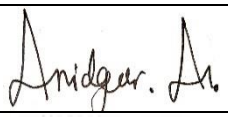
RELIABILITY & H.V. EQUIPMENT DEPARTMENT

Main Technical Requirements

For 400 kV

POWER TRANSFORMER / AUTOTRANSFORMERS

September 2025

	Name	Signature	Date
Prepared by:	Carlos Lisman		25-09-2025
Checked by:	Adir Anidgar		01-10-2025
Approved by:	Chen Marchini		07-12-2025

Requirements for purchase, installation and connection to the Israeli grid

The purchase of equipment, its installation, or its integration into the electricity sector in Israel shall be permitted solely upon receipt of prior written approval from NOGA-ISO (for private customers, within the framework of the technical coordination process, and, with respect to the Israel Electric Corporation - written approval), confirming that the System Requirements Document - as published and updated from time to time on NOGA-ISO's official website - has been fully complied with by the purchaser, and further subject to the submission, in full, of all required technical materials, information, and accompanying documents, as detailed in the System Requirements Document, and upon completion of a formal, full, and final examination and approval, to the sole satisfaction of NOGA-ISO.

MAIN TECHNICAL REQUIREMENTS FOR 400 KV POWER TRANSFORMER /AUTOTRANSFORMERS

Scope of work:

This document describes the System data and the main transformers components, focusing on the threshold requirements.

Its primary purpose is to serve as a technical compulsory guideline for parties involved in preparing a detailed specification for a Power Transformer that complies with applicable local regulations and the Purchaser's requirements in the Israel grid.

Notes:

1. *This document adopts the IEC 60076 as the primary international standard governing power transformers.*
2. *The technical data, procedures, and requirements specified herein shall be regarded as part of the System's Threshold Requirements.*
3. *The final Transformer Specification shall be jointly reviewed by the Customer and the Manufacturer to define the detailed design of each component, in accordance with the Israel Grid Code requirements* https://www.noga-iso.co.il/pdt/grid-code/*.*
4. *In cases where certain components lack the required documentation or fail to meet NOGA-ISO's technical requirements, the equipment or the affected parts may be disqualified for use.*
5. ***This document must be approved and signed by:***

   5.1. End Customer or his representative

   5.2. The entity responsible for preparing the Power transformer specification (if applicable)

   5.3. Power transformer manufacturer

The Customer shall be responsible for providing all data and information requested in this document, and for ensuring that all technical requirements are fully met by the Manufacturer in the final supplied product.
The Customer is also responsible for verifying the accuracy and validity of all data submitted by the Manufacturer.

Project Name:				
Spec. No.				
No. of units:				
	Name	**Company & country**	**Date**	**Sign**
End-Customer or his representative				
Entity responsible for preparing the power transformer spec.				
Manufacturer				

General:

- **Location:** This document covers the installation of transformers indoors or outdoors.
- The applicable standards are included in the respective clauses of this document.
- **Required Information and Documentation:** Requirements about documentation are in Clause 25.
- All clauses must be referenced. It is possible to indicate a ***"data value"***, specify compliance with the requirement (***Comply***), or indicate that the requirement is not applicable (***N/A***).

