INDEPENDENT POWER TRANSMISSION OPERATOR S.A.
TNPRD/ SUBSTATION SPECIFICATION & EQUIPMENT SECTION

November 2013

SPECIFICATION No SS-25/20
40/50MVA, 150 / 15,75 – 21KV THREE-PHASE TRANSFORMERS

I. SCOPE

The scope of the present specification is to describe IPTO's requirements regarding design features, technical characteristics and testing of three – phase, 150/15,75 -21kV transformers rated at 40/50MVA.

II. KEY WORDS

Transformers.

III. USE

The transformers are installed in substations for the transformation of the 150KV network voltage to 15,75KV or 21KV level, covering the load requirements of the 20KV distribution network.

IV. ELECTRICAL SYSTEM CHARACTERISTICS

IV.1. 150KV NETWORK

1. Nominal Voltage	: 150KV
2. Maximum Operating Voltage	: 170KV
3. Minimum permissible operating voltage	: 135KV
4. Number of phases	: 3
5. Number of conductors	: 3
6. Short Circuit level	: 30KA
7. Basic Insulation level	: 750KV (peak)
8. Power frequency withstand voltage (1min)	: 325KV (r.m.s.)
9. Nominal frequency	: 50Hz
10. Variations of nominal frequency	: ±0.2Hz
11. Available auxiliary D.C. supply voltage	: 110V D.C. from substation batteries
12. Available auxiliary A.C. supply voltage	: 3 – phase, 4 – conductors 230/400V

IV.2. 15,75KV or *21KV NETWORK*

1. Nominal System Voltage	: 15,75KV or 21KV
2. Maximum Operating Voltage	: 17,5KV-24KV
3. Number of phases	: 3
4. Number of conductors	: 3
5. Short Circuit level	: 10KA
6. Basic Insulation level	: 145KV (peak)
7. Power frequency withstand voltage (1min)	: 50KV (r.m.s.)
8. Nominal frequency	: 50Hz
9. Method of earthing (grounding)	: Earthed neutral (via resistance of 12Ω).
10. Available auxiliary D.C. supply voltage	: 110V from substation batteries
11. Available auxiliary A.C. supply voltage	: 230/400V

V. OPERATING AMBIENT CONDITIONS

Installation	: Outdoors
Limits of ambient temperature	: -25 ^{0}C to + 45 ^{0}C
Altitude	: Up to 1000 m above sea level
Other climatic conditions	: Snow, ice and fog

VI. STANDARDS

All the technical, nominal characteristics and testing of transformers shall conform to the last edition of IEC 60076 standard.

VII. REQUIRED DESIGN CHARACTERISTICS OF THE TRANSFORMER

1. Type

Three-phase oil immersed transformer of two windings with earthed neutral, suitable for outdoor installation.

2. Voltage ratings and number of phase windings

- Primary : 150 KV, 3 - phases
- Secondary : 15,75KV or 21KV, 3 - phases

3. Symbolism of transformers windings connection (Vector Group)

Dyn1.

The HV Vectors shall lead the LV Vectors by 30^o degrees.

4. Nominal apparent power (capacity) ratings

Nominal simultaneous continuous capacity, for 65^{o}C average winding temperature rise, measured by resistance up to 40^{o}C ambient:

- 40 MVA ONAN – natural cooling (natural oil and air circulating)
- 50 MVA ONAF – forced cooling (air circulating via fans, oil natural circulating)

5. Type of core

The type of transformers core will be core-form. The core shall consist of 3 limbs.

6. Insulation Levels

HV			
- H.V line terminals	170 kV	LI/AC	: 750/325 kV
- H.V Bushings	170 kV	LI/AC	: 750/325 kV
Neutral			
- Neutral winding	24KV	LI/AC	: 145/50 kV
- Neutral Bushing	24KV	LI/AC	: 145/50 kV
LV			
- L.V line terminals	24kV	LI/AC	: 145/50 kV
- L.V Bushings	24kV	LI/AC	: 145/50 kV

7. Short circuit withstand capability

Transformer shall be capable of withstanding under service conditions for 2 (two) seconds, on any tap-setting, three-phase or one-phase short circuit at the terminals of any winding without being damaged due to excessive forces or thermal effects. The thermal and dynamic ability of the transformers to withstand short circuit shall be demonstrated by calculation or the performance of a special test, in accordance with IEC 60076-5.

8. Winding insulation category and connections

8.1. The primary winding shall be delta-connected, The primary winding shall be of uniform insulation category.

8.2. The secondary winding will be star-connected with the neutral brought out a fully insulated bushing (145KV BIL), grounded at the grounding grid of the substation via a resistance of 12Ω. The secondary winding shall be of uniform category.

9. Temperature rise limits

9.1 The average value of the windings temperature rise will be 65^{o}C (class A), for ambient temperature up to 40 ^{o}C.

9.2 The temperature rise at top oil level will be limited up to 60^{o}C for an ambient temperature up to 40 ^{o}C.

The limits of the temperature rise will be verified by the execution of the corresponding type test.

The transformer thermal model constants, following IEC 60076-7, will be calculated and provided in “ATTACHMENT A” of this specification.

10. Over-Voltage Capability

Transformers shall have an over-voltage capability of 10% at no load and 5% at rated MVA without exceeding the limiting temperature rise at load power factor of 80% or higher.

11. Limits of insulations resistance at 20^0C

a. For HV winding : 5 GΩ
b. For LV winding : 3 GΩ

12. Impedance Voltage

40MVA

a. (150KV to 15,75KV or 21KV): Not less than 15,2% at any tap of OLTC

50MVA

b. (150KV to 15,75KV or 21kV): Not less than 19% at any tap of OLTC

13. Limits of losses

The no-load (iron) losses of the transformer shall not exceed 24KW.
The load (copper) losses at 40MVA shall not exceed 110KW at the principal tap No.7.
The cooling losses at 50MVA shall not exceed 4KW.

14. Limits of magnetizing current values

The magnetizing current of the transformer, will not exceed the following values:

Secondary voltage	Magn. current in % of nominal current	
For V_r=15,75KV or 21 KV	0,35%	tolerance + 30%
For 1.1×Vr=17,32KV or 23,1 KV	1%	

The limits of the magnetizing current values will be verified by the execution of the corresponding routine test.

15. Audible noise

The audible noise level of the transformer with the cooling equipment (fans) in service shall not exceed the value of 72dB(A).
The determination of the audible noise level and the measurement methods for the various parts of transformers will be in accordance with IEC 60076-10 and will be verified by the measurements of the relevant test.

16. Harmonics

The maximum harmonic content, produced by the subject transformer shall be given in detail by the Bidders and will be confirmed by the execution of the corresponding test.

Harmonics of no-load current for voltage ratio 150/21kV shall be limited as follows:

- third harmonic ≤ 25% of no load current
- fifth harmonic ≤ 15% of " " "

- seventh harmonic ≤ 7% of " " "

17. **Guaranteed losses**
    The bidder must clearly indicate in his technical and economic offer the following guaranteed losses:
    a. No load losses at 15,75KVand 21KV
    b. Copper losses at principal tap (Nb7) 150/21KV at 40 MVA
    c. Total losses (No load + copper losses) at 150/21 KV at 40MVA
    d. Cooling losses at 50 MVA

18. **Maximum efficiency**
    Maximum efficiency is desired at approximately 34MW (Refer to evaluation of losses)

19. **Off-circuit tap changer**
    The power transformer shall be equipped with suitable off-circuit tap changer, so arranged as to give two nominal low voltage ratings, 15,75kV and 21kV.
    Off-circuit tap changer is considered to be operated de-energized.

VIII. ON – LOAD TAP – CHANGER (OLTC) AND VOLTAGE REGULATOR

On-load tap changer (O.L.T.C.) of the resistance type with transfer switches, selector switches and reversing switches for voltage regulation from +7,5% to -12,5% in steps of 1875V.
The O.L.T.C. shall be on the High Voltage winding of the transformer. Three separate OLTC with common drive mechanism will be installed, one on each HV phase winding.

The transfer switches shall be placed in a separate oil tank.

The O.L.T.C. shall be motor operated controlled by an automatic voltage regulator supplied by seller. The voltage regulator shall have current and voltage input from 20kV or 15kV level and it will be digital. It will supplied as a loose component. The power supply to the voltage regulator will be with 110V DC.
Available voltage and current for the analogue inputs: substation voltage transformer with secondary nominal voltage 100V or 110V, current transformer with secondary nominal current 1A or 5A.
The voltage setpoint shall be adjustable in the range 90-110% of nominal voltage. The overlap voltage shall be adjustable in the range 0,5%-5% of the setpoint voltage. The line-drop compensator shall have two elements X and R for reactance and resistance compensating. Both of these elements shall be adjustable to obtain values corresponding to the voltage drop in the 15 or 20 kV primary distribution lines. The voltage regulator will include also undervoltage, overvoltage and overcurrent function, which will block the operation of the OLTC.

