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**TECHNICAL JOB
SPECIFICATION**

722/1

REVISION 0

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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

POWER TRANSFORMERS

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CHANGES LOG
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REFERENCED DOCUMENTS

EU DIRECTIVE 2006/95/EC, LVD
[Low Voltage Directive]

EU DIRECTIVE 2004/108/EC, EMC
[Electromagnetic Compatibility Directive]

EU DIRECTIVE 2006/42/EC
[Machinery Directive]

EU DIRECTIVE 94/9/EC, ATEX
[Explosive Atmospheres Directive]

ELOT EN 60027
[Letter Symbols to be used in Electrical Technology]

ELOT EN 60076
[Power Transformers]

ELOT EN 60076-1
[Power Transformers - Part 1: General]

ELOT EN 60076-2
[Power Transformers - Part 2: Temperature Rise]

ELOT EN 60076-3
[Power Transformers - Part 3: Insulation Levels, Dielectric Tests and External Clearances in Air]

ELOT EN 60076-4
[Power Transformers - Part 4: Guide to the Lightning Impulse and Switching Impulse Testing Power Transformers and Reactors]

ELOT EN 60076-5
[Power Transformers - Part 5: Ability to Withstand Short Circuit]

ELOT EN 60076-10
[Power Transformers - Part 10: Determination of Sound Levels]

ELOT EN 60076-11
[Power Transformers - Part 11: Dry Type Transformers]

ELOT EN 60079
[Electrical Apparatus for Explosive Gas Atmospheres]

ELOT EN 60085
[Electrical Insulation Thermal Classification]

ELOT EN 60214-1
[Tap Changers - Part 1: Performance Requirements and Test Methods]

ELOT EN 60617
[Graphical Symbols for Diagrams]

IEC 60050
[International Electrotechnical Vocabulary]

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IEC 60076-8
[Power Transformers - Part 8: Application Guide]
IEC 60214-2
[Tap / Changers - Part 2: Application Guide]
IEC 60354
[Loading Guide for Oil-Immersed Power Transformers]
IEC 60616
[Terminal and Tapping Markings for Power Transformers]
IEC 60905
[Loading Guide for Dry-Type Power Transformers]

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1.0 SCOPE

This specification specifies selection, manufacture and testing of the power transformers rated up to 40 MVA.

This specification which specifies particular requirements with respect construction and operation characteristics which are required the transformers to comply with, is an integral part of each Material Requisition (MR), covering individual equipment.

2.0 GENERAL

This specification is appropriate for use in conjunction with the relevant Material Requisition.

Unless otherwise specified in the Material Requisition, Vendor shall comply with the requirements of this specification.

Should conflict exist between requirements of this specification and those of the Material Requisition, the latter shall govern: in case of doubt Vendor shall apply to Contractor.

Any deviation shall be listed by Vendor in his bid, with explanation of reasons and advantages of suggested solution.

2.1 EUROPEAN AND INTERNATIONAL STANDARDS

Unless otherwise specified in the Material Requisition, the following standards shall apply:

ELOT EN 60076	"Power Transformers"
ELOT EN 60076-1	"Power Transformers - Part 1: General"
ELOT EN 60076-2	"Power Transformers - Part 2: Temperature Rise"
ELOT EN 60076-3	"Power Transformers - Part 3: Insulation Levels, Dielectric Tests and External Clearances in Air"
ELOT EN 60076-4	"Power Transformers - Part 4: Guide to the Lightning Impulse and Switching Impulse Testing Power Transformers and Reactors"
ELOT EN 60076-5	"Power Transformers - Part 5: Ability to Withstand Short Circuit"
ELOT EN 60076-10	"Power Transformers - Part 10: Determination of Sound Levels"
ELOT EN 60076-11	"Power Transformers - Part 11: Dry Type Transformers"
ELOT EN 60085	"Electrical Insulation Thermal Classification"
ELOT EN 60214-1	"Tap Changers - Part 1: Performance Requirements and Test Methods"
IEC 60076-8	"Power Transformers - Part 8: Application Guide"
IEC 60214-2	"Tap Changers - Part 2: Application Guide"
IEC 60354	"Loading Guide for Oil-Immersed Power Transformers"
IEC 60616	"Terminal and Tapping Markings for Power Transformers"
IEC 60905	"Loading Guide for Dry-Type Power Transformers"

Codes and standards of the country of origin of transformers and components shall be accepted, provided that the said standards are equal to or more restrictive than **ELOT EN** and **IEC standards** or other codes and standards called for in the Material Requisition.

