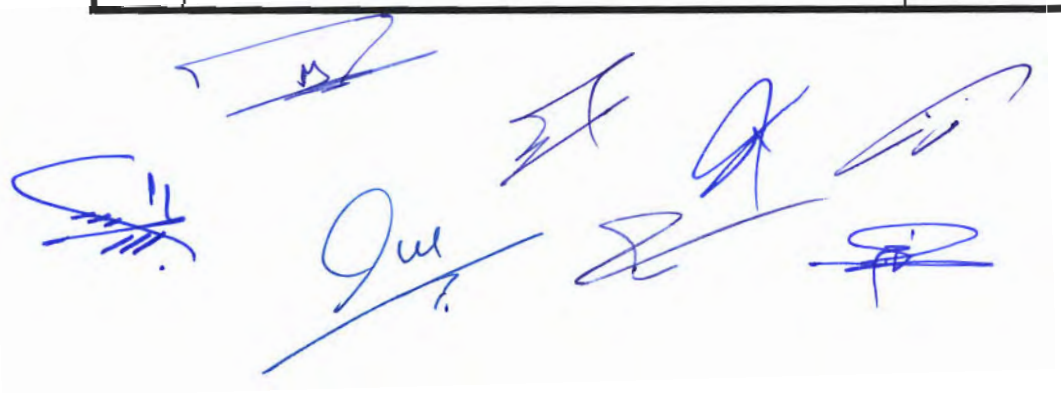
1.3- ON - LOAD TAP CHANGER

Item	Description		PETDE Requierments	Particulars
1	Manufacturer's name		MR Germany	
2	Type / designation			
3	Standard specification applied		IEC 214	
4	Rated voltage	KV	300	
5	Maximum rated through - current	A	600	
6	Number of taps	+-	+5 -15	
7	Rated step voltage	V	3300	
8	Breaking capacity	MVA		
9	Tapping range (in %of rated voltage)	+ %		
10	Tapping arrangement			
11	Position of tappings in winding			
12	Winding connection		Auto star	
13	Insulation levels			
	a) power frquency withstand voltage	KV	460	
	b) Impulse withstand voltage	KV	1050	
14	Maximum short - circuit current	KA/S	8 KA / 3 sec	
15	Rated current at lowest position of OLTC	A		
16	Permissible duration of			
	overloading at : 50%			
	a) 10 % overload			
	b) 20 % overload			
	c) 30% overload			
	d) 40% overload			
	e) 50% overload			
	overloading at : 100%			
	a) 10 % overload			
	b) 20 % overload			
	c) 30% overload			
	d) 40% overload			
	e) 50% overload			
17	Number of on - load changeovers without changing of	No.		
18	Number of switching operation after which a	No.		
19	Power consumption	KW		

SCHEDULE H1

1.4- BUSHINGS FOR TRANSFORMER IN ACCORDANCE WITH CAPACITY FOR 400, 230, 20 kV (if any)

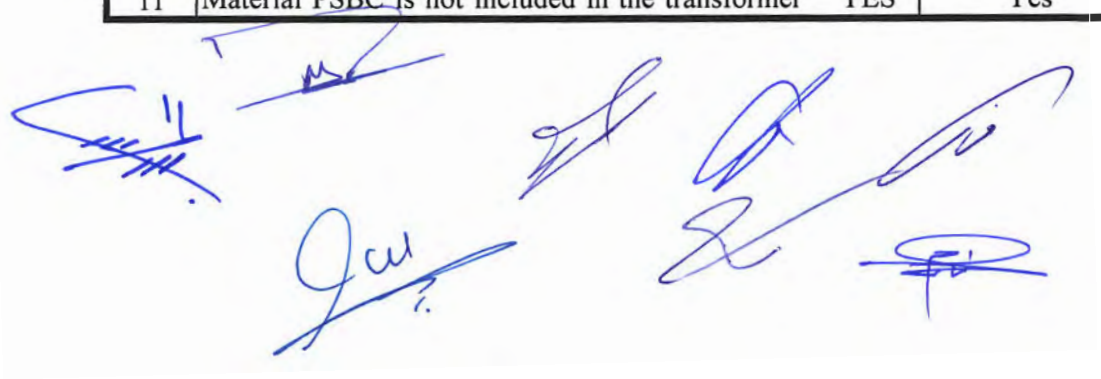
Item	Description		PETDE Requierments	Particulars
1	Insulator bushing material		Porcalain	
2	Type			
3	Manufacturer / Country			
4	Length of insulator (overall)	M		
5	rated current	A		
6	power frequency withstand voltage	KV		
7	Impulse withstand voltage	KV		
8	Weight of complete bushing	Kg		
9	Applied standard specifications		IEC 60137	
10	Creepage distance	mm		
11	Acceptable mech. Load	N	As per IEC 60137	



SCHEDULE H1

1.5- ELECTRICAL INSULATING OIL

Item	Description		PETDE Requierments	Particulars
1	Manufacturer's name			
2	Type			
3	Brand			
4	Disruptive voltage	KV	60	
5	Viscosity:	mm^2/sec		
	- at 20°C			
	- at 50°C			
6	Flash point	°C	min 135	
7	pour point	°C	max -40	
8	Tan delta (at 50 HZ)		max 0.005	
9	Ash content	%		
10	Acid number (mg KOH/g)	MG	max 0.01	
11	Material PSBC is not included in the transformer	YES	Yes	