To avoid excessively frequent operation of the O.L.T.C. a time delay device is necessary to be provided with possibilities of adjustment from 10 to 100 sec.

The voltage regulator will follow selectively, either the inverse time delay or the fixed time delay principle. The time delay will be by-passed in case of large voltage deviation from setpoint.
The voltage regulator will include a digital display for indication of the tap position and the measured voltage. The control of the OLTC will be realized either automatically or with manual operation through buttons included in the voltage regulator, or manually through remote up-down commands to the voltage regulator.
The OLTC can be controlled also locally at the transformer, through local buttons.
The voltage regulator will be set through the local buttons and display or through a setting software, installed in a personal computer. The software and the relevant communication cable shall be delivered by the supplier.
A step by step device must be incorporated in the control circuit to ensure one tap-change only, even when the control switches are held continuously in the 'ON' position.

The O.L.T.C. shall be equipped with auxiliary contacts for remote position indication as well as with an operation counter. Provision shall be made for a switchboard change over switch with at least (3) three positions i.e. (a) OFF, (b) automatic load ratio control, (c) remote-local manual load-ratio control.

The motor drive mechanism of the O.L.T.C. shall be fed by three (3) phase voltage 230/400V, 50Hz. The motor and the O.L.T.C. mechanism shall be protected through a circuit breaker against overload, under voltage and loss of one phase voltage. If a sudden interruption of the current feeding the motor occurs, the switch must not stay between two positions.

All relays, switches, fuses etc., of the O.L.T.C. shall be mounted in a weather-proof control cabinet mounted on transformer. The control voltage of the OLTC will be 230V AC. The signaling will be realized by voltage-free contacts. A heat resistance shall be provided in the cabinet supplied by 230V A.C. and controlled by a thermostat.

1. Parts of the on – load tap – changer
   The on – load tap changer generally shall consist of a diverter switch, transition resistors, a tap selector and a reversing change – over selector.
   The whole being operated by a driving mechanism (motor drive).

2. Type of the on – load tap – changer
   Mechanical oil – immersed type or vacuum/oil (diverter switch and the transition resistors in vacuum and the tap selector and the reversing change – over selector in oil).

3. Number of tapping positions and the corresponding voltage level of each tapping position.
   Total number of tapping positions : 17 including one principal tap and +6/-10 tapping positions above/below of the principal tap.

ON LOAD TAP CHANGER WITH (17) SEVENTEEN POSITIONS (OLTC)		
Voltage regulation +7.5% 150KV +6 steps principal tap→ -10 steps -12.5% in steps of 1875V	HV (KV) 1. 161,250 2. 159,375 3. 157,500 4. 155,625 5. 153,750 6. 151,875 7. 150,000 8. 148,125 9. 146,250 10. 144,375 11. 142,500 12. 140,625 13. 138,750 14. 136,875 15. 135,000 16. 133,125 17. 131,250	LV (KV) 15,75KV or 21KV at no load operation

4. Applicable Standards
   IEC 60214-1 and IEC 60214-2

5. Required operating temperatures of on – load tap – changer

Tap – changer Environment	Temperature	
	Minimum	Maximum
Oil	-25^{o} C	100^{o} C
Vacuum	-25^{o} C	100^{o} C

6. Location of the tap changer components and method of installation
   A. For oil – immersed type OLTCs
      a. The diverter switch and the transition resistors shall be oil immersed in their own compartment which shall be hermetically tight.
      b. The tap selector and the reversing change – over selector shall be placed in their own compartment which shall be not oil tight and thus the tap selector can be in contact with the transformer oil.
      c. Both compartments which are mentioned above shall be placed inside the tank of the transformer.

B. For oil/vacuum type OLTCs

a. The diverter switch and the transition resistors shall be placed in their own hermetically sealed oil comportment. The switching contacts must be of vacuum type.
b. The tap selector and the reversing change – over selector shall be placed in the transformer oil.
c. Both compartments which are mentioned above shall be placed inside the tank of the transformer.

C. Access to the OLTC and its individual components shall be possible without disturbing connections or other parts of the transformer. Suitable manholes shall be available on the transformer tank so that the OLTC or any of its components can be removed, on site, in case of failure.

It is of paramount importance that the removal of the OLTC or any of its components does not cause any problems to any of the transformer parts.

7. Conservator of the OLTC

a. Regardless of weather the OLTC is of oil or vacuum type, the diverter switch and the transition resistors shall have their own conservator (oil expansion tank).
b. The OLTC conservator shall be equipped with an oil level indicator.

NOTE: Is also accepted one conservator with two (2) rooms, one for the transformer tank and one for OLTC.

8. Type of oil of the OLTC

The oil used in the diverter switch and transition resistors compartment shall be mineral oil suitable for transformers, free from any PCBs or PCTs and in accordance with IEC – 60296 Standard.

9. Accessories of the diverter switch and transition resistors oil compartment

- The compartment shall be equipped with a drain and filling tap.

10. Rating and other characteristics of the OLTC

a. Single or three phase : Three single phase units
b. Tapping arrangement : Reversing
c. Position of tapping in winding : Middle of the high voltage winding
d. Maximum rated through current : ≥ 250 A
e. Rated frequency : 50Hz
f. Rated voltage : 170KV r.m.s
g. Rated power – frequency withstand voltage (50Hz, 1 min): 325 KV r.m.s
h. Rated lightning impulse withstand voltage (1.2/50μs) : 750KV peak
i. Number of electrical positions : 17
j. Rated phase step voltage : ≥ 1970 V

11. Operations under load

The OLTC shall be able to perform 500.000 operations without contact change, under step voltage of 1875V and through current equal to the rated HV transformer winding current at the principal tap (No.7).

12. Required protective devices for the OLTC

Three of the below mentioned protective devices (a) and (b) shall be installed, one per each separate OLTC.

a. Oil-flow controlled relay

This oil –flow relay shall be installed in the pipe between the tap changer head and oil conservator and shall respond to a predetermined oil flow (due to low energy phenomena) and enable the transformer to the tripped. The relay shall be designed and tested following EN 50216-1 and EN 50216-2 standards. The test certificates shall be presented to IPTO inspector.

This oil-flow relay shall be MR or EMB type and with the following contact characteristics:

- Two (2) N.O contacts suitable for 110V DC.
  One for tripping purposes and one for alarm.

b. Pressure relief device

This pressure relief device will respond in the event of the pressure in the diverter switch compartment exceeds a predetermined value (explosive energy phenomena) and enable the transformer to be tripped. The device will include a metallic cover with a drain, in order to convey the oil safely to the ground. The device shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector.

The Pressure relief device shall be made by Qualitrol and with the following contact characteristics:

- Two (2) N.O contacts suitable for 110V DC.
  One for tripping purposes and one for alarm.

13. Motor Drive Unit (Driving Mechanism)

a. Control : Local/Remote.

For this reason the motor drive unit panel shall be equipped with a three (3) position selector switch “Off– Local– Remote”. The motor drive and control panel shall also be equipped with two (2) push buttons used in conjunction with the “Local” position of the selector switch, for raising and lowering the voltage step of the OLTC.

b. Emergency control : Emergency control is required and for this reason the motor drive control panel shall be equipped with an emergency push – button for emergency stopping of the motor drive.

c. Supply Voltage for the control circuits of the motor drive unit: 230V A.C

d. Supply voltage and frequency of the motor : 3ph, 400V AC, 50Hz with tolerances of 85% to 110%.

e. Installation : Outside of the transformer tank and connected to the OLTC by drive shafts and gears.

f. Motor drive and control cabinet: The motor drive and control cabinet ofthe motor drive unit shall be of IP55 protection as per IEC 60529.

g. Motor drive and control cabinet equipment : The motor drive and control cabinet besides the “Off – Local – Remote” selector switch, the two(2) push–buttons for raise, lowering and the emergency stop push button shall contain the following:

1. A tap indicator, indicating tap position
2. Anti – condensation heaters controlled by thermostat.
3. A counter indicating the number of tap – changers accomplished.

h. Manual operation : Operation of the tap – changer manually by a hand lever blocking at the same time operation by the electric motor.

i. Remote control and indication: The motor drive unit shall be capable of being operated from the substation’s automation control system located at the control building of the substation (raise – lowering and emergency stop). Also tap position number of operations and any alarms originated from the motor drive, will have to be displayed in the HMI center of the substation’s automation control system.

j. Power frequency withstand voltage : 2KV, 1 minute between all live parts of auxiliary circuits and the frame.