2.2 EU LEGISLATION AND CE MARK

Transformers to be installed in any country of EU, shall bear the CE mark, together with:

- The Certification of Conformity to EMC Directive (2004/108/EC).
- The Certification of Conformity to Low Voltage Directive (2006/95/EC).
- The Certification of Conformity to Machinery Directive (2006/42/EC).
- The Certification of Conformity to **ATEX** Directive (94/9/EC) where applicable.

2.3 EEx-TYPE TRANSFORMERS

Transformers with any degree of protection against the hazard of explosion or fire shall comply with **ELOT EN 60079** - "Electrical Apparatus for Explosive Gas Atmospheres".

Vendor of EEx-type transformers shall exhibit the reports relevant to the tests carried out on the prototype by a testing station approved by the national authority of the country of origin or by another appropriate authority and shall produce routine-acceptance test protocols as specified by the applied **IEC** Standards and by the applied Standards of the country of origin.

2.4 UNITS, ELECTRICAL TERMS AND DEFINITIONS

Units, electrical terms and definitions used in this specification and to be used by Vendor, shall be in accordance with the following:

ELOT EN 60027 "Letter Symbols to be used in Electrical Technology"

IEC 60050 "International Electrotechnical Vocabulary"

Electrical diagrams shall be with graphical symbols in accordance with **EN 60617** "Graphical Symbols for Diagrams".

2.5 EARTHQUAKE DESIGN CRITERIA

The earthquake withstand of the power transformers must comply with the safety and operability requirements of the plant and of particular loads of the plant.

3.0 ENVIRONMENTAL CONDITIONS

Unless otherwise specified in the Material Requisition, transformers shall be suitable for the following conditions.

3.1 CLIMATE

CLIMATE		TEMPERATE	TROPICAL
Temperature (dry bulb) (°C)	Maximum	42	
	Max. daily average	35	50
	Yearly average	20	40
	Minimum	-15	
Humidity (%)		100 at max. temperature	100 with presence of condensate

3.2 COOLING WATER

For water-cooled apparatus, cooling water temperature not exceeding 35°C at the inlet shall be considered.

3.3 ALTITUDE

The height above sea level shall be assumed as not exceeding 1000 m. and shall be conventionally shown in the Material Requisition as 0,00 m. a.s.l.

3.4 ATMOSPHERE

Ambient air shall be assumed to be corrosive atmosphere.

4.0 RATING AND PERFORMANCE REQUIREMENTS

4.1 SYSTEM VARIATIONS

Unless otherwise specified in Material Requisition, the transformer shall be capable of operating at rated power with supply system variations as specified below:

Variation range	Normal (*)	Exceptional (**)	NOTES
Voltage	± 5 %	± 10%	Referred to rated voltage of the tap (***)
Frequency	± 2%	± 5%	Referred to rated frequency
Combined voltage and frequency	± 5 %	± 10%	Sum of absolute values

(*) Within normal variation range the operation shall be continuous. Temperature rise may be over rated values, but as per applicable standard, without appreciable life reduction of the transformer.

(**) In the range between +5 +10% and -5 -10% the operation shall be for short periods (not exceeding 1 hour each, with a total of 100 hours per year), without reaching such temperatures which can permanently compromise the life of insulating materials.

(***) Unless otherwise specified in Material Requisition, reduced rating shall be considered for taps exceeding ± 5%.

4.2 RATING

Rated power of the transformer shall be shown in the Material Requisition. Transformer parameters and quantities on which the guarantees and the tests are based are referred to rated power, rated voltage and rated frequency.

If the transformer has different values of power due to:

- Different type of cooling.
- Different values of system variations.
- Different values of turn ratios.

These values of power and the related parameters and quantities shall be considered as "INFORMATIVE", unless the Material Requisition specifies that these different values of power are to be considered as "RATED".