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TECHNICAL REQUIREMENTS AND REQUIRED INFORMATION

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
1.	**System data**		
1.1.	**System frequency,** according to definition in:	IEC 60050-421, 421-04-03, modified	
1.1.1.	Rated frequency [Hz]	50	
1.1.2.	Range of frequency variation [Hz]	According to ***Israel Grid code***	
1.2.	**System voltages,** according to definitions in:	IEC 60050-421, 421-03-05	
1.2.1.	Rated system voltage (line to line) 400kV/161 [kV]	400/161	
1.2.2.	Highest system voltage (line to line) 400kV/161 [kV]	420/170	
1.3.	**Symmetrical short circuit current 400kV/161kV [KA rms]**	63/50	
1.4.	**Methods of the transformer system neutral earthing**	According to ***Israel Grid Code***	
1.5.	**Fault duration** [sec.]	1	
1.6.	**Earth fault factor (EFF)**	1.4	
1.7.	**Line auto reclosing policy for 400kV / 161kV Sys**.	Single-phase single shot 0.8/0.6 sec.	
2.	**Environmental Conditions**		
2.1.	Environmental conditions according to:	IEC 60721/3-4	
2.1.1.	7 months a year without rain with more than 100 nights with dew and high humidity in the air as experienced in coastal or desert areas in this country.		
2.1.2.	Severe atmospheric and industrial air pollution, dust, salt spray and sandstorms		
2.1.3.	Altitude over the sea level up to [m]	1000	
2.1.4.	**Chemically active substances**: **corrosively category** according to:	ISO 9223, C5	
2.1.5.	**Classification of mechanically active substances** according to:	IEC 60721-3-4 Table 4 4S13	
2.1.6.	Bushing's pollution levels: Desert and Coastal types of environments, according to:	IEC 60815-1/ Table 5, E6 E7	
2.1.7.	Type of Pollution: Desert-Coastal, high inert content	Mixed A+B, A prevalent IEC TS 60815-1	
2.1.8.	Site pollution severity (SPS) class	e (very heavy)	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
2.1.9.	Non-Soluble Deposit Density (NSDD) [mg/cm^2]	2	
2.1.10.	Equivalent Salt Deposit Density (ESDD) [mg/cm^2]	0.45	
2.1.11.	Annual number of dangerous wetting events	200	
2.2.	**Classification of Climatic Conditions** according to:	IEC 60721-3-4 Table 1 4K26	
2.2.1.	Water from sources other than rain [m/s]	15	
2.2.2.	Classification of special climatic conditions according to:	IEC 60721-3-4 Table 2 4Z5	
2.3.	**Ambient air temperatures**		
2.3.1.	The indicated temperatures will be considered as default. Other temperatures values must be justified by customer and approved by NOGA-ISO	Maximum: 50°C	
2.3.2.		Minimum -5°C	
2.3.3.		Monthly average (hottest month) 40 °C	
2.3.4.		Yearly average 30 °C	
3.	**Seismic Qualification Level**		
Note 1	**The specified Seismic Qualification Level shall apply to the transformer and all associated accessories. The transformer and its components shall be tested and / or analyzed to demonstrate compliance with the seismic design requirements**		
3.1.	Applicable standard:	• IEEE 693-2018 • IEEE 693A-2024 • IEC TS 61463	
3.2.	Seismicity of site:	Moderate level	
3.3.	Peak ground acceleration with an 85% probability not to be exceeded over a 50-year period:	0.5g	
4.	**Electromagnetic Environment**		
4.1.	The electronic devices delivered with the transformer shall withstand an electromagnetic environment having the following maximum severity levels according to:	• IEC 60255-26 • IEC 60255-22-part 1-2-3-4	
4.2.	Severity level for electrostatic discharge [kV]	4	
4.3.	Severity level for radio frequency interference [V/m]	10	
4.4.	Severity level for electrical 1 MHz burst disturbance [kV]	2.5	
4.5.	Severity level for fast transients according to [kV]	2	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
5.	**Acceleration During Transport**		
5.1.	Typical accelerations expected during handling and transport of power transformer by crane, rail, road, sea or air, shall be considered in the mechanical design.	The manufacturer shall specify the maximum permissible acceleration values along the three geometrical axes of the transformer (X-Y-Z) based on the intended mode(s) of transport. These values shall not be lower than 1g, in accordance with Clause 5.7.4.2 of IEC 60076 -1	
5.1.1.	Longitudinal / Transversal / Vertical [g]	Proposal values	/ /
5.1.2.	At least two impact recorders will be installed at factory. The recorders shall remain attached to the transformer throughout the entire transportation process, including final offloading onto the foundations pad at the installation site according to Section 6.1.3 of IEEE C57-150 (2012)		
6.	**Functional Specifications**		
6.1.	**The transformer ratings shall be based on the temperature conditions specified in Clause 2**		
6.2.	**Type of transformer**	Transformer / Autotransformer / GSU / Other	
6.3.	**Number of phases:**	1 / 3	
6.4.	Cooling method	According to IEC 60076-2	
6.5.	**Rated power [MVA]:**		
6.5.1.	Rated power with all cooling system in operation [MVA]		
6.5.2.	Rated power considering alternative fans and/or pumps operating configurations [MVA]	No operation/partial operation	/
6.5.3.	Rated power of tertiary winding	If applicable	
6.6.	Connection phase displacement symbol	• According to IEC 60076-1 and ***Israel Grid Code***. • Shall be considered the possibility of parallel connection with existing or future units.	
6.7.	Minimum required isolation levels: For 400 kV: at least LI 1425 - SW 1050, for 170 kV; LI 650 kV/ AC 275 kV, for neutral terminal LI 250 kV according to:	IEC 60076-3 clause 7.2.2 and Table 2	HV: / LV: / N: T: /
6.8.	Rated Currents with full operation of cooling system and under climatic conditions in Clause 2:		
6.8.1.	Principal tap [A]	(HV/LV)	/
6.8.2.	Maximum tap [A]	(HV/LV)	/
6.8.3.	Minimum tap [A]	(HV/LV)	/