SCHEDULE F

No.	Description			Particulars
1	**SYSTEM DETAILS**			
1	Maximum votage		kV	420
2	Rated system votage		kV	400
3	Earthing of system neutral			Solid
4	System frequency		Hz	50
5	System X/R ratio			10
2	**INSULATION LEVEL**			
	(All equipment at site altitude)			
1	Lightning impulse voltage withstand level , positive and negative polarity		kVp	1425
	Switching impulse voltage withstand level of insulation to ground , positive and negative polarity .	dry	kVp	1050
		wet	kVp	1050
2	Power frequency withstand voltage	dry	kV	520
		wet	kV	520
3	Voltage below which corona shall not be visible		kV	279
4*	Maximun radio influence voltage level measured at 1.1 times Us / $\sqrt{3}$ at 1 MHz		μ v	500
5	Minimum creepage to earth over insulation on rated system voltage (to IEC 815)		mm/kV	31
6	Surface stress of overhead conductors at rated system voltage		kV/mm	1.65
3	**TYPE OF SWITCHGEAR**			
1	Type of switchgear			Open terminal
2	Installation			Outdoor
4	**SHORT TIME CURRENT CAPACITY**			
1	All equipment 1 second		kA	40
2	Maintenance earthing devices , 1 second		kA	40

* Us is rated system voltage

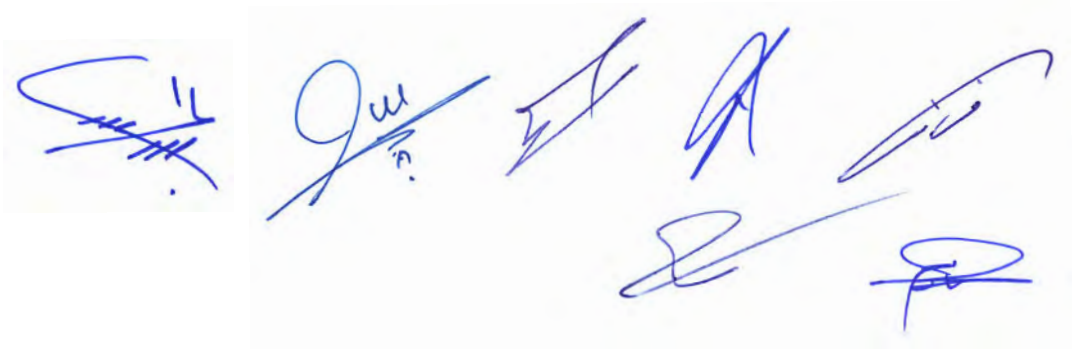
Creepage distance across the interrupter chambers shall be at least 10% greater than the creepage distance to earth and shall comply with the pollution conditions of IEC 815 .

SCHEDULE F

Item	Description		Particulars
5-	POWER TRANSFORMER 400/230/20kV 300 MVA		
1	Rated voltage ratio	kV	400/230/20
2	Continuous maximum rating (C . M. R)		
	(HV / LV) OFAF	MVA	300
3	Continuous tertiary rating OFAF	MVA	60
4	Type/Vector group (Auto delta tertiary)		3 ph. Unit/YNaod11
5	Type of cooling		ONAN/ONAF/OFAF
6	Rated frequency	Hz	50
7	On – load taps changer :		
	Total range	%	+5-15
	Total No. of steps		21
	Size of step	%	1
8	Tertiary winding :		
	a) phase to phase voltage	kV	20
	b) Nominal rating	MVA	60
9	-Impedance voltage at 75 ˚ C and normal ratio and C.M.R		400/230/20 kV
	a) Between HV and LV windings	%	= 15 (Base 300 MVA)
	b) Between HV and tertiary windings	%	(Base 60 MVA)
	c) Between LV and tertiary windings	%	(Base 60 MVA)
10	Average winding temperature rise above		
	maximum 45 ˚ C ambient by resistance		
	measurements at C.M.R OFAF	℃	60
	Top oil temperature rise by thermometer		
	Above 45 ˚C ambient temperature	℃	55
11	Hottest spot temperature at C.M.R	℃	115
12	Basic insulation withstand voltage (1.2 x 50 μ sec)	kV peak	
	a) HV winding	kV	1425
	b) HV bushing	kV	1425
	c) LV winding	kV	950
	d) LV bushing	kV	1050
	e) Neutral winding	kV	95
	f) Neutral bushing	kV	95
	g) Tertiary winding and bushing	kV	125
	h) switching surge voltage		
	- HV winding	kV	1050
	- HV bushing	kV	1175
13	Power frequency withstand	kV (R.M.S)	
	a) HV winding	kV	610
	b) HV bushing	kV	630
	c) LV winding	kV	395
	d) LV bushing	kV	460
	e) Neutral winding	kV	230
	f) Neutral bushing	kV	275
	g) Tertiary winding and bushing	kV	50
14	Multiration Bushing current transformer details		
	a)Accuracy class		>=5P20
	b)Rated burden	VA	>=30

SCHEDULE F

Item	Description		Particulars
6-	**STATION SERVICE TRANSFORMER 20/0.4 KV , 400 KVA**		
	Station service transformer combined with earthing transformer:		
1	Primary rated voltage	kV	20
2	Highest primary voltage	kV	24
3	Secondary voltage (phase to phase)	V	400
4	Continuous ONAN rated capacity	kVA	400
5	Vector group		ZNyn11
6	Type of cooling		ONAN
7	Basic insulation withstand voltage (1.2 x 50 µ sec)	kV peak	
	a) HV winding	kV	125
	b) HV bushing	kV	125
8	Power frequency withstand		
	a) HV winding	kv	50
	b) HV bushing	kv	50
9	Short time earth fault current (30sec)	A	800
10	Impedance	%	>=3.8
11	Off-circuit taps:		
	a)range on increasing step	%	2
	b)range on decreasing step	%	2
	c)size of steps	%	2.5
12	a)Winding temperature rise by resistance above 45 °C ambient temperature	°C	60
	b) Top oil temperature rise by thermometer		
	Above 45 °C ambient temperature	°C	55
13	Zero sequence impedance under line to Ground fault condition at rated MVA and Voltage between HV and LV windings	ohm	<=60
14	Current transformer details		>= 400 / 1 - 20 vA C:5P10