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4.3 FORCED COOLING

If the Material Requisition indicates that "FORCED COOLING" is to be "INCLUDED", Vendor shall include in the supply all provisions requested to increase the power of the transformer up to the given value or values; if no values are shown in the Material Requisition, the power increase shall be as follows:

Rated Power with Natural Cooling (kVA)	Increased Power with Forced Cooling (%)
400 - 800	115
1000 - 1600	120
2000 - 10000	125
above 10000	133

Provision shall include: enough capacity in all current carrying parts (connections, bushings, tap changer etc.) for increased power, suitable arrangement of radiators, air ducts, fan supports, motor driven fans, separate terminal and control boxes, oil temperature switch and wiring. Data relevant to increased power shall be shown on the main or on an additional nameplate.

If the Material Requisition indicates that only "PROVISIONS" for "FORCED COOLING" is requested, Vendor shall design the transformer for the given increased power or for the figures shown in the **table** above.

The transformer supply shall include the above specified provisions, excluding air ducts, motor driven fans, terminal and control boxes, oil temperature switch and wiring.

These devices shall be quoted separately.

Data relevant to increased power shall be shown on the main or on an additional nameplate.

If the transformer is foreseen with forced oil circulation, the transformer supply shall include the motor driven oil pump (or pumps), the gate valves, supports, terminal and control box and wiring. Vendor shall specify if in absence of forced oil circulation (or in absence of forced air cooling), the transformer may be energized at least on no load.

Control box(es) shall be equipped with: incoming circuit breaker, contactor or contactors for group or single fan control, miniature breakers for short circuit and overload protection of each drive motor, indicating lamps with fuses, auto-manual switches, space heaters with thermostat and any other requested device.

Terminals shall be provided for remote signalling of contactor (contactors) closed and for remote alarm in case of trip of miniature circuit breakers. Safety provisions and general requirements shall be as per para 7.3.

The oil temperature thermostat shall permit the setting 10°C above and below the rated oil temperature.

4.4 SHORT CIRCUIT WITHSTAND CAPABILITY

Transformer shall be designed and constructed in such a way so as to withstand the short circuit currents for the duration specified by **ELOT EN**, **IEC** and by the applied standards, or in Material Requisition.

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The same requirement shall be applied to the supporting and fixing fittings for cable terminations to be supplied by transformer Vendor, including terminal boxes.

4.5 NOISE LEVEL

The level of noise produced by the transformer, operating at rated voltage and frequency either on no-load or full-load, shall be below established industrial limits, as shown on the table below.

For transformers to be installed within urban areas a lower noise level shall be considered and specified in the bid, if requested in Material Requisition.

PERMISSIBLE NOISE LEVEL, FOR OIL - IMMERSED TRANSFORMERS											
Rated power (MVA)	0,4	0,5 0,63	0,8 1,0	1,25 1,6	2	2,5	3,15	4	5	6,3	8
Noise level [dB (A)]	50	52	54	56	52	53	55	56	57	59	60
Rated power (MVA)	10	12,5	16	20	25	31,5	40				
Noise level [dB (A)]	62	63	65	66	67	69	70				

Reference distance for sound level pressure shall be 1 m up to 1,6 MVA, and 3 m for larger transformers.

If required in Material Requisition, Vendor shall furnish the following information:

- Sound level spectrum at octave band center frequency [dB(A)]
- Sound power level (dB)

Air fans for forced air cooling shall be of the reduced noise type; the design of air ducts and air passages shall reduce the noise level within the specified values.

4.6 INSULATION OF WINDINGS

4.6.1 EXPOSED WINDINGS

In general, windings connected to overhead lines either directly or through a short length of cable, shall be considered as exposed winding and shall be designed to withstand the impulse test in accordance with the applied standard.

Terminals shall be equipped with spark gap rods, suitable for setting at rated BIL and at the values specified in the Material Requisition.

Unless otherwise specified in Material Requisition, all windings shall be considered exposed.

4.6.2 NON EXPOSED WINDINGS

In general, windings directly connected to cable network shall be considered as non exposed type and shall not be designed for impulse test.

The non exposed windings shall be specified in Material Requisition.

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4.6.3 WINDING MATERIALS

Unless otherwise specified in Material Requisition, oil immersed, three phase transformers shall have copper windings. In any case, Vendor may quote alternatively aluminium windings.