14. Warranty

The offered OLTC shall be MR of Germany or ABB of Sweden or HYUNDAI make, and a warranty period of three (3) years from the received date must be given which shall cover any OLTC damages or damages to the transformer due to OLTC malfunctioning.

15. Nameplates

A. OLTC

The nameplate of the OLTC shall be included in the nameplate of the transformer and shall contain the following:

1. Schematic diagram of the OLTC.
2. Tap positions and corresponding voltage.
3. Tapping arrangement.
4. Maximum rated through current for each tap position.
5. Rated voltage.
6. Rated lightning impulse withstand voltage.
7. Maximum number of operations under load.

B. Motor Drive

The motor drive control cabinet shall bear a nameplate of non – corrosive material and it shall contain at least the following:

1. Manufacturer's name
2. Type and serial number
3. Supply voltage
4. Frequency
5. Power of motor
6. Runtime per tap operation

16. TESTS

The transformer manufacturer is obliged to present to the IPTO inspector OLTC's test reports while the inspector is at the manufacturer's premises for the transformer inspection and testing.

The test reports which are to be presented shall include the following type and routine tests.

A. Type tests

a. Temperature rise of contacts
b. Switching tests
c. Short – circuit test
d. Transition resistor test
e. Mechanical tests
f. Dielectric tests

B. Routine Tests

a. Pressure and vacuum tests
b. Additional routine tests shall be carried out by the manufacturer of the transformer and they are indicated in paragraph X-1.11.

IX. BASIC EQUIPMENT OF TRANSFORMERS ACCESSORIES AND PARTICULARS

1. Transformer tank

a. The transformer tank will be of BELL type or cover bolted type.
b. The bell type tank will be connected with the transformer base by bolted flange.
c. The transformer tank will be constructed to withstand a 20 Torr at least vacuum when it is without oil.
d. For lifting purposes, the transformer tank must be provided with suitable lugs. Also the transformer shall have pulling eyes or other arrangement for attaching pulling rig for moving the transformer.
   Furthermore the transformer shall have jack bosses for handling the entire weight of the transformer.
e. Manholes should be provided on the tank cover and walls dimensioned no less than 50x50cm^2. At least, two manholes should be required on the tank cover for the access inside the transformer tank.
f. Grounding pads shall be provided near the bottom of the transformer tank. The tank will be grounded in two points at least diagonally. The transformer tank should be designed so that the losses caused by circulating eddy – currents to be minimized and also the creation of onerous temperatures at the tank surface to be avoided.
g. The magnetic core of the transformer will be earthed at only one point. The core earthing will be realised through an insulated conductor, connecting the core to an earthing box, placed externally on the transformer tank. By this way the core earthing could be tested without opening the transformer tank.
h. The cover of the transformer tank should be designed in such way so the stagnation of the water to be avoided

2. Conservator tank

The transformer must be equipped with a conservator tank to accommodate the changes in oil volume caused by the changes of the ambient temperature or the transformer load.

The conservator tank will be composed of one piece ready for installation. Is also accepted one conservator tank with two (2) rooms one for the tank and one for the OLTC.

The design must be of such a type as the direct contact between air and oil to be avoided. To avoid moisture entering in the oil of the conservator tank during the oil volume fluctuations, the tank will be fitted with a breather per separate room, which shall contain an absorbent material (silicagel crystals) and a drainage tank. The breathers shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector. Also for that reason, a dry air cushion will float on the oil surface and will increase or decrease as the oil volume changes. The dry air cushion will be in contact with the breather so that it is always at atmospheric pressure and the incoming air is always dry.

The silicagel crystals must be active in order to be able to absorb moisture and this property will be checked by periodical optical inspections of the silicagel crystals color. Except for the oil level indicator a drain valve will be mounted on the tank and there will be one Buchholz relay with isolating valves on the tube connecting the conservator tank with the transformer body as it is described in detail in paragraph IX-7.1 of this hereby specification.

3. Radiators

The radiators shall be designed and tested following EN 50216-1 and EN 50216-6 standards. The test certificates shall be presented to IPTO inspector. Radiators shall be detachable and tank connections shall be provided with valves, so that radiators may be removed without draining oil from tank. Each radiator shall be provided with lifting eyes and drain valves or plugs. A lifting plug shall be provided at the highest point of the upper radiator header.

The radiators shall be attached and supported only by the body of the transformer. The radiators support will be realized by mechanical means, separate from the connecting oil pipes to the tank.

4. Bushings

The design of bushings will be in accordance with the IEC 60137 Standard.

The bushings of each transformer winding will be of outdoor – immersed capacitance graded oil insulated type with one end exposed in ambient air and the other end immersed in the transformer oil.

The active part of the bushing will consist of an Oil Impregnated Paper (O.I.P.) condenser type core, impregnated with the transformer oil.

The insulation housing of HV, LV and neutral bushings will be of high grade porcelain or of resin impregnated fibre tube and silicon rubber covering.

The porcelain housing will comply in all relevant respects with IEC 62155 .

The composite housing will comply in all relevant respects with IEC 61462.

The space between the active part (core) and the insulating envelope will be oil filled (liquid-insulated bushings).

The bushings of transformer are required to be of the following rating characteristics:

		H.V.	**L.V.**	**Neutral**
1	Highest rated Voltage (phase to phase) (Um) (KV-r.m.s.)	170	24	24
2	Rated phase to earth operating voltage (KV-r.m.s.)	98	$24/\sqrt{3}$	$24/\sqrt{3}$
3	Rated current (Ir*)(A)	800	1600	1600
4	Rated thermal short time current, 1 sec (Ith)	25Ir	25Ir	25Ir
5	Rated dynamic current (Id)	2.5Ith	2.5Ith	2.5Ith
6	Cantilever operating load (N)	2000	625	625
7	Creepage distance (mm)	4250	600	600
8	Angle of mounting	$\leq 30^{o}$/vertical	$\leq 30^{o}$/vertical	$\leq 30^{o}$/vertical

		H.V.	L.V.	Neutral
9	Temperature limits – class of the insulating material in contact with metal parts	105^{o}C Class A	105^{o}C Class A	105^{o}C Class A
10	Dielectric dissipation factor (tanδ) at 1,05Um/√3 voltage	≤0.007	-	-
11	Maximum value of partial discharge quantity at Um operating voltage	≤10pC	-	-
12	Lightning impulse withstand voltage (KV)	750	145	145
13	Power frequency withstand voltage (KV)	325	50	50

4.1 Additional characteristics of bushings

a. Seismic withstand capabilities.
All bushings shall be capable of withstand the following seismic stresses as per IEC-61463 and IEC-60068-3-3.
1. Horizontally (axes x and y) :0.5g (5m/s^2)
2. Vertically (axe Z) :0.25g (2,5m/s^2)
3. The frequency range should be 1Hz to 35Hz.
4. Acceptable methods of seismic qualification are:
   - Qualification by vibration test or
   - Qualification by static calculation or
   - Qualification by dynamic analysis

   Bidders are obliged to submit in their offers, test reports or calculation by dynamic analysis, or static calculation.
   Approval or not of all the above lies on IPTO's judgment.

b. Bushings shall be designed for operation at ambient temperature from -25^{o}C to +45 ^{o}C and an altitude not exceeding 1000m.

c. The maximum oil temperature under operating emergency conditions will be 115 ^{o}C.

d. The HV bushings shall have a tin plated copper terminal of cylindrical shape with diameter of 30mm and length of about 100mm. The LV bushings shall have a tin plated copper terminal of rectangular shape with dimensions of about 100mm x 100mm x 15mm.

e. If the HV bushings are of a drawn lead or drawn rod type, the cross-section of the lead or rod will be selected according to the instructions of the bushing manufacturer, in order the complete bushings to have a continuous current rating of at least 125% of the rated HV winding current at the tap No.17.

f. (*) If after taking into consideration the above stated operating characteristics, the above indicated bushings rating current is less

than what it should, then offerers must offer bushings with suitable rating.

4.2 Accessories:

Bushings will be equipped with the accessories below:

a. Oil level indicator.
b. Test tap (tanδ tap) suitable for measurement of the dielectric dissipation factor, capacitance and partial discharge value of the bushing. The test tap will be electrically isolated from the mounting flange and will be always earthed directly when it is not used.
c. Air release plug.
d. Oil expansion compensator.
e. Oil sampling and oil filling plugs.
f. Lifting lugs if required by the manufacturer and there are no other means of
lifting the bushings.

