POWER TRANSFORMERS

Revision	Data	List of modifications
00	29/11/2013	First emission
01	15/01/2014	General editorial improvements Local Section updated for dimensions and CT prescriptions
02	18/06/2020	General editorial improvements Amendments integration (2017-2018, Painting guide 2018) Efficiency requirements for Europe General criteria for common features updated: Service Conditions, Rated Power, common Insulation Voltage Levels, Voltage Regulations, bushings interchangeability, Sound Levels, Common Accessories and Tank constructive details, Polymeric Bushings and Documentation, as main referred updates.
03	20/01/2025	Issuing the 3-edition corresponding to the organizational changes

Department	Redacted	Verified	Approved	Date
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CONTENTS

1. SCOPE

The scope of this document is to provide technical requirements for the supply of the power transformers to be used in the distribution networks of the RETELE ELECTRICE.

This document is structured as follows:

■ The “Common Part” with the common requirements for all the all type of transformer HV/MV or MV/MV.

■ The “List of Components” (Annex A) with the Type Code/ Material Code for each transformer of the RETELE ELECTRICE. The “List of Components” may be revised without revision of this Standard.

■ The “Datasheet” (information at Annex B) with the main ratings and requirements of each transformer type. Datasheet files for the required transformers are part of this Standard.

■ The “Technical Offer” document for the technical information (example at Annex C) with the main technical data to be submitted during the tender.

2. LIST OF COMPONENTS

The list of components with the transformers type codifications is reported in the Annex A. The Common List contains the transformers feature-data and it is used for the Datasheet compilation.

3. REFERENCE LAWS AND STANDARDS

The lists of reference laws and standards, relevant for this document, are reported here below.

3.1. LAWS

The efficiency performance of the transformers shall comply with the related :

- European Commission Regulation (EU) No 548/2014 on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers and the corresponding amending Commission Regulation (EU) 2019/1783 of 1 October 2019.

- Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

- L 319/2006 – Occupational health and safety act, as amended and supplemented.

- L 265/2006 - Environmental Protection Act, as amended and supplemented.

- Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives – consolidated version.

3.2. INTERNATIONAL STANDARDS

For Romania the reference standards are the IEC/ISO and shall prevail the correspondent European reference standards (EN).

IEC 60076-1 Power transformers - Part 1: General.

IEC 60076-2 Power transformers - Part 2: Temperature rise for liquid-immersed transformers.

IEC 60076-3 Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air.

IEC 60076-5 Power transformers - Part 5: Ability to withstand short circuit.

IEC 60076-7 Power transformers - Part 7: Loading guide for oil-immersed power transformers.

IEC 60076-10 Power transformers - Part 10: Determination of sound levels.

IEC 60076-10-1 Power transformers - Part 10-1: Determination of sound levels – Application Guide.

IEC 60076-18 Power transformers - Part 18: Measurement of frequency response.

IEC 60076-22 series Power transformer and reactor fittings - Protective devices.

IEC 60085 Electrical insulation - Thermal evaluation and designation

IEC 60137 Insulated bushings for alternating voltages above 1 000 V.

IEC 60296 Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear.

IEC 60641-2 Pressboard and presspaper for electrical purposes - Part 2: Methods of tests.

IEC 62770 Fluids for electrotechnical applications - Unused natural esters for transformers and similar electrical equipment.

IEC 61099 Insulating liquids - Specifications for unused synthetic organic esters for electrical purposes.

IEC 60422 Mineral insulating oils in electrical equipment - Supervision and maintenance guidance.

IEC 60599 Mineral oil impregnated in electrical equipment in service - Guide to the interpretation of dissolved and free gases analysis.

IEC 61198 Mineral insulating oils - Methods for the determination of 2-furfural and related compounds.

IEC 60666 Detection and determination of specified additives in mineral insulating oils.

IEC 62535 Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil.

IEC 60815 Guide for selection and dimensioning of high-voltage insulators for polluted conditions.

IEC 60214-1 Tap-Changers - Part 1: Performance requirements and test methods

IEC 60214-2 Tap-Changers - Part 2: Application guide.

IEC 61462 Composite hollow insulators - Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1000 V - Definitions, test methods, acceptance criteria and design recommendations.

IEC 62155 Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltage greater than 1000 V.

IEC 62217 Polymeric HV insulators for indoor and outdoor use - General definitions, test methods and acceptance criteria.

IEC 62271-209 High-voltage switchgear and controlgear - Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV and above.

IEC 62271-211 High-voltage switchgear and controlgear - Part 211: Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages above 52 kV.

IEC 60529 Degree of protections provided by enclosures (IP Code).

IEC 60947-7-2 Low-voltage switchgear and controlgear - Part 7-2: Ancillary equipment – Protective conductor terminal blocks for copper conductors.

IEC 60417-2 Graphical symbols for use on equipment - Part 2: Symbol originals

IEC 60751 Industrial platinum resistance thermometers and platinum temperature sensors

ISO 12944 series Paints and varnishes - Corrosion protection of steel structures by protective paint systems.

ISO 19840 Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces.

ISO 8501 Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness.

ISO 2178 Non-magnetic coatings on magnetic substrates - Measurement of coating thickness - Magnetic method.

ISO 2808 Paints and varnishes - Determination of film thickness.

ISO 2409 Paints and varnishes - Cross-cut test.

EN 50708 series Power transformers - Additional European requirements.

EN 50180 Bushings above 1 kV up to 52 kV and from 250 A to 3,15 kA for liquid filled transformers.

EN 50181 Plug-in type bushings above 1 kV up to 52 kV and from 250 A to 2,50 kA for equipment other than liquid filled transformers.

CLC/TS 50458 Capacitance graded outdoor bushing 52 kV up to 420 kV for oil immersed transformers;

and all the Standards referred in those listed above.

When the date of issue is not mentioned in the list above, the date to be taken as reference is that of the standard in force when the present document has been issued.

3.3. LOCAL STANDARDS

SR EN 50216 (Series) Accessories for Power Transformers and Reactance Coils (Part 1 to Part 12)

SR EN 50299 Oil-filled Terminals for Highest Voltage Transformer and Reactance Coil Connection Cables for Um Equipment from 72.5 kV to 550 kV

EN 60068-3-3 Environmental testing - Part 3: Guidance - Seismic test methods for equipments

EN 13674-1 Railway applications - Track - Rail - Part 1: Vignole railway rails 46 kg/m and above

SR EN ISO 1461 Requirements for Verification of Hot Dipped Galvanizing on Ferrous Components Used in Lines and in Electrical Installations

3.4. OTHER RELEVANT DOCUMENTS

3.5. REPLACED STANDARDS

GST002 rev01 & rev02

4. SERVICE CONDITIONS

Transformers are generally used for step-down voltage purpose but they can also be used as step-up. In the network, they could occasionally be subjected to frequent energizations, over voltages and short-circuits.

Unless otherwise specified the normal service conditions of IEC 60076-1 apply with the following exceptions:

Country	*Altitude (m)*	*Pollution level (IEC 60815)*	*RUSCD (mm/kV)*	*Seismic Req.(1)*	*Network Frequency*	*Ambient Temp (Min/Max)*	Corrosivity (ISO 12944)
Romania	--	Heavy	43,3	0,5g	50 Hz	-30/+40 ºC	C4

The seismic qualification level is: AG5 - EN 60068-3-3, with reference to the value indicate in the table above, corresponding to 5 m/s on the ground, for the transformers fully assembled with components and accessories.

5. RATINGS

For the definitions, IEC 60076-1 applies.

5.1. TYPES OF TRANSFORMERS

This document is applicable for liquid immersed transformers or auto-transformers, three-phase, bi-phase and single-phase, step-up or step-down and refers to the following types of transformers:

- Separate windings Transformer (TR).

• Auto-Transformer (ATR).

Separate windings Transformers are usually HV/MV, but they can also be HV/HV or MV/MV, in such cases they are conventionally indicated as HV/MV in the present standard.

For further details see annexes.

5.2. NUMBER OF WINDINGS

The standard value is 2.

5.3. NUMBER OF PHASES

The standard value is 3.

5.4. COOLING SYSTEM

The standard system is ONAN, other systems are specified in the annexes.

5.5. RATED POWER

See annexes.

Preferred Rated Powers shall be 10, 16, 25, 40, 63 MVA.

Other values according to IEC can be prescribed only if strictly necessary.

These values of power are referred to ONAN, or alternatively ONAN-ONAF (with ONAN=0,8·ONAF).

5.6. RATED VOLTAGES

The standard values for the HV part are 115 kV.

The standard values for the MV part are 20.8 kV, 10.4 and 20.8-10.4 kV.

See annexes.

5.7. RATED FREQUENCY

Rated value is 50 Hz.

5.8. VOLTAGE REGULATION

The standard value is ±12 x 1.5%.

5.8.1. HV regulation

When specified, the HV windings shall be provided with voltage regulation according to the values specified.

5.8.2. MV regulation

Secondary regulation shall be done preferably by copper bars connections under the tank cover (“intanked” bars), accessible through a specific windows on the cover, after lowering the oil level.

5.9. WINDINGS CONNECTIONS

The standard connection is YnD11.

When requested, the parameters for double voltage connection (i.e. 20,8 and 10,4 kV) or delta/star connection are indicated in annexes/Datasheets.

5.10. INSTALLATION

The type of installation can be indoor or outdoor.

5.11. HV AND MV NEUTRAL

The MV neutral connection shall be suitable for the connection of the neutral point with the Petersen coil. Specific prescriptions are given in the clauses of the design requirements.

5.12. OVER-LOAD CAPABILITY

According to IEC 60076-7.

No limitation of the transformer power supply shall come from the capability of the bushings, the on-load tap changer and all the other accessories and auxiliary equipment.

The hot-spot temperature of the windings shall be calculated by a proper method, according to IEC 60076-2.

5.13. BUSHINGS

The bushings shall be compliant with IEC 60137.

All the bushings shall be marked with unalterable name plates, fixed on the tank cover at the base of the bushing, visible from both the HV and MV side, reporting the symbols indicated in annexes.

The bushings shall be selected according to the transformer rated power, rated voltages and their interfaces in the substation.

The bushing types for the main transformer typologies (historically called “unified transformers”) are indicated in Table 1, different solutions can be requested for specific rated power and voltages, in this case indications are given in the datasheet of the transformer.

The type of HV and MV bushing interfaces with the network (Oil/Air – Oil/Oil – Oil/SF6) for the main transformer typologies are given in the List of Components. The main characteristics of the bushing types are in sub- clauses of 7.1.

If optionally requested the MV bushings shall be of plug-in type as specified in 7.1.2.4.

The bushings shall be marked as indicated in the following:

- HV: 1U, 1V, 1W and 1N
- MV: 2U, 2V, 2W

TABLE 1 – HV AND MV BUSHINGS TYPE

Transformer Rated Power (MVA)	**MV Bushing type (EN 50180)**			**HV Bushing type**
	MV Rated Voltage of transformers (kV)			HV Connection type
	10,4	20,8	20,8-10,4	Overhead Line
10	24-630/P3	24-630/P3	24-1250/P3	O/A U_m 145 kV for U_r 115 kV
16	24-1250/P3	24-1250/P3	24-2000/P3	
25	24-2000/P3	24-1250/P3	24-2000/P3	

40	24-2000/P3	24-2000/P3	24-3150/P3	
63	24-3150/P3	24-3150/P3	--	

5.13.1. HV Bushings

With regard to the type of connection with the HV feeders, four different types are defined:

- Oil/Air (O/A) bushings.
- Oil/SF6 (O/S) bushings.
- Oil/Oil (O/O) bushings.
- Plug-in type (Plug-in) bushings

The type of HV bushings, for each transformer type, is indicated in annexes.

All the bushings, from Um 72,5 kV, shall be of the capacitor type. Bushings technologies to be considered shall be OIP, RIP or RIS.

5.13.2. MV Bushings

MV bushings shall be of the following types:

- Polymeric type Oil/Air (O/A) bushings.
- Porcelain type Oil/Air (O/A) bushings.
- Plug-in type (Plug-in) bushings.

5.14. INSULATION LEVELS

The insulation levels for the main transformer typologies (historically called “unified transformers”) are indicated in Table 2, specific values are reported in the datasheet of each transformer.

TABLE 2 – INSULATION LEVELS

Rated voltage (U_r)	Highest voltage for equipment (U_m)	Lightning impulse (LI)	Applied voltage (AC)
(kV)	(kV)	(kV)	(kV)
115	145	550	230
20,8	24	125	50
10,4			

Note: HV Neutral insulation can be uniform insulation in cases where Neutral is not directly connected to earth and of Um 72,5 kV in cases where is directly connected to earth.

5.15. LOSSES AND SHORT CIRCUIT IMPEDANCES

Short Circuit impedances are given in annexes.

For Romania (European countries), the prescribed values of Efficiency Index (EI) at the required Load Factor (kEI), shall be in compliance with the level of efficiency Regulation PEI – TIER2, with the additional following indications.

For the Efficiency Index (EI) at the prescribed Load Factor (kEI), the Losses shall be calculated according to the following formula to take into account the influence of the voltage regulation:

$$P_k = \frac{P_{k+} + P_{k1} + P_{k2} + P_{k-}}{4}$$

Where:

Pk Load Loss calculated (guaranteed value)

Pk+ and Pk- Load Loss values at the extreme voltage regulation positions.

Pk1 and Pk2 Load Loss values at the possible principal voltage positions (the same in case of reversing voltage regulation and respectively with coarse IN (connected) and fine OUT (disconnected) and vice versa, in case of coarse-fine voltage regulations).

Note: These requirements are deemed necessary to compare different types of voltage regulations and to take into account the effective load of the transformer in operation.

Anyway, in the rating plate shall be reported the corresponding PEI, kPEI, No Load Loss values and Load Loss values, related to the principal tap (according to Regulation).

All European DSO shall accomplish what shall apply for the standard series EN 50708.

Losses may also be prescribed by giving maximum values and/or capitalized values according to local rules or regulation.

