

April 2021

TECHNICAL DESCRIPTION ND-387/2

THREE-PHASE POWER TRANSFORMERS, 150 / 21kV, 40/50MVA AND 20/25 MVA, Dyn1

I. SCOPE

The scope of the present description is to describe HEDNO's requirements regarding, technical characteristics, design features and testing of three – phase 150/21kV power transformers, rated at 40/50MVA and 20/25 MVA.

II. KEY WORDS

Power Transformers, on load tap changer, transformer components, transformer protection devices, transformer tests

III. USE

The transformers are installed in substations for the transformation of the 150kV network voltage to 21kV level, covering the load requirements of the 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	: 31kA
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	: ± 0.2 Hz
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. 21kV NETWORK

1. Nominal Voltage	: 21kV
2. Maximum Operating Voltage	: 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	: 3 – phase, 4 – conductors, 230/400 V

V. OPERATING AMBIENT CONDITIONS

Installation	: Outdoor
Limits of ambient temperature	: -25 °C to + 45 °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, as well as to no. 548/28.05.2014 European Union Regulation and its amendment with no. 1783/01.10.2019 .

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	: 21kV, 3 - phases

3. Symbolism of transformers windings connection (Vector Group)

Dyn1.

The HV Vectors shall lead the LV Vectors by 30° degrees.

4. Nominal power

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

4.1 For 40/50 MVA Transformers

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

4.2 For 20/25 MVA Transformers

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

5. Type of core

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

6. Insulation Levels

H.V.

- | | | | | |
|-----------------------|--------|-------|---|------------|
| - 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 |

L.V.

- | | | | | |
|-----------------------|------|-------|---|-----------|
| - L.V. line terminals | 24kV | LI/AC | : | 145/50 kV |
| - L.V. Bushings | 24kV | LI/AC | : | 145/50 kV |

7. Short circuit withstand capability

The power transformer shall be capable of withstanding under service conditions (for 2 (two) seconds on every tap-setting), three-phase or one-phase short circuit at the terminals of each 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 special calculations in accordance with IEC 60076-5. These calculations must be provided by the Bidders. Moreover, participants must provide the certificate of the real test, performed in a similar Power Transformer.

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 insulation category.

9. Temperature rise limits

- 9.1** The average value of the windings temperature rise will be 65°C (class A), for ambient temperature up to 40 °C.
- 9.2** The temperature rise at top oil level will be limited up to 60°C for an ambient temperature up to 40 °C.
- 9.3** The temperature rise at the hottest point of the winding (hot - spot), will have a limit of 78°C.

The limits of the temperature rise will be verified by the execution of the corresponding type test. Furthermore, the hottest spot (hot- spot) of the winding must be specified, according to paragraph X.3.6.

10. Over-Voltage Capability

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

11. Minimum Limits of insulation resistance at 20 °C

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

12. Impedance Voltage

12.1 For 40/50 MVA Transformers

- a. 40MVA : Not less than 16% at any tap of OLTC
- b. 50MVA : Not less than 20% at any tap of OLTC

12.2 For 20/25 MVA Transformers

- a. 20MVA : Not less than 16% at any tap of OLTC
- b. 25MVA : Not less than 20% at any tap of OLTC

13. Peak Efficiency Index (PEI) - Limits of losses

- 13.1** The load (copper) losses of the 40/50 MVA Power Transformer, at 40 MVA, must not be greater than 110 kW at the principal OLTC tap (No7). The no-load (iron) losses must not exceed the value of 24 kW. In any case, the values of the load and no load losses must ensure that the Peak Efficiency Index PEI, according to EU regulation N°548/28.05.2014 and its amendment No 1783/01.10.2019, will be:

- For 40 MVA ONAN **PEI ≥ 99,724 %**.
- For 50 MVA ONAF **PEI ≥ 99,734 %**.

Furthermore, the cooling losses of the transformer at 50 MVA shall not exceed the value of 4kW.

- 13.2** The load (copper) losses of the 20/25 MVA Power Transformer, at 20 MVA, must not be greater than 71 kW at the principal OLTC tap (No7).

The no-load (iron) losses must not exceed the value of 14 kW. In any case, the values of the load and no load losses must ensure that the PEI, according to EU regulation N°548/28.05.2014 and its amendment No 1783/01.10.2019, will be:

- For 20 MVA ONAN **PEI ≥ 99,684 %**.
- For 25 MVA ONAF **PEI ≥ 99,700%**.