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
6.9.	**Rated voltages**	Should consider the possibility of parallel connection with existing or future units	
6.9.1.	HV [kV]		
6.9.2.	LV [kV]		
6.9.3.	Tertiary (T) [kV]		
6.9.4.	HV, LV or Autotransformer Neutral voltage [kV] according to:	• IEC 60076-3, Clause 7.4.2 • ***Israel Grid Code***	
6.9.4.1.	The Neutral shall be brought out through a neutral bushing and shall be suitable for grounding connection		
6.9.5.	Rated voltage ratio at principal tap (Primary/Secondary) [kV]		/
6.9.6.	Rated voltage ratio at maximum tap (Primary/Secondary) [kV]		/
6.9.7.	Rated voltage ratio at minimum tap (Primary/Secondary) [kV]		/
6.10.	**Short-circuit voltage at 75°C, based on rated power between HV and LV winding terminals**	• Tolerances according to IEC 60076-1 Table 1 • Should consider the permissible short circuit currents and the possibility of parallel connection with existing or future units. • The minimum short-circuit voltage will be according to IEC 60076-5 Table 1	
Note 2	**The short-circuit voltage at 75°C must be verified and approved by NOGA-ISO**		
6.10.1.	Principal tap [%]		
6.10.2.	Maximum tap [%]		
6.10.3.	Minimum tap [%]		
6.11.	**Zero sequence impedance measured at rated frequency by applying a single-phase voltage**		
6.11.1.	Principal tap [ohm/phase]		
6.11.2.	Maximum tap [ohm/phase]		
6.11.3.	Minimum tap [ohm/phase]		
6.12.	**Temperature rise limit** according to:	IEC 60076-2, Table 1 and Table 2	
Note 3	**The temperature rise correction factor must be K = -10 in accordance with Table 2 of IEC 60076-2. This correction factor shall be applied to the temperature rise limits specified in Table 1 of the same standard. The use of any other K value shall be subject to justification by Customer and shall require NOGA-ISO's prior approval.**		

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
6.12.1.1.	Selected K factor:		
6.12.1.2.	Top insulation oil temp. rise, no more than [K]	50	
6.12.1.3.	Average winding temp. rise (by resistance variation) no more than [K]	55 60 for ODAF	
6.12.1.4.	Winding Hot-Spot temperature rise, no more than [K]	68	
6.13.	Inrush r.m.s. magnetizing current with no residual magnetism at rated voltage (p.u based on full load current) according to:	Grid connection Survey	
6.14.	**Permissible time the transformer can withstand the following power frequency over-voltages at no-load:**		
6.14.1.	140% overvoltage [sec] **(Load rejection in GSU transformers)**	At least 5 sec according to IEC 60076-1 clauses 5.3 and 5.5	
6.14.2.	135% overvoltage [sec]		
6.14.3.	130% overvoltage [sec]		
6.14.4.	125% overvoltage [sec]		
6.14.5.	120% overvoltage [sec]		
6.14.6.	115% overvoltage [min]		
6.14.7.	110% overvoltage [min]		
6.15.	**Max. Overload capability** according to:	IEC 60076-7	
6.16.	**Overcurrent capability** according to:	• IEC 60076-7, Table 3 • IEC 60076-1 clause 5.1.4	
6.17.	**Overcurrent conditions** according to:	IEC 60076-5 clause 3.2	
6.17.1.	Indicate if there is an overcurrent condition and the type according to:	IEC 60076-5 clause 3.2.1.1	
Note 4	**All associated transformer components, including bushings, CT's, tap changer, and others. shall be capable of withstanding the transformer's overload an overvoltage characteristic considering IEC 60076-1 clauses 5.1.4 and 5.8**		