If the capitalization of losses applies, the related capitalization factors are specified in the offer request. The capitalization of losses is given by:

Cc = C + A × Pv + B × Pj

Where:

Cc is the capitalized cost of the transformer (expressed in the appropriate currency)

C is the cost declared by the Manufacturer in the offer (expressed in the appropriate currency)

A is the no-load loss factor (expressed in the appropriate currency per kW) (1)

B is the load loss factor (expressed in the appropriate currency per kW) (1)

Pv is the no-load loss declared by the Manufacturer (expressed in kW)

Pj is the load loss declared by the Manufacturer (expressed in kW)

(1) Values given at tender stage

The prescribed values for the main transformer typologies (historically called “unified transformers”) are indicated in Table 3, specific values are reported in the datasheet of each transformer.

TABLE 3 - LOSSES AND SHORT CIRCUIT IMPEDANCES

Rated Power (Sr)	Efficiency Index (EI)	Load Factors (LF)	Short circuit impedance on tap position

(MVA)	(%)	(pu)	Min. tap (%)	Central tap (%)	Max. tap (%)
10 (all voltages)	PEI Tier 2	0,35	7,62	8,25	**9**,21
16 (all voltages)	PEI Tier 2	0,35	12,2	13	14,1
25 (all voltages)	PEI Tier 2	0,35	13,7	14,6	15,8
40 (20,8 and 10,4 kV)	PEI Tier 2	0,34	14,6	15,5	16,8
40 - double voltage 20,8-10,4 kV	PEI Tier 2	0,34	19,4	20,5	22
63 (20,8 and 10,8 kV)	PEI Tier 2	0,33	21,2	22,5	24,2
The prescribed short circuit impedance values are sufficiently high to take into account that the HV regulation could be either of the reversing type or coarse-fine type					

RESIDUAL ZERO-SEQUENCE IMPEDANCE

The short circuit impedances and related voltage drops shall not affect significantly the network parameters monitored by the protection and network control systems to ensure their correct functioning with the MV neutral grounded through Petersen coil.

Such requirement is verified by the conventional test of the residual zero-sequence impedance of the MV side of the transformer under rated power supply, as reported in the chapter relevant to the tests.

The residual zero-sequence impedance values shall be:

■ For 10-16-25-40 MVA transformers: < 0,6% of the MV rated single phase voltage (ex $10,4/\sqrt{3}$ or $20,8/\sqrt{3}$)

■ For 63 MVA transformers: Not applicable

In case of transformer with double voltage level on the MV side, it shall be taken as reference $20,8/\sqrt{3}$ kV.

5.15.1 Penalties for losses

If the losses exceed the maximum tolerance limits admitted by IEC 60076-1 or local regulation (if case), the transformer is rejected.

For the measured losses exceeding the values declared by the Manufacturer, within the tolerance indicated in 5.23, penalties will be applied.

The calculation of the penalties to apply to the single transformer is the following:

$Lv = 2 \times A \times \Delta Pv$

$Lj = 2 \times B \times \Delta Pj$

Where:

Lv penalties for no-load loss excess (expressed in the appropriate currency);

Lj penalties for load loss excess (expressed in the appropriate currency);

ΔPv difference between measured no-load loss and no-load loss declared by the Manufacturer (kW);

ΔPj difference between measured load loss and load loss declared by the Manufacturer (kW).

5.16. OVER-EXCITATION CONDITIONS

In compliance with IEC 60076-1.

Moreover, the transformer shall be able to operate at no-load with a magnetic flux in the core increased by the 10% of the nominal magnetic flux (therefore, the prescriptions relevant to the off-load current and the over-temperature of the core shall take into account such an over-excitation condition).

5.17. NO-LOAD CURRENT

The no-load current at the rated voltage shall be ≤ 0,2 % of the rated current.

On over-excitation condition, with the magnetic flux increased by 10% of the nominal flux, the no-load current shall be ≤ 0,5 % of the rated current.

5.18. OVER-TEMPERATURE OF THE CORE

According to IEC 60076-1 and IEC 60076-2.

For transformers with a rated power of 63 MVA or higher, the surface temperature of the magnetic circuit shall not exceed 75°C.

5.19. CAPABILITY TO WITHSTAND SHORT-CIRCUIT

The transformers shall be able to withstand the short circuit test in compliance with IEC 60076-5.

5.20. SOUND LEVELS

In compliance with IEC 60076-10 and IEC 60076-10-1.

The preferred sound values for each cooling regime are indicated in the next table:

S_r (MVA)	Primary High Voltage (U_m) - Cooling System ≤170 kV	
	ONAN	***ONAF***
10	60,7	80,7
16	63	83
25	66	86
40	70	90
≥63	74	94

TABLE 4: NOISE LEVEL

Different values may be prescribed in the Datasheets, according to Romanian regulations or needs.

5.21. OVERALL DIMENSIONS

The dimensions and the position of the main accessories for the main transformer typologies are shown in the Figures listed below, different requirements can be reporteted in the datasheet for specific type of transformer.

■ Transformers with Oil/Air HV bushings: Figures 1,2 and 3

■ Supporting plates: Figure 4

5.22. RATING PLATES

In compliance with IEC 60076-1.

In addition to all the data specified in the related standard, the following information shall be added:

- Maximum Ambient Air Temperature, if different of Normal value (ºC).
- Maximum Altitude, if different of Normal value (m.a.s.l).
- Sound level referred to Sound Power, in dB(A).
- Standard Code and Material Code (TAM).
- Scheme of the “intanked” bar connections (winding connection changes - double voltage transformers, Y-D changes, etc) to achieve the possible configurations of the transformer.

Additional requirements are given in EN 50708-1-1.

Two rating plates shall be provided, and shall be fixed on appropriate supports on the longer sides of the transformers, on exactly opposite positions.

The rating plates shall be in local languages of the country of destination of the transformer.

The rating plates shall be resistant to atmospheric conditions and made of waterproof material.

5.23. TOLERANCES

The admitted tolerances are the values prescribed in IEC 60076-1, if not otherwise specified.

- Guaranteed Losses values: Penalties indicated in 5.15.1 apply for values over the guaranteed losses.
- Prescribed EI value (@kEI): Penalties apply for the losses exceeding (within the respect of Regulation).
- Sound level: No positive tolerance is admitted.

6. DESIGN REQUIREMENTS

Unless otherwise specified, the transformers shall comply with IEC 60076-1 standard; the single parts of the transformers shall comply with the relevant standards.

6.1. CORE AND FRAME

The core and the frame shall be connected to ground on the external part of tank (usually the cover) by two proper bushings. Such connections inside the tank shall be made with insulated copper wirings of proper section (taking into account the value of the short circuit current and in any case not less than 50 mm^2).

Possible magnetic shields have to be connected to ground in the same way, by an additional third bushing, or directly to the tank where leaned down.

The above mentioned bushings shall be connected to the ground on the cover tank, in a box easily accessible such that to facilitate the verification of the proper insulation.

6.2. WINDINGS

The windings shall be made with electrolytic copper conductors, insulated with paper, or with continuously transposed cables.

In case of continuously transposed cables resin bonded, a sample shall be provided for each winding in order to check the polymerization degree reached during the treatment. The procedure for the verification of the polymerization degree is reported in the chapter 8.2.1.1 relevant to the tests.

6.3. HV AND MV NEUTRAL

The MV neutral of the transformer shall be able to withstand the current values indicated in the following Table 5 for one minute long in such a way that the maximum over-temperature of the tank (usually detectable on the middle of the tank itself-regenerating) will not exceed 70 K.

The section of the neutral conductor shall be the same of the phase conductors.

TABLE 5 - NEUTRAL CURRENT

Rated power (MVA)	Neutral current (A)
10	250
16	400
25	720
40	920
63	Not applicable

Note: the scope of this prescription, and of the relevant test, is the verification of the maximum over-temperature reached by the tank during the application of the above indicated neutral current in order to prevent generation of gas bubbling in the oil and degradation of the painting of the tank.

6.4. TANK

The tank shall be manufactured such that to not allow neither the water accumulation on the external surface nor gas/air accumulation below the cover and inside the tank.

The tank shall be vacuum proof. The tank shall not show appreciable permanent deflections as prescribed in vacuum test and in relevant standard.

The withstanding of the different joints (tank-cover, tank-flanges, cover-flanges, etc) shall be made through seal-gasket able to withstand the hot insulating liquids.

All the materials of the tank shall be chosen to prevent corrosion processes.

The couplings of the tank and the different pipes shall be made with uninterrupted metallic connections to guarantee the metallic continuity.

The tank shall be provided with the following auxiliaries. Indication of the positions and/or additional requirements of these auxiliaries are given in annexes:

1) **Supporting plates** on the base for the lay down of the transformer, provided with holed bolts to allow the installation of wheels (if wheels are required).

2) **Four shelf plates/supporting plates** for hoisting the transformer by means of lifting jacks (jacking points, jack pads), making possible, among other functions, to change wheels direction. The manufacturer will indicate the relative location for these supporting plates according to the best performance.

3) **Lifting points/hooks** for tying up/hooking slings or lifting chains, to lift the completely assembled transformer, the extractable part (cover and active part) and the conservator.

4) **Pulling eyes/hooks** for horizontal movement of the transformer in the two orthogonal directions, to be positioned at the bottom of the transformer close to the base..

5) **Two grounding/earthing terminals** on the opposite walls of the tank, each of them shall be according to IEC-60076-22-7 (Earth terminal type B7) positioned at the base of the tank (at the longest sides).

6) **Frames for fans fixing/supporting**. If required, the tank shall have the proper supporting system to fix and hold the fans. The fan's frame shall be directly fixed on the tank walls and shall be completely independent from the radiators.

6.4.1 Tank Cover

The transformer tank/cover shall be built to avoid stagnation of water on the cover and a proper inclination shall be considered to facilitate the gas evacuation.

In order to avoid water flowing through the cover holes (any of them), there shall be frames (welded on the tank cover) that will elevate them over the cover level, at least 15 mm.

6.5. INSULATING LIQUID AND MATERIAL

For general purpose, the insulating liquid shall be compliant to IEC 60296, class "U", without any anti-oxidant additive. The mineral oil shall not contain PCB.

Any other type of an insulating liquid required, shall be specifically indicated in the corresponding Datasheet.

It is forbidden the use of any insulating liquid, which presents characteristics such that to make it be classified as dangerous substance.

The insulating liquid Supplier and the insulating liquid type shall be clearly indicated in the rating plate and/or in the manual.

For the classification of hazardous oil, the Romanian law of reference is 265/2006 - Law on Environmental Protection, with subsequent amendments and completions.

The specific risks of oils classified as hazardous are identified by the "R45, R46 and R49 risk marking", listed in Law 265/2006.

The solid insulation material used shall be in compliance to class "A" (105°C) of IEC 60085 or higher. The evaluation of the material should be carried out in accordance with the IEC 60641-2. Materials with higher characteristics may be evaluated.

6.6. MV WINDINGS CONNECTIONS CHANGE

For transformer with double voltage level of the MV windings (i.e. 20,8-10,4 kV) and/or Y-D change, the connection changing shall be made by an in-tank bar connection located under the tank cover, accessible through specific windows, after lowering the oil level, if not otherwise specified.

6.7. COOLING SYSTEM

The cooling of the transformers is ONAN, carried out by radiators attached directly to the tank through flanges, with the interposition of suitable butterfly valves, according to the provisions of paragraph 6.8, to dismantle the radiators without emptying the oil from the tank**.**

6.8. ACCESSORIES AND AUXILIARIES

The mechanical and electrical accessories shall be compliant with IEC 60076-22, unless otherwise specified. The screws for the couplings among the different components shall guarantee a very good performance against corrosivity, and shall have a good durability. Screws having diameters ≤ M10 shall be of stainless steel.

The cases of all the devices shall be IP 55 accordingly to IEC 60529, unless otherwise specified.

Transformer shall be provided with the accessories/auxiliaries specified in the following:

1) **Conservator**, adapted to compensate the insulating liquid volume variation in the range -25 °C; +90 °C.

The conservator shall have two separated compartments. The main for the transformer and a second one appropriate to be used for the insulating liquid of the on-load tap changer. The liquids in the two compartments shall be the same and shall be kept separated.

Each of the two compartments shall be provided with:

1a) Liquid level indicator with the levels -20 °C, +20 °C, +85 °C and electric contacts for the minimum level alarms

1b) Tap for filling the liquid

1c) Tap for draining the liquid

1d) Removable side-wall or window for the inspection

1e) Piping system for the dehydrating breather connections

1f) Eyebolts for lifting, if necessary.

2) **Radiators** in compliance with IEC 60076-22-2 and moreover:

• Able to withstand vacuum conditions;

• Painted with the same protective cover of the tank (see clause 6.10)

• Each radiator will have the eyebolts necessary for lifting them, and will have a drain plug on its lower part and an air purging screw/device on its upper part.

• They shall be equipped with thermometer pockets at the inlet and outlet collectors (50 mm from each corresponding flange), to be used during the tests.

The coupling of the radiators and the tank shall be made in order to ensure the electrical continuity.

The radiators shall be connected directly to the tank by means of the butterfly valves indicated below.

3) **Two butterfly valves** for each radiator, in compliance with IEC 60076-22-7, on the connection pipes on the tank side.

4) **A set of blind flanges** with washers for locking the butterfly radiator's valves when the radiators are removed.

5) **Dehydrating breathers** with hygroscopic substances, self-regenerating (maintenance free), one for each compartment, mounted at man's height. The oil dehydrating devices shall be cobalt free and their control signals according to the DSOs requirements. Dehydrating breathers in compliance with IEC 60076-22-7.

The two dehydrating breathers may be replaced by only one device, considering that the dimensioning is made taking into account the total liquid content. In this case the two separated

compartments in the conservator shall be however maintained, and they shall be connected to the de-hydrating breather trough an unique pipe (without interception valves).

6) Two DN25 (1") shut-off ball valves for extracting liquid samples. Each valve shall correspond with the middle and the bottom parts of the tank (to get samples of the middle and bottom liquids). They shall be located on the front wall of the tank, in an accessible position, on the same vertical line and having their corresponding name plates. The one for bottom liquid shall be mounted no lower than 60 mm from the tank bottom.

All these valves will be independent from any other and shall have a flange provided with a nipple/male quick-acting/connecting metal coupler ISO B standard profile and its probe with a shut-off/ball locking mechanism (coupling thread DN10 (3/8")).