4.3 Rating plates – markings

The H.V bushings shall carry a rating plate including the following markings.
Markings for L.V. and neutral bushings that indicated below with ■ are adequate:

- ■ Manufacture's name.
- ■ Year of manufacture and serial number
- ■ Maximum operating phase – phase voltage (Um) or rated operating phase to earth voltage and rated frequency.
- ■ Operating rated current (Ir)
- ■ Insulation levels BIL, P.F.
- ■ Bushings capacitance, dielectric dissipation factor.
- ■ Mass
- ■ Angle of mounting

4.4 Tests

The transformer manufacturer is obliged to present to the IPTO inspector bushings test reports while the inspector is at the manufacturer's premises for the transformer inspection and testing.
The test reports which are to be presented shall include the following type, routine and special tests:
The tests will be in accordance with IEC – 60137 Standard

A. Type tests

1. Power – frequency voltage withstand test
2. Lightning impulse voltage withstand test
3. Electromagnetic compatibility test

4. Thermal stability test
5. Temperature rise test
6. Verification of thermal short – time current withstand
7. Cantilever load withstand test
8. Tightness test
9. Verification of dimensions.

B. Routine tests

1. Measurement of dielectric dissipation factor (tanδ) and capacitance at ambient temperature
2. Lightning impulse voltage withstand test
3. Power – frequency voltage withstand test
4. Measurement of partial discharge quantity
5. Test of tap insulation
6. Tightness test
7. Visual inspection and dimensional check

C. Special tests

1. Seismic test (IEC – 61463)
2. Artificial pollution test (IEC – 60507)

The bushings of 150kV shall be manufactured from ALSTOM of Italy or TRENCH of France or ABB of Sweden.
The bushings of 20kV shall be manufactured from ALSTOM of Italy or TRENCH of Trance or ABB of Sweden or COMEM.

4.5 Bushing current transformers

The bushings will be equipped with bushing current transformers as follows:

Terminals	Number	Ratio	Accuracy & Burden
H1,H2,H3	1	200/1	5P20 25VA For transformer differential protection
H1,H2,H3	1	1000-500/1	5P20 50VA For bus bar differential protection

Terminals	Number	Ratio	Accuracy & Burden
X1, X3	1	---	As required for thermal replica relays supply
X2	1	---	As required for the automatic load ratio control

Complete test protocols for the above bushing current transformers shall be available at the time of inspection of the transformers.
Also the secondary windings of CT's of bushings will be tested with the applying a power frequency voltage of 3KV to earth.

5. Transformer oil

The transformer insulating oil will be mineral suitable for transformers and in accordance with the latest edition of IEC–60296 Standard. It shall be non-toxic and biodegradable without PCB's or PCTs etc.

6. Cooling system with fans

The transformer shall be equipped with fans for the forced circulation of the air (ONAF) at 50MVA.
The fans, shall be mounted under radiators or on the side of them. The fans shall be designed and tested following EN 50216-1 and EN 50216-12 standards. The test certificates shall be presented to IPTO inspector.
For the selection of "automatic or manual" operation of the fans, a selector switch will be available to permit the automatic or manual operation.
All the fan motors will be of the squirrel – cage type, three phase 400V AC, of the enclosed design.
All necessary automatic operation equipment for the fans operation must be assembled in a metal cabinet with IP55 protection class located on to the transformer. The control voltage will be 230V AC. The signaling will be realized by voltage-free contacts. The grounding (earthing) of the air fans motors will be done locally and not through the transformer control panel.

7. Instruments – Relays and transformer protection devices

7.1. Buchholz relay

An earthquake proof Buchholz relay of EMB make must be provided and be mounted in the pipe connecting the conservator to the transformer tank. Also a by-pass pipe of the relay will be installed, in order to facilitate the exchange of the relay with the transformer in operation. The relay shall be designed and tested following EN 50216-1 and EN 50216-2 standards. The

test certificates shall be presented to IPTO inspector. Isolating valves will be installed before and after the relay. This relay will be of the double float type with two sets of signaling contacts one for alarm and one for trip.
The relay is full of oil under normal conditions and due to the buoyancy its two float elements will be at the upper level. When a slight or incipient fault occurs inside the transformer, (e.g. local overheating, a small quantity of oil leakage etc), bubbles of gas will be created and trapped in the relay housing, causing its oil level to fall and simultaneously the above situated element to move, resulting in the closing of the alarm contacts.
In case that a serious fault occurs in the transformer (e.g. a leakage of large quantity of oil, short circuits, puncture of bushings), the gas generation will be violent causing a surge of oil inside the relay which will result in the movement of the second float element and the closing of the trip contacts.
The above mentioned contacts will be suitable for 110V D.C. voltage.
The trapped gas in the Buchholz relay will be possible to be reclaimed through a gas collection device, which will be installed on the transformer at a person's height and will be connected permanently with the relay through a hose.

7.2. Oil Temperature Indicator

Each transformer will be provided with an oil temperature indicator measuring the transformer oil temperature at its hottest part. The indicator shall be designed and tested following EN 50216-1 and EN 50216-11 standards. The test certificates shall be presented to IPTO inspector.
The thermometer bulb is enclosed in a pocket fixed on the tank at the hottest oil region. The connection between the thermometer bulb and dial indicator is made by a flexible steel capillary tube.
The measurement will be taken via a driving motion operated by the expansion of the fluid inside the bulb and afterwards through the capillary tube will be transferred to the dial pointer.
Moreover, for the transformer oil temperature indicator a telemetering function will be provided for the teletransmission of the measurement from the transformer to the substation's automation control system, by mounting inside the instrument a teletransmitter with transducer of analogue output current 4-20mA.
Two (2) changeover or N.O. contacts are required to be available, one (1) for alarm and one (1) for trip, suitable for 110V D.C. voltage.
The oil temperature indicator should be of AKM, Swedish make.

7.3. Winding Temperature Indicator

The transformer winding temperature indicator will be functionally similar with the Oil Temperature Indicator having in addition only the heating element which is a "thermal replica" of the transformer winding. This element will be connected to a Current Transformer via a matching resistance unit suitably calibrated to measure the current through the transformer winding. In this way, the thermal load and consequently the temperature of the winding will be measured indirectly. The indicator shall be designed and tested following EN 50216-1 and EN 50216-11 standards. The test certificates shall be presented to IPTO inspector.

For the teletransmission of the winding temperature indication from the transformer to the substation's automation control system, the instrument will include a teletransmitter which can be connected with a transducer of analogue output current 4-20mA.
Referring to the electrical contacts, two (2) changeover or N.O. contacts are required at least, one (1) for alarm and one (1) for trip. In addition, for the automatic energization of the transformer fans one (1) changeover or N.O. contact is required.
All contacts will be suitable for 110V D.C. voltage.
The winding temperature indicator should be of AKM, Swedish make.

7.4 Shutter - Valve.

The transformer will be equipped with a shutter-valve.
The shutter-valve will be mounted in the pipe between conservator and Buchholz relay, checking the flow of the oil from the conservator to transformer tank.
One normally open (NO) contact is required, suitable for 110V D.C. (~ 0.5 A).

7.5. Oil level indicator.

The transformer will be provided with magnetic oil level indicator. The indicator shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector. The indicator will be mounted on the outdoor surface of the conservator having a float located inside the conservator oil. The oil level will order the float movement which by a drive shaft will cause the movement of a pointer in the dial.
One (1) normally open contact will be provided for annunciating a low oil level alarm, suitable for 110 V D.C. (~ 0.5A) voltage.

8. Pressure relief device

Each transformer will be equipped with one at least pressure relief device QUALITROL make, type XPRD. The device will be mounted horizontally or vertically on the transformer tank and will operate by a spring mechanism automatically. The mechanism will hold pressed a stainless steel diaphragm, with one side of which to be exposed to transformer tank pressure. In case of internal over-pressures caused by internal failures, the diaphragm will open and regain its position as soon as the pressure in the tank drops below a set limit. There will also be capability for manual check of the device operation. The device will include a metallic cover with a drain, in order to convey the oil safely to the ground. The device shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector. For the annunciation of its operation, the pressure relief device will be provided with two (2) N.O. alarm contacts suitable for 110V D.C. voltage.

9. Valves

Each transformer will be equipped with the necessary quantity of valves e.g. for draining the tank, sampling oil, isolating each radiator. Two oil filling valves diagonally situated shall be provided on the transformer cover. Oil filtering valve and vacuum connection valve shall be provided too. The radiator valves shall be designed and tested following EN 50216-1 and EN 50216-8 standards. The test certificates shall be presented to IPTO inspector.

10. Gaskets

Gasketed joints for bushings, manholes and radiators shall be designed so that the gasket will not be exposed to the weather and shall be provided with mechanical stops to prevent crushing of gasket.