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
6.18.	**Maximum guaranteed total sound power level under full load, at rated voltage, rated current and rated frequency with all the cooling sections in operation [dB(A)],** according to:	The selection of the transformer's "Maximum Guaranteed Total Sound Power Level" shall be determined based on the findings of an environmental survey duly approved by the Ministry of Environmental Protection or by any other competent authority having jurisdiction over the site of the transformer installation. The Customer acknowledges and accepts that the determination and selection of the appropriate sound power level shall be under the Customer's sole and exclusive responsibility.	
6.19.	**Provision for unusual service conditions**		
6.19.1.	Indicate whether the transformer will be used under unusual service conditions and the type according to:	IEC 60076-1 clause 5.5	
6.20.	Indicate the duration of the symmetrical short-circuit current [sec.] to be used for the calculation of the thermal ability to withstand short circuit according to:	IEC 60076-5 clause 4.1.3	
7.	**Bushings**		
Note 5	**The data required for HV 400 kV bushings in clauses 7.1 to 7.22 must also be provided for all types of bushings installed on the transformer.**		
7.1.	The bushings shall be designed for the service conditions stated in clause 2 and 3 of this document and according to:	IEC 60137	
7.2.	HV bushing manufacturer and model / type		
7.3.	LV bushing manufacturer and model / type		
7.4.	N bushing manufacturer and model / type		
7.5.	Tertiary bushing manufacturer and model / type		
7.6.	All bushings shall be tested according to:	IEC 60137	
7.7.	Required minimum values of cantilever withstand load applied on the bushings according to	IEC 60137 clause 4.5 (level II)	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
7.8.	Rated voltage [kV]	400	
7.9.	Highest phase-to-phase voltage [kV r.m.s]	420	
7.10.	Highest phase-to-earth voltage [kV r.m.s]	242	
7.11.	Maximum phase–to-earth temporary over-voltages the bushings can withstand according to:	IEC 60137 clause 5.1	
7.12.	HV Bushings Insulation levels must be according to IEC 60137 Table 3 and at least:		
7.12.1.	Lightning & switching impulse withstand voltage for 400kV and Lightning impulse for 170 kV [kV peak]	1550-1175/750	
7.12.2.	Power frequency withstand voltage (dry) [kV r.m.s] 400kV/170 kV	750/355	
7.12.3.	Power frequency withstand voltage(wet) for 170 kV only [kV r.m.s]	325	
7.12.4.	Neutral Bushing	According to the selected Neutral voltage in Clause 6.9	
7.13.	Creepage distance [mm] according to SPS class e and RU SCD= 53.7 IEC 60815-3 / 60815-1. For HV bushings, at least:	13200/5270	
7.14.	The bushing profile shall include Alternating Sheds according to:	IEC 60815-3	
7.15.	Arcing distance at least [mm] 400kV/170 kV considering IEC 60845-2 clause 9.7	3500/1500	
7.16.	Rated current according to:	• Clauses 6.8 and 6.16 • IEC 60137 Clause 4.2	
7.17.	Rated thermal short-time current (Ith) at 2 sec, at least	25 Ir	
7.18.	Dynamic short-circuit withstand current according to:	IEC 60137, clause 4.4	
7.19.	The seismic qualification for all bushings will be in accordance with:	Clause 3	
Note 6	**The qualification procedure must comply with the requirements of one of the following standards.**		
7.19.1.	IEEE 693-2018, IEEE 693a-2024	According to Annex D, clause D5	
7.19.2.	IEC TS 61463		