7) Two DN50 (2") shut-off ball valves for liquid treatment, with flanges closed by blind hinges. The two taps shall be mounted close to each other, on the lower part of the tank, and shall be connected through pipelines to two diametrically opposite zones of the tank in order to allow an optimal re-circulation of the oil. The tap mounted on the lower part shall be used also for the oil draining tasks. They will be placed on the frontal wall of the tank and the "lower one" shall be placed in such a way that a complete draining is permitted.

8) One valve for the vacuum pump, with spherical moving element.

9) Thermo-pockets (thermometer pockets) for the temperature measurement of the top liquid (OTI), for the WTI temperature sensor (if any), for the PT-100 probes and at least one spare, accordingly to IEC 60076-22-7, type - A1.

10) One liquid temperature indicator (quadrant thermometer) in complain with IEC 60076-22-1 for the liquid temperature measurement, elastically fixed on the tank wall with anti-vibration support.

ONAN: provided with two settable electric contacts for the maximum temperature alarm, with independent electric circuits (adjustable in a proper range for the insulating liquid):

■ Alarm threshold

■ Tripping Threshold

ONAF: provided with four settable electric contacts for the maximum temperature alarm and cooling system control, with independent electric circuits (adjustable in a proper range for the insulating liquid):

■ Fans Start-up

■ Fans Stop

■ Alarm threshold

■ Tripping Threshold

The following thresholds shall be set:

▪ Alarm threshold: 95 °C

▪ Tripping threshold: 105 °C

11) One PT-100 temperature sensor for the top liquid temperature monitoring. The sensor shall be in compliance with IEC 60751. It shall be a PT-100 (alpha 385), class A (tolerance class) and shall be connected to the marshalling box.

12) One Buchholz Relay, according to IEC 60076-22-1:2019 (7.1.2.8), mounted in the pipeline that connects the conservator and the tank. It will have two floats, provided with independent magnetic contacts (alarm/tripping), normally opened.

The relay set up (tripping contacts) for the liquid flux, shall be superior to 1,5 m/s, if not otherwise specifically indicated.

13) Two interception valves to be mounted both upstream and downstream of the Buchholz relay. In case of butterfly type valves (IEC 60076-22-7), a set of flanged pipelines trunks shall be provided in order to be installed when the Buchholz relay is removed.

14) **A Gas and Liquid Sampling Device** at man's height for gas storage in compliance with IEC 60076-22-1 shall be provided and mounted on the tank near the marshalling cabinet. Such a device will have a metallic body. All covers, pipes, flanges and adaptors able to house or retain gas shall be connected in a way to not keep gas accumulation. Piping shall not have a gradient less than 4%, shall be of copper material (internal ø of 5 mm) and shall be properly fixed to the tank.

15) **Oil flow relays for OLTC**, mounted in the pipeline that connects the compartment of the diverter switch of the OLTC and the relevant conservator compartment.

16) **Two interception valves**, to be mounted both upstream and downstream of each of the OLTC relay. In case of butterfly type valves (IEC 60076-22-7), a set of flanged pipelines trunks shall be provided in order to be installed when the relays are removed.

17) **Pressure Relief Devices (PRDs. "over-pressure valves**"). There shall be, at least, one PRD to prevent pressure increasing inside the tank in case of internal fault. The PRD shall be according to IEC 60076¬22-1 and shall be mounted on the tank cover with a directional type liquid spray protection in order to avoid spread, in open air, during the operation.

The size and the number of overpressure devices to be installed on the transformers shall be according to the quantity of insulating liquid, the size of the transformer and the PRD manufacturer specifications.

18) **Specific fall arrest system for the operator**. If requested, it is specifically indicated in Local Sections.

19) **Adjustable wheels/sliding rolls**, in compliance with EN 13674-1.

20) **Winding Temperature Indicators (WTI**), in compliance with IEC 60076-22-1, if specifically requested.

21) **Fans for ONAF cooling.** Fans shall be in compliance with IEC 60076-22-6.

General features for the transformer valves:

- They shall not be welded directly to the tank or pipes.
- They can be cast steel (DIN 1681 EN 10293), bronze or stainless steel valves.
- The actuating levers/handles of the valves shall show a clear logical identification for the OPEN or CLOSE states, due to their longitudinal or transversal position in relation to the valve collector.

For HV connection with GIS or cable, the following accessories shall be also provided:

22) **Three compensators for the GIS or oil cable boxes**.

23) **Four plates and relevant supports for the GIL** (Gas Insulated Transmission Line) or cable boxes

24) **Buchholz gas relays mounted on the pipe connecting the conservator and the relief junctions** of the bottom flange of the Oil-SF6 or Oil-Oil bushings.

For HV connections with cable, moreover the following accessories shall be also provided:

25) **Three oil cable boxes compliant with EN 50299**, if not otherwise indicated.

26) **Buchholz gas relays mounted** on the pipe connecting the cable boxes and the conservator.

Each accessory shall have its corresponding nameplate according to its standard specification and/or the indications on the annexes.

6.9. MARSHALLING BOX

All the electric circuits of the auxiliaries shall be attested to the marshalling box.

The identification of the connectors shall be in Romanian Language as reported in the attached Figures (translation is also given attached).

The marshalling box shall be installed on the tank in the shorter side opposite to the MV bushings.

The box shall have an IP 55 protection degree according to EN 60529 and shall be provided with appropriate door, laterally hinged, to be opened with either special key or removable door handle.

The box shall be realized with either stainless steel sheets or hot zinc-coated (EN ISO 1461 Standard) or with metallic not subject to corrosion.

The box shall be painted with the same transformer colour (7031 of the RAL F2 scale) by using painting cycles complaint with this specification. In case of stainless steel AISI 316 is used, the box can be not painted, but shall not produce burnings or glarings.

The box shall contain:

1) Lamp and single phase sock 230 V - 10 A, inserted in the warming circuit.

2) Heating resistances - One for the removal of the moisture always active and a second one activated by thermostat and protected by an automatic circuit breaker with NC contact provided in the marshalling box.

3) Marshallings detailed in Figures 5, 6 and 7.

4) Earth collector consisting of a copper plate 25 x 3 mm2 for the grounding of all the metallic parts and of the cable shields.

All connections wires shall have appropriate sections both with regard to the nominal operating current and the short circuit current (4,5 kA) of the power supply. All the wires conveying signals and to the actuations shall be realized with appropriate section conductors, in any case not smaller than 1,5 mm^2.

Wirings inside the cabinet shall be “not fire not-spreading”, with insulation level Uo/U = 450/750 V. At the terminals of the flexible conductors shall be applied compressed pre-insulated terminals and these terminals shall be identifiable with appropriate marks and/or indications.

All the wires for the connection between the marshalling box cabinet and the devices (apparatuses/auxiliaries) mounted on the transformer shall be laid into rigid steel pipelines; only terminals/trunks wires entering inside the devices and the cabinet could be laid, alternatively, into flexible pipelines. The flexible pipelines, withstanding to accidental impacts and crushings and the relevant screws, shall be made by stainless material. The supply voltage shall be:

- for the warming circuit: 230 V ± 10%, 50 Hz
- for the signalling and protection circuits: 110 V +10% -15% c.c.

The marshalling installed inside the box shall be of the modular type and structured as in the following.

- Marshalling box for the transformer: Figures 5 and 6
- Marshalling box for the on-load tap changer: Figure 7

The clamps shall be at indirect tightening, switable both rigid and flexible wires of section up to 4 mm^2, compliant with EN 60947-7-2 and mounted on appropriate metallic support.

The clamps shall be provided with appropriate name plates reporting the marks in compliance with the above mentioned Figure 6 and Figure 7.

The marshalling boxes and the eventual pipelines of the conductors shall be mounted in such a way that to facilitate the wirings of the conductors. In particular, between the gland plane and the marshalling boxes shall be left appropriate distances in order to facilitate the stripping of the cable and the connection of the cable shields to the earthing collector.

6.10. PROTECTIVE PAINTING

The external painting of transformers and metallic accessories, made of iron materials, shall use liquid epoxy or polyurethane paints and varnishes according to ISO 12944 (standardized paint

systems). Total Nominal Thickness[1] shall be fulfilled whatever the type of primers (Zn (R) or Misc.) used.

Pollution Levels	Corrosivity	Durability	Painting Category
Heavy	C4	Medium - High	***C4M or C3H***
Very Heavy	C5	Medium - High	***C5M or C4H***

The internal surfaces of the transformers, shall be protected by hot oil resistant painting (epoxy-polyamine or equivalent) having at least a thickness[1] ≥ 30 µm.

1 Total Dry Nominal Thickness according to NDFT and its acceptance criteria, as stated in ISO 19840 and ISO 2808.

All the surfaces to be painted shall be prepared by manufacturer with a suitable sandblasting or chemical cleaning (degreasing) treatments, specific for the painting cycle adopted The effectiveness of surface preparation work shall be assessed using standards from series ISO 8501: Preparation of steel substrates before application of paints and related products -- Visual assessment of surface cleanliness --.

Any other Coating System/Painting cycle, different from the one indicated above (even for those indicating the same Painting Category or superior), shall require the RETELE ELECTRICE's specific acceptance based on tests and certificates validated by independent third bodies, in compliance to ISO 12944 or equivalent standards.

The colour of the protective painting is 7031 of the RAL F2 scale.

The inner surfaces of the transformer (including the conservatory) will be protected with a hot oil-resistant paint (maximum temperature 110°C).

7. MAIN COMPONENTS

The Manufacturer of the transformer shall provide all the documentation to demonstrate the compliance of the components to this Standard and to the relevant standard.

7.1. BUSHINGS GENERAL REQUIREMENTS

For general purpose and unless otherwise specified, the bushings required by RETELE ELECTRICE shall have polymeric-housed insulators. Composite insulators shall be of light grey color and in compliance with IEC 61462. The envelope shall be made of silicone rubber, HTV type (High-Temperature Vulcanized) or LSR type (Liquid Silicon Rubber) and completely free of EPDM or other organic rubbers.

The polymeric material of the insulators shall be tested in compliance with IEC 62217, with the "tracking and erosion test" duration of 1000 h.

The flanges and the external metallic parts, not made by stainless steel or not protected by zinc-coated or anti-oxidant substances, shall be painted with the same protective paint prescribed for the transformer. The bushings shall be positioned accordingly to the layouts reported in the Standard.

All the hollow insulators shall be manufactured in one piece only, without any intermediate flange or joint.

All the metallic parts shall be in aluminum alloy, stainless steel, or hot galvanized steel.

The screws and the other small parts shall be made by stainless material.

No bushings shall have any spark gap shaft.

7.1.1. HV Bushings

The characteristics of the bushings used for the main transformer's typologies are reported in following table:

TABLE 6 – HV BUSHINGS CLASSIFICATION

Type of Bushing	**O/A for U_m 145 kV**
Drawings of dimensions and interfaces	CLC/TS 50458 + Terminal (*)
Designation accordingly to CLC/TS 50458	NRUE0
Ratings	
Rated voltage Ur (kV)	145
Rated frequency withstand voltage (kV)	275
Rated lightning impulse withstand voltage (kV)	650
Rated current (A)	400
Allowable inclination respect to vertical position	≤ 30°
Minimum pollution level SPS Class (IEC 60815)	D-Heavy
RUSCD	43,3
Creepage distance	3625
Cantilever test load - IEC 60137	Class II
Seismic requirements - IEC/TS 61463	AG 5
(*) Under the Supplier responsibility in accordance to the dimensions specified for the transformer	
(**) The Supplier shall verify the interfaces of the transformer with the substation in order to ensure the proper connection, if necessary, the Supplier shall provide proper junctions	

7.1.1.1. Ratings

According to the transformer ratings.

7.1.1.2. Design requirements

The Oil/Air bushings shall be RIP or RIS technology of polymeric type.

Metallic parts shall be in aluminium alloy, stainless steel, or hot galvanized in compliance with EN ISO 1467.

The flange and the junction for the connection of the external cable shall be designed accordingly to IEC 62271-209. For coupling the Transformer and the GIS conducts, the connection shall be according to IEC 62271-211.

The impregnating or filling liquids shall be environmentally compatible.

The bushing shall be provided with the following accessories on the flange:

1) Power factor tap for measurement of the capacitance-to-ground. The Supplier shall provide drawings for the correct usage of the tap and for the inspections.

2) Hooks for lifting the bushing

7.1.1.3. Overall dimensions

In order to ensure the interchangeability of bushings with comparable technical requirements and for European countries the indicated in the document CLC/TS 50458: Capacitance graded outdoor bushing 52 kV up to 420 kV for oil immersed transformers, shall be considered.

Capacitance graded bushings from 52 kV the conductor arrangement shall be Type U – Draw Lead conductor.

The dimensions and the interfaces for the connection with HV un-covered overhead lines are in accordance with CLC/TS 50458 and Terminal in Figure 8.

7.1.1.4 Tests

IEC 60137 applies, unless otherwise specified.

7.1.2.MV Bushings

The bushings shall be compliant with EN 50180.

7.1.2.1.Ratings

According to the transformer ratings.

7.1.2.2. Design Requirements

The MV bushings shall be with external insulating of composite material.

7.1.2.3. Overall dimensions

The overall dimensions of the bushings shall be in compliance with the relevant standard.

Dimension and typologies of interfaces are reported in Figure 9.

7.1.2.4. MV Plug-in bushings inside cone type

If specifically requested Medium Voltage plug-in bushings shall be directly installed by the transformer Manufacturer in place of the Oil/Air bushings.

The transformer Manufacturer shall supply the plug-in bushings in accordance to IEC 60137 and EN 50180 and shall provide the documentation together with the transformer documentation as prescribed at the point 9.3 of the GST002 Standard.

The plug-in bushings can be requested with the following connections solutions:

a) **Solution with two plug-in per phase and one plug-in for neutral terminals**

Each single bushing to be used for the phases shall have the following ratings and characteristics: Um ≥ 24 kV; In ≥ 2.000 A; two plug-in terminals inner-cone type compliant with EN 50180, clause 4.7.2 – interface: 3, with insulating cup usable also with the transformer in operation.