5.0 LOSS EVALUATION

5.1 **TRANSFORMERS WITH SPECIFIED LOSS - RATIO OR LOADING DIAGRAM**

Vendor shall design the transformer on the basis of the no load to load-loss ratio, or on the basis of operating point, or on the basis of loading diagram specified in the Material Requisition. If the design criteria are not specified, the cost comparison shall be on the basis of losses evaluation cost, specified in the Material Requisition.

5.2 **PENALTY ON LOSS EXCEEDING GUARANTEED VALUES**

Penalty on loss exceeding tolerances over guaranteed values as per IEC or EN Standards or other applicable standard, if more restrictive, shall be based on figures given in the Material Requisition.

6.0 CONSTRUCTION REQUIREMENTS

6.1 **TERMINALS**

Terminals for the connection of cables or wires shall be provided with bolted type connectors of adequate dimension and rating, suitable for the current and cross section specified in Material Requisition.

Terminations with threaded stems and nuts only, are not acceptable.

6.2 **TERMINAL BOXES FOR POWER CIRCUITS**

Terminal boxes shall be as specified in Material Requisition and shown on **Figures 1 to 3**; the shown arrangements do not pretend to be a constructive drawing and Vendor shall provide solutions based on best practice.

Terminal boxes for windings at voltage level higher than 1000 V a.c. may be air or compound or oil filled type.

The oil level and the gas development in the terminal box may be controlled by the Buchholz relay of the transformer or by a separate Buchholz relay. One oil level indicating gauge shall be provided on the terminal box.

The basic arrangement of the terminal boxes shown on **Figures 1 to 3** consists of a terminal box with two parts: one part integral with the transformer and the other part fixed with the cable termination or with the bus-duct.

- a. The junction between the two parts of the terminal box shall be by means of a flange. The flange shall permit the easy removal of the transformer without removing the fixed part of the terminal box and of the cable termination or bus duct.
- b. The connection between the transformer terminals and cable or bus duct terminal points shall be by means of removable links. The links shall permit isolation of transformer terminals from cable or bus duct for testing and for maintenance or repair works. The isolating distance in air, compound or oil shall be suitable for the test voltage (power frequency or impulse) of the transformer

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or of the cable or bus-duct. In the case of filled terminal box, the isolating distance may be in oil, or respectively in compound. The links for connection with rigid bus bars or rigid cables shall be flexible type.

- c. In case of compound or oil filled terminal boxes, for removal of transformer it shall be accepted to drain out the compound or the oil.
- d. Bushings, connection links, bus bars and cords shall be suitably fixed, distanced and supported taking into account the expected short circuit current (see **para 4.4**).
- e. Supporting and fixing of cables or bus duct shall be by others. The removable part of the terminal box shall be supported by the transformer itself; provision for supporting the same in case of removal of the transformer shall be by others.

Terminal boxes shall be generously sized and shall be provided with removable covers in order to permit easy installation and inspection.

Where single core conductors are used, cable entries shall be through non magnetic plates to prevent local heating.

Suitable fittings shall be adopted and furnished by transformer Vendor.
Insulation method between phases may be:

- a. Air insulation.
- b. Oil insulation.
- c. Compound filling.
- d. Phases fully insulated (complete taping of exposed parts, in order to obtain the rated insulation level).
- e. Phases separated (by means of insulating material sheet).
- f. Phase segregated (by means of metallic, earthed sheet).
- g. Single phase bus-duct.

Unless otherwise specified in Material Requisition, Vendor shall include in the supply the complete terminal box (integral and removable parts) and in addition: fitting for cable termination (cable pothead, cable glands, fixing clamps, lugs, etc.) connection bolts and links, distance and clamping pieces and any other miscellaneous material required to complete the connection.

In case of outdoor installation exposed to solar radiation, the terminal box shall be provided with a suitable screen.

7.0 FITTINGS AND ACCESSORIES

Unless otherwise specified in Material Requisition, transformer shall be equipped with the following fittings and accessories.