Furthermore, the cooling losses of the transformer at 25 MVA shall not exceed the value of 3kW.

It must be noted that for the calculation of PEI, the losses of the Transformer on the principal tap (No 7) of OLTC will be taken into account.

14. Limits of magnetizing current values

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

<u>Secondary voltage</u>	<u>Magn. current in % of nominal current</u>
For $V_r = 21$ kV	0,35% with tolerance + 30%
For $1.1 \times V_r = 23,1$ kV	1% with tolerance + 30%

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

15. Audible noise

The calculation test of the audible noise level of the transformer, will confirm that the level of the audible power will not exceed the value of 72 dB(A), in the distance of 2 meters from the transformer, when the cooling equipment (fans) is under operation, and in the distance of 0,3 meters from the transformer, when the cooling operation (fans) are on off mode. The measurement will be performed according to IEC 60076-10 and the transformer tested will be on no load operation.

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.

17. Guaranteed losses

The bidder must clearly indicate in his technical and financial offer the following guaranteed losses:

- 17.1** For the 40/50 MVA Transformer
- a. No load losses at 21kV
 - b. Copper losses on principal tap (No7) 150/21kV at 40 MVA.
 - c. Copper losses on principal tap (No7) 150/21kV at 50 MVA.
 - d. Total losses (No load + copper losses) at 150/21 kV at 40MVA

- and at 50 MVA.
- e. Cooling losses at 50 MVA.

17.2 For the 20/25 MVA Transformer

- a. No load losses at 21kV
- b. Copper losses on principal tap (No7) 150/21kV at 20 MVA.
- c. Copper losses on principal tap (No7) 150/21kV at 25 MVA.
- d. Total losses (No load + copper losses) at 150/21 kV at 20 MVA and at 25 MVA.
- e. Cooling losses at 25 MVA.

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

The OLTC shall be on the High Voltage winding of the transformer. Three separate OLTCs, with common drive mechanism, will be installed, one on each HV phase winding. The On-load tap changer will be of resistance type, suitable for voltage regulation from +7,5% to – 12,5% of the nominal voltage 150 kV in steps of 1875V.

The OLTC shall be electrically motor operated and controlled either from the control panel of the transformer, through local buttons, or by an automatic voltage regulator.

1. Parts of the on – load tap – changer

The on – load tap changer main parts are:

- a) the diverter switch, that will contain the vacuum interrupters and the transition resistors,
- b) the selector, that will contain the tap selector and the reversing change – over selector.

The whole system shall be operated by a single driving mechanism (motor drive).

2. Type of the on – load tap – changer

Mechanical, oil / vacuum type.

More precisely, the diverter switch shall be in its separate oil compartment; the interrupters shall be of vacuum switching technology and the transition resistors will be inside the oil tank.

The selector will be inside the transformer's oil tank.

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 the principal tap.

ON LOAD TAP CHANGER WITH (17) SEVENTEEN POSITIONS (OLTC)		
Voltage regulation in steps of 1875V	HV (kV)	LV (kV)
+6 steps +7.5%	1. 161,250	21kV
	2. 159,375	
	3. 157,500	
	4. 155,625	
	5. 153,750	
	6. 151,875	
150kV principal tap (No 7)	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	
-10 steps -12.5%	17. 131,250	

4. Applicable Standards

IEC 60214-1 and IEC 60214-2

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

Minimum Temperature: -25 °C

Maximum Temperature: +100 °C

6. Location of the tap changer components and method of installation

- The diverter switch shall be placed in its own hermetically sealed oil compartment. The interrupters must be of vacuum switching technology. The transition resistors must be inside the oil.
- The tap selector and the reversing change – over selector shall be installed in the transformer oil.
- Both the diverter switch and the selector shall be placed inside the tank of the transformer.

Suitable manholes shall be available on the transformer tank so that the OLTC can be checked and any of its components can be decomposed. It is of paramount importance that the removal of the OLTC or any of its components is not constrained by the installation of any of the transformer parts (cover, pipings, oil expansion tank e.t.c).

7. Conservator of the OLTC

- a. The diverter switch shall be inside its own hermitically closed compartment and have its own conservator (oil expansion tank).
- b. The OLTC conservator shall be equipped with an oil level indicator.
- c. The OLTC conservator shall be equipped also with a “breather” that will contain an absorbent material (silicagel crystals).