The bushing to be used for the neutral shall have the following ratings and characteristics:

Um ≥ 24 kV; In ≥ 400 A; two plug-in terminals inner-cone type compliant with EN 50180, clause 4.7.2 – interface: 1, with insulating cup usable also with the transformer in operation.

b) **Solution with four plug-in per phase and one plug-in for neutral terminals**

Each single bushing to be used for the phases shall have the following ratings and characteristics: Um ≥ 24 kV; In ≥ 3.150 A; four plug-in terminals inner-cone type compliant with EN 50180, clause 4.7.2 – interface: 3, with insulating cup usable also with the transformer in operation.

The bushing to be used for the neutral shall have the same characteristics as for solution a)

The bushings, both for phases and neutral, shall be installed such that to facilitate the connection with the cables terminals coming from the horizontal directions from the shorter side of the transformer tank. Slight inclinations are however admitted in order to facilitate the descent of the cables to ground.

The plug-in bushings shall be in a single block for each phase terminal and interchangeable with the traditional oil/air polymeric type bushings.

For the possible substitution of the plug-in bushings, one or more windows shall be foreseen in order to allow the replacement without the removal of the tank cover.

7.1.2.5. Tests

IEC 60137 applies, unless otherwise specified.

7.2. ON LOAD TAP CHANGER

The scope of the present chapter is to define the technical-functional parameters, the design requirements and the tests definitions of the on-load tap changers to be used for the voltage regulation.

7.2.1. Ratings

Unless otherwise specified, IEC 60214-1 applies.

The on load tap changer shall be vacuum type.

The regulating positions shall be in accordance with the transformer ratings.

The On Load Tap Changer shall be in accordance with the transformer characteristics with the change over selector either fine coarse type or reversing type.

7.2.2. Design Requirements

Diverter switch

The diverter switch contains an energy storage device, a set of moving and fixed contacts and the commutation resistances.

The diverter switch shall be installed into a sealed chamber which has to ensure the separation with the oil of the transformer. This chamber shall be connected with the relevant compartment contained into the main conservator of the transformer.

The diverter switch shall be moreover provided with the following devices:

1) Relays for the oil flux control (prescribed in item 15 of clause 6.8).
2) Pressure limitation device (rupture disk).

The diverter switch shall allow the maintenance operations and/or replacement without requiring the opening of transformer’s tank.

OLTC driving mechanism

The OLTC shall be driven by a mechanism contained into a box, installed outside the tank of the transformer.

The moving mechanical parts connecting the motor drive and the diverter switch shall be fully protected with appropriate carters.

The commutation of the diverter switch shall be activated by an energy store device. The energy charge shall be achievable both through a motor drive and manually.

The motor drive commutation shall be achievable both remotely and locally through electric signals.

When the crank-handle is inserted, the electric/motorized commutation shall be inhibited through the interruption of both the supply circuit and the electric signalling circuit.

Tap-Selector and change-over selector

The tap-selector and the change-over selector shall be for installation inside the transformer tank.

Cabinet

The OLTC control and driving devices shall be positioned inside a box, fixed on the transformer tank.

The box shall be manufactured with hot painted or galvanized steel sheets or with metal not susceptible to corrosion.

The box shall be IP 55 - IEC 60529 provided with an appropriate door, laterally hinged and lockable.

On the door, a window, protected with transparent material withstanding the atmospheric agents and UV radiations, which allow the visualization of the position indicator of the OLTC, shall be fitted.

All the wiring relevant to the signalling and command circuits (supplied at 100÷140 Vcc or 230 Vac) shall have a section not smaller than 1,5 mm2.

The wires for the connections inside the box shall be of the not-fire-propagate type, with insulating level Uo/U = 450/750 V; to the extremes of the flexible wires shall be applied pre-insulated compressed terminals and the extremes themselves shall be identifiable with appropriate marks.

The plugs of the marshalling shall be indirectly tightened, and shall be in compliance with EN 60947-7-2 and fixed on appropriate metallic support.

Inside the cabinet the following devices shall be located:

1) **Push buttons or cran**k for the on-site electric commutation provided with the labels “increase MV” and “decrease MV”

2) **Motor gear and the electrical devices for its command**

3) **Automatic circuit bracker on the motor circuit**, provided with NC contacts wires in the marshalling

4) **Heating anti-moisture resistance** (always on) and additional heating resistance controlled by a thermostat and protected with automatic circuit bracher, provided with NC contacts wire in the marshalling, or with an equivalent system preventing the moisture generation

5) **Ground terminal** for of all the metallic parts of the box

6) **Lamp and one single-phase**

7) **Socket 230V, 10 A,** supply by the heating circuit

8) **The protection and signalling devices**

9) **One marshalling for the interface** with the marshalling box of the transformer.

The supply voltages shall be:

- Three phase motor 400 V ± 10%, 50 Hz
- Command circuits 230 V ± 10%, 50 Hz

■ Heating system 230 V ± 10%, 50 Hz

■ Protection and signalling circuits 100 ÷ 140 Vdc

The contacts of the signals on the marshalling box are defined in the Figure 5.

The marshalling of the motor drive is reported in Figure 7.

7.2.2.1. Painting

The external paint of the motor drive box and of the flange of the divert switch" shall comply the same requirements of the external painting of the transformer, except color.

7.2.2.2. Maintenance

The OLTC shall be able to work without any maintenance before 300.000 commutations.

This prescription shall not limit the normal service conditions and the lifetime (the OLTC Supplier shall give evidence of the compliance with this requirement).

7.2.2.3. Functional requirements

The main functional requirements are the following.

1) The execution of the commutation shall be inhibited or interrupted when the over-current arrest relays (I max) installed outside the diverter switch activates.

2) A device that allows the completion of a tap commutation already started, regardless of the control activation time.

3) A device that prevents the execution of more than one commutation in case of control button pushed longer than time necessary to activate the commutation

4) An electrical and/or mechanical device for the motor drive re-starting after an interruption of the supply voltage, in order to complete a commutation already started

5) An electrical and a mechanical block that prevents commutations beyond the extreme positions

6) An electrical device that prevents the activation of an increasing commutation while a decreasing commutation is in operation and vice versa

7) A mechanical indicator of the position. The main central position shall be indicated with zero, the other positions shall correspond to the progressive number +1, +2, etc. e -1, -2, etc. from the central position respectively for increasing and decreasing the taps of the HV winding.

8) Electrical contacts for the indication of the tap positions.

9) Indication of the tab positions available also by BCD with the following configuration:

• Input: 28 stage-state of the OLTC

• Output: 5-bit binary code

10) Counter with 6 digits for the indication of the commutations number.

7.2.3. Tests

According to IEC 60214-1.

8. TESTS

Unless otherwise specified, IEC 60076-1 applies.

8.1. LIST AND CLASSIFICATION OF TESTS

Requirements and Tests for different categories of transformers based on the Um of the highest voltage winding.

		Um		
Routine		≤ 72,5	> 72,5	≤ 170 kV
R.1	Check of the correspondence with the approved prototype.	X	X	X
R.2	Measurement of winding resistance.	X	X	X
R.3	Measurement of voltage ratio and check of phase displacement.	X	X	X
R.4	Measurement of short-circuit impedance and load loss (11.4).	X	X	X
R.5	Measurement of no-load loss and current (11.5).	X	X	X
R.6	*Applied Voltage*	X	X	X
R.7	*Induced Voltage + PD*	X	X	X
R.8	*Auxiliary wiring*	X	X	X
R.9	*Lighting Impulse (Routine)*	X	X	X
R.10	Tests on on-load tap changer (11.7).	X	X	X
R.11	Leak testing with pressure for liquid-immersed transformers (tightness test) (11.8).	X	X	X
R.12	Check of the ratio and polarity of built-in current transformers.	X	X	X
R.13	Check of core and frame insulation for liquid immersed transformers with core or frame insulation (11.12).	X	X	X
R.14	Measurement of DC insulation resistance between each winding to earth and between windings.	X	X	X
R.15	Check and verification of the functionalities of accessories.	X	X	X
R.16	Insulating Liquid tests.	X	X	X
R.17	Determination of sound level (IEC 60076-10) for each method of cooling for which a guaranteed sound level is specified.	X	X	X
R.18	Check of external coating (ISO 2178 and ISO 2409 or as specified).	X	X	X
R.19	Measurement of zero-sequence residual voltage	X	X	X

Additional Routine				
AR.1	Determination of capacitances windings-to-earth and between windings.	X	X	X
AR.2	Measurement of dissipation factor (tan δ) of the insulation system capacitances.	X	X	X
AR.3	Measurement of frequency response (Frequency Response Analysis or FRA).	X	X	X

Type			

T.1	Evaluation of the compliance with the specification requirements.	X	X	X
T.2	Temperature-rise type test (IEC 60076-2).	X	X	X
T.3	*Lighting Impulse Type - See Routine Tests -*			
T.4	Measurement of the power taken by fans and liquid pump motors	X	X	X
T.5	Temperature rise test with zero sequence current	X	X	X

Specials				
S.1	*Switching Impulse Special - See Routine Tests -*			
S.2	Determination of transient voltage transfer characteristics (Annex B of IEC 60076-3:2013).			
S.3	Vacuum deflection test on liquid immersed transformers (11.9)	X	X	X
S.4	Pressure test on liquid immersed transformers (11.10)	X	X	X
S.5	Short-circuit withstand test (IEC 60076-5).	X	X	X

8.1.1. General statements for the tests

For Certification, Technical Conformity Assessment or Approval, the indicated routine tests, additional routine tests, type tests and special tests shall be performed on one unit of identical transformers which have the same type code, if not otherwise specified. Such statement does not include the short circuit test for which the criteria are given in the sub-clause 8.1.1.1.

Active Part Inspection for transformers not subjected to TCA: The manufacturer shall inform RETELE ELECTRICE department in charge for the quality control and the routine tests assistance for the inspection of the active part before the assembling into the tank, in a due time according to the contractual documentation.

In case of continuously transposed cable (CTC) is used, the report of mechanical performance of the witnesses of the windings wires with respect to the one checked on the approved prototype shall be available. The mechanical behavior is determined through the flexion characterization (graph “arch-arrow” up to breakdown).

Further tests in addition to the ones listed above may be requested to the transformers Manufacturer in case of particular technologies adopted.

8.1.1.1 Short circuit test criteria

The short circuit test is required in compliance with IEC 60076-5 and in accordance to the following criteria.

For each type of transformers, the capability to withstand the short circuit test may be verified by calculation, based on a test performed on a Similar Transformer, in compliance with IEC 60076-5 Annex B.

8.2. TEST DESCRIPTION

The prescriptions and the tests conditions shall be compliant with the reference standards, unless otherwise specified.

The transformers shall be completely assembled (as in operation) during the tests, except in case of Oil/SF_6 or oil/oil HV bushings whose criteria are given in the relevant standards.

8.2.1. Routine Tests

8.2.1.1 Check of the correspondence with the approved prototype

The ratings and the design requirements of the transformer under test (including bushings, tap changer, accessories, etc.) shall be compared with the approved prototype drawings.

This Test shall be reported in the list of the tests with a specific test report.

The visual inspection shall also be performed in order to verify the absence of imperfections and defects.

8.2.1.2 Measurement of winding resistance

According to IEC 60076-1 (11.2).

For transformers with Technical Conformity, submitted only to routine tests, the test can be performed only on the delivering configuration.

Anyway, the supplier shall produce the report of the measurements for all voltage configuration.

8.2.1.3 Measurement of voltage ratio and check of phase displacement

According to IEC 60076-1 (11.3).

For transformers with different voltage configurations (double HV voltage, double MV voltage, etc), the measurement shall be performed on each voltage position.

For transformers with Technical Conformity, submitted only to routine tests, the test can be performed only on the delivering configuration.

Anyway, the supplier shall produce the report of the measurement for all voltage configuration.

8.2.1.4 Measurement of short-circuit impedance and load loss

According to IEC 60076-1 (11.4).

8.2.1.5 Measurement of no-load loss and current

According to IEC 60076-1 (11.5).

The measurements shall be performed at 90%, 100% and 110% of rated voltage.

8.2.1.6 Dielectric routine tests

According to IEC 60076-3.

In case of different voltage configurations, the dielectric routine tests shall be performed in the delivering configuration and/or in the most stressed configuration by agreement.

8.2.1.7 Tests on on-load tap changer, where appropriate

According to IEC 60076-1 (11.7).

8.2.1.8 Leak testing with pressure for liquid-immersed transformers (tightness test)

According to IEC 60076-1 (11.8).

8.2.1.9 Check of the ratio and polarity of built-in current transformers

According to IEC 60076-1.

To be performed only in case of built-in current transformers.

8.2.1.10 Check of core and frame insulation for liq. Im. Transf. with core or frame insulation

According to IEC 60076-1 (11.12).

8.2.1.11 Measurement of DC ins. Res. between each winding to earth and between windings

According to IEC 60076-1.

8.2.1.12 Check and verification of the components and accessories.

According to IEC 60076-1 and IEC 60076-3.

The functionality of the accessories and the wiring continuity shall be verified and reported.

The documentation of the sub-Supplier that confirms the compliance of the components and accessories to the related standard shall be provided by the transformer Manufacturer.

8.2.1.13 Insulating liquid tests

The manufacturer shall provide:

1. The certificate containing all the parameters prescribed in the IEC 60296 – Table 2 (PCBs included), with the following additional indication. The supplier of the liquid shall declare possible anti-oxidant additives (type and concentration), if they are present, or the absence of anti-oxidant additives shall be verified (IEC 60666 - verification of the "U" classification - not-inhibited mineral oil).

2. The liquid tests according to IEC 60422–Table 3 (acceptance and type test where applicable) made in a laboratory on the same batch of liquid used in the transformer, under the transformer manufacturer responsibility.

However, in case of having an insulating liquid for the transformer commissioning, different from the one used for the tests, the manufacturer shall provide:

1. For both liquids (tests/commissioning) the certificates containing all the parameters prescribed in the IEC 60296 – Table 2 (PCBs included), with the following additional indication. The supplier of the liquid shall declare possible anti-oxidant additives (type and concentration), if they are present, or the absence of anti-oxidant additives shall be verified (IEC 60666 - verification of the "U" classification - not-inhibited mineral oil).