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
7.19.2.1.	The qualification can be demonstrated by dynamic analysis when:	The manufacturer can demonstrate that the bushing behaves linearly and elastically under seismic stress according to IEC TS 61463.	
7.19.2.2.	The qualification must be demonstrated by vibration including time-history test when:	The behavior of the specimen under test is not linear according to IEC TS 61463.	
7.20.	The temperature limits of metal parts in contact with insulating material must be according to:	IEC 600137	
7.21.	The bushing hottest spot temperature above the temperature of the immersion medium in overload condition must be according to:		
7.22.	Required profile parameters for bushings according to:	The required parameters must be completed in the Remarks column of Annex 2	
8.	**Tap Changer**		
Note 7	**For transformers equipped with an OLTC, it must be provided with all necessary control, alarm and protection devices.**		
8.1.	Applicable standard:	IEC 60214	
8.2.	Type:	OLTC / DETC	
8.3.	Manufacturer and model		
8.4.	Location:	Primary/ Secondary/ Neutral end/ Auto point	
8.5.	Voltage range [%]	According to the target voltage desired value and the possibility of working in parallel with existing or future units	
8.6.	Step voltage [V]		
8.7.	Tap No. at nominal ratio (Principal Tap)		
8.8.	Number of taps above principal position		
8.9.	Number of taps below principal position		
8.10.	Rated step capacity [kVA]		
8.11.	The isolation level of the tap-changer must be appropriate considering the installation place in clause 8.4.		
8.12.	OLTC maximum rated through current Irm (A) as defined in:	IEC 60214-2	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
8.12.1.	The maximum rated through current Irm shall be at least 120% from the highest transformer tapping current in Clause 6.8	Irm ≥ 1.2 It	
8.13.	Overload capability of the tap changer according to:	IEC 60076-7	
8.14.	Dynamic short-circuit withstand current [KA peak]:		
8.15.	Voltage class [kV]:		
8.15.1.	Lightning impulse withstand voltage 1.2/50µsec [kV peak]		
8.15.2.	Power frequency withstand voltage 50 Hz, 1 min [kV rms]		
8.15.3.	Maximum continuously operating voltage:		
8.15.3.1.	To earth at least [kV peak] / [kV rms]		/
8.15.3.2.	Between phases [kV peak] / [kV rms]		/
8.15.3.3.	Between the first and last contacts of the tap selector or selector switch and, where fitted, of the change-over selector [kV peak] / [kV rms]		/
8.15.3.4.	Between any two adjacent contacts of the tap selector or selector switch or any other contacts relevant to the tap-changer contact configuration [kV peak] / [kV rms]		/
8.15.3.5.	Between diverter switch contacts in their final open position [kV peak] / [kV rms]		/
8.16.	The OLTC must be provided with a protection device. The following devices can be considered:	• PRD • Gas and oil flow relay • Overpressure relay	
9.	**X/R ratio:**		
9.1.	Principal tap		
9.2.	Maximum tap		
9.3.	Minimum tap		
9.4.	Voltage drop [kV]		
10.	**Windings**		
10.1.	Applicable standards for winding wires and cables:	• IEC 60317 • IEC 60554	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
10.2.	The copper conductor used for winding production shall be enamel-insulated according to:	IEC 60317	
10.3.	Insulation:		
10.3.1.	Thermal insulation class of the winding wire/cable will be at least 120 °C (E) according to:	IEC 60085	
10.3.2.	The winding wire/cable paper insulation material shall be at least Thermally Upgraded Paper		
10.4.	The temperature rise at Rated Power must not exceed the values in:	clause 6.12	
10.5.	The transformer windings will be able to withstand three-phase short-circuit currents (thermal and dynamic) in all taps.		
10.6.	The transformer windings shall be able to withstand the stated symmetrical short-circuits for not less than [sec]	2 or according to clause 6.20	
10.7.	The maximum permissible value of average temperature of the winding after short-circuit shall be according to:	IEC 60076-5 Table 3	
10.8.	Transformers with primary and secondary windings in Y (star) configuration must be equipped with tertiary windings for stabilizing purposes.		
10.9.	The insulation of the Delta Tertiary winding must be thermally adequate to the main windings transformer's overload capacity.		
10.10.	The dimension of the Tertiary winding must be suitable to withstand the conditions of Clause 10.5, single phase short circuits and unbalanced loads.		
11.	**Insulation oil**		
11.1.	The transformer oil shall meet the requirements indicated in:	• Annex 1 • IEC 60296	
11.2.	The mixability between oils must be in accordance with:	• IEC 60296 • IEC 60422	
12.	**Gas and liquid actuated relay (Buchholz relay)**	According to IEC 60076-22-1	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
13.	**Pressure relief devices**	According to IEC 60076-22-1	
14.	**Voltage Control and Parallel System**		
14.1.	The voltage control and parallel operation system (VCS) shall include an Automatic Voltage Regulator, Limit Volt Instrument and Voltage Regulator Topology instrument (if applicable)		
14.2.	Parallel operation is based on a MASTER-FOLLOWER configuration (if applicable)		
14.3.	VCS software shall fulfill the CYBER REQUIREMENTS according to:	Israel Grid code	
15.	**Oil Preservation System**		
15.1.	The oil preservation system must include a system that prevents direct contact between the oil and air.		
15.2.	The oil for the OLTC diverter and main tank shall be separated		
16.	**Transformer Cooling System**		
16.1.	The cooling system will include the necessary heat exchangers, fans and/or pumps, which together with automatic control equipment will maintain the transformer temperature within the established limits taking in consideration the environment conditions according to:	• IEC 60076-22 • Clause 2	
16.2.	The control of the cooling system will be carried out through a transformer monitoring system	See Clause 17	
17.	**Transformer Monitoring Systems**		
17.1.	A Monitor/s for Oil-Filled Transformer shall be provided for control and monitoring at least the following functions:		
17.1.1.	Winding temperature monitoring		
17.1.2.	Top oil temperature monitoring		
17.1.3.	On-Load Tap changer temperature monitoring		
17.1.4.	Cooling system and fan control.		
17.1.5.	PRD actuation alarms		