NOTE: It is also accepted one conservator with two (2) compartments, one for the transformer tank and one for OLTC.

8. Type of oil of the OLTC

The oil used in the diverter switch compartment shall contain naphthenic base inhibitors (inhibited transformer oil) suitable for transformers, free of any toxic fluids, such as PCBs or PCTs and be in accordance with Paragraph IX -5 of this description for the oil of the transformers.

9. Accessories of the diverter switch oil compartment

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

10. Rating and other characteristics of the OLTC

- a. Single : Three (3) 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 (1.2/50 μ s) : 750kV peak
- i. Number of electrical positions : 17
- j. Rated phase step voltage : 1875 V

11. Other characteristics of the on load tap changer

The OLTC shall be able to perform 300.000 operations without contact change, under step voltage of 1875V and through current equal to the rated current of the HV transformer winding on the principal tap (No.7). The OLTC's tap positions must be provided to the protection and control system at least:

- in BCD code format,
- as 4-20 mA analog signal,
- in distinct format (one contact per OLTC's position).

The OLTC 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 and the OLTC 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 OLTC. shall be mounted in

weather- proof control cabinet installed on the transformer. The control voltage of the OLTC will be 110V DC. 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.

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 relay

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

This oil-flow relay shall have contacts with the following characteristics:

- Two (2) N.O contacts suitable for 110V DC. One contact will be used for tripping purposes and the other 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 it can trip the transformer. 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 HEDNO inspector.

The Pressure relief device shall have contacts with the following characteristics:

- Two (2) N.O contacts suitable for 110V DC. One contact will be used for tripping purposes and the other 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 so 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 : 110 V DC
- d. Supply voltage and frequency of the motor drive unit : 3ph, 400V AC, 50Hz with tolerances of 85% up 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 of the 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 – changes 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 – lower the voltage level and emergency stop). Also, the tap position, the number of operations and any alarms originated from the motor drive, will be displayed in 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. Automatic voltage regulator

As already mentioned, the OLTC shall be controlled automatically by suitable voltage regulator, which is an accessory of the transformer and will be given as an extra part. The voltage regulator will have current and voltage input from 20kV level and it will be digital. Available voltage and current for the analogue inputs: voltage transformer with secondary nominal voltage 100V, current transformer with secondary nominal current 1A or 5A. The power supply of the voltage regulator shall be 110 V DC.

The voltage set point will be adjustable in the range 90-110% of nominal voltage. The overlap voltage shall be adjustable in the range 0,5%-5% of the set point 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 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 set point.

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 (raise voltage – lower voltage) commands to the voltage regulator. The voltage regulator will be set through the local buttons and display or through 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.

Automatic voltage regulator will be able to communicate via the IEC 61850 communication protocol.

15. Warranty

A warranty period of three (3) years from the delivery date of the transformer must be given for the offered OLTC, which shall cover any OLTC damages or damages to the transformer due to OLTC malfunctioning.

16. 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

17. TESTS

The transformer manufacturer is obliged to present to the HEDNO inspector OLTC's test certificates while the inspector is at the manufacturer's premises for the transformer inspection and testing. The test certificates 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 AND ACCESSORIES

1. Transformer tank

- a. The transformer tank will be of BELL 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 upper side of the cover and/or side walls, dimensioned indicatively of 50x50cm², so as to fix/ inspect the transformer bushings. At least, two manholes should also 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 realized 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
 - i. A metallic climbing ladder shall be provided in order to access the upper part of the transformer's radiators and of the conservation tank

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. It is also accepted to have 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 HEDNO inspector.

Also for that reason, a rubber air cell (for oil preservation system of transformer) will float on the oil surface and will increase or decrease as the oil volume changes. The Rubber Air Cell will be in contact with the breather so that it is always at atmospheric pressure and the incoming air will always be 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 conservator tank and there will be one Buchholz relay with isolating valves as it is described in detail in paragraph IX-7 of this hereby description.

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 HEDNO 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, in a way that both the mechanical protection is assured and the mechanical vibrations are prevented.

4. **Bushings**

The design of HV, LV and Neutral bushings will be in accordance with the IEC 60137 Standard. All the transformer winding bushings 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 Condenser Type Core, impregnated with the transformer oil. Especially the LV and Neutral bushings can be of solid type.