11. Connecting material

All connecting material that is bolts, nuts and lock washers must be hot-dip galvanized.

12. Wiring – conductors

All windings conductors, joints and other connections shall be made of electrolytic copper.
All small wire connections from alarm contacts, temperature indicating coils, current transformers, control and other devices, shall be brought to terminal blocks in the fans control cabinet from which control cables to the control room are be connected .
All wiring shall be color coded, moisture resistant wire in galvanized steel conduit.
All terminals shall be suitably identified. Fans control cabinet shall be provided with heat resistance controlled by suitable thermostat.
All L.V. circuits shall be tested with 2kV RMS voltage for 1 min.

13. Spill Gaps

Each transformer will be equipped with spill gaps which must be adjusted as below:

On Terminals	Spill gap adjustment (inches)		
	From	To	Factory Setting
H1, H2, H3	25”	40”	26”
X1, X2, X3	3”	6”	4.5”

14. Auxiliary power supply

Available aux. A.C. power supply: three phase voltage 220/400V 50Hz.
Available aux. D.C. power supply: 110V

15. Painting requirements for the transformer

The transformer including coolers shall be painted with Gray color RAL 7040 of thickness 120μm ±20μm.

16. Transportation requirements

The transformers, for transportation purposes, shall be filled with insulating oil and Nitrogen (N_2).

X. TESTS

The tests will be carried out in accordance with the IEC 60076-1, 2 & 3 Standards. Any limitations regarding testing procedures (e.g test voltage, lightning impulse waveform, etc) should be declared from the relevant bidder.

1. Routine tests

It is desirable that the accumulative uncertainty in no-load and load losses measurement is calculated by the manufacturer, following IEC 60076-19 or EN 50462, prior to the execution of the relevant measurements (par. 1.1, 1.3, 1.4)

1.1 Measurement of winding resistance

The measurement will be performed by the supply of a direct current for each transformer winding per phase. The winding resistance will be measured after the transformer has been without excitation for at least 3hours, so as the average oil temperature and the temperature of the windings to be equal. The average oil temperature is considered as the mean of the top and bottom oil temperature.

1.2 Check of voltage ratio and windings connection (Vector group)

During the test performance, the voltage ratio will be measured on each OLTC tapping and the vector group of the transformer will be checked.

1.3 Measurement of short circuit impedance and load losses

The measurement will be performed at rated frequency with sinusoidal voltage applied to the measured winding, with the terminals of the second winding short – circuited. The short – circuit impedance shall be not less than 15.2% at 40.000KVA and 19% at 50.000KVA at any tap of the on-load tap changer (OLTC). The supplied current through the measured winding will not be less than 50% of the relevant rated current (tapping current). For the load losses calculation the measured values will be corrected to the temperature of 75 ^{o}C, according to the IEC – 60076-1 Standard.

1.4 Measurement of no-load losses and current

The test will be carried out before the dielectric tests and temperature rise test. The measurement will be performed on the H.V. or L.V. windings at rated voltage and rated frequency for the principal tapping. The remaining winding will be open – circuited. For the test voltage adjusting, two (2) voltmeters connected in parallel will be used. The one voltmeter will measure the rms value of the voltage (V) and the other one will measure the mean value of the voltage (V´).
The test voltage wave shape is satisfactory if the readings V´ and V are equal within 3%. For the no-load losses calculation, the measured value of power losses Pm will be corrected according to the following formula:

$$P_o = P_m \cdot \left(1 + \frac{V' - V}{V'}\right)$$

The rms value of no-load current is measured at the same time with the losses while the mean value of readings in the three phases is taken into account.
The no-load losses test shall be repeated after the dielectric tests and these losses shall be the true no-load losses of the transformer.

1.5 Measurement of capacitance and dissipation factor

The measurement shall be carried out for the following connections:
a. HV-(LV+tank) earthed
b. HV-LV with tank only earthed
c. LV-(HV+tank) earthed
The test voltage shall be 10kV.
Tanδ ≤ 0.5%

1.6 Measurement of the insulation resistance

The measurements shall be carried out for the following connections and for two time periods (60 seconds and 15 seconds, DAR value measurement).
a. HV-(LV+earth)
b. LV-(HV+earth)
c. (HV+LV)-earth
d. HV-LV

The test voltage shall be 2,5kV.

1.7 Sealing test for the transformer tank

The tank with the live part of transformer installed in it and filled with appropriate amount of oil shall be tested by injecting nitrogen at a pressure specified by the manufacturer. Test duration =24hours.

1.8 Transformer oil tests

a. Dielectric test (breakdown voltage ≥ 220KV/cm).
b. Tanδ

1.9 Dielectric tests

1.9.1 Separate source AC withstand voltage test (50Hz, 1min.)

The test will be made by the application of a single – phase A.C. voltage as nearly as possible on sine-wave form and not less than 40Hz. The applied voltage will be reduced to one – third of the test value at the beginning and at the end of the test.
The full test voltage will be applied for 1 min. between the terminals of the under test windings.
For the L.V. winding test, the applied voltage will be 50KV. The H.V. windings and the transformer tank will be short – circuited and earthed.
For the H.V. winding test, the applied voltage will be 325KV. The L.V. windings the neutral winding and the transformer tank will be short – circuited and earthed.

1.9.2 Lightning Impulse test

The impulse test will be performed for each terminal of the HV and LV winding and also for the neutral winding, with the following test sequence:

HV winding
1. Application of one (1) reduced full–wave impulse voltage 50%-75% of the
full-wave (375KV-562.5KV), 1.2/50 μS in shape.
2. Application of three (3) subsequent full-waves impulse voltages 750KV
1.2/50μS in shape.

LV and Neutral winding
1. Application of one (1) reduced full–wave impulse voltage 50%-75% of the
full-wave (72.5KV-108.75KV), 1.2/50 μS in shape.
2. Application of three (3) subsequent full-waves impulse voltages 145KV
1.2/50μS in shape.

For the impulse test on the neutral winding, the duration of the tested impulse front time is allowed to be up to 13 μS.

1.9.3 Short – duration induced AC voltage test (ACSD)

1. For the short duration induced AC voltage test the 3-phase connection shall be used and the voltage shall be applied to all three L.V phases of the transformer with the On Load Tap Changer being on the 1 position (161.250/21kV).
2. The neutral terminal shall be earthed.
3. The H.V terminals shall be open-circuited.
4. The induced voltage will be produced by the application, a phase – to – phase sinusoidal voltage of frequency up to 100Hz. If the frequency of the test voltage is greater than 100Hz, the test time (sec) for the induced voltage will be given by the formula : 120*(fr/ft), where fr: rated frequency, ft : test frequency, but not less than 15 sec.

5. The time sequence for the application of test voltage for the induced AC short–duration test shall be as follows:
   a. Switched on at a level not higher than one – third of 75KV.
   b. Raised to 1.1 * U_m (187KV) and held there for duration of 5 min.
   c. Raised to 225KV and held there for duration of 5 min.
   d. Raised to 325KV held there for test time (paragraph 4).
   e. Immediately after the test time, reduced without interruption to 225KV and held there for a duration of at least 5 min to measure partial discharges.
   f. Reduced to 1.1 * U_m (187KV) and held there for a duration of 5min.
   g. Reduced to a value below one – third of 75KV before switching off.

Where Um = 170KV

During the whole application of the test voltage, partial discharges shall be monitored.
The test is successful if:
No collapse of the test voltage occurs.
The continuous level of apparent charge at 225KV during the second 5 min does not exceed 300pC.
- The partial discharge behavior shows no continuously rising tendency.
- The continuous level of apparent charges does not exceed 100pC at 1. 1 * U_m (187KV).

As long as no breakdown occurs, and unless very high partial discharges are sustained for a long time, the test is regarded as non – destructive. A failure to meet the partial discharge acceptance criteria shall therefore not warrant immediate rejection, but lead to consultation between purchaser and supplier about further investigations. Suggestions for such procedures are given in annex A of IEC-60076-3 standard.

1.10 Operation test On – Load Tap Changer

With the tap–changer fully assembled on the transformer, the following operations shall be performed:

a. With the transformer un–energized, eight complete cycles of operation (a complete cycle of operation goes from one end of the tapping range to the other and back again).
b. With the transformer un–energized and with auxiliary voltage reduced to 85% of its rated value, one complete cycle of operation.
c. With the transformer energized at rated voltage and frequency at no load, one complete cycle of operation.
d. With one winding short-circuited and rated current in the tapped winding, 10 tap–change operations across the range of two steps on each side from the middle tapping.

After the tap-changer is fully assembled on the transformer, a power frequency test will be performed to the auxiliary circuits.