3. The test shall re-commences as soon as possible at 1.5 pu ONAF rated current and continue for 2 hours after the top oil temperature has established, ie. Changes less than 3°C per hour. However, if it becomes evident that the top oil temperature will exceed 110°C or the winding hot spot temperatures will exceed 140°C at 1.5 pu load, then the current shall be reduced to a per unit load which can be carried within the constraint of a top oil temperature not exceeding 110°C and a winding hot spot temperature of 140°C(+0-5°C) measured during the 2 hour period, or calculated from the earlier of the1.5 pu part emergency load test.

The test shall establish:

a)Time/temperature graph for top oil , tank and winding hot spots at 1.5xfull load current from a pre-overload load condition of 0.8pu load.

b) Maximum local temperature rise in frames, tank and fittings at 1.5xfull load current. This temperature shall not exceed the winding hot spot temperature.

c) Wining gradient of the primary and secondary windings, at 1.5xfull load current.

d) The maximum increase in hydrocarbon and carbon oxide gasses dissolved in the oil during the test and the rate of increase of such gasses within the constraint of 1.5 pu Load. a top oil temperature not exceeding 110°C and a Winding hot spot temperature of 140°C (+0-5 °C).

e) The amount of dissolved gasses evolving in the oil during the emergency overload test.

For this purpose samples of oil shall be collected from the transformer for Dissolved Gas Analysis (DGA):

a. Before the emergency temperature rise test commences.
b. At six(6) hours after the top oil temperature has stabilised.
c. After completion of the test.

The Winding Hot Spot temperature (THS) shall be determined as follows:

THS = TA + TOR + 1.3x TWG °C (at rated current)

Definitions:

THS	= The Winding Hot Spot Temperature	°C	
TA	= Ambient Temperature (Air)	°C	
THSR	= THS – TA = TOR + 1.3xTWG	°C =	The winding hot spot rise temperature
THS	= Winding Hot Spot Temperature	°C	
TO	= Top Oil Temperature	°C	(as measured during the tests)

MO = TO – (Cooler top – Cooler bottom Temperatures)/2
TOR = TO –TA = Top Oil Rise Temperature °C
MOR = Mean Oil Rise = TOR – (Cooler top – Cooler bottom Temperature)/2
TWG = Winding temperature Gradient = (Average Winding Temperature – Mean Oil Temperature) °C Determined temperature rise test.
Refer IEC 60076-2 fig B.1.

The tank hot spot temperatures shall be measured by either infra red scans, or their location determined and marked within 20-30 minutes of the test commencing so the actual hot spot temperatures in frames, tank and fittings can be determined after when the top oil temperature rise stabilised, using thermocouples or thermometers.

The Buchholz gas relay shall be operational during the temperature rise test and shall be checked for gas accumulation and gas levels detected before and after this test.

Dissolved gas analysis shall be carried out by an independent testing laboratory acceptable to PETDE on oil samples taken before and after the test. The cost of this test shall be deemed to have been included in the tender price. The Tenderer shall advise if he can perform these tests.

The rates of increase of gas levels and final gas levels after the emergency temperature rise test shall not be greater than the set out in table below:

	CO	CO2	H2	CH4+C2H6+C2H4	C2H2
Rate of increase ppm/hr at 1pu load				**1**	
Final gas level ppm				**38**	

The maximum permissible increase in gas levels at load in excess of 1pu. Shall be adjusted as follows:

$$\text{Rate of rise at Xpu.} = \text{Rate of rise at 1pu.} \times \frac{(\text{Actual load @XMVA})^2}{(\text{1pu. MVA})^2}$$

The correct functioning and indication of all thermometers shall be checked during the temperature rise tests.

32.28.**2.3.3** **On-load tap-changer**

The on-load tap changer shall be tested in accordance with IEC Publication 214 with the latest revision there of.
But only designs which have been type tested in accordance with IEC 214 will be accepted.

32.28.3 SHUNT REACTOR TESTING

The shunt reactors shall be tested at the manufacturers works in accordance with IEC 289.
The following tests shall be made in the reactor and witnessed by the engineer and his representatives, but not necessarily in the order shown, except that the lost tests shall be performed before the impulse tests.

32.28.3.1 **ROUTINE TESTS**

a) Core insulation test for core type reactors as per section (a).
b) Resistance of windings (IEC):
c) Current and losses (IEC):
The losses and current shall preferably be measured and rated voltage and normal frequency. The impedance shall be determinated from the test.
d) Inter-turn over voltage and separate source voltage withstand test (IEC).
e) Installation tests on auxiliary devices and wiring (IEC).
f) Mechanical test:
Such as oil level gauges, fans, pumps etc., shall be tested for proper functioning.

32.28.3.1.1 Magnetic circuit insulation (where appropriate).

a. A power frequency voltage of 2 kV for 1 minute applied as follows:-
Core bolts to core, to yoke clamps and to core leg side plates.
Core to yoke clamps and to core leg side plates.
Clamping bolts to screens and screens to earthed metal paths from which the screens are isolated.

b. Immediately prior to despatch, 2 kV for 1 minute applied between core and earth . A megger may be used for this test.