2. For the commissioning, out acceptance tests, the liquid tests according to IEC 60422–Table 3 made in a laboratory on sample of liquid from the transformer totally assembled, on site.

Note: On site requirements (according to the local procedures for installation and commissioning) may also apply over the insulating liquid during the commissioning, such as specific analysis on a specific sample directly obtained from the transformer tank).

8.2.1.14 Determination of sound level

According to IEC 60076-10-1, for each method of cooling for which a guaranteed sound level is specified.

8.2.1.15 Check of external coating

In compliance with ISO 2178 (according to the specific Painting System) and ISO 2409 or as specified.

8.2.1.16 Measurement of zero-sequence residual voltage

The transformer shall be supplied from the HV side, with the three MV terminals short-circuited as for the load losses measurement, with a (practically) direct-sequence tern of phase-to-phase voltages (supply R, S, T respectively on terminals 1U, 1V, 1W). In such conditions the voltage between the three short-circuited MV terminals and the star-point N shall be measured.

The measurement shall be further repeated with a (practically) inverse-sequence tern of phase-to-phase voltages (supply R, S, T respectively on terminals 1V, 1U, 1W).

On the above prescribed conditions, the measurements shall be executed with the OLTC positioned on the central tap and shall be referred to the rated current.

Note: It is allowed to execute the measurements at reduced currents, provided that the measured values will be reported to the rated current, with the same method prescribed for the load losses measurements.

The average of the two zero-sequence voltage measurements (between the three short-circuited MV terminals and the neutral N) shall not be higher than the limit values prescribed in the ratings clause (section 5.15) of this document.

Moreover, in the former measurement conditions, the measurements shall be performed and recorded, for acknowledgment purposes only, with the OLTC positioned on the extreme taps, min. and max, of the regulating range.

8.2.2. Additional Routine Tests

According to IEC 60076-1.

8.2.2.1 Determination of capacitances windings-to-earth and between windings

According to IEC 60076-1.

8.2.2.2 Measurement of dissipation factor (tan δ) of the insulation system capacitances

According to IEC 60076-1.

For the transformer, a maximum value for tan δ is permitted:

- 0,005 for transformers Um ≤ 170 kV
- 0,004 for transformers Um > 170 kV

Values over those indicated shall require a deeper analysis of the causes. The manufacturer and RETELE ELECTRICE shall agree these technical solutions or processes.

8.2.2.3 Measurement of frequency response (FRA).

According to IEC 60076-18.

Measurement of frequency response (Frequency Response Analysis or FRA/SFRA).

The specification does not define any particular test mode, thereby it is acceptable the mode proposed by the Manufacturer as long as in compliance with the reference standard and clearly

reported in the test report in order to allow the test repeatability (procedure, materials and equipment used).

8.2.3. Type Tests

8.2.3.1. Evaluation of the compliance with the specification requirements

The evaluation of conformity shall be performed through the comparison between the characteristics and the documentation of the transformer under test, and the specifications stated in the present standard concerning the ratings and the design requirements (accessories, control cabinet, painting cycles, etc).

For what concerns the main subcomponents, the compliance of the bushings and the on-load tap changer with the relevant prescriptions shall be verified.

This Test shall be reported in the list of the tests with a specific test report.

8.2.3.2. Temperature-rise type test

According to IEC 60076-2.

For all the transformer typologies in addition to the standard temperature rise type test, after the thermal stabilization, a special test with DGA shall be performed by extending for 8 hours the condition of thermal stabilization.

Insulating Liquid samples for DGA shall be spilled at the test beginning and at the end of the complete tests (after the 8 hour extension); the reference values shall be the ones of IEC 60076-2:2011, Annex D.

The hot-spot calculation shall be reported on the temperature rise test report in order to verify the respect of the limit prescribed by the relevant standard.

8.2.3.3. Dielectric type tests

According to IEC 60076-3.

8.2.3.4. Measurement of the power taken by the fans and liquid pump motors, if any

According to IEC 60076-1.

8.2.3.5. Temperature rise test with zero-sequence current

The transformer shall be supplied form the MV side with a zero-sequence voltage (between the three MV terminal connected together and the neutral) by injecting the neutral current prescribed in 6.3.

The test shall be repeated after 30 minutes.

The maximum over-temperature reached in the tank due to the neutral current circulation (usually some tens of seconds after the minute of the neutral current circulation) shall be measured through appropriate thermal probes applied in the expected hot-spot points (at least two for each side of the transformer).

The identification of those points may be facilitated by using a thermal camera; however, usually the most critical point are expected to be about on the half height of the tank, about the half-height of the core, and on the central part of the longest sides of the transformer.

The maximum measured over-temperature shall not exceed the prescribed value of 6.3.

The transformer with double secondary voltage shall be tested on the highest voltage level.

8.2.4.Special Tests

8.2.4.1. Dielectric special tests

According to IEC 60076-3.

8.2.4.2. Determination of transient stress transfer characteristics

According to Annex B of IEC 60076-3.

8.2.4.3. Measurement of zero-sequence impedance(s) on three-phase transformers

According to IEC 60076-1 (11.6).

8.2.4.4. Short-circuit withstand test

According to IEC 60076-5 and sub-clause 8.1.1.1 in this standard, with the following indications:

• For Short-Circuit (SC) matters, Test or Evaluation by comparison, specific reference of currents and apparent powers may be given in the Local Sections/Datasheets or amendments.

• In case of transformers with Power Tertiary windings under short-circuit test, the SC Test shall be also performed, if there is not a Similar Transformer validated (IEC 60076-5).

• In case of Stabilizing/Tertiary windings, the manufacturer shall demonstrate the ability of those windings to withstand short-circuits; by testing or by calculation if there is a Similar Transformer.

8.2.4.5. Vacuum deflection test on liquid immersed transformers

According to IEC 60076-1 (11.9).

The test shall ensure a verification of the residual vacuum. The vacuum leakage shall be lower than 5,3 kPa after 6 hours.

8.2.4.6. Pressure test on liquid immersed transformers

According to IEC 60076-1 (11.10).

8.3. Tests before commissioning

8.3.1. Special dielectric tests

Complies with IEC 60076-3.

8.3.1.1. Determination of transient stress transfer characteristics

In accordance with Annex B of IEC 60076-3.

8.3.1.2. Measurement of homopolar impedance(s) in three-phase transformers

In accordance with IEC 60076-1 (11.6).

8.3.1.3. Measurement of the tangent of the angle of dielectric losses (tan δ) and capacities of insulating passages

Complies with IEC 60076-1.

For a transformer with a ≤ 170 kV, a maximum permissible value is for tan δ = 0,005

Values above those indicated require a more in-depth analysis of the causes. Manufacturer & NETWORKS

ELECTRICE will agree on these technical solutions or processes.

8.3.1.4. Short-circuit resistance tests

In accordance with IEC 60076-5 and sub-clause 8.1.1.1 of this standard, with the following indications:

• For problems related to short circuit (SC), testing or comparative evaluation, specific references for apparent currents and powers can be found in annexes/data sheets or amendments.

• In the case of three-winding power transformers subjected to the short-circuit test, the SC test must also be carried out, if there is no similar validated transformer (IEC 60076-5).

• In the case of stabilizing/tertiary windings, the manufacturer must demonstrate their capability windings to withstand short circuits; by testing or by calculation if there is a similar transformer.

8.3.1.5. Vacuum deformation test of transformers immersed in liquid

In accordance with IEC 60076-1 (11.9)

The test shall ensure that the residual vacuum is checked. The vacuum loss must be less than 5.3 kPa after 6 hours.

8.3.1.6. Pressure test of transformers immersed in liquid.

In accordance with IEC 60076-1 (11.10)

9. SUPPLY REQUIREMENTS

Unless otherwise specified, IEC 60076-1 applies.

9.1.TRANSPORT

The transformers with rated power of 10 MVA, 16 MVA and 25 MVA shall be transportable in operating conditions (full of liquid and fully assembled with bushings, radiators, conservator etc).

The transformers of 40 MVA and 63 MVA shall be transportable with the oil level decreased at the tank level and by disassembling HV bushings, radiators and conservator.

The center of gravity of the transformer shall be marked on at least two adjacent sides.

The transformer, during the transport from the Factory to the Substation, shall be equipped with impact recorders made available by the Supplier. Two suitable impact recorders with waveforms data and frequency analysis (to avoid the possible data loss due to the failure of any recorder) shall be placed on two adjacent sides of the transformer (if requested, raw data and a report shall be delivered to RETELE ELECTRICE for verification). In case of solicitations stronger than the admissible ones, the Manufacturer shall verify, by a proper method, the good conditions of the transformer.

9.2. DOCUMENTATION

9.2.1. Documentation for the offer

The technical documentation to be produced by the Supplier for the economical offer shall contain the following items:

1) The data of the Annex C with the documentation requested (excel file containing data from Annex C provided for each tender)

2) Short circuit test as requested in 8.2.4.4. (file to compile the comparative data for Similar transformer validation)

The full compliance to the prescriptions indicated in this document and relevant standards of the main components and the accessories shall be ensured by the Manufacturer.

Each exception to this Standard and to the related ones shall be expressly evidenced in the Annex C during the technical offer submission, otherwise it will not be considered.

9.2.2.Documentation for the Technical Conformity Assessment (TCA)

The procedures concerning the technical conformity assessment (TCA) and all the activities required are described in IL-RE-097 “EVALUAREA CONFORMITATII TEHNICE”.

The Supplier, for each transformer type code to be subjected to TCA, shall make available a complete documentation containing calculations, drawings, schemas, pictures of the HV and MV side, internal and external, descriptions, list of characteristics, performances, assembling, maintenance and operational norms and whatever necessary for the complete acknowledgment of the transformer.

All the final technical documentation shall be delivered according to the IL-RE-097 with the following additional integration specific for Power transformers.

• For a total overview of the process, the supplier shall issue a Transformer Manufacturing Plan (Engineering, Manufacturing, Tests, shipping, commissioning …)

9.2.2.1 Not-reserved documentation (Type A)

This is the documentation specific for Power Transformers, according to indicated in IL-RE-097.

It shall contain at least:

1. List of Type B documents.
2. List of Type A documents.
3. Overall drawings and relevant details/parts/components of both, the completely assembled transformer (all side views as in operation) and of the transformer transportation (in romanian language).
4. Drawing of the Rating Plates (in romanian language).
5. Drawing of the auxiliaries circuits (in romanian language).
6. Drawing of the OLTC motor-drive circuits (in romanian language).
7. The list of the components and accessories containing the description, model, serial number and manufacturers.
8. Components, materials and accessories certificates.
9. Accessories and components datasheets/manuals (romanian language if possible).
10. Documentation of painting system and related certification and tests of the painting supplier.
11. List of Control Cabinets’ components (Aux. and OLTC), related certificates (if any) and components information/characteristics.
12. Manual of the transport, installation, operation and maintenance (in romanian language).

13. Report of the Winding and Active Part inspection with photos of the main parts (the real photos are Type B documents. The photos in this report can be in small size in order to have an idea of them - quantity and subjects).
14. Pictures of the Assembled Transformers (all sides).
15. Report to demonstrate the seismic level according to the countries requirements.

Further documents can be requested (in case that visual inspections of the prototypes cannot be attended), such as pictures/photos of accessories and plates, specific parts of the transformers, Control Cabinets (Aux and OLTC motor-drive) and their components, etc.

9.2.2.2 Reserved documentation (Type B)

This is the documentation specific for Power Transformers, according to indicated in IL-RE-097.

Some specific reserved documentation has to be shared with the person in charge for the TCA for validation (by email or other tool out of MLM system):

- The Comparative Report (and table) of the capability to withstand the short circuit (in case of the test is not performed).
- Real pictures/photos indicated for the Report of Windings and Active Part.
- A document for the technical review (design and final reviews).

9.2.3 Transformers Documents

For general purpose, every transformer manufactured for RETELE ELECTRICE shall be delivered with its own related information -Transformer Dossier/Technical Book-. That information consist in a complete dossier for the transformer (stamped book (x2) and an electronic copy (x2)).

9.2.3.1 Transformer Documentation -Transformer Dossier/Technical Book-

The documents that shall to be delivered with the transformers will be, at least:

1. The corresponding Datasheet of the transformer.
2. The Overall Drawings (As-built; as in operation, including all side views) with all the relevant details and list of parts (in local language).
3. The Transport Drawing with detailed indications of the weights (kg) and the packing list (main weights and dimensions of the separated parts to be transported) (in romanian language).
4. The drawing of the final Rating Plate - As-built - (in romanian language).
5. A drawing of the Auxiliaries circuits, including the list of components (in romanian language).
6. A drawing of the OLTC motor-drive circuits, including the list of components (in romanian language).
7. The list of the components and accessories containing the description, model, serial number and manufacturers.
8. The datasheets/manuals of the components and accessories.
9. A transformer Manual of the Transport, Installation, Operation and Maintenance (in romanian language).
10. The transformer Test Report and the insulating liquid certificate.
11. Legal Declarations and/or Legal Certificates according to local laws.

9.3. WARANTY

The minimal requested guarantee period is 5 years.

The transformer Supplier guarantees the transformers and all the sub-components with respect to all the defects.

In case of defects on the protective coating, the Distribution Company can require the protective coating re- painting by the transformers manufacture to its own cost.

The transformers in operation are managed with a proper maintenance. In case of insulating liquid parameters out the proper values given in IEC 60422 and IEC 60599, the transformers Manufacturer has to recondition the transformer, on its own cost, in order to re-establish the proper conditions.