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7.1 NORMAL FITTINGS FOR OIL IMMERSSED TRANSFORMERS "CONSERVATOR TYPE" OR "SEALED TYPE" (See Notes)

Pos.	Description	Required	Notes
1	Oil conservator complete with: 1.1) Oil level indicating gauge 1.2) Oil level switch	*(C) **(C)	See 7.2.1
2	Dehydrating breather (silicagel) complete with fittings and breather valve	*(C)	
3	Buchholz relay (gas and oil relay) 3.1) Two contact type (alarm, trip) 3.2) Three contact type (alarm, trip, level) 3.3) Oil sampling device 3.4) By pass valves and pipe	*(C) (S) *≥5 MVA(C) (S) *(C) *≥5MVA(C)	(-) See 7.2.5
4	Oil filling hole and plug	*	
5	Oil drain valve 5.1) Quick oil discharge valve	* **	
6	Filter valves 6.1) Vacuum valve	* **	
7	Oil sampling valve	*	
8	Gate valve at top and bottom connections of detachable radiations	*	
9	Thermometer pocket (one) 9.1) Thermometer pockets (two)	* *≥5 MVA	
10	Dial type thermometer 10.1) Complete with two contacts for alarm and trip 10.2) Temperature detector in oil 10.3) Temperature detector in core	* * **≥5 MVA **≥5 MVA	See 7.2.3 See 7.2.6 See 7.2.6
11	Skids 11.1) Rollers for sliding in two directions and pulling lugs 11.2) Support plates for hydraulic jacks 11.3) Hydraulic jacks 11.4) Station support plates with fixing bolts and supports	* ** **≥5 MVA **≥5 MVA **≥5 MVA	See 7.2.8 See 7.2.4
12	Lifting lugs for the complete transformer and removable part	*	
13	Earthing terminal (two on opposite side of the tank)	*	See 7.2.2
14	Terminal box(es) for auxiliary and control circuits	*	See 7.3
15	Nameplate and terminal marking plate	*	
16	Additional nameplate	*	
17	Tap changer handle with locking features and position indicators	*	See 7.2.7
18	Pressure relief vent or device	* (C) (S)	
19	Manhole or handhole		

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Pos.	Description	Required	Notes
20	Spark gaps	**	See 4.6.1
21	Oil level gauge on tank	*(S)	
22	Pressure vacuum gauge	*(S)	
23	Gas sampling valve	*(S)	

- * Indicates included in the transformer supply.
- ** Indicates to be furnished only if required in the Material Requisition.
- (C) Indicates to be provided only on conservator type transformers.
- (S) Indicates to be provided only on sealed type transformers.
- (+) For sealed type transformers; sudden pressure type relay.

7.2 NOTES ON NORMAL FITTINGS

- 7.2.1 Oil level gauge fitted on the conservator (C) or on tanks (S) shall be marked to indicate the level at the following temperatures 0°C; 30°C; 95°C. Gauges shall be visible from grade.
- 7.2.2 All exposed conductive parts shall be bonded to the transformer main tank by means of protective conductors or stud connections. Conductivity of these connections shall not be less than conductivity required for the main protective conductors, which shall be sized for the prospective earth fault currents. Studs serving this scope shall be identified with the graphical symbol of earth.
- 7.2.3 Dial type thermometer shall be complete with two hands, the former showing oil temperature at time of reading and the latter showing maximum temperature reached since last resetting. The thermometer shall be provided with 2 single pole double throw contacts, the former to be set for alarm and the latter to be set for trip.
- 7.2.4 Additional fixing devices shall be furnished for transformers to be installed in earth quake endangered areas and for transformers specified for blast proof installation.
- 7.2.5 Three contact-type Buchholz relay shall be provided in any case for transformers with oil filled terminal boxes in communication with the main conservator, to monitor oil level in the terminal boxes. In case of sealed type transformer (S) a separate Buchholz relay shall be furnished in the terminal boxes.
- 7.2.6 Temperature detectors to be platinum resistance type, 100 ohm, 0°C, coefficient $3,85 \times 10^{-3}$.
- 7.2.7 For transformers rated over 5 MVA, the tap changer control handle shall be accessible for operation from floor level, if required in the Material Requisition.
- 7.2.8 For transformers rated over 1,6 MVA, the roller gauge shall be 1435 mm. or as specified in the Material Requisition.