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) (U_m) (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 (I_r^*)(A)	800	1600	1600
4	Rated thermal short time current, 1 sec (I_{th})	$25I_r$	$25I_r$	$25I_r$
5	Rated dynamic current (I_d)	$2.5I_{th}$	$2.5I_{th}$	$2.5I_{th}$
6	Cantilever operating load (N)	2000	625	625
7	Creepage distance (mm)	4250	600	600
8	Angle of mounting	$\leq 30^\circ$ /vertical	$\leq 30^\circ$ /vertical	$\leq 30^\circ$ /vertical
9	Temperature limits – class of the insulating material in contact with metal parts	105°C Class A	105°C Class A	105°C Class A
10	Dielectric dissipation factor ($\tan\delta$) at $1.05U_m/\sqrt{3}$ voltage	≤ 0.007	-	-
11	Maximum value of partial discharge quantity at U_m operating voltage	$\leq 10\text{pC}$	-	-
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/s²)
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 certificates or calculation by dynamic analysis, or static calculation. HEDNO will decide for the approval or not of all the above.

- b. Bushings shall be designed for operation at ambient temperature from -25°C to +45°C and at altitude not exceeding 1000m.
- c. The maximum oil temperature under operating emergency conditions will be 115°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

HV bushings will be equipped with the accessories below:

- a. Oil level indicator.
- b. Test tap (tanδ tap) suitable for measurement of the capacitance, dielectric dissipation factor 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 indicated below are adequate:

- Manufacturer's or supplier's name.
- Year of manufacture and serial number
- Maximum operating phase – phase voltage (Um) or rated operating phase 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 HEDNO inspector, bushings test certificates while the inspector is at the manufacturer's premises for the transformer inspection and testing.

The test certificates 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 (when applicable)

1. Power – frequency voltage withstand test
2. Lightning impulse voltage withstand test from environmental overvoltage
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 (when applicable)

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

C. Special tests (when applicable)

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

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	100/1 (20/25 MVA) 200/1 (40/50 MVA)	5P20 25VA For transformer differential protection
H1,H2,H3	1	1000- 500/1	5P20 50VA For bus bar differential protection
X1, X3	1	---	As required by thermal replica relays
X2	1	---	As required by 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 contain naphthenic base inhibitors (inhibited transformer oil) suitable for transformers and shall be in accordance with the latest edition of IEC-60296 Standard. It shall be non-toxic without PCB's or PCTs etc. Its physicochemical properties will comply with IEC-60422 standard for new transformers 150/21 kV.

6. **Cooling system with fans**

The transformer shall be equipped with fans for the forced circulation of the air (cooling type ONAF) at 50MVA (it is applied on 40/50 MVA transformers) and at 25 MVA (it is applied on 20/25 MVA transformers).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 HEDNO 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 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 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 HEDNO inspector. 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 HEDNO 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.

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 HEDNO 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.

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 that is 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 HEDNO 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, oil directed. 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 HEDNO 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. Optical Fiber System (hot-spot calculation)

For the calculation of the temperature of the hottest point (hot-spot) of all the transformer's windings, it will be used an optical fiber system (of many channels) according to Annex E of IEC60076-2. The system will include a temperature supervisor, as well as temperature sensors that will be connected via compatible optical fibers. The sensors will be placed in positions in every winding where it is predicted that the hottest points will be found. The optical fibers will end up in a junction box placed in the transformer's tank. An optical cable will connect the junction box with the temperature supervisor that will also be placed in the transformer's tank. Due to the fragility of the optical fibers, their installation in the windings must follow strictly the manufacturer's instructions. The temperature supervisor will "give" an analogical output 4-20mA for every temperature sensor for the transmission of the measurements to the automation and control system.

10. 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 HEDNO inspector.

11. 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.

12. Connecting material

All connecting material such as bolts, nuts and lock washers must be made of stainless steel.

13. 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 or in special UV resistant & moisture protected PVC corrugated 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.