10.EXCEPTIONS

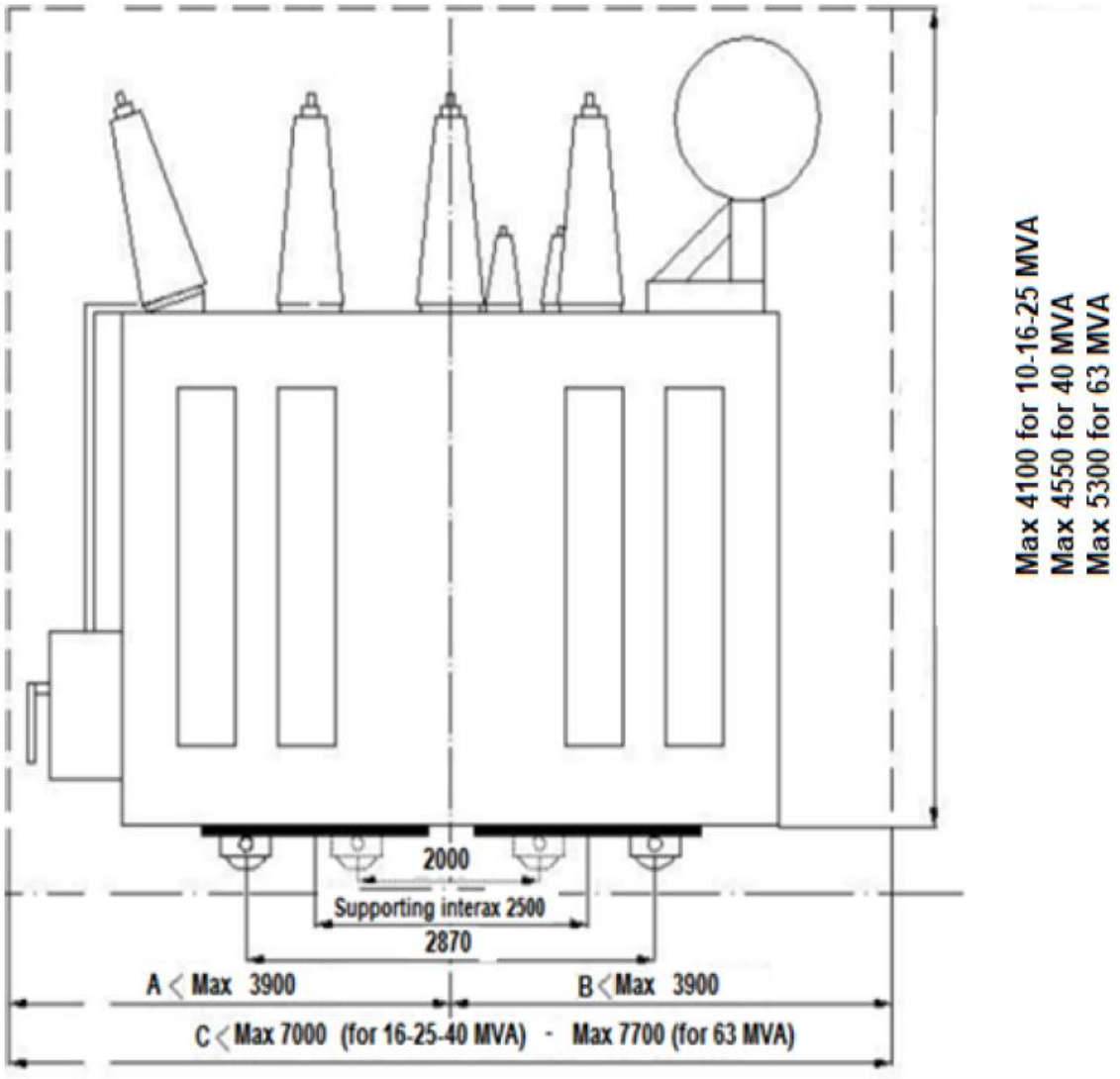
Possible exceptions to the present prescriptions, concerning the adoption of technical and/or manufacturing aspects different from the ones prescribed in the present Standard, may be evaluated by the Distribution Company. In such a case, the Distribution Company will take into account the opportunity to require additional tests with regard to the technical/manufacturing proposed solutions.

Such exceptions can be approved exclusively by the Distribution Company.

11. FIGURES

Figures, drawings, and details are reported in the following:

FIGURE 1 – FRONT VIEW OF THE HV SIDE (FOR AIR LINES CONNECTIONS)



1)The bushings can be installed at max. 30° from the vertical.

2)The possible radiators installed on the shorter side of the transformer shall not overcome, with their top, the horizontal plane identified by the base of the hollow insulator.

3)The axes of the HV bushings and the ones of the supporting plates shall coincide; however, the maximum allowable deviation shall be no longer than 250 mm.

FIGURE 2 – LATERAL VIEW FROM THE MV SIDE (AIR LINES CONNECTIONS)

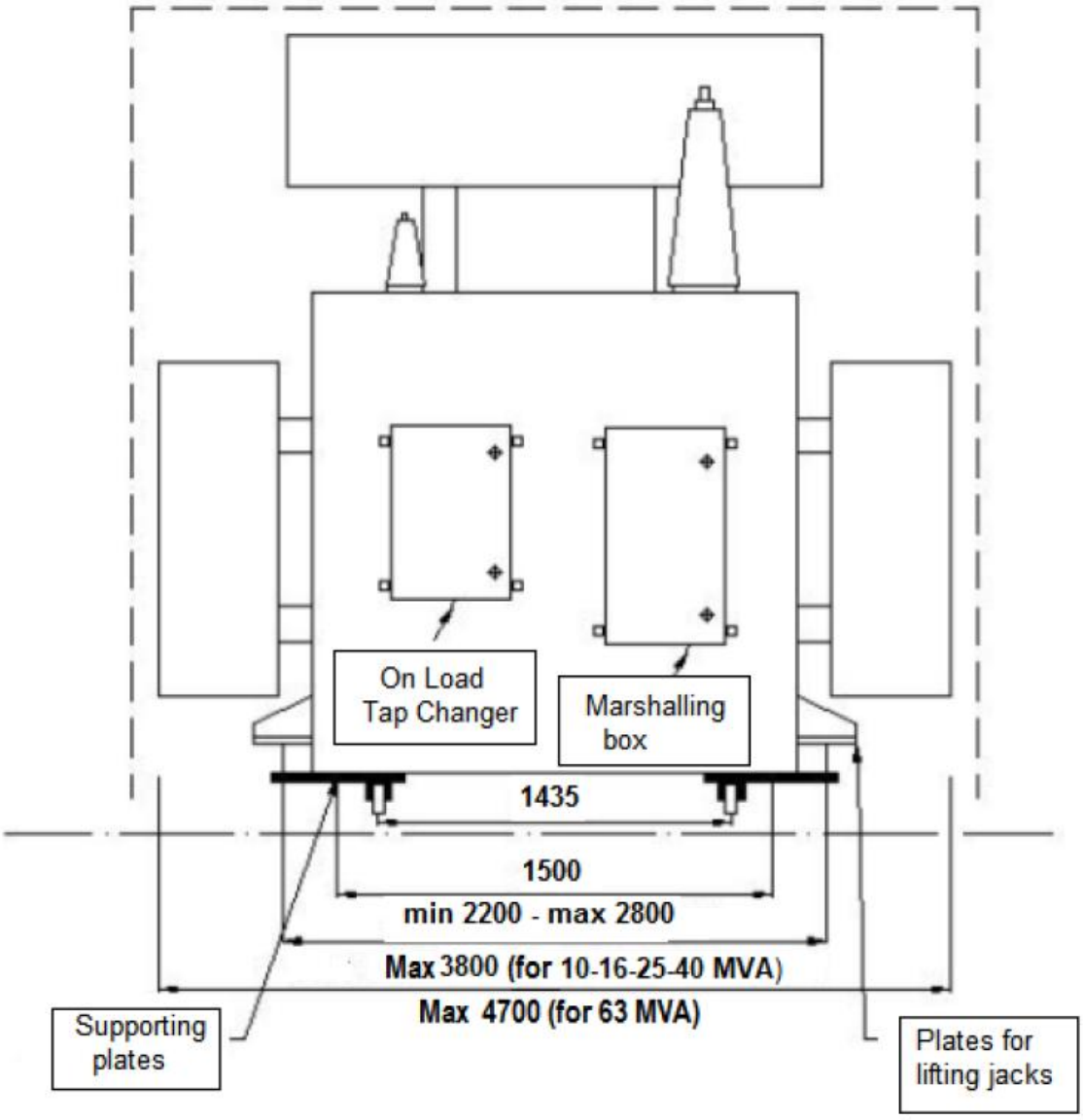


FIGURE 3 – OVERVIEW (FOR AIR LINES CONNECTIONS)

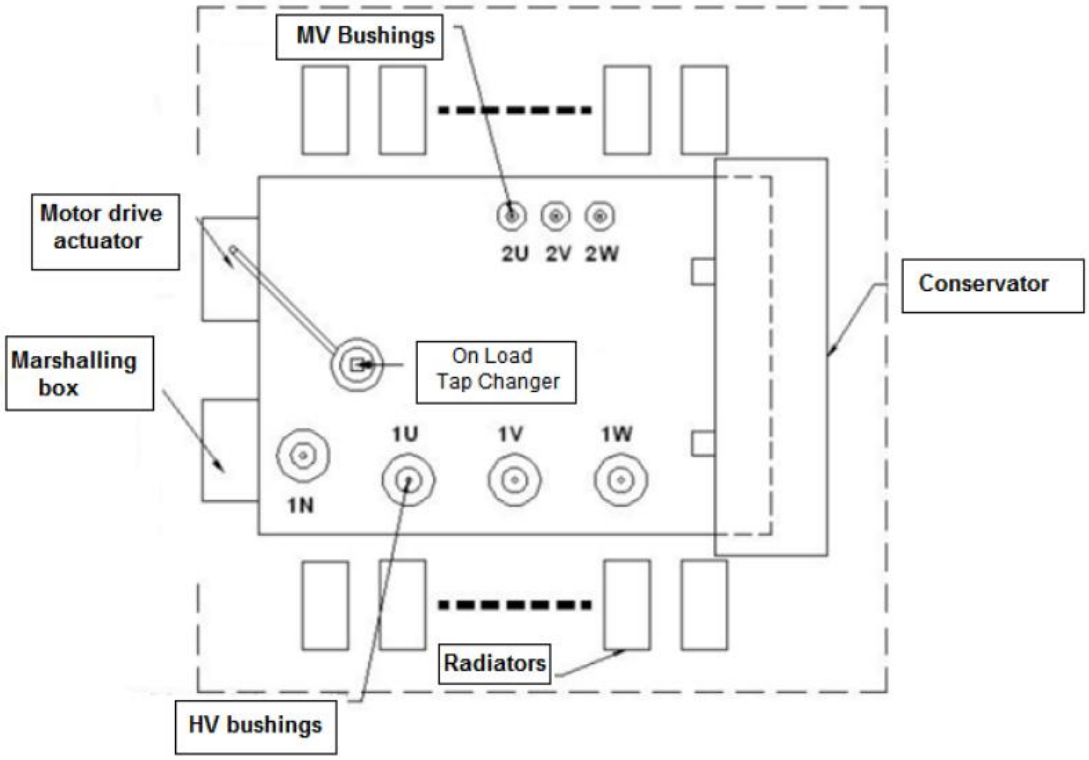


FIGURE 4 – SUPPORTING PLATES

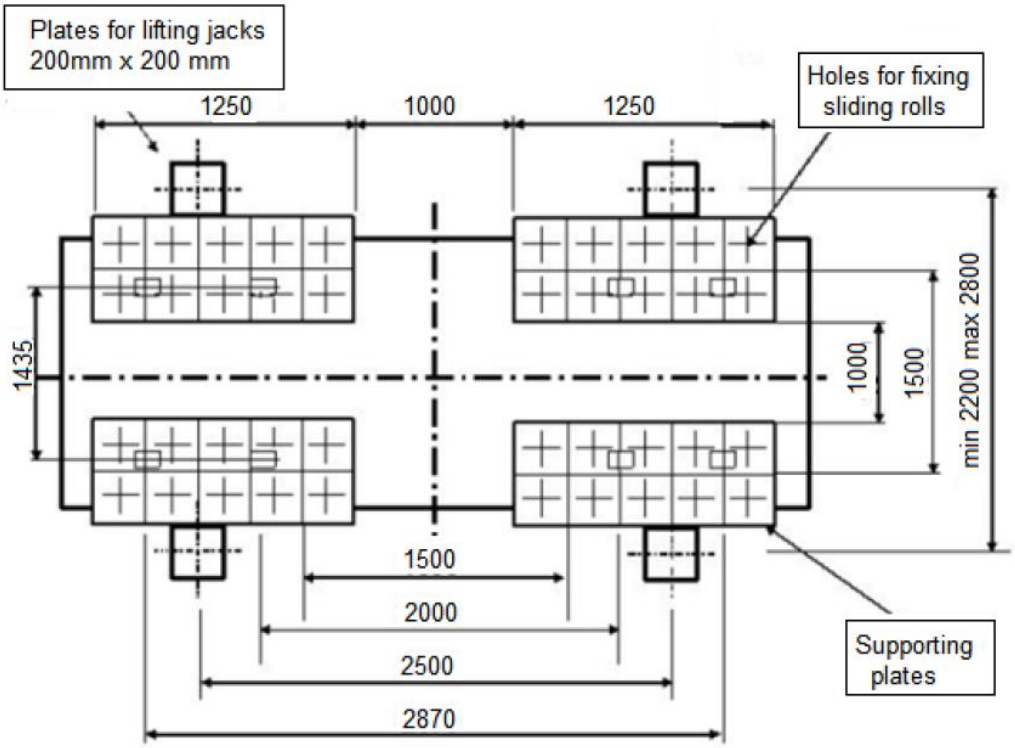


FIGURE 5 – MARSHALLING OF TRANSFORMER SIGNALS

The name of identification of the contacts is reported in Romanien language, as requested to the Supplier for the corresponding drawings (the translation in English is given in the following)