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7.3 AUXILIARY TERMINAL BOXES AND CONTROL PANELS

7.3.1 AUXILIARY TERMINAL BOXES

Alarm, control, measuring and in general auxiliary wiring shall be terminated in suitable auxiliary terminal box or boxes.

- The degree of mechanical protection shall be not less than IP 45.
- Cable entry shall be with suitable cable glands or conduit as specified in the Material Requisition.
- Terminal strips shall be of the composite type, fixed on standard profile.
- Terminals relevant to different functions (alarms, controls, measuring etc.) shall be grouped together and properly identified; only one wire per terminal shall be permitted.
- Terminals shall be of the non loosening type and shall be suitable for 2,5 mm² wire cross-section minimum.
- The internal of boxes shall be with anticondensing coating.
- Opening of covers or doors shall be by key or special tool.
- The connection diagram shall be engraved indelibly on the internal surface of cover.

7.3.2 CONTROL PANELS

Circuit breakers on supply feeders for power and control circuits shall be interlocked with the door.

Control device of airfans, oil pumps and for on load tap changer shall be housed in suitable control boxes or panels. The complete **para 7.3.1** applies also to control panels, with the following additions:

- Terminals relevant to power circuits shall be separated from terminals relevant to other circuits with suitable separators.
- For A.C. power supply and connections to motors and space heaters, terminals shall be suitable for 6 mm² wire cross section; for D.C. power supply terminals shall be suitable for 4 mm² wire cross section.
- Space heaters shall be provided in each control panel and shall be controlled by a thermostat.
- Equipment insulation test voltage shall not be less than 2 kV.

7.4 AUXILIARY SWITCHES AND CONTACTS

In general auxiliary contact rating shall not be less than the values indicated below:

Circuit	Control	Alarm & Signaling
Ampacity	10 A	2 A
Breaking capacity at 110 V D.C. or at 230 V A.C.	2 A inductive	0,5 A inductive

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7.5 AUXILIARY WIRING

In general, wiring between auxiliary devices and terminal boxes or control panels shall be with cables fixed to the transformer tank and mechanically protected. Cable type shall be suitable for the expected temperatures and for the stresses due to transformer vibrations.

Connections to air fans shall be protected with flexible metallic conduit.

Generally cable mechanical protection shall be by means of rigid or flexible metal conduit.

Vendor to furnish details in the bid.

Wires and terminals shall be with insulation class 1 kV (3 kV test voltage).

Cable entries into connection boxes and control panels shall be from below and through cable glands.

7.6 PAINTING AND RUST-PREVENTING PROTECTION

Surfaces of transformers shall be treated to withstand service conditions. The outside finish shall be an oil resistant paint, colour shall be as per Vendor standard, unless otherwise specified in the Material Requisition.

Vendor to consider exposure to solar radiation in selecting colour and type of paint and to specify in the bid.

Surfaces shall be treated with at least:

- Two coats of primer paint.
- Two coats of intermediate paint.
- Two coats of oil resistant finishing paint.
- The internal parts shall be painted or treated to make them resistant against corrosion of insulating oil.

All bolts, nuts and tags, etc. shall be made of corrosion resisting material.

8.0 ON LOAD TAP CHANGER

8.1 CONTROL PANEL

Control panel and auxiliary terminal boxes shall comply with **para 7.3, 7.4 and 7.5** and in addition, as far as applicable, the control panel shall include the following:

- Auxiliary relays as required.
- Local control push-buttons; these push-buttons shall be active only for testing and shall be excluded by means of a key-lock-out device.
- Operating indicating lamps.
- Operations counter.
- Terminals for remote position signaling contacts.
- Terminals for remote operating indicating lamps.
- Terminals for remote alarm:
 - Abnormal operation of the mechanism.
 - Trip of protection miniature circuit breakers.

8.2 PERFORMANCE REQUIREMENTS

The crank for manual operation shall be provided with a disconnect device acting on the control of the drive motor.

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Operation of the crank shall be at floor level.

The device requested to prevent the operation of the on load tap changer when the current exceeds 200% of rated current value shall be included in the supply of the automatic voltage regulator (see Material Requisition).