14. Spill Gaps

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

On Terminals	Spill gap adjustment (cm)		
	From	To	Factory Setting
H1, H2, H3	65	110	66,04
X1, X2, X3	7	13	11,43

15. Auxiliary power supply

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

Available aux. D.C. power supply: 110V

16. Painting requirements for the transformer

The inside part of the transformers must be painted with a layer of white special paint, that will be environmentally friendly, without toxic substances, at least of 40µm thickness and oil resistant. Externally, the transformer, including coolers, shall be painted with Grey color RAL 7040, of C3 category, according to ISO 12944-2. It must be given to HEDNO, for approval, a description of the proposed painting procedure (number of layers, thickness, ingredients).

17. Transportation requirements

The transformers, for transportation purposes, shall be filled with insulating oil and dry Nitrogen (N₂) or only with dry Nitrogen.

X. TESTS

The tests will be carried out in accordance with 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. The tests will be carried out in accordance with the latest publication of the relevant standards that are valid during the submission of offers date.

Apart from the required tests according to IEC, when the active part of every transformer is fully constructed and before the start of the drying procedure, the Contractor must – as it is required and for the final inspection/ tests of the

transformer -inform HEDNO on time, so as HEDNOs inspector proceeds to optical inspection of the fully constructed active part of the transformer. The construction procedure of the transformer will continue after the written command of the HEDNO inspector, except if the inspector exempts the Power Transformer of optical inspection.

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 test will be executed according to paragraph 11.2 of IEC 60076-1.

1.2 Check of voltage ratio and check of phase displacement (Vector group)

The test will be executed according to paragraph 11.3 of IEC 60076-1.

1.3 Measurement of short circuit impedance and load losses

The test will be executed according to paragraph 11.4 of IEC 60076-1.

1.4 Measurement of magnetic current and no-load losses at the 90%, 100% and 110% of rated voltage

The test will be executed according to paragraph 11.5 of IEC 60076-1.

1.5 Measurement of capacitance between windings – earth, between windings and dissipation factor ($\tan\delta$)

The measurement should be performed according to par. 11.1.2.2 of IEC 60076-1.

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.

$\tan\delta \leq 0.5\%$ at 20 °C

1.6 Measurement of the insulation resistance

The measurement should be performed according to paragraph 11.1.2.2 of IEC 60076-1.

The measurements shall be carried out for the following connections and for three time periods (15 seconds, 60 seconds and 10 minutes, DAR and PI value measurement).

- a. HV-(LV+earth)
- b. LV-(HV+earth)
- c. (HV+LV)-earth
- d. HV-LV

The test voltage shall be 5kV.

Furthermore, it will be carried out measurement of the insulation resistance between core - tank, frame – tank and core – frame, according to paragraph 11.12 of IEC 60076-1. The test voltage shall be 2,5kV.

1.7 Frequency response measurement

Two frequency response measurements will be executed on each transformer, with and without oil, after all routine and special tests and prior to shipment, following IEC 60076-18. The measurement will be executed on every winding and phase of the transformer. The results of the measurement (curves) will be part of the routine tests certificates and will be given to HEDNO in electronic format as well, for comparative reasons. The cost for the execution of this test will be included in the cost of the material unit.

In case that the manufacturer of the Power Transformer has measurement instruments of different producers, HEDNO will choose the one for the measurements.

1.8 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 at a pressure of at least 0,3 bar greater than the pressure of the oil that will be measured, according to the provisions of paragraph 11.8 of IEC 60076-1. Test duration will be 24 hours.

1.9 Transformer oil tests

- a. Dielectric test of breakdown voltage ($\geq 220\text{kV/cm}$) according to IEC 60156.
- b. $\tan\delta$ according to IEC 60247.
- c. Dissolved Gas in oil analysis before and after the tests of the transformer, according to IEC 60599.
- d. Existence of corrosive sulfur according to DIN 51353, with negative result (non - corrosive).
- e. Existence of potential corrosive sulfur according to IEC 62535, with negative result (non – corrosive), as well as of PCB.

1.10 Dielectric tests

1.10.1 Full Wave Lighting Impulse Test (LI TEST – LIN TEST)

The test will be executed according to paragraph 13.2 of IEC 60076-3. The test will be executed as well for the neutral terminal.

1.10.2 Applied Voltage Test (AV TEST)

The test will be executed according to paragraph 10 of IEC 60076-3.

1.10.3 Induced Voltage test by measuring partial discharges (IVW test and IVPD test)

The test will be carried on according to paragraphs 11.2 and 11.3 of IEC 60076-3.

1.10.4 Insulation test of auxiliary wirings (AuxW test)

The test will be executed according to paragraph 9 of IEC 60076-3.