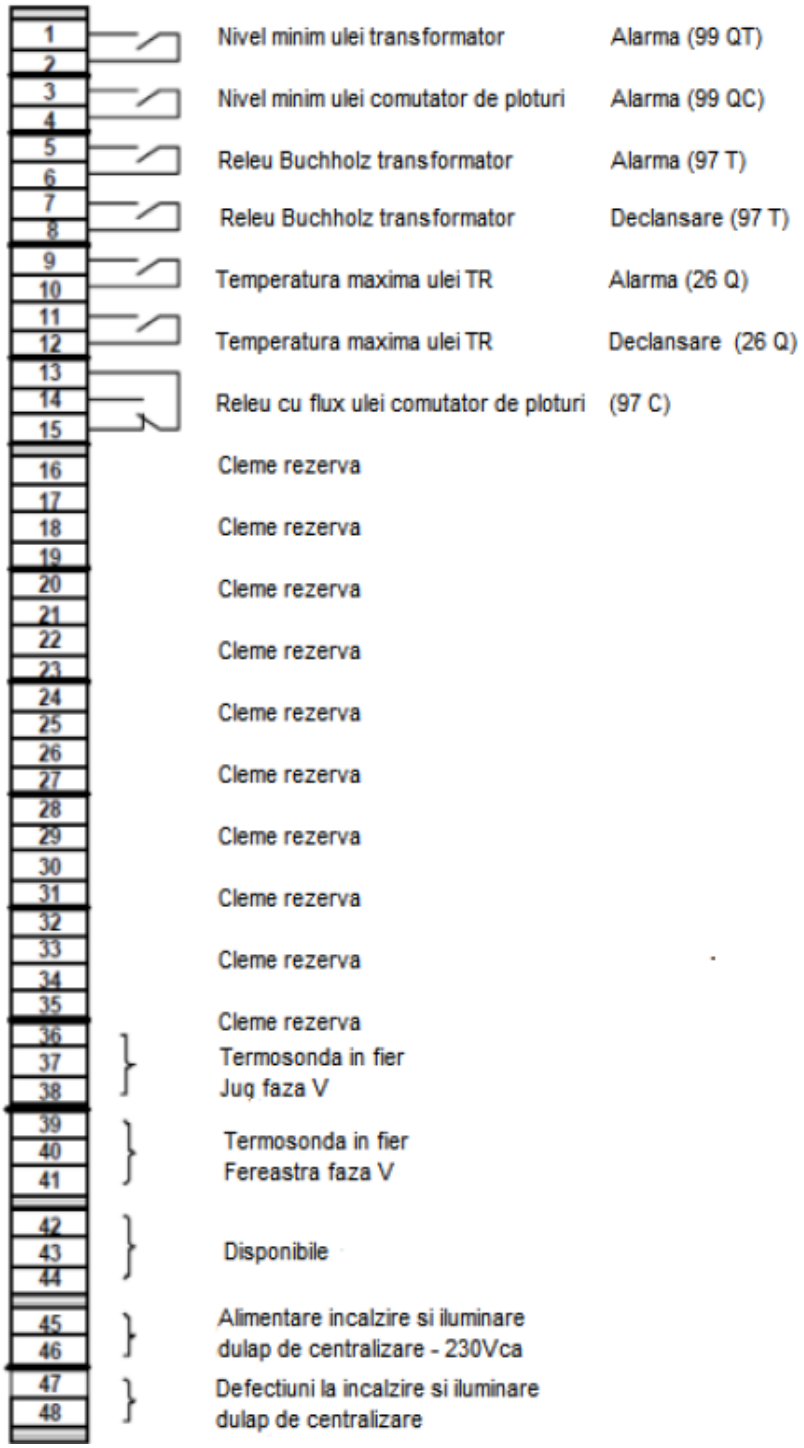


FIGURE 6 – MARSHALLING OF THE AUTO-REGENERATING SILICAGEL

(Examples for two separate breathers for transformer and OLTC)

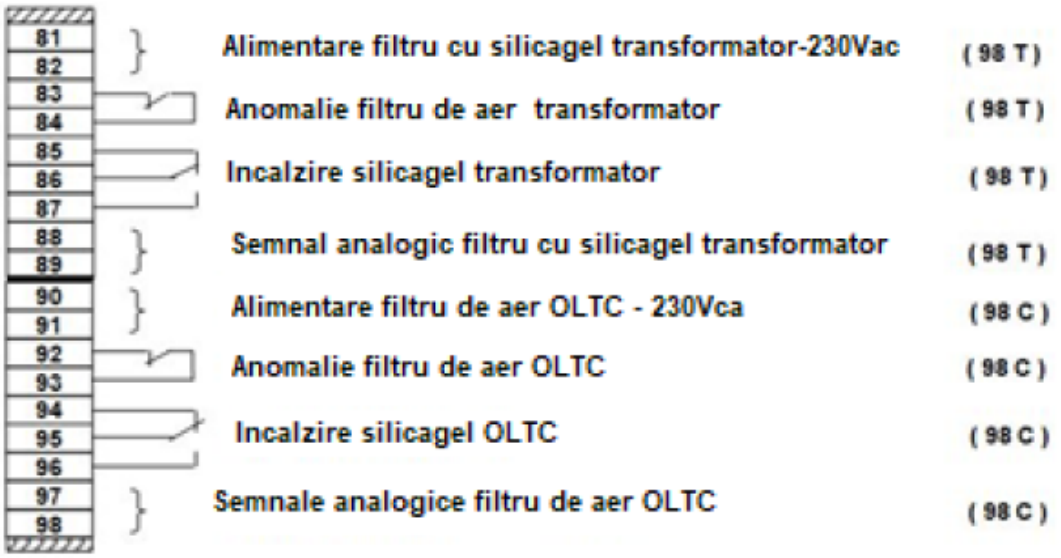
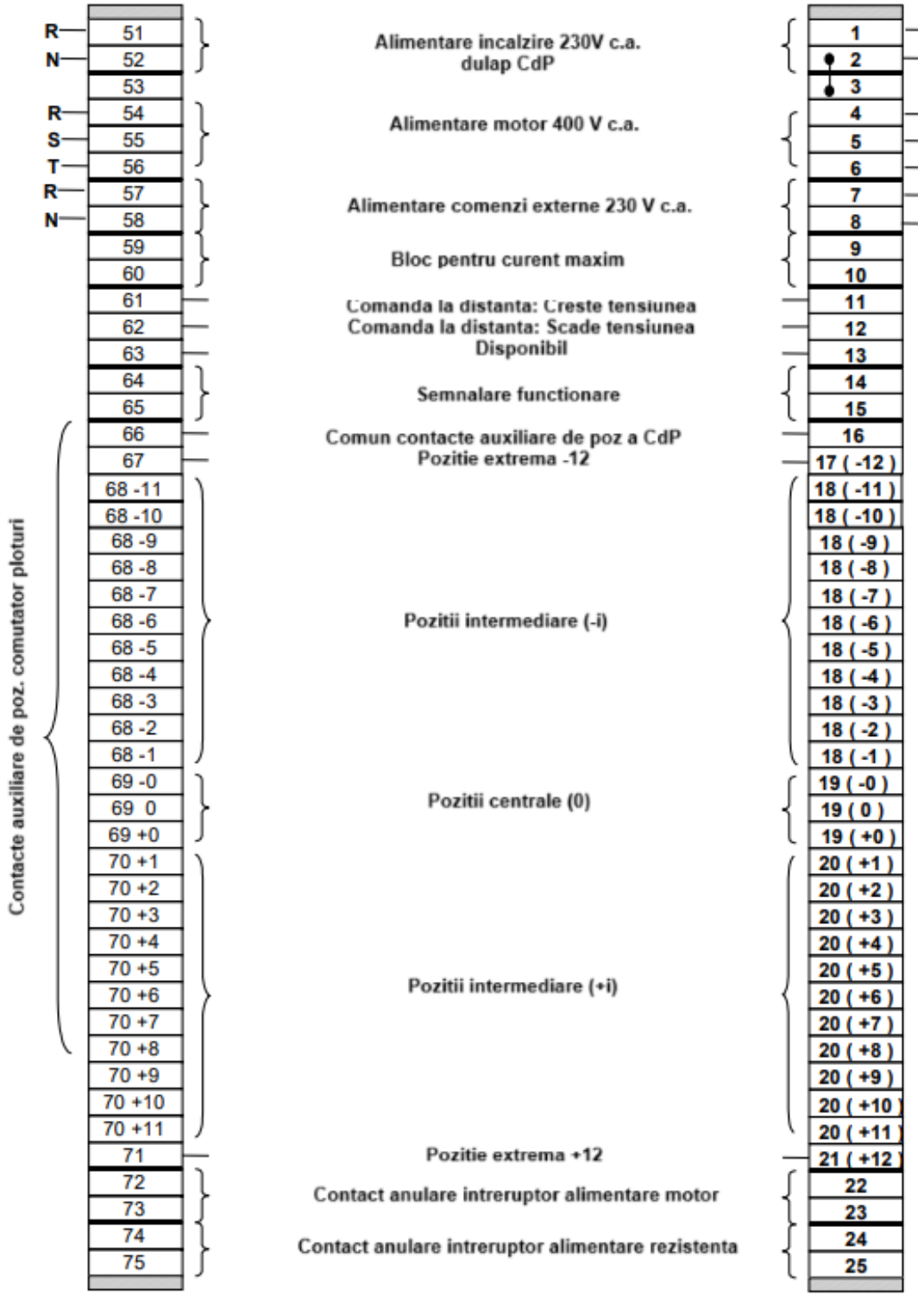


FIGURE 7 – MARSHALLING OF THE OLTC SIGNALS



Sir cleme cofret trafo *Sir cleme dulap comanda motor*

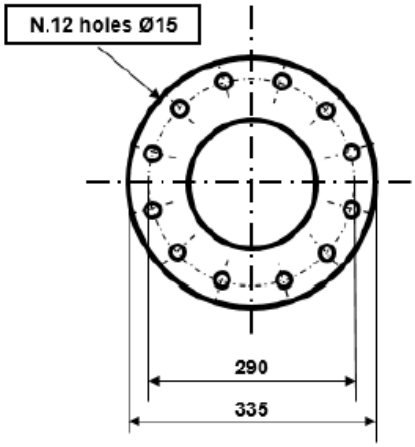
comutator de ploturi (CdP)

TRANSLATION OF THE TEXT IN FIGURE 5, 6 AND 7

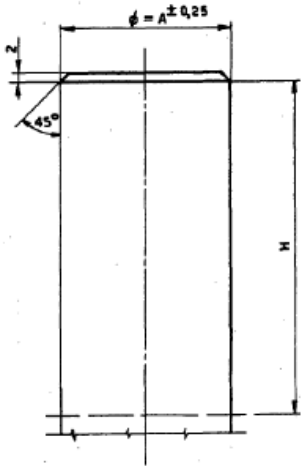
Contacts	Translation	
1-2	Minimum oil level of the transformer	Alarm (99 QT)
3-4	Minimum oil level of the OLTC	Alarm (99 QC)
5-6	Buchholz relays of the transformer	Alarm (97 T)
7-8	Buchholz relays of the transformer	Trip (97 T)
9-10	Maximum oil temperature of the transformer	Alarm (26 Q)
11-12	Maximum oil temperature of the transformer	Trip (26 Q)
13-14-15	Oil flow relays of the OLTC	Trip (97 C)
16-17	Buchholz relays of the bushing flange oil/SF6-oil oil	Alarm (97 F)
18-19	Buchholz relays of the bushing flange oil/SF6-oil oil	Trip (97 F)
20-21	Pressure gauge bushing phase U	minimum pressure (63 U)
22-23	Pressure gauge bushing phase U	maximum pressure (63 U)
24-25	Pressure gauge bushing phase V	minimum pressure (63 V)
26-27	Pressure gauge bushing phase V	maximum pressure (63 V)
28-29	Pressure gauge bushing phase V	minimum pressure (63 W)
30-31	Pressure gauge bushing phase V	maximum pressure (63 W)
32-33	Buchholz relays of the oil cable box	Alarm (97 M)
34-35	Buchholz relays of the oil cable box	Trip (97 M)
36-37-38	Thermal probe in thermometer pocket	
39-40-41	free	
42-43-44	Over-pressure valve	
45-46	230 Vac Supply of marshalling box heating and lightning	
47-48	Anomaly of marshalling box heating and lightning	
51-52	230 Vac Control cabinet heating supply	
53-54-55-56	400 Vac Motor drive supply	
57-58	230 Vac remote signal supply	
59-60	Max current stop	
61	"Increase MV" remote signal	
62	"Decrease MV" remote signal	
63	Available	
64-65	"Motor On" signalling	
66	Common of OLTC auxiliary contact positions	
67	Extreme position -12	
68	Intermediate positions (- i)	
69	Central positions 0	
70	Intermediate positions (+ i)	
71	Extreme positions +12	
72-73	NC contact of the circuit breaker of the motor drive supply	
74-75	NC contact of the circuit breaker of the heating resistance supply	
81-82	230 Vac Supply self-regenerating breather/s of the transformer	(98 T)
83-84	Anomaly self-regenerating breather/s of the transformer	(98 T)
85-86-87	Warming on self-regenerating breather/s of the transformers	(98 T)
88-89	Analogue remote signal self-regenerating breather/s of the transformers	(98 T)
90-91	230 Vac Supply self-regenerating breather/s of the OLTC	(98 C)
92-93	Anomaly self-regenerating breather/s of the OLTC	(98 C)
94-95-96	Warming on self-regenerating breather/s of the OLTC	(98 C)
97-98	Analogue remote signal self-regenerating breather/s of the OLTC	(98 C)

FIGURE 8– HV OIL/AIR BUSHING: FLANGE AND TERMINAL

FLANGE TRANSFORMER SIDE (CLC/TS 50458)