32.28.3.1.2 Noise level: The level of noise shall be measured in accordance with IEC 551.

32.28.3.1.3 Vibration: Vibration measurements shall be taken and the level recorded shall be subject to approval. This test shall be carried out unless it can be shown to the satisfaction of PETDE that the level of vibration in the reactor and its auxiliaries is harmless.

32.28.3.1.4 Voltage/reactance characteristics shall be recorded from 50 per cent to 100 per cent in steps of 10 per cent rated voltage. Reactance values up to 150 per cent rated voltage shall be determined by test or calculation.

32.28.3.2 TYPE TESTS

(on one reactor of each type)

a) Impulse tests including chopped waves (IEC):
Test values:

HV full wave	125 kV
HV chopped wave	125 kV

Sequence of these test shall be as follows:
- one reduce wave
- one full wave
- two chopped waves
- one full wave

The last full wave shall be applied as soon as possible after the second chopped wave.
There shall be no more than 10 minutes between the two tests.
For chopped wave, it shall be applied at least 3 microseconds before chopping.

b) Radio interference voltage test (NEMA)
The test shall be performed as per section.

c) Temperature rise test (IEC).

d) **Sound level test (NEMA)**
The sound levelled all not exceed the values 70 dB.

e) Vibration tests:
The tests shall demonstrate that the tests figures are within those set out in Section I.
(i) At reduced voltage – A complete series of measurements of vibration amplitude shall be made on the tank wall, in order to determine the place where the greatest vibration occurs.
(ii) At full voltage - Measurements of vibration at full voltage shall be made at most critical points as agreed upon with engineer. This test shall be of at least one minute duration.

f) Linearity:
The contractor shall supply current and voltage oscillograms recorded during the full voltage tests as a means of checking the linearity of the reactors.
The reactance shall be linear up to 150 per cent of rated voltage with a tolerance of ±5 per cent.

h) Oil leak test:
See section.

32.28.4 BUSHING TESTING

The bushing shall be tested at the bushing manufactur's works in accordance with IEC 289. The test shall be made on the bushings and witnessed by the engineer and his representative. but not necessarily in the order shown, Only designs which have been typed tested in accordance with IEC will be accepted.

32.28.4.1 ROUTINE TESTS

a) Dielectric dissipation factor (tan delta) and the capacitance at ambient trmperature (for bushing with organic insulation, not applicable with inorganic insulation) (IEC).

b) The dry power frequency voltage withstand test (IEC):

c) Partial discharge level (for bushings with-in organic insulation, not applicable with in organic insulation) (IEC).

d) Power frequency voltage withstand test of the voltage tapping and test tapping insulation (for bushings with organic insulation, not applicable with-in organic insulation) (IEC).

e) Leakage of internal filling (for liquifilled bushings) (IEC).

32.28.4.2 TYPE TESTS

a) Wet power frequency voltage withstand test (IEC):
The test shall be made in accordance with IEC Publication 60-2.
Duration of test - 1 minute.

b) Switching impulse voltage withstand test (IEC) :
(for 400 kV bushings only).

c) Dry ligthtning impulse voltage withstand test (IEC) :
wave shape: 1.2x20 micro seconds.
Each test consists in applying fifteen (15) waves of positive polarity and fifteen (15) waves of negative polarity to the bushings. The probability of withstand at the specified value shall be equal or superior to 90 per cent, which means that there shall be no more than three (3) flashover by series of fifteen (15) tests.

d) External radio interference voltage (R.I.V.) (IEC):
Measurements shall be made accordance with C/I/S/P.R Publication 1.

32.28.5 CURRENT TRANSFORMER TESTING

The current transformer shall be tested in accordance with IEC Publication 185 with the latest revision there-of.

32.28.6 RECORDS

The contractor shall keep a complete log of all tests, including calibration tests and test diagrams. The log shall include all oscilloscopic records, failure detections, test conditions and observed evidence, such as flashover, etc.

The log shall be available to the engineer at all times.
Copies of test results, taken at the time of test, shall be handed to the clients inspector or forwarded to the engineer.

A report shall be submitted to the engineer, regarding the official tests, failure detections, copies of final test and with data and calibration tests. The details regarding the submittals are given in section.

32.29 - TRANSFORMER VOLTAGE CONTROL EQUIPMENT

Routine and type tests shall be carried out in accordance with IEC 214.

32.30 - CABLE BOXES AND DISCONNECTING CHAMBERS

32.30.1 - Routine test

Oil tightness - All cable boxes and disconnecting chambers shall be tested with oil, having a viscosity not greater than that of IEC 296 insulating oil when at a temperature of 15°C , at a pressure of 70 kN/m^2 for 12 hours; during this time no leakage shall occur nor shall there be any permanent set when the pressure is released.

32.31 - TRANSFORMER AND REACTOR TANKS AND ONAN COOLERS

32.31.1 - Routine tests

32.31.1.1 Oil leakage - All tanks and oil filled compartments including all forms of radiator but excluding separate coolers using forced oil circulation, (for which see Section 8 below) shall be tested for oil tightness by being completely filled with oil of a viscosity not greater than that of IEC 296 insulating oil at a temperature of 15°C and subjected to a pressure equal to the normal pressure plus 35 kN/m^2. This pressure shall be maintained for a period of not less than 24 hours, during which time no leakage shall occur.

1. The tap-changer barrier shall be subjected to normal oil pressure head for 24 hours, during which time there shall be no leakage from the panel or bushings.

2. Detachable radiators may be tested as separate units.

32.31.2 - Type tests

32.31.2.1 Vacuum:

a. One transformer and reactor tank, tap-changing compartment, radiator and cooler of each size shall be subjected when empty of oil to that vacuum test level specified in the Schedules. There shall be no permanent deflection of the stiffeners, nor shall the permanent deflection of the panels exceed the value specified in the following table.