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
17.1.6.	Main tank and OLTC conservator compartments oil level monitoring.		
17.1.7.	On-Line monitoring and analysis system for dissolved gases and moisture in transformer oil		
18.	**Control Box**		
18.1.	All control and protection devices, switches, CT terminals, etc., will be assembled in a dustproof and weatherproof box, with a temperature and humidity control system considering clauses 2 and in accordance with:	IEC 61439-1 and 2	
18.2.	The control box shall be mounted directly on the tank walls or in its proximity.		
18.3.	The degree of protection shall be at least IP 55 According to	IEC 60529	
18.4.	Electromagnetic Control box code shall be at least EM4677xx, according to:	IEC 61000-5-7	
18.5.	The control box shall be supported by suitable vibration damping device designed to withstand the seismic characteristics described in:	clause 3	
18.6.	The coating must be designed to withstand the Climatic and Environmental Conditions according to:	clause 2	
18.7.	Thermal calculations of the control box must be performed according to:	IEC 61439-1 clause 10.10	
19.	**Tank**		
19.1.	The transformer tank shall be of welded steel plate construction reinforced to withstand the most severe conditions of operation, transport and vacuum treatment according to:	IEC 60076-1	
19.2.	The transformer tank shall be absolutely water and hot-oil tight and provided with an oil tight cover according to:	IEC 60076-1, Clauses 11.8 and 11.11	
19.3.	Tank anchorage design according to:	IEEE 693-2018, cl. D 8.2	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
19.4.	The mechanical design of the tank should avoid any accumulation of water.		
19.5.	Grounding pads should be designed at least for the maximum short circuit current according to:	• Clause 1.3 • IEC 60076-22-7	
19.6.	It is advisable to include in the tank design a suitable support for surge arresters mounting to minimize the distance between them and the bushings.		
19.7.	Ground connection must be provided to all removable metal parts and accessories of the transformer.		
20.	**Coating Application System**		
20.1.	The coating system shall provide protection against atmospheric erosion and corrosion in accordance with the environmental conditions defined in:	clause 2	
20.2.	All coating for internal and external parts must be compatible with the transformer oil		
20.3.	Certificates of mechanical inspection and coating must be included in FAT report.		
21.	**Rating plates**		
21.1.	The Rating Plate must include all the information requested in:	IEC 60076-1 clause 8	
21.2.	Data on the Rating Plate must be engraved with any system that guarantees its readability throughout the transformer service life.		
22.	**Transformer test**		
22.1.	**Routine tests** according to:	IEC 60076-1 clause11	
Note 8	**All routine tests and marked with asterisk (*) special tests shall be performed on each supplied power transformer**		
22.1.1.	Measurement of winding resistance according to:	IEC 60076-1, clause11.2	
22.1.2.	Measurement of voltage ratio and check of phase displacement according to:	IEC 60076-1 clause11.3	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
22.1.3.	Measuring of short-circuit impedance and load losses. Shall be performed at principal tap and on the highest and lowest tap	IEC 60076-1 clause11.4	
22.1.4.	Measuring of no-load loss and exciting current at 90%, 100% and 110% of rated voltage, according to	IEC 60076-1 clause11.5	
Note 9	**Insulation oil tests according to Annex 1, shall be performed before and after dielectric test.**		
22.1.5.	Dielectric Test for windings with **U_m > 170 kV**:	IEC 60076-3 clause 7.3.3	
22.1.5.1.	Chopped wave lightning impulse test (LIC)	IEC 60076-3 clause 7.3.3.1 a	
22.1.5.2.	* Lightning impulse test on the neutral terminal (LIN)	IEC 60076-3 clause 7.3.3.2 a	
22.1.5.3.	Switching impulse test for the line terminal (SI)	IEC 60076-3 clause 7.3.3.1 b	
22.1.5.4.	Applied voltage test (AV), according to	IEC 60076-3 clause 7.3.3.1 c	
22.1.5.5.	Induce voltage test &PD (IVPD)	IEC 60076-3 clause 7.3.3.1 d	
22.1.6.	Dielectric Test for windings with **72.5 < U_m ≤ 170 kV**	IEC 60076-3 clause 7.3.2	
22.1.6.1.	*Chopped wave lightning impulse test (LIC)	IEC 60076-3 clause 7.3.2.2 b	
22.1.6.2.	Applied voltage test (AV)	IEC 60076-3 clause 7.3.2.1 b	
22.1.6.3.	Line terminal AC withstand voltage test for non-uniformly insulated transformers (LTAC) or Switching impulse test (SI)	IEC 60076-3 clause7.3.2.1 d or IEC 60076-3 clause7.3.2.2 a	
22.1.6.4.	* Lightning impulse test on the neutral terminal (LIN)	IEC 60076-3 clause 7.3.2.2 d	
22.1.7	Dielectric Test for windings with **U_m ≤ 72.5 kV**	IEC 60076-3 clause 7.3.1	
22.1.7.1.	*Chopped wave lightning impulse test (LIC)	IEC 60076-3 clause 7.3.1.3 b	
22.1.7.2.	Applied voltage test (AV)	IEC 60076-3 clause 7.3.1.1 a	
22.1.7.3.	* Lightning impulse test on the neutral terminal (LIN)	IEC 60076-3 clause 7.3.1.3 c	
22.1.8.	Auxiliary wiring insulation test (Aux W)		
22.1.9.	Test on On Load Tap Changer, where appropriate according to:	IEC 60076-1 clause 11.7	
22.1.10.	Check of ratio and polarity of built in CTs	IEC 60076-1 clause 11.1.2.1 i	
22.1.11.	*CT insulation resistance measurement tests shall be performed for each transformer, on the CT terminals block, at 2.5 kV r.m.s		