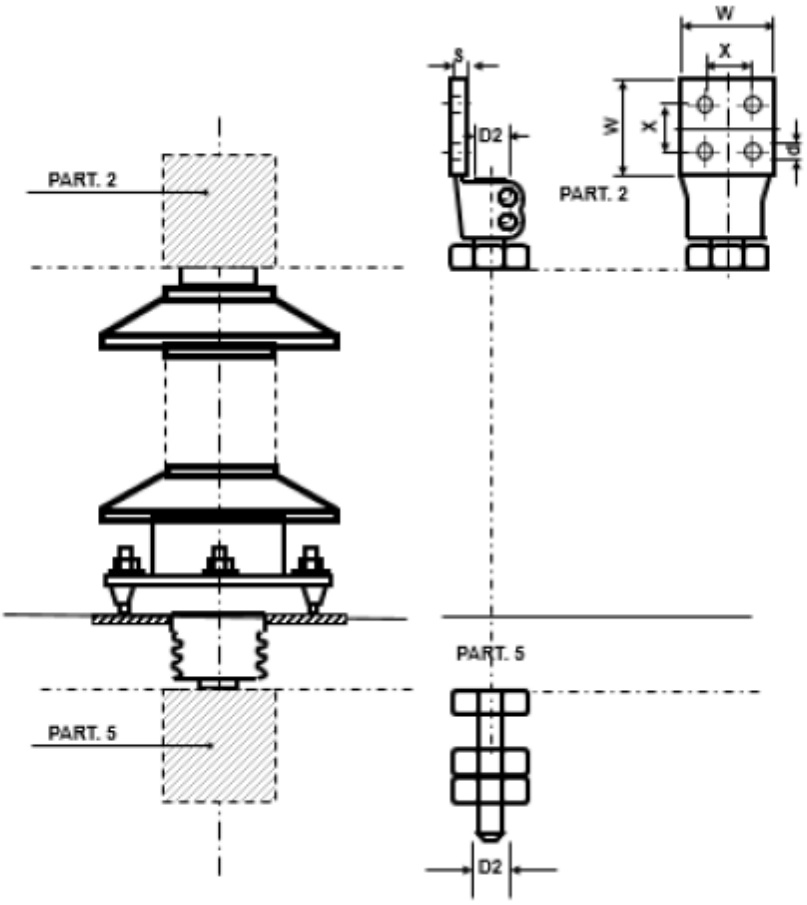


TERMINAL



A – diameter (mm)	40 ± 0,25
H – length (mm)	min. 80
Material: copper o copper league, covered by nickel or silver or tin	

FIGURE 9 – MV BUSHING TYPES AND DIMENSIONS



Classification EN 50180	I_r (A)	Upper interface	Lower interface	D1 (mm)	D2 (mm)	W (mm)	X (mm)	d (mm) x n° holes	S (mm)
24-250/P3	250	Part. 1	(*)	M12	--	--	--	--	--
24-630/P3	630	Part. 1	Part. 4	M20	--	--	--	--	--
24-1250/P3	1250	Part. 2	Part. 5	--	M30x2	60	32	14 x 2	12
24-2000/P3	2000	Part. 2	Part. 5	--	M42x3	100	50	18 x 4	20
24-3150/P3	3150	Part. 2	Part. 5	--	M48x3	120	60	18 x 4	20
(*) direct connection to the upper plug									

ANNEX A – LIST OF COMPONENTS

#	GS Code	TAM	Country	TR/ ATR	Ph	N° of windings	Connection Symbol	Sr (MVA)	Cooling System	Service Cond.	HV Ur (kV)	HV Volt. Reg.	MV Ur (kV)	MV Volt. Reg.	MV2 Ur (kV)	k_{PEI} (pu)	Minimum EI (%)	Bushings Types		
																		HV	MV	MV2
1	GST002-1101	110032	**ROMANIA**	TR	3P	1/1	YNd11	16/16	ONAN	Special	115	±12x1,25%	10,4	-	-	0,35	99,663	OIL/AIR	OIL/AIR	-
2	GST002-1102	110033	**ROMANIA**	TR	3P	1/1	YNd11	16/16	ONAN	Special	115	±12x1,25%	20,8	-	-	0,35	99,663	OIL/AIR	OIL/AIR	-
3	GST002-1103	110034	**ROMANIA**	TR	3P	1/1	YNd11(d11)	16/16	ONAN	Special	115	±12x1,25%	20,8(10,4)	-	-	0,35	99,663	OIL/AIR	OIL/AIR	-
4	GST002-1104	110035	**ROMANIA**	TR	3P	1/1	YNd11	25/25	ONAN	Special	115	±12x1,25%	10,4	-	-	0,35	99,700	OIL/AIR	OIL/AIR	-
5	GST002-1105	110036	**ROMANIA**	TR	3P	1/1	YNd11	25/25	ONAN	Special	115	±12x1,25%	20,8	-	-	0,35	99,700	OIL/AIR	OIL/AIR	-
6	GST002-1106	110037	**ROMANIA**	TR	3P	1/1	YNd11(d11)	25/25	ONAN	Special	115	±12x1,25%	20,8(10,4)	-	-	0,35	99,700	OIL/AIR	OIL/AIR	-
7	GST002-1107	110038	**ROMANIA**	TR	3P	1/1	YNd11	40/40	ONAN	Special	115	±12x1,25%	10,4	-	-	0,34	99,724	OIL/AIR	OIL/AIR	-
8	GST002-1108	110039	**ROMANIA**	TR	3P	1/1	YNd11	40/40	ONAN	Special	115	±12x1,25%	20,8	-	-	0,34	99,724	OIL/AIR	OIL/AIR	-
9	GST002-1109	110040	**ROMANIA**	TR	3P	1/1	YNd11(d11)	40/40	ONAN	Special	115	±12x1,25%	20,8(10,4)	-	-	0,34	99,724	OIL/AIR	OIL/AIR	-
10	GST002-1110	110041	**ROMANIA**	TR	3P	1/1	YNd11	63/63	ONAN	Special	115	±12x1,25%	20,8	-	-	0,33	99,745	OIL/AIR	OIL/AIR	-
11	GST002-1111	110042	**ROMANIA**	TR	3P	1/1	YNd11	10/10	ONAN	Special	115	±12x1,25%	10,4	-	-	0,33	99,615	OIL/AIR	OIL/AIR	-
12	GST002-1112	110043	**ROMANIA**	TR	3P	1/1	YNd11	10/10	ONAN	Special	115	±12x1,25%	20,8	-	-	0,35	99,615	OIL/AIR	OIL/AIR	-
13	GST002-1113	110044	**ROMANIA**	TR	3P	1/1	YNd11(d11)	10/10	ONAN	Special	115	±12x1,25%	20,8(10,4)	-	-	0,35	99,615	OIL/AIR	OIL/AIR	-
14	GST002-1120N	110045	**ROMANIA**	TR	3P	1/1	YNd11	25/25	KNAN	Special	115	±12x1,25%	20,8	-	-	0,35	99,700	OIL/AIR	OIL/AIR	-
15	GST002-1121N	110046	**ROMANIA**	TR	3P	1/1	YNd11	40/40	KNAN	Special	115	±12x1,25%	20,8	-	-	0,34	99,724	OIL/AIR	OIL/AIR	-
16	GST002-RO0122	110108	**ROMANIA**	TR	3P	1/1	Dd0	4/4	ONAN	Special	20	±4x2,5%	6,3	-	-	0,35	99,532	OIL/AIR	OIL/AIR	-

ANNEX B – DATASHEET (example of content*)

Country	ROMANIA
Transformer (TR) or Autotransformer (ATR)	TR
Nº of Phases	3P
Rated frequency: fr (Hz)	50
Number of windings	1/1
Connection Symbol	YNd11
Rated Power Sr (MVA) - (1^{st}W/2^{nd}W/3^{th}W +SW)	40/40
Cooling System (ONAN-AF, … , Powers (MVA))	ONAN (40 MVA)
Installation (Indoor, Outdoor)	Outdoor
Service Conditions (acc. to IEC 60076-1)	Special
Ref. ΔTemp. (TopOil/AvrgWindg/HotSpot)	60/65/78
Rated HV U_r(kV)	115 kV
HV Insulation Levels - (U_m/LI/AV/LIC/SI) (kV)	145/550/230
HV Neutral (Accessible/Not Accessible)	Accessible
HV Neutral insulation levels (U_m/LI/AV) (kV)	145/550/230
HV Volt. Reg. Type (OLTC-DECT-NO)	OLTC
HV Volt. Reg. (n. of steps, value %)	±12x1,25%
MV Rated Voltage U_r(kV)	10,4 kV
MV Insulation levels (U_m/LI/AV) (kV)	24/125/50
MV Neutral (Accessible/Not Accessible)	-
MV Neutral insulation levels (U_m/LI/AC) (kV)	-
MV Volt. Reg. Type (DETC, Intanked Bars, No)	-
MV Volt. Reg. (n. of steps, value %)	-
MV2 Rated Voltage U_r (kV)	-
MV2 Insulation levels (U_m/LI/AC) (kV)	-
MV2 Neutral (inside/outside)	-
MV2 Neutral insulation levels (U_m/LI/AC) (kV)	-
MV2 Volt. Reg. Type (DETC, Intanked Bars, NO)	-

MV2 Volt. Reg. (n. of steps, value %)	-
Tertiary/Stabilizing Winding - (U_{rT} (U_m/LI/AV) - S_{rT})	-
$Zsc_{MIN\ TAP}$ HV-MV (%, ref Sr)	14,6% (40 MVA)
$Zsc_{RATED\ TAP}$ HV-MV (%, ref Sr)	15,5% (40 MVA)
$Zsc_{MAX\ TAP}$ HV-MV (%, ref Sr)	16,8% (40 MVA)
Zsc HV-MV2 (%, ref Sr)	-
Zsc MV-MV2 (%, ref Sr)	-
Zsc HV-SW/Tertiary (%, ref Sr)	-
Zsc MV-SW/Tertiary (%, ref Sr)	-
Load Loss HV - MV (kW)	TIER 2 – GST002 – 5.15
No Load Loss HV - MV (kW)	TIER 2 – GST002 – 5.15
Load Loss HV - MV2 (kW)	-
No Load Loss HV - MV2 (kW)	-
k_{EI} - Load Factor (pu) for the Efficiency Index calculation	0,34
EI - Efficiency Index (%) @ Load Factor – Minimum value required	99,724%
Sound Power Level (L_w(A)) - ONAN or ONAN-ONAF	70,0 dB(A)
HV bushing type	OIL/AIR
HV Neutral bushing type	OIL/AIR
MV bushing type	OIL/AIR
MV neutral bushing type	-
MV2 bushing type	-
MV2 neutral bushing type	-
Pollution Level/Corrosivity	Heavy/C4
Main Accessories	See GST002
Seismic requirements	Yes
Dimensions	See GST002

ADDITIONAL REQUIREMENTS/COMMENTS

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DRAWINGS (OVERALL/DETAILED INDICATIONS

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For a specific component see the datasheet file containing technical requiremets for: GST002-1101 ÷1113, 1120N, 1121N, RO0122.

ANNEX C - TECHNICAL OFFER

(example of content)

This information has been designed for evaluating the compliance of a technical proposal (exclusively in a technical point of view) during the tender process and also might be used for the technical data validation during homologation, certification and/or approval procedures, if not specific documents is indicated.

The acceptance of the document for the tender stage does not mean the acceptance of any deviation to the technical specification if such deviations are not clearly reported.

Deviations are in principle not acceptable. Any deviation or any approach different from the Technical Specification GST002/Datasheet shall be declared and explicitly highlighted, in order to be evaluated during the tender process.

Item	RATINGS	Manufacturer Declared Data (if not relevant indicate "---")	Manufacturer Notes (add remarks, if necessary)
1	TYPE CODE		
2	Country Code (TAM Code)		
3	Country		
4	Transformer (TR) or Autotransformer (ATR)		
5	Nº of Phases		
6	Rated frequency: fr (Hz)		
7	Number of windings		
8	Connection Symbol		
9	Rated Power S_r (MVA) - (1^{st}W/2^{nd}W/3^{th}W +TfCW)		
10	Cooling System (ONAN-AF, … , Powers (MVA))		
11	Installation (Indoor, Outdoor)		
12	Service Conditions (acc. to IEC 60076-1)		
13	Ref. ΔTemp. (TopOil/AvrgWindg/HotSpot)		
14	Rated HV U_r(kV)		
15	HV Insulation Levels - (U_m/SI/LI/LIC/AC) (kV)		
16	HV Neutral (Accessible/No Accessible)		
17	HV Neutral insulation levels (U_m/LI/AC) (kV)		
18	HV Volt. Reg. Type (OLTC-DECT-NO)		
19	HV Volt. Reg. (n. of steps, value %)		
20	MV Rated Voltage U_r (kV)		
21	MV Insulation levels (U_m/LI/AC) (kV)		
22	MV Neutral (Accessible/Not Accessible)		
23	MV Neutral insulation levels (U_m/LI/AC) (kV)		
24	MV Volt. Reg. Type (DECT, Intanked Bars, NO)		
25	MV Volt. Reg. (n. of steps, value %)		
26	MV_2 Rated Voltage U_r (kV)		
27	MV_2 Insulation levels (U_m/LI/AC) (kV)		

28	MV_2 Neutral (Accessible/Not Accessible)		
29	MV_2 Neutral insulation levels (U_m/LI/AC) (kV)		
30	MV_2 Volt. Reg. Type (DECT, Intanked Bars, NO)		
31	MV_2 Volt. Reg. (n. of steps, value %)		
32	Tertiary - Stabilizing winding - (description)		
33	$Zsc_{MIN\ TAP}$ HV-MV		
34	$Zsc_{RATED\ TAP}$ HV-MV (%, ref Sr)		
35	$Zsc_{MAX\ TAP}$ HV-MV		
36	Zsc HV-MV2 (%, ref Sr)		
37	Zsc MV-MV2 (%, ref Sr)		
38	Zsc HV-SW/Tertiary (%, ref Sr)		
39	Zsc MV-SW/Tertiary (%, ref Sr)		
40	Load Loss HV-MV (kW)		
41	No Load Loss HV-MV (kW)		
42	Load Loss HV-MV_2 (kW)		
43	No Load Loss HV-MV_2 (kW)		
44	k_{PEI} - Load Factor @ Peak Efficiency Index (pu)		
45	PEI - Peak Efficiency Index (%) - Minimum		
46	Sound Power Level (Lw(A)) - ONAN or ONAN-ONAF		
47	Pollution Level/Corrosivity		
48	Seismic requirements		
49	Overall dimensions (mm) (lxwxh - lenghtxwidthxheight)		
50	Dimensions for Transport (mm) (lxwxh)		
51	Dimensional drawing (file name)		
52	**Other parameters to be specified**		
52.1	P_{c0}(kW)		
52.2	$P_{ck(kPEI)}$ (kW)		
52.3	To be indicated by manufacturer if needed		
53	**MAIN COMPONENTS**	**Manufacturer Declared Data** (if not relevant indicate "-")	**Manufacturer Notes** (add remarks, if necessary)
53.1	**HV BUSHINGS**	**Phase - Neutral**	
53.1.1	Supplier		
53.1.2	Type		
..	..		