Major dimension of panel between stiffeners (metres) vertical or horizontal	Maximum permanent deflection
Up to 1.5 m	3 mm
1.5 m - 3 m	8 mm
Above 3 m	13 mm

b. A further test a vacuum equivalent to 3 m bar absolute pressure for a period of 8 hours shall be made for the purpose of checking the mechanical withstand capability of the tank; during this test no damage or fractures shall occur. This test is only applicable to units of 220 kV and above and may be combined with other tests or made during the processing of the unit.

32.31.2.2 Pressure:

a. One transformer and reactor tank of each size shall be subjected to a pressure corresponding to the normal pressure plus 35 kN/m^2. After the release of the excess pressure there shall be no permanent deflection of the stiffeners nor shall the permanent deflection of panels between stiffeners exceed the value specified in the above table. This test may be combined with a routine oil leakage test.

b. The tap-changer barrier shall be shown to withstand an over pressure test of normal pressure plus 35 kN/m^2 for 12 hours.

32.31.3 - Pressure relief device

When required by PETDE one pressure relief device of each size shall be subjected to increasing oil pressure and shall operate before reaching normal pressure plus 35 kN/m^2.

The operating pressure shall be recorded on the test certificate.

32.32 - TRANSFORMER COOLING PLANT WITH FORCED OIL CIRCULATION

32.32.1 - Routine tests

Air/oil coolers - All coolers using forced oil circulation shall be filled with oil of a viscosity not greater than that of IEC 296 insulating oil at a temperature of 15°C and subjected to a pressure equal to twice the maximum working pressure at the inlet to the cooler under service conditions which shall be maintained for a period of not less than 24 hours; during this time no leakage shall occur.

32.32.2 - Type tests

One forced-oil cooler of each type shall be subjected, when empty of oil, to that vacuum test level specified in the Schedules. There shall be no permanent deformation or distortion of any part of the cooler.

32.33 - FANS, PUMPS, MOTORS, PIPEWORK, OIL SAMPLING DEVICES AND VALVES

32.33.1 - Routine tests

32.33.1.1 Oil filled equipment - The bodies of all oil pumps complete with submerged motors, if any, and the oil pipework, oil sampling devices and valves shall withstand an hydraulic pressure of 140 kN/m^2 for 15 minutes.

32.33.1.2 Fans - Static and dynamic balance shall be checked on all fan impellers.

32.33.1.3 Control gear - All control gear shall be subjected to the tests specified in the appropriate IEC.

32.33.1.4 Motors - Each machine shall be subjected to the following tests where applicable:-

a. Measurement of winding resistance (cold).
b. No load test at rated voltage for determination of fixed losses.
c. An overvoltage test at 1.5 times rated voltage applied with the machine running at no load, for a period of 3 minutes, to test interturn insulation.
d. High voltage in accordance with IEC 34-1.

32.33.2 - Type tests

32.37.2.1 Motors - Performance tests shall be in accordance with IEC 34-1 however, certificates of type tests in accordance with IEC will be accepted.

32.37.2.2 Except for non-return valves, all valves and oil sampling devices which are subject in service or during maintenance to oil pressure shall withstand, when empty of oil, absolute pressure not exceeding 350 m bars. In the case of valves this test is to be applied to the body only. This type test shall subsequently be followed by a repeat oil leakage test.

32.34 - OIL

32.34.1 - Sample tests

Samples of oil from each consignment shall be tested in accordance with IEC 296 before despatch.
Subject to the agreement of PETDE a test certificate, confirming that the oil from which the consignment was drawn has been tested in accordance with IEC 296, may be accepted. Before commissioning any transformer, the electric strength of its oil shall be check-tested and the results approved by PETDE.

32.35 - GAS AND OIL ACTUATED RELAYS

32.35.1 - Routine tests

The following tests shall be made on relays when completely assembled. Where oil is referred to it shall have a viscosity not greater than that of IEC 296 insulating oil at 15°C.

32.35.1.1 Oil leakage -
The relay, when filled with oil shall be subjected to an internal pressure of 140 kN/m^2 for 15 minutes. No leakage shall occur either from the casing or into normally oil free spaces, such as floats, within the casing.

32.35.1.2 Gas collection:

a. With the relay mounted as in service and at a rising angle of 5 degrees (tank to conservator) and full of oil, gas shall be introduced into the relay until the gas collection contacts close. The oil level contacts shall not close when gas is escaping freely from the relay on the conservator side. These contacts shall, however, close when the pipework is empty of oil.
b. The empty relay shall be tilted, as if mounted in pipework rising from tank to conservator, at an increasing angle until the gas collection contacts open. the angle of tilt shall then be reduced and the gas collection contacts shall close before the angle is reduced to less than 13 degrees to the horizontal.
c. With the relay mounted at a falling angle of 16 degrees to the horizontal and full of oil, the gas collection contacts shall be open.

32.35.1.3 Oil surge - With the relay mounted as in service and full of oil at approximately 15°C the surge contacts shall close within the steady oil flow limits specified in the Schedules. This option shall not be adversely affected when the gas collection contacts have already closed and gas is escaping freely.

32.35.1.4 Voltage - With the relay empty of oil, a voltage of 2 kV shall be applied in turn between each of the electrical circuits and the casing for one minute, the remaining circuits being connected to the casing.

32.35.1.5 Operation - With the transformer assembled with its cooling plant as in service, tests shall be made to demonstrate that the relay does not operate whilst the oil pump motors are being started or stopped.