2. Type tests

2.1. Temperature rise test

The test will be carried out in accordance with the IEC-60076-2 Standard. Two oil temperature pockets shall be available on the transformer cover. Additionally, one oil temperature pocket shall be available at the oil input and one at the oil output of the radiators.

The purpose of the test is to establish:

a. The top oil temperature rise in steady – state condition with dissipation of total losses (load-losses and no-load losses).
b. The average winding temperature rise at rated current and with the top oil temperature rise in conditions as mentioned in the above paragraph.

For this reason the test will be performed in two steps:

1. Application of a test voltage such that the measured active power is equal to the total losses of the transformer. The test current will be above rated current to the extent necessary to cover the no-load losses. The test for this step may be terminated when the rate of change of top oil temperature rise has fallen bellow 1 ^{0}C per hour and has remained there for a period of three (3) hours.
2. When the top oil temperature rise has been established, the test will immediately continue with the test current reduced to rated current of the tested winding. At the end of the hour, the resistance of the winding is measured after a rapid disconnection of the supply and is calculated by a graphical method (extrapolation).

The temperature rise test will be carried out before the dielectric routine tests.

3. Special tests

The special tests shall be carried out on one (1) only piece of the order.

3.1 Long-duration A.C. Voltage test (ACLD)

1. For the long duration induced A.C. Voltage test the 3-phase connection shall be used and the voltage shall be applied to all three L.V. phases of the transformer.
2. The neutral terminal shall be earthed.
3. The H.V. terminals shall be open-circuited.
4. The induced Voltage will be produced by the application a phase-to-phase sinusoidal Voltage of frequency up to 100Hz if the frequency of the test voltage is greater than 100Hz the test time (sec) for the induced Voltage will be given by the formula:

$$t = 120 \cdot \frac{rated \quad frequency}{test \quad frequency}$$

but no les than 15 sec.

5. The time sequence for the application of test voltage for the induced A.C. long duration test shall be as follows:
   a. Switched on at a level not higher than one-third of 85KV.
   b. Raised to 1. 1 * U_m (187KV) and held there for duration of 5 min.
   c. Raised to 255KV and held there for duration of 5 min.
   d. Raised to 289KV and held there for test time (paragraph 4).
   e. Immediately after, reduced without interruption to 255KV and held there for duration of at least 30 min to measure partial discharges.
   f. Reduced to 1.1 * U_m (187KV) and held there for duration of 5 min.
   g. Reduced to a value below one-third of 85 before switching off.

   Where U_m = 170KV.

   During the whole application of the test voltage, partial discharges shall be monitored.

   The test is successful if:
   - No collapse of the test voltage occurs
   - The continuous level of apparent charge at 255KV during the 30 min does not exceed 500pC.
   - The partial discharge behavior does not show a continuing rising tendency.
   - The continuous level of apparent charges does not exceed 100pC at 1.1 * U_m (187KV).

   As long as no breakdown and unless very high partial discharges are sustained for a long time, the test is regarded as non-destructive. A failure to meet the partial discharge acceptance criteria shall therefore not warrant immediate rejection, but lead to consultation between purchaser and supplier about further investigations. Suggestions for such procedures are given in annex A of IEC-60076-3 Standard.

3.2 Test with lightning impulse chopped on the tail (LIC)

The test will be carried out by the use of the same test equipment as of the lightning withstand impulse test with only the chopping gap to be added. During the full-wave impulse test and for each winding, application of chopped

impulses with a peak value 10% greater than the amplitude of corresponding full impulse should be inserted, forming the test sequence as follows:

1. Application of one (1) reduced full wave impulse voltage 1.2/50μS in shape and 50%÷70% of the full wave
2. Application of one (1) full wave impulse voltage 1.2/50 μS in shape
3. Application of one or more reduced full waves chopped impulses 1.2/50 μS in shape
4. Application of two (2) full waves chopped impulses 1.2/50 μS in shape
5. Application of two full waves impulses 1.2/50 μS in shape

The chopping time of the chopped lightning impulse will be between 2 μS and 6 μS.

3.3 Measurement of zero-sequence impedance

The test will be performed at the rated frequency and between the L.V. terminals of the star-connected windings and the neutral terminal. The zero-sequence impedance expressed in ohms per phase and is given by 3 V/I, where V is the test voltage and I is the test current (test current per phase I/3).

3.4 Determination of noise level

The test will confirm the allowable limit of the transformer audible noise level at first without the fans in operation and after with the fans, that is 72db(A).

3.5 Measurements of the harmonics of the no-load current

The measurement of the harmonics of the no-load current will be performed for the three (3) phases of the transformer and the magnitude of the harmonics will be stated as a percentage of the fundamental component.

3.6 Measurement of the power taken by the fans

The measurement will be carried out so that the power requirements of the transformer cooling system is verified and taken into account in the total losses guaranteed by the Bidder.
This measurement shall be carried out at the same time with the temperature rise test.
Any possible excess of the guaranteed losses will burden (affect) not only the transformer under test but all pieces of the order.

4. Frequency response measurement

A frequency response measurement will be executed on each transformer after all routine and special tests and prior to shipment, following IEC 60076-18. The SFRA device used for the measurement will be provided and owned by IPTO.

XI. SPARE PARTS

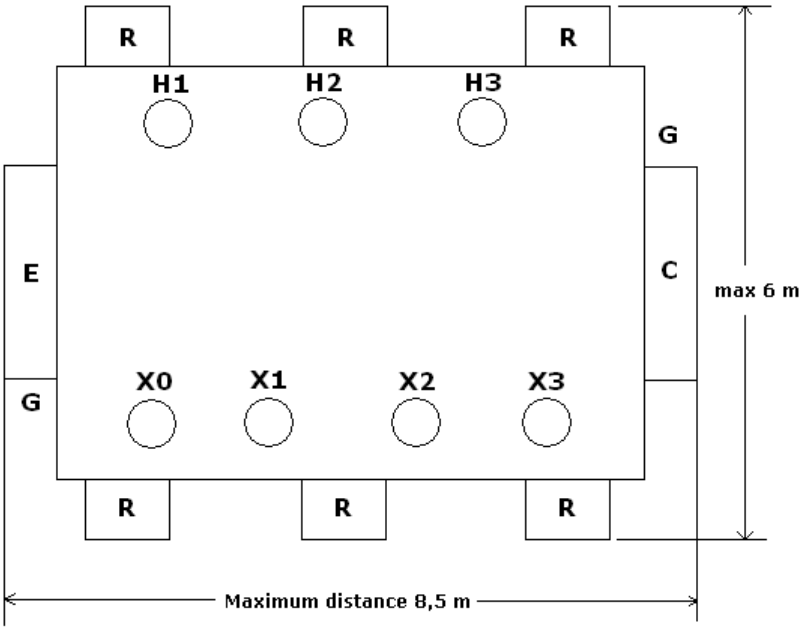
Bidders should quote the following spare parts for each transformer, giving item prices.

Item No	Description
1	One H.V. bushing complete
2	One L.V. bushing complete
3	Complete set of gaskets for all bushings, covers, radiator flanges manholes and handholes for one transformer.
4	Cooling fan and motor set
5	Set of replacement parts for each type of part likely to be damaged upon operation of the relays contactors instruments safety devices etc.
6	Two sets of replacement parts of the O.L.T.C. likely to be damaged during operation (complete set of contacts for the diverter switch).

The Purchaser reserves the right to determine when signing the contract, the spare parts which Seller shall furnish on the basis of the prices set forth in his proposal or not to purchase any spare parts at all.

XII. LOCATION SKETCH

The outline arrangement and overall dimensions of the transformer must be as indicated below.



The height of the transformer including the conservator tank shall not exceed

8 meters.

(H)	High Voltage bushings	(G)	Grounding Terminals
(X)	Low Voltage bushing	(R)	Radiators
(C)	Conservator	(E)	Fans control cabinet
(X0)	Neutral bushing		

XIII. TRANSFORMER MOVEMENT SYSTEM

Transformers shall be provided with wheels which will permit the movement of the completely filled with oil transformer either in longitudinal or transverse direction. The wheels will run on rails and be able to rotate 90^0.
The distance between rails shall be 1435mm.

XIV. DATA TO BE SUBMITTED BY BIDDERS

1. All bidders must provide all information requested in "ATTACHMENT A" of this hereby specification as well as any proposed deviation from the present specification and the reason therefore. Failure on bidder's part to comply with this request will be taken as sufficient reason for rejection of the offer.
2. All bidders must take note of attachments B and C of this hereby specification.
3. Technical pamphlets and brochures of the offered transformers, which will help the technical evaluation process.
4. Technical data for the OLTC and the transformer accessories and systems.
5. Drawings showing the outline dimensions of the transformers offered and any other information deemed necessary, including terminal markings.
6. Any type test certificates for the type and special tests specified in this hereby specification.