1.11 Operation test On Load Tap Changer

The test will be executed according to paragraph 11.7 of IEC 60076-1.

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

2 Type tests

The type tests shall be carried out on only one (1) only piece of the order, per nominal capacity.

2.1. Temperature rise test

The test will be carried out in accordance with the IEC-60076-2 Standard.

2.2 Noise Level Test

The test will be carried out in accordance with paragraph 11 of the IEC-60076-10 Standard. The measurement will be carried out at nominal voltage and frequency, right after the end of the temperature rise test, close to the operation temperature.

2.3 Measurement of the power taken by the fans

The measurement will take place in accordance with paragraph 11.1.3 of the IEC 60076-1 Standard.

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.

3 Special tests

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

3.1 Chopped wave lightning impulse test (LIC)

The test will be carried out in accordance with paragraph 13.3 of the IEC-60076-3 Standard.

3.2 Switching impulse test (SI)

The test will be carried out in accordance with paragraph 14 of the IEC-60076-3 Standard.

3.3 Line terminal AC withstand test (LTAC)

The test will be carried out in accordance with paragraph 12 of the IEC-60076-3

Standard.

3.4 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, according to IEC 60076-1/2000.

3.5 Measurement of Zero Sequence Impedance

The test will be carried out in accordance with paragraph 11.6 of the IEC-60076-1 Standard.

3.6 Winding hot-spot temperature-rise measurements

The test will be carried out in accordance with paragraph 11.1.4 of the IEC-60076-1 Standard.

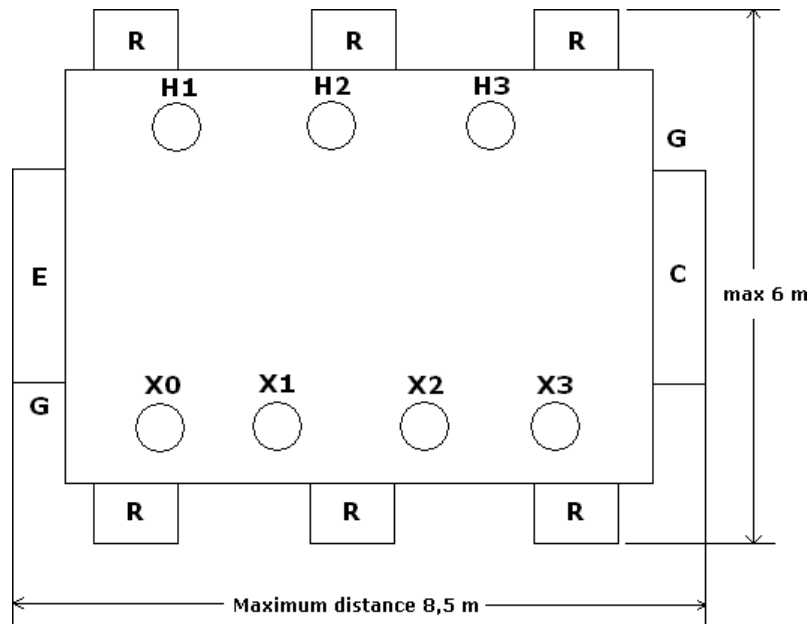
XI. SPARE PARTS

Bidders should quote the following spare parts for each transformer, giving item prices. The precise number of the spare parts of each item will be defined in the tender invitation.

- H.V. bushing complete
- M.V. bushing complete
- H.V Coil , Regulator Coil and M.V. Coil (one phase «column»)
- Current Transformer for AVR
- Complete set of gaskets for all bushings, covers, radiator flanges manholes and handholes for one transformer
- Transformers Body Pressure Relief Device
- Transformers Body Buchholz Relay
- Cooling fan motor
- Cooling fan
- Oil Temperature Indicator
- Winding Temperature Indicator
- OLTC Oil-flow relay
- OLTC Pressure Relief Device
- Automatic Voltage Regulator
- Complete one – phase mechanism of OLTC, as described in paragraph VIII.1.
- OLTC mechanisms Electric Motor – Reducer Set (Motor Drive Unit)
- Elastic – multi-use – oil containers, capable to take the entire oil transformer's volume.

XII. LOCATION SKETCH

The outline arrangement and overall dimensions of the 40/50 MVA and 20/25 MVA transformers must be as indicated below.