32. TESTING

32.28 – TRANSFORMERS AND SHUNT REACTORS

32.28.1 GENERAL

32.28.1.1 TESTING

Testing shall conform to the codes mentioned below, except specified other wise or approved by the Engineer.
The Contractor shall provide the engineer with a schedule of proposed arrangements and tests prior to the testing date.
The contractor shall make as many tests as, in the opinion of the engineer, can be made together. All arrangement for the test and the methods of computing test results shall be approved by the engineer. All instruments to be used for testing shall be calibrated by a recognized and approved laboratory. The test certificates shall bear the details of calibration. All tests including calibration tests, may be witnessed by the engineer or his representative or an approved inspecting authority. The equipment shall be painted after passing the tests. At least one month's notice shall be given to the engineer so that he may witness the test.

32.28.1.2 CODES AND DIFINITIONS

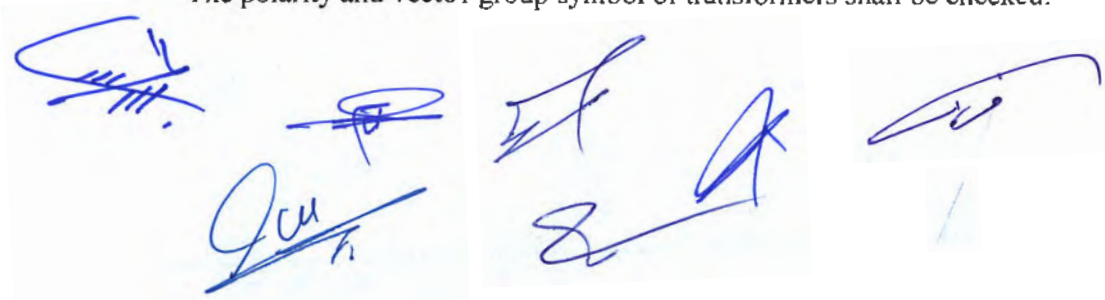
The code of the IEC shall be regarded as the source of reference for definitions, methods of measurements, etc..
A list of theses codes are given in the general part of the specification. All tests specified in this section shall be performed at the manufacturers works.

32.28.2 AUTO TRANSFORMER TESTING

The transformer shall be regarded tested at the manufacturers works in accordance with latest IEC .
In case of omission of a particular test, it shall conform to relevant ANSI or NEMA standards. The following tests are briefly outlined and shall be carried out to the detailed instructions set out in the relevant standards. The test shall be made on the transformers and witnessed by the engineer or his representative, but not necessarily in the order shown, except that the ratio test and no-load test shall be performed before the impulse tests.

32.28.2.1 ROUTINE TESTS

a) Core insulation test:
   Insulation resistance shall be measured at 1.000 volts and shall indicate a minimum resistance of 5 meg ohms during the core stacking.
b) Resistance of high voltage, low voltage and tertiary windings (IEC):
   The resistance measurement shall include all taps.
c) No-Load current and no load losses test (IEC):
   The NO-load current and No-load losses shall be measured at rated voltage and frequency.
d) Induced over voltage and separate source voltage withstand test (IEC)
e) Voltage ratio, polarity and phase relation-ship tests (IEC)
   The voltage ratio shall be measures on each tapping.
   The polarity and vector group symbol of transformers shall be checked.



f) Load losses measurements at rated current and normal frequency (IEC)
g) Impedance voltage test (IEC):
The test shall be performed at rated current and normal frequency on the principal tapping and also on the highest and lowest value on the tapings.
h) Insulation tests on auxiliary devices and wiring (IEC).
i) Mechanical test:
Such as oil level gauges, fans, pumps etc., shall be tested for proper functioning.

32.28.2.1.1 The winding resistance and impedance voltage tests should also be carried out at the principal, maximum and minimum tapping positions.

32.28.2.1.2 Magnetic circuit insulation.

a. A power frequency voltage of 2 kV for 1 minute applied as follows:-
Core bolts to core, to yoke clamps and to core leg side plates.
Core to yoke clamps and to core leg side plates.
b. Immediately prior to despatch, 2 kV for 1 minute applied between core and earth. A megger may be used for this test.

32.28.2.1.3 No load current at:-

a. 90 per cent rated voltage.
b. 100 per cent rated voltage.
c. 110 per cent rated voltage.
d. The maximum voltage equivalent to the value quoted in the Schedules.

32.28.2.1.4 Lightning impulse test on all terminals including neutral.

32.28.2.1.5 Dissolved gas analysis: A dissolved gas analysis test shall be carried out before and after a temperature rise test and before and after the series of dielectric tests, for all windings of 22 kV and above. The tests shall be in accordance with IEC 567 and IEC 599.

32.28.2.2 Type tests

(on one transformer of each type)
a) Switching surge test : IEC

The test shall applied to all high voltage terminals
- one reduce wave
- one full wave (negative).

These waves shall be applied before the impulse tests.

The wave shapes shall be as follows:
- crest voltage on HV terminal 1050 kV.
- Voltage shall be mentioned above 90 percent of its peak value for at least 200 microseconds.

b) Impulse tests including chopped waves (IEC):
Test values:

HV full wave	1425 kVP
LV full wave	950 kVP
HV chopped wave	1425 kVP
LV chopped wave	950 kVP

Sequence of these test shall be as follows:

*Type test on HV and LV terminals of one transformer of each type:

- one reduce wave
- one full wave
- two chopped waves
- one full wave

The last full wave shall be applied as soon as possible after the second chopped wave.
There shall be no more than 10 minutes between the two tests.
For chopped wave, it shall be applied at least 3microseconds before chopping.

c) Radio interference voltage test (NEMA)
The test shall be performed as per section.

d) Temperature rise test (IEC).

e) Sound level test (NEMA)
The sound level shall not exceed the values set out in section 3.8.

f) Oil leak test:
The tank and oil-filled compartments shall be tested for oil tightness at a pressure 1kg/cm2 measure at the bottom of the tank.
No leakage shall occur during a period under pressure of 24 hours.