On load tap changer shall comply with **ELOT EN 60214-1** and **IEC 60214-2** and with codes and standards of the country of origin.

Number of steps and relevant per cent of each steps shall be indicated in the Material Requisition.

9.0 NAMEPLATE DATA

Transformers shall be tagged with nameplates and additional plates of stainless steel or equivalent corrosion-resistant material as follows:

Nameplate according to applied standards.

Additional nameplate shall be stamped with the following data:

- a. Type of oil and Manufacturer.
- b. Transformer item.
- c. Performance data with operation conditions different from rating (forced cooling, abnormal supply conditions etc.).

Auxiliary terminal boxes and control panels shall have plate indicating function for manual operations.

All equipment shall bear the CE mark.

10.0 TESTS

Extent and method of tests to be carried out shall be as specified by applicable standards.

The transformer tests carried out in the Vendor's workshop shall be witnessed by Contractor and/or Owner's Inspector.

10.1 ROUTINE TEST

All transformers shall be submitted to acceptance routine test and the cost of this test shall be included in the transformer price.

The routine test shall be as follows:

- Measurement of voltage ratio and check of phase displacement.
- Measurement of winding resistance.
- Dielectric routine tests according to **ELOT EN 60076-3**.
- Measurement of load loss and of short-circuit impedance.
- Measurement of no load loss and of no load current.
- The tap changer shall be submitted to acceptance test as required by applicable Standards.

10.2 TYPE AND SPECIAL TESTS

The transformers shall be submitted to type and special tests, only if requested in Material Requisition.

The cost of tests shall always be quoted separately in the transformer bid.

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The prototype tests shall be as follows:

- Impulse type tests according to **ELOT EN 60076-3**.
- Temperature - rise test according to **ELOT EN 60076-2**.
- Prototype test of the bushings as per applied standard.

The special tests to be performed shall be determined in the Material Requisition and shall be one or more of the following:

- Dielectric special tests (**ELOT EN 60076-3**).
- Determination of capacitances windings-to-earth and between windings.
- Determination of transient voltage transfer characteristics.
- Measurement of zero-sequence impedance(s) on three-phase transformers.
- Short-circuit withstand test (**ELOT EN 60076-5**).
- Determination of sound levels (**ELOT EN 60076-10**).
- Measurement of the harmonics of the no-load current.
- Measurement of the power taken by the fan and oil pump motors.
- Measurement of insulation resistance to earth of the windings, and/or measurement of dissipation factor ($\tan \delta$) of the insulation system capacitances. (These are reference values for comparison with later measurement in the field).

If test methods are not prescribed in the standards, or if tests other than those listed above are specified in the Material Requisition, such test methods are subject to agreement.

10.3 ADDITIONAL TANK TEST FOR SEALED TYPE TRANSFORMERS

For sealed type transformers, before final sealing, the complete transformer shall be filled with oil and subjected to a hydraulic pressure test.

The pressure shall be stated in the bid.

No loss of pressure for 24 hours shall be detected.

After test the oil level shall be adjusted to its correct value and the filler cap sealed.

11.0 GUARANTEED QUANTITIES

Guarantees shall be given upon the quantities considered in the applicable standards and for the conditions specified therein or specified as "RATED" in the Material Requisition.

Unless otherwise required, any other quantity or special condition specified in addition to, or awaiving from the applicable standards, or specified in Material Requisition as "INFORMATIVE", have to be considered as informative.

12.0 INFORMATION REQUIRED FROM VENDOR

12.1 INFORMATION FROM VENDOR

Information from Vendor shall be as listed below but not limited to:

- Type of transformer.
- Applied standards.
- Rated power.
- Rated current.
- Connection diagram.
- Impedance voltage at rated tap and self-cooled rating.
- Load loss.
- No load current.
- No load loss, at 100 and 110 per cent rated voltage.

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- Core weight.
- Coils weight.
- Oil weight.
- Volume of liquid, in liters.
- Type of oil furnished.
- Total assembled transformer weight - removable part weight.
- Outline drawings with dimensions, including motor information when fans are specified.
- X/R ration at rated tap.
- Vector group.
- Paint specifications.
- Exciting current at 100 and 110 per cent rated voltage (amperes or percent).
- Deviations from specification and Material Requisition.
- Additional data suggested by Vendor.
- Transformer descriptions.
- Test reports shall be submitted to the Purchaser for each transformer.
- For sealed type transformers:
- Pressure value of hydraulic pressure test.