The height of the transformer including the conservator tank shall not exceed eight (8) meters.

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

The arrangement of the radiators is not compulsory. The manufacturers are able to propose their own way of arrangement.

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°. The distance between rails shall be 1435mm.

XIV. DATA TO BE SUBMITTED BY BIDDERS

1. All bidders must provide all technical information requested in “compliance sheet” of this hereby description as well as any proposed deviation from the present description 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. If both 40/50 MV and 20/25 MVA power transformers are included in a tender/contract, then the offered accessories/devices of all transformers should be the same, regardless of the nominal capacity of the transformers.

3. All bidders must take note of the attachment of this hereby description.
4. Technical pamphlets and brochures of the offered transformers, which will help the technical evaluation process.
5. Technical data, characteristics and technical pamphlets for the OLTC and the transformer accessories and systems.
6. Drawings showing the outline dimensions of the transformers offered and any other information deemed necessary, including terminal markings.
7. Test certificates for the type and special tests specified in this hereby description (only the test of paragraph X3.4 is excluded), as a result of the respective tests on the same or similar transformer. Type tests must be given as well for the OLTC rendered. It must be pointed out that the provided test certificates must be about tests of equipment / materials made in the same factory as the factory of the supplied equipment / materials.

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) All the above should be supplied in digital format as well (that can be edited, where applicable).

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 – IEC60076 and EU Regulation 548/2014 Eco Design
2. The manufacturer's name
3. Serial number
4. Year of manufacture
5. Number of phases
6. Peak efficiency (PEI) and k_{pei} index
7. Rated power (MVA)
8. Rated frequency (Hz)
9. Rated voltages (V or kV) and tapping range.
10. Rated currents (A or kA)

11. Symbol of the windings connection
12. Short circuit impedance in (%)
13. Type of cooling.
14. Insulation levels
15. OLTC plate
16. Temperature rise of top oil and windings.
17. Type of transformer insulation oil
18. Windings Material
19. Core Material
20. Diagram of the windings connection
21. Transformer total mass
22. Oil mass (Transformer insulation material)
23. Transformer transportation mass.
24. Transformer untanking mass
25. Core and windings mass
26. Vacuum withstand capability of the tank and conservator.
27. No load losses
28. Copper losses

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 the technical characteristics of auxiliary equipment, such as bushings, CTs, fans and OLTC according to the individual Standards.

XVII. ECONOMIC COMPARISON OF THE OFFERS

The economic comparison of the offers shall be based on the lowest transformer cost.

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 insulating oil will be given into appropriate barrels. Any alternative packing of the insulating oil will be “ad hoc” examined and should be approved by HEDNO. The voltage regulator and its accessories will be supplied in a separate box, suitable for indoor storage.

After the inspections and for the transfer of the transformer to HEDNO's storage premises, at least two (2) digital impact/ shock recorders will be provided and installed by the manufacturer on the transformer tank. The manufacturer must reassure that the installation position of these devices, with screws in the body of the transformer, is stable. The devices will be installed and set in operation

after the completion of the predefined type, series and special tests and the acceptance of the transformer.

The Shock Recorders will be of digital type and will include GPS and time recordings. The Shock Recorders can be reused by the Manufacturer during the execution of the same Contract. HEDNO will specify in each contract the minimum number of Shock recorders that are going to be delivered to him at the end. The manufacturer will predict the installation of the supply of shock recorder (batteries), capable to endure until the arrival of the transformer in the delivery place.

ATTACHMENT

PENALTY FOR EXCESS LOSSES

With regard to load and no-load losses, a transformer is considered as successfully inspected if the losses ascertained during testing do not exceed the maximum tolerance, specified in the IEC standards versus the losses guaranteed by Seller. Otherwise the transformer is rejected. Furthermore, in case that the real losses of the Power Transformer do not satisfy the requirements of the Commission Implementing Regulation 584/2014 & Amend. 1783/2019 about the Peak Efficiency Index – PEI (Eco Design), then the transformer will be rejected.

On each successfully inspected transformer, if any difference in the losses versus the guaranteed ones (without tolerance), is positive, (i.e. 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 (copper) losses in excess on principal tap
(No 7) 150/21 kV at 40 MVA (for 40/50 MVA transformer)
or at 20 MVA (for 20/25 MVA transformer)

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:

1949,63 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 (payment).