32.28.**2.2.1** The lightning impulse chopped wave test shall be carried out on all windings of 300 kV and above in accordance with IEC 76-3 Clause 13.

32.28.**2.2.2** Transferred surge: Where transferred surge tests are required by the Schedules, the transformer shall be tested so that with the test voltage applied to the other windings, the maximum surge that can be transferred to the unloaded winding(s) does not exceed its specified insulation lever. Compliance with this requirement may be achieved by the use of external equipment connected to the unloaded winding and shall be proved by recurrent surge oscillograph measurements, by comparison with the transferred voltage on open circuit.

32.28.2.2.3 Noise level: The level of noise shall be measured in accordance with IEC 551.

32.28.2.2.4 The measurement of zero sequence impedance shall be carried out in accordance with IEC 76-1 subclause 8.7.

During the temperature rise test the accuracy of oil and/or winding temperature indicating devices shall be determined.

32.28.2.3 SPECIAL TESTS

All special tests under clause 32.31.2.3 (See SRS Book) shall be carried out on all transformers supplied under this contract with the exception of test 32.31.2.3.2 and optional testy 32.31.2.3.1.
Test 32.31.2.3.2 shall only be carried out on one unit of transformers.

32.28.2.3.1 Short circuit withstand test (optional at PETDE discretion)

The Tenderers shall include an offer for short circuit withstand test at an international recognised testing laboratory for each type of transformer included in this specifications and list the place proposed for such test. The test shall be performed in accordance with the requirements of IEC 60076 -5 for such tests if PETDE accepts the offer for this.
The tenderers shall also advise if such test has been performed on identical or similar design manufactured at his works. PETDE will also give consideration to a design review of the short – circuit withstand calculations as an alternative to performance of short the circuit test.

32.28.2.3.2 Temperature rise test under emergency load conditions

The purpose of the temperature rise test under emergency load condition is to verify that the transformer has no manufacturing defects limiting it load carrying capability, and that it can be operated in accordance with IEC 60354 1991 without causing any damage to the transformer. beyond the accelerated aging normally occurring at higher temperatures.

The emergency temperature rise test shall be carried out as a normal temperature rise test except for the following:

1. The tap position for the test shall be the maximum loss tap position (unless directed otherwise by PETDE representatives).

2. The Emergency load test shall commence with oil temperature rise corresponding to that present at steady state of 0.8.pu ONAF load and a winding current shall be of 1.5 pu ONAF rated current for two (2) hours. A temperature rise shutdown shall be carried out (2) hours. to determine the winding temperature rises and the winding gradients.
However, if it becomes evident that the top oil temperature will exceed 110°C or the winding hot spot temperature will exceed 140°C at 1.5 pu in less than 2 hours, then the temperature rise shutdown shall be carried out after the winding hotspot temperature reaches 135°C and before it reaches 140°C.

32.35.2 - Sample test

At the discretion of PETDEs, the following test shall be made:-

32.35.2.1 Variation of performance with mounting angle with the mounting conditions as in service, the mounting angle shall be varied within the rising angle limits 1 and 9 and tests repeated in the manner prescribed for the routine tests.

32.36 - TRANSFORMER SECONDARY WIRING

All secondary wiring, including panel wiring and control circuits and all apparatus connected thereto shall be subjected to the following tests:

32.36.1 - Routine tests

32.36.1.1 Voltage - 2 kV applied for one minute except where this requirement is modified by a British Standard, to which item the appropriate test shall be applied.

32.36.1.2 Insulation resistance - By megger of not less than 500 volts.

32.37- OIL FILTERING EQUIPMENT

Such tests as are considered necessary by PETDE to show that the guaranteed particulars in the Schedules are met.

32.38 - FIRE PROTECTION EQUIPMENT

All parts of the fire alarm system, fire extinguishers and transformer fire protection system shall be tested in accordance with the appropriate IEC or other standards to the approval of PETDE.

32.39 - TESTS AT SITE

After the plant and ancillary equipment have been erected and connected up on site, the Contractor shall carry out to the satisfaction of PETDE such tests as may be required to prove compliance with the specification, independently of any tests carried out at the manufacturer's works.

Not less than thirteen weeks before any section of the plant is required to enter commercial service, the Contractor shall submit for the approval of PETDE his detailed site test proposals for that section of the plant, together with details of the test equipment and methods that he proposes to use. Subject to approval of the tests, these will be written by PETDE into an overall programme of tests, which will be issued to all directly concerned prior to the starting date for the tests.

SCHEDULE E1.1

SCHEDULE OF UNIT FOR PROGECT

Item No.	Description	Qty	Unit	Foreign Currency		
				FOB Unit Rate	FOB Total	warehouse of PETDE Total
1	**400 / 230 / 20 kV Transformer**	4	No.			
1.1	**300 MVA auto transformer with 60 MVA tertiary** each Shall have : a- 3 oil / air bushings to make connection to 400kV switchgear b- 1 current transformer ratio 600/1A for thermal image c- 3 oil / air bushings to make connection to 230kV switchgear d- 1 current transformer ratio 800/1A for thermal image e- 3 oil / air bushings to make connection to 20kV system f- 1 current transformer ratio 2500/1A for thermal image, 3 current transformers ratio (2500 / 1500 / 1000 / 1 A) for transformer differential protection . g- 1 - oil / air neutral bushing h- 1 neutral current transformer ratio 2500/1500/1000/1 A . i- Set of valves and sampling device j- Conservator tanks , with oil level gauges and breathers . k- Cooling fans and radiators l- Oil pumps m-Tap changers n- Cubicle to house all local controls and indications					
1.2	**Insulating oil plus 10 per cent spare**					
	Total price 400/230/20 kv transformers					