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
22.1.12.	Check of core and frame insulation according to:	IEC 60076-1 clause 11.12	
22.1.13.	Determination of capacitances windings to earth and between windings		
22.1.13.1	Measurement of the dissipation factor (tan δ) of the insulation system capacitances	IEEE Std C.57.12.90 clause 10.10	
22.1.13.2	*Measurement of d.c. insulation resistance each winding to earth and between windings		
22.1.14.	Measurement of dissolved gases in dielectric liquid according to:	• IEC 61181 • IEC 60567	
22.1.15.	Measurement of non-load loss and current at 90% and 110% of rated voltage according to	IEC 60076-1 clause 11.5	
22.1.16.	Leak testing with pressure according to:	IEC 60076-1 clause 11.8	
22.1.17.	*Vacuum tightness test according to:	IEC 60076-1 clause 11.11	
22.1.18.	*Measurement of frequency response (SFRA)	IEC 60076-18	
22.1.19.	*Check of external coating according to:	ISO 2178 and 2409 or as specified	
22.2.	Type test according to:	IEC 60076-1 clause 11	
Note 10	**Type tests and special tests marked with a double asterisk (**) shall be conducted on at least one transformer, when one or more units are supplied under the same Functional Specifications in clause 6**		
22.2.1.	Temperature-rise tests according to:	IEC 60076-2	
22.2.1.1.	** Winding hot-spot temperature-rise measurement (**If applicable**) as a part of temperature-rise test according to:	IEC 60076-1 clause 11.1.4 b	
Note 11	**In the event of two or more power ratings indicated on the nameplate (for example, where two or more cooling methods are provided), the Temperature-rise tests must be carried out for all declared power ratings.**		
22.2.1.2.	The temperature rise test shall be made also for tertiary winding		
22.2.1.3.	A chromatographic analysis of dissolved gases in the oil shall be performed before and after the temperature rise test according to	• IEC 61181 • IEC 60567	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
22.2.2.	Determination of transformer sound power level with the OLTC on the principal tapping and other tap position if needed for maximum sound power level, and for each method of cooling, including No load excitation and Short-circuit impedance voltage rated current according to:	IEC 60076 - 10	
22.2.3.	**Determination of the transient voltage transfer characteristics according to:	IEC 60076-3: 2018 Annex B	
22.2.4.	**The thermal and dynamic ability to withstand the short-circuit currents with the duration indicated in clause 6.21, shall be demonstrated by calculation according to:	IEC 60076-5	
22.2.5.	**Measurement of zero-sequence impedance, according to:	IEC 60076-1 clause 11.6	
22.2.6.	**Vacuum deflection test according to:	IEC 60076-1 clause 11.9	
22.2.7.	**Pressure deflection test according to:	IEC 60076-1 clause 11.10	
22.2.8.	Measurement of the power taken by the cooling system		
Note 12	**Special tests according to IEC 60076-1 clause 11:** *** Special tests required by NOGA-ISO for all routine or type test transformers** **** NOGA-ISO required special test in type test transformers only**		
23.	**NOGA-ISO additional tests requirements**		
23.1.	If the transformer is shipped without oil, the moisture content expressed as a percentage of insulation's dry weight, shall be provided for each delivered transformer according to:	IEEE Std C57.93-2019	
23.1.1.	The moisture content in percent of insulation dry weight on each transformer shall not exceed (%)	0.5	
23.2.	Measurement of the bushing's dielectric dissipation factor (tan δ) and C1-C2		
23.3.	**No-load harmonics**		
23.3.1.	No-load harmonics at 100% rated voltage [%]**:**	3rd, 5th and 7th	
23.3.2.	No-load harmonics at 110% rated voltage [%]:	3rd, 5th and 7th	

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
24.	**Cyber & Information Security**		
24.1.	Safety information for design and manufacturing equipment is set out in:	Israel Grid Code	
24.2.	Network and equipment security safeguards are set in:		
25.	**Required Attachments**		
25.1.	Filled " Main Technical Requirements For 400 kV power transformer / autotransformers"		
25.2.	Valid manufacturer certifications according to:	• ISO 9001 • ISO/IEC 17025	
25.3.	Transformer instruction book		
25.4.	Tap Changer and VCS devices: Routine and Type Test certificate according to:	IEC 60214	
25.5.	Buchholtz Relay: C.O.T and Type test certificates according to:	IEC 60076-22	
25.6.	PRD: C.O.T and Type test certificates according to	IEC 60076-22	
25.7.	Bushings: Routine and Type Test certificates, data sheet and drawings, including sheds profile drawings according to:	IEC 60137	
25.8.	Bushings seismic qualification test	According to clause 7.19	
25.9.	Calculations demonstrating that the transformer complies with the clause 3: Seismic Qualification Level for the following components:	• Tank • Core and coils. • Anchorage • Radiators • Conservators • Control cabinets	
25.10.	The thermal and dynamic ability to withstand the short-circuit currents calculation with the duration indicated in clause 6.20, according to:	IEC 60076-5	
25.11.	Oil certificates according to	Annex 1	
25.12.	Rating plate drawing		
25.13.	Transformer general dimensions drawing		
25.14.	Anchoring system drawing of the transformer and pad.		