XV. DATA TO BE SUPPLIED BY THE SUCCESSFUL BIDDER

The Bidder shall furnish (3) three copies for approval and (5) five copies of final drawings at or before the time of shipment of the following:

a) Assembled transformer outline drawing
b) Transformers operation schematics and wiring diagrams
c) Bushings outline drawings
d) Nameplate and valve plate drawings
e) Terminals
f) Current transformers wiring diagram
g) Current transformers characteristic curves showing open circuit secondary saturation, ratio and phase angle correction.
h) O.L.T.C. control system operation diagram and wiring diagram.
i) Calculations for the thermal and dynamic ability of the transformers under short circuit, according to par.VII.7.
j) Instruction manual covering installation operation and maintenance

k) A final plan for the unloading, loading and transportation of the transformer.

l) Whatever of the above existing in software will be submitted in that form.

XVI. RATING PLATES

The transformer will be provided with a rating plate of a non-corrosive material, fitted in a visible location showing the items indicated below:

1. Relevant Standard – IEC – 60076
2. The manufacturer's name
3. Serial number
4. Year of manufacture
5. Number of phases
6. Rated power (MVA)
7. Rated frequency (Hz)
8. Rated voltages (V or KV) and tapping range.
9. Rated currents (A or KA)
10. Symbol of the windings connection
11. Short circuit impedance in (%)
12. Type of cooling.
13. Transformer total mass
14. Oil mass (Transformer insulation material)
15. Insulation levels
16. OLTC plate
17. Temperature rise of top oil and windings.
18. Type of transformer insulation oil
19. Diagram of the windings configuration
20. Transformer transportation mass.
21. Transformer untanking mass
22. Vacuum withstand capability of the tank and conservator.

The transformer will be also provided with a plate indicating the designation, position, scope of use and dimensions of all valves of the transformer tank and oil conservator. Each valve will include a small plate with its own designation.
In addition to the above mentioned plates with the above information, the transformer shall also carry nameplates with technical characteristics of auxiliary equipment, such as bushings, CTs, cooling system and OLTC according to the individual Standards.

XVII. ECONOMIC COMPARISON OF THE OFFERS

The economic comparison of the offers shall be based on the transformer initial cost as it will be amended after taking into consideration the terms of payment and any custom duties and the cost of the guaranteed losses, that is the

comparison will be carried out on the annual cost of the transformer as indicated in the attachment “B” of this specification.
For this reason, the paragraphs 1c, 1d and 1e of the attachment “B” only must be filled and the attachment must be submitted along with all others technical information in the technical offer, while the attachment ΄΄Β΄΄ must be submitted completely filled in the economic offer, as well.

XVIII. PACKING

The transformer accessories must be packed inside robust, entirely closed wooden boxes of at least 20mm thickness and maximum gross weight of five (5) tons.
The boxes will be of pallet type and they will be protected internally by an insulating material (e.g.nylon).
The above requirement does not include the bushings of the transformer which must be packed separately, one bushing per one wooden box.
The voltage regulator and its accessories will be supplied in a separate box, suitable for indoor storage.
For each shipment lot of transformers, at least one shock recorder will be provided and installed by the manufacturer on a transformer tank. For each contract, shock recorders will be installed on the 30% at least of the number of provided transformers.
The shock recorders will be of digital type and they will include GPS and time tagging of the recordings. They will be of type SMT HYBRID – MONILOG ENDAL or SHOCKWATCH – SHOCK LOG 298 or MESSKO – CARGOLOG or of an equivalent type, subject to IPTO’s approval.

SPECIFICATION No SS-25/20
40/50MVA, 150/15,75 - 21kV THREE-PHASE TRANSFORMERS

ATTACHMENT "A"

INFORMATION BY SELLER

1. Type of transformer (short description):
   Nominal voltage, number of phases, connections symbolism, rated power
   ……..
   ……
   ……..
   ……..

2. Core type :……
   a. Flux density at rated voltages (at no load and principal tap position) :……
   ……
   b. Number of core limbs :……

3. Insulation levels :……
   ……
   ……
   ……
   ……
   ……
   ……
   ……
   ……

4. Maximum permissible short circuit duration :……
   ……

5. Over-voltage capability
   a. at no load :……
   b. at 40.000 kVA :……

6. Transformer connection. :……

7. Insulation category of windings (uniform or non-uniform) :H.V……
   L.V..……

8. Temperature rise limits : ……...for windings
   : ...……..……...for oil

9. Thermal model constants
(calculated values following IEC 60076-7):

a. Top-oil to ambient temperature gradient at rated current - $\Delta\theta_{or}$: ……..
b. Hot-spot to top-oil temperature gradient at rated losses (no-load + load) - $\Delta\theta_{hr}$: ……..
c. Exponential power of total losses versus top-oil temperature rise (oil exponent) - x : ……..
d. Exponential power of current versus winding temperature rise (winding exponent) - y : ……..
e. Average oil time constant - τ_o : ……..
f. Winding time constant - τ_w : ……..
g. Constant k_{11} : ……..
h. Constant k_{21} : ……..
i. Constant k_{22} : ……..

10. Losses data
(The guaranteed losses shall be as indicated in paragraph VII-18):

10.1.

Voltage level	No load losses kW		Exciting current % Rating kVA (40,000)	
	15,75KV	21KV	15,75KV	21KV
α) at rated voltage				
β) at 110% of rated voltage				

10.2. Copper losses, total losses and impedance at principal tap 150/21 kV
(Fans losses not included)

Load (kVA)	Cu losses (kW)	Total losses (kW)	Impedance (%)
50,000	……	……	……
40,000	……	……	……
30,000	……	……	……
20,000	……	……	……

10.3. Copper losses, total losses and impedance at principal tap 150/15,75kV
(Fans losses not included)

Load (kVA)	Cu losses (kW)	Total losses (kW)	Impedance (%)
50,000	……	……	……
40,000	……	……	……
30,000	……	……	……

20,000	……	……	……

10.4. Losses in kW due to the fans at 50MVA :…… kW

10.5. Zero-sequence copper losses and impedance at principal tap 150/21 kV (estimated copper losses)

Load (kVA)	Cu losses (kW)	Impedance (%)
50,000	……	……
40,000	……	……

10.6. Zero-sequence copper losses and impedance at principal tap 150/15,75 kV (estimated copper losses)

Load (kVA)	Cu losses (kW)	Impedance (%)
50,000	……	……
40,000	……	……

11. Noise level (at rated power)
- Transformer without fans :……
- with the fans in operation :……

12. Harmonics of no-load current for principal tap (150/21kV) :
   a. Third harmonic :……% of no-load current
   b. Fifth harmonic :……% of no-load current
   c. Seventh harmonic :……% of no-load current

13. On - load tap changer (OLTC)
   a. Manufacturer and type of the OLTC : ……..
   b. List of all parts of the OLTC : ……..
      ……
      ……
      ……
   c. Type of the OLTC (oil or vacuum) : ……..
      ……
      ……
   d. Number of tapping positions : ……..
      ……
   e. Vacuum operating temperature (if applicable)
      Minimum : ……
      Maximum : ……...
   f. Oil operating temperature
      Minimum : ……
      Maximum : ……

g. Is the tap selector and the reversing change – over selector in their own not oil – tight compartment? : ……
……..
……..

h. Is the diverter switch and the transition resistors in their own oil – tight compartment (For oil type OLTC)? : ……
……

i. Is the diverter switch and the transition Resistors in their own vacuum-tight compartment (For the vacuum-oil type OLTC)? : ……

j. Is the OLTC equipped with its own conservator ? : ……..

k. Is the oil of OLTC free from PCBs or PCTs, suitable for transformers and in accordance with IEC – 60296? : ……

l. Is the conservator equipped with oil level indicator ? : ……
……

m. Is the diverter switch and transition resistors compartment equipped with a filling and a drain tap ? : ……
……..

n. Does the OLTC consist of three single – phase units ? : ……

o. Is the OLTC equipped with its own oil-flow relay? : ……
Describe where it is installed : ……
Type and manufacturer : ……