SCHEDULE E1.2
SCHEDULE OF UNIT PRICES FOR PROJECT

Item No	Description	QT	Unit	Foreign Currency		
				FOB Unit Rate	FOB Total	warehouse of PETE Total
2	**20/0.4 kV earthing/auxiliary transformer**	**4**	**No.**			
2.1	20/0.4 kV earthing/auxiliary transformer, 3-phase (400) kVA complete with off-load tap-changer and all accessories and fittings					
2.2	Insulating oil plus 10 per cent spare					
Total price 20/0.4 kV earthing/auxiliary transformers						
3	**Spare parts acc.to E2.1 & E2.2**	**1**	**SET**			
4	**Training abroad of PETDE staff (2 man/week)**					
5	**Testing at works (2 man/week)**					
6	**Optional work of project (if any)**					
Total price for project						

SCHEDULE E2 (E2.1)

SCHEDULE OF PRICES AND QUANTITIES FOR SPARE PARTS

1.400/230/20kV POWER TRANSFORMER 300 M V A

Item No	Description	Unit	Qty	Foreign Currency			
				FOB Unit Rate	FOB Total	warehouse PETDE Unit Rate	warehouse PETDE Total
1	400 bushing complete with internal connections	Nos	4				
2	230 bushing complete with internal connections	Nos	4				
3	20 bushing complete with internal connections	Nos	4				
4	neutral bushing complete with internal connections	Nos	2				
5	Thermostat	Nos	2				
6	Gaskets	1 set	4				
7	Oil level indicator	Nos	4				
8	Buchholz relay	Nos	4				
9	Complete set of thermometers	set	4				
10	OLTC control motor	Nos	2				
11	OLTC commutating switch	Nos	2				
12	OLTC control relay	Nos	2				
13	OLTC selector switch	Nos	2				
14	OLTC position indicator	Nos	2				
15	Cooler	set	2				
16	Motor fan	Nos	4				
17	Winding temperature indicator	Nos	2				
18	Complete On-Load tap changer	Nos	1				
19	Other items as recommended by the Tenderer						
Total price for spare parts for power transformers							

SCHEDULE E2 (E2.2)

SCHEDULE OF PRICES AND QUANTITIES FOR SPARE PARTS

2. 20/0.4 kV EARTHING TRANSFORMER 400 KVA

Item No	Description	Unit	Qty	Foreign Currency			
				FOB Unit Rate	FOB Total	warehouse PETDE Unit Rate	warehouse PETDE Total
1	HV bushing, complete with internal connections	set	2				
2	LV bushing complete with internal connections	set	2				
3	Set of joints complete	set	2				
4	Thermometers complete set	set	4				
5	Buchholz relay	Nos	4				
6	Oil level indicator	Nos	4				
7	Gaskets	set	2				
8	Other items as recommended by the Tenderer						
Total price for spare parts for earthing transformers							

E3.1
PLACE OF MANUFATURE AND INSPECTION

Tenderer shall state in the appropriate places below of the manufacturer,
Place of Manufacture and place of inspection and testing for transformers,
its major and minor components and other accessories .
The Tenderer shall name one manufacturer for each item.
Any ((Equivalent)) with respect to the manufacturer is not acceptable .

TRANSFORMER :300 MVA 400/230/20KV

Item No	Description	Manufacturer	Place of manufacturer	Place of Inspection & Testing
1	Transformers, complete 300 MVA 400/230/20 kv			
2	Insulating Cylinders			
3	Copper			
4	Steel castings			
5	Core plates			
6	Tanks			
7	Radiators			
8	Oil piping and Coolers			
9	Fan blowers			
10	Conservator Airbag			
11	Oil pumps			
12	Oil valves			
13	Terminals:			
	a)400kv Air bushings			
	b)230kv Air bushings			
	c)20kv Air bushings			
14	Cable boxes and accessories			
15	On Load Tap Changer			
16	OLTC Motor Drive			
17	Oil Surge Relay			
18	Buchhols relays			
19	Pressure relief devices			
20	Automatic voltage control relay			
21	Winding Temperature Indicators			
22	Oil Temperature Indicators			
23	Magentic Oil level guage (Main Conservator)			
24	Magentic Oil level guage (OLTC Conservator)			
25	Remote tap changer control panels			
26	Marshalling kiosks/cubicles			
27	Gas sampling device			

E3.2

PLACE OF MANUFATURE AND INSPECTION

Tenderer shall state in the appropriate places below of the manufacturer, Place of Manufacture and place of inspection and testing for transformers, its major and minor components and other accessories .

The Tenderer shall name one manufacturer for each item.
Any ((Equivalent)) with respect to the manufacturer is not acceptable .

EARTHING TRANSFORMER :400 KVA 20/0.4KV

Item No	Description	Manufacturer	Place of manufacturer	Place of Inspection & Testing
	Transformers, complete 400 KVA -20/0.4 kV ZNyn11			
2	Insulating Cylinders			
3	Copper			
4	Steel castings			
5	Core plates			
6	Tanks			
7	Valves			
8	Terminals:			
	a)20 kv Air bushings			
	b)0.4 kvCable Box			
9	Cable boxes and accessories			
10	Oil Temperature Indicators			
11	Marshalling kiosk/cubicles			
12	Buchhols relays			
13	Magentic Oil level guage for Main Conservator			
14	Pressure relief Devices			