12.2 LOADING GUIDE

After order placement the Vendor shall furnish the loading guide of the transformer, in accordance with **IEC 60354** "Loading Guide for Oil Immersed Transformers".

13.0 SPARE PARTS

Unless otherwise specified in Material Requisition, Vendor shall quote for each type and size of transformer at least the following spare parts:

- | | |
|---------------|---------------------------------------|
| - Thermometer | - Buchholz or gas relay. |
| - Radiator | - Complete column with enclosure. |
| - Bushing | - Auxiliary motor if any. |
| | - Contacts and alike for tap changer. |

Additional spare part may be suggested by Vendor.

All spare parts shall comply with the original specification and tests, and shall be suitable for replacing the relevant parts as originally fitted.

14.0 JOINT RESPONSIBILITY

In case of assembled transformer units such as:

- Assembled load-center unit substation,
- Bus duct connected transformer,

and when specified in the Material Requisition, the Vendor of the transformer shall contact directly the Vendor of the assembled unit, in order to exchange any information required for the perfect matching of the unit's features (copy of letter to Contractor).

Both the Vendor of the transformer and the Vendor of the assembled unit shall be held jointly responsible for the satisfactory performance of the assembly as a whole. The position and shape of the flange shall be an optimum for the transformer and assembled unit and for the installation.

The problem of restricted heat dissipation between transformer and assembled unit shall be considered.

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In particular both Vendors shall study and agree the method for fixing and connecting bushing terminals and bus bars from the point of view of thermal and dynamic stresses. Also, arrangement for combined short circuit test shall be agreed.

15.0 ATTACHED DOCUMENTS

1. **Figure 1**
[Typical Boxes for Low Voltage Side 1kV) - Typical Arrangement]
2. **Figure 2**
[Typical Boxes for Medium Voltage Side (> 1 kV) - Typical Arrangement]
3. **Figure 3**
[Typical Boxes for Medium Voltage Side (> 1kV) - Typical Arrangement]

REFERENCED DOCUMENTS

1. **EN 60076**
[Power Transformers]
2. **EN 60076-1**
[Power Transformers - Part 1 : General]
3. **EN 60076-2**
[Power Transformers - Part 2 : Temperature Rise]
4. **EN 60076-3**
[Power Transformers - Part 3 : Insulation Levels, Dielectric Tests and External Clearances in Air]
5. **EN 60076-4**
[Power Transformers - Part 4 : Guide to the Lightning Impulse and Switching Impulse Testing Power Transformers and Reactors]
6. **EN 60076-5**
[Power Transformers - Part 5 : Ability to Withstand Short Circuit]
7. **EN 60076-10**
[Power Transformers - Part 10 : Determination of Sound Levels]
8. **EN 60079**
[Electrical Apparatus for Explosive Gas Atmospheres]
9. **EN 60214-1**
[Tap Changers - Part 1 : Performance Requirements and Test Methods]
10. **EN 60617**
[Graphical Symbols for Diagrams]
11. **IEC 60027**
[Letter Symbols to be used in Electrical Technology]

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- 12. IEC 60050**
[International Electrotechnical Vocabulary]
- 13. IEC 60076-8**
[Power Transformers - Part 8 : Application Guide]
- 14. IEC 60076-11**
[Power Transformers - Part 11 : Dry Type Transformers]
- 15. IEC 60085**
[Electrical Insulation Thermal Classification]
- 16. IEC 60214-2**
[Tap / Changers - Part 2 : Application Guide]
- 17. IEC 60354**
[Loading Guide for Oil-Immersed Power Transformers]
- 18. IEC 60616**
[Terminal and Tapping Markings for Power Transformers]
- 19. IEC 60905**
[Loading Guide for Dry-Type Power Transformers]
- 20. 2004/108/EC**
[EMC Directive]
- 21. 93/68/EEC**
[Low Voltage Directives]
- 22. 98/37/EC**
[Machinery Directive]
- 23. 94/9/EC**
[ATEX Directive]