14. Tapping arrangement : ……
15. Position of tapping : ……
16. Maximum rated through current of OLTC : ……

17. Maximum rated step voltage of OLTC : ……

18. Rated frequency of OLTC : ……

19. Rated Voltage of OLTC : ……...

20. Supply voltage for the control circuits of the motor drive unit : ……...

21. Rated power frequency withstand voltage : ……

22. Rated lightning impulse withstand voltage 1.2/50μs in shape : ……...

23. Describe the pressure relief device and where it is installed : …….
……
-Type manufacturer : …….

24. Number of N.O output contacts of the pressure relief device : ……

25. Time response of the pressure relief device : ……

26. Pressure or vacuum values for the diverter switch compartment and transition resistors : ……

27. Is the motor drive unit suitable for Local/Remote operation? : …….
……..

28. Is the motor drive unit equipped with emergency stop? : …….

29. Indicate installation position of the motor drive unit : …….
……
……

30. Supply voltage of the motor drive unit motor : ……

31. Frequency of the motor of the motor drive unit : ……

32. IP class protection of the motor drive unit panel acc. IEC 60529 : ……

33. Is the motor drive control cabinet equipped with :

a. Local/Remote selector switch : ……..
b. Three (3) Push – buttons for raising, lowering and emergency stop : …….
c. A device indicating tap position : …….
d. Tap counter : …….
e. Anti - condensation heaters

controlled via thermostat : ……

f. Supply voltage of the anti – condensation heaters : ……

34. Can the motor drive unit be controlled remotely? : ……

35. Can tap position, number of operations and any alarms be displayed at a remote distance? : ……

36. Power frequency withstand voltage of the auxiliary circuits of the motor drive unit : ……

37. Warranty terms : ……
……...
……
……

38. Manufacturer and type of the voltage regulator : ……
……...
……

39. Cooling System (Fans)
1. Number of fans : ……
2. Power of the fan motor when starting: : ……
3. Power of the fan motor when running: : ……
4. Type of the fan motor : ……

40. Transformer tank
a. Type : ……
b. Material of the tank : ……
c. Is the transformer tank in accordance with the requirements of paragraphs IX-1-b, c, d, e, f and g? : ……

41. Transformer conservator tank
a. Type : ……
b. Is the conservator composed of one piece? : ……
c. Describe the method of protection against moisture: : ……
……

d. Does the conservator meet all requirements of paragraph IX-2? : ……

42. Pressure relief device for the transformer tank
- Type and manufacturer : ……

- Location of installation : ……
- Alarm contacts : ……

43. Shutter-Valve
    - Type : ……
    - Location of installation : ……
      ……..……..
    - Contact :……..……

44. Valves
    - Type : ……
    - Use : ……

45. Oil of the transformer :……
    a. Type and manufacturer :……
    b. Does the oil contain any PCBs or PCTs? :……
    c. Is the oil suitable for transformers and in all other respects in accordance with IEC 60296? :……

46. Bushings

	H.V	L.V.	Neutral
a. Type	.....	.....	……..
b. Manufacturer	.....	.....	……..
c. Max phase-phase operating voltage (rms)	.....	.....	……..
d. Rated phase to earth operating voltage (rms)	.....	.....	……..
e. Rated current (A)	.....	.....	……..
f. Rated thermal current (A)	.....	.....	……..
g. Rated dynamic current (A)	.....	.....	……..
h. Cantilever withstand load (N)	.....	.....	……..
i. Creepage distance	.....	.....	……..
j. Angle of mounting	.....	.....	……..
k. Thermal limits – class	.....	.....	……..
l. Dielectric dissipation factor	.....	.....	……..
m. Partial discharges at max operating phase-phase Voltage	.....	.....	……..
n. Insulation levels :	.....	.....	……..
o. Cross-section of drawn lead or rod :	.....		
p. Seismic withstand capability:		.....	
q. Indicate as to whether the bushings meet the requirements of paragraph IX-4.1 and 4.2		.....	

47. Bushings current transformers
    (Ratio, accuracy class, burden)

    - H.V. : ……
      ……
    - L.V. : ……
      ……

48. Are all cables which run on the transformer inside cable trays? : ……

49. Type of material of the winding conductors : ……
Cross section of the winding conductors : ……

50. Type and manufacturer of BUCHHOLZ : ……
- Location : ……
- Characteristics of alarm contacts : ……
- Characteristics of trip contacts : ……

51. Type and manufacturer of oil temperature indicator. : ……
- Characteristics of alarm contacts and trip contacts : ……
- Measurements teletransmission capability : ……

52. Type and manufacturer of winding temperature indicator. : ……
- Characteristics of alarm contacts and trip contacts : ……
- Measurements teletransmission capability (Yes or No) : ……

53. Type and manufacturer of oil level indicator. : ……
- Characteristics of the alarm contacts : ……

54. Full load regulation
a. at rated service and p.f.=1 : ……
b. at p.f.=0.85 : ……

55. Efficiency at 150/21 kV

	p.f.=1	p.f. = 0.85
at 50,000 kVA	…….	…….
at 40,000 kVA	…….	…….
at 20,000 kVA	…….	…….
at 10,000 kVA	…….	…….

56. Net weights and dimensions
- Transportation weight : ……..… kg
- Core and coils : ……..… kg
- Tank and fittings : ……..… kg
- Oil : ……..… kg
- Total weight : ……..… kg
- Untanking weight : ……..… kg
- Overall height (including bushings): ……m
- Height over tank : ……m
- Projected floor dimensions related to

line through H.V. bushings:
Parallel to : ……m
Right angles to : ……m

57. Tests (acceptance of the specified tests) (Yes or No) : ……

58. Describe with what the transformer tank will be filled for transport purposes : ……
..……

59. Type of material, manufacturer and country of origin of the transformer core material : ……
..……
..……

60. Limits of magnetizing current (in% of the rated current)
at 135KV : ……..%
at 150KV : ……..%
at 170KV : ……..%

61. Color of the transformer : ……

SPECIFICATION No SS-25 / 20
40/50MVA, 150/15,75 - 21kV THREE-PHASE TRANSFORMERS

ATTACHMENT "B" - INFORMATION BY SELLER

EVALUATION OF LOSSES

1. Transformer first cost and losses :

   a. Transformer rating (kVA) : 40,000 kVA

   b. Transformer first cost
   (The transformer total first cost will be computed by the Purchaser who will consider the Seller C+F price as amended after the evaluation of the proposed terms of payment) : k=……..… EURO

   c. No-load losses
   (at rated voltage 150/21kV) : A = ……..…kW

   d. Copper losses at 40,000kVA
   (at rated voltage 150/21kV) : B = ……kW

   e. Cooling requirement (fans) for 50,000kVA : C = ……kW

   f. Total losses : A+B+C = ..……kW

2. Transformer annual cost

   1. Transformer carrying charges (at 9.37 per cent) : $\frac{9{,}37K}{100}$ = …….EURO

   2. Capacity loss (referred to the H.V. side
   (118 EURO per kilowatt-year) : 118˙(A+B) = …….. EURO

   3. Energy loss (referred to the H.V. side)
   (0,0436 EURO per kWh)

      a) No-load losses for 8.760 hours : 0,0436˙A.8.760 = …….. EURO

      b) Copper losses
      (Load factor 50%,
      Loss factor 30%,
      Loss hours 2.630) : 0,0436˙B˙2.630=…… EURO

   4. Cooling power (referred to the L.V. side)

(112 EURO per kilowatt year)
required for 50,000kVA : 112 ˙ C= ……EURO

5. Cooling energy requirements (at 0,0372 EURO per kWh)
Loss hours 1.900 : 0,0372˙C ˙1.900= …….EURO

Total annual cost (Sum of 1, 2, 3, 4 and 5) = _____ EURO

SPECIFICATION No SS-25 / 20
40/50MVA, 150/15,75- 21kV THREE-PHASE TRANSFORMERS

ATTACHMENT "C"

INFORMATION BY SELLER

Penalty for excess losses:
With regard to load and no-load losses, a transformer is considered as successfully inspected if the losses ascertained during inspecting do not exceed the maximum tolerance, specified in the IEC standards versus the losses guaranteed by Seller. Otherwise the transformer is rejected. On each successfully inspected transformer, any difference in the losses versus the guaranteed ones (without tolerance), shall be negative or zero. If such difference is positive, i.c. the losses ascertained during inspection exceed the guaranteed ones (without tolerance), a penalty shall be imposed on Seller consisting of:

5335,5 EURO - per kW of no-load losses in excess

2483,12 EURO - per kW of load losses in excess

The corresponding amount for excess load losses shall be balanced by the corresponding amount for reduced, if any no load losses and vice-versa.

However, if this algebraic sum is negative the Seller is not entitled to any additional payment, whilst if this sum is positive the penalty shall be imposed.

Furthermore, if the cooling power ascertained during inspection exceeds the offered one, a penalty shall be imposed on Seller consisting of:

1949,626 EURO - per kW of cooling power in excess

However, if the actual cooling power is found to be less than the offered one, Seller is not entitled to any benefit.