	Description	Required Value or Applicable Standard	Manufacturer's Confirmation or Proposal
25.15.	FAT and SAT programs and tests reports according to:	• NOGA-ISO requirements in clause 22, 23 and 26 • IEC 60076	
25.16.	A manufacturer commissioning authorization according to:	Clause 26.3	
25.17.	Filled Annex 1 "Operational experience"		
25.18.	Filled Annex 2 "RAMS"		
26.	**FAT, Arrival test and SAT**		
26.1.	• NOGA-ISO shall evaluate and approve the content of the FAT and SAT programs. The FAT program must be submitted to NOGA-ISO at least one month prior the scheduled test date, and SAT program at least one month prior the scheduled installation date. • The FAT program and report shall include the description of each test, the applicable standard, test voltage (where applicable), acceptance criteria, guaranteed values, and tolerances. The FAT report must include a Rating Plate drawing. • The results of the FAT and SAT must be sent to NOGA-ISO for evaluation. • **The transformer will not be shipped to its destination before obtaining the FAT approval by NOGA-ISO**.		
26.2.	Arrival test and SAT: The manufacturer may propose alternative procedures for the Arrival test and SAT. The final content shall be agreed upon by the Customer, the Manufacturer and NOGA-ISO. The Arrival test and SAT programs shall, at minimum, include the recommendations of standard:	IEEE C57.150	
26.3.	**The manufacturer must grant a commissioning authorization based in the results of the SAT report**		
27.	**Operational experience**	See Threshold Requirements on NOGA-ISO website	
28.	**Reliability, Availability, Maintainability and Safety**	See RAMS document on NOGA-ISO website	

Annex 1: Insulation oil

Insulation oil

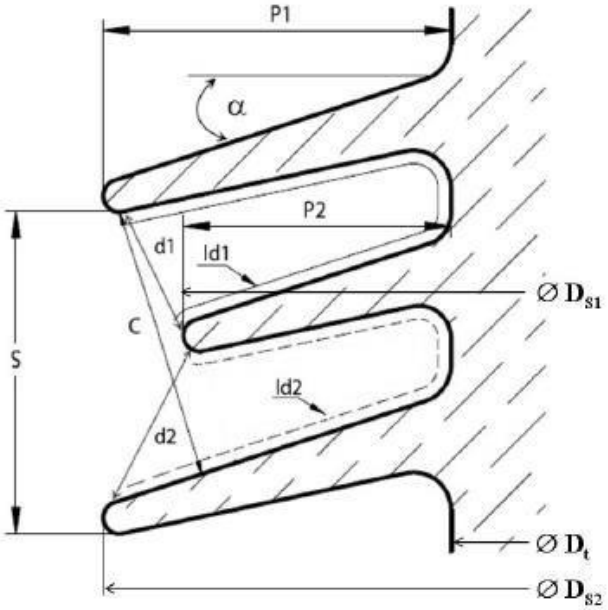
1.	The transformer oil shall meet the requirements indicated in:		IEC 60296
1.1.	The mixability between oils must be in accordance with:		• IEC 60296 • IEC 60422
1.2.	**Requirements for Insulation Oil:**		
	Property	**Test method**	**Limits**
1.2.1.	**Function**		
1.2.1.1.	Viscosity at 40 °C	ISO 3104	Max. 12 mm²/s
1.2.1.2.	Viscosity at -30 °C	ISO 3104	Max. 1 800 mm²/s
1.2.1.3.	Pour point	ISO 3016	Max. -40 °C
1.2.1.4.	Water content	IEC 60814	Max. 30 mg/kg [a]/40 mg/kg [b]
1.2.1.5.	Breakdown voltage	IEC 60156	Min. 30 kV/70 kV [c]
1.2.1.6.	Density at 20 °C	ISO 3675 or ISO 12185	Max. 0.895 g/ml
1.2.1.7.	DDF at 90 °C	IEC 60247 or IEC 61620	Max. 0.005
1.2.2.	**Refining/stability**		
1.2.2.1.	Appearance		Clear, free from sediment and suspended matter
1.2.2.2.	Acidity	IEC 62021-1	Max. 0.01 mg KOH/g
1.2.2.3.	Interfacial tension	EN 14210 or ASTM D971	Min. 40 mN/m
1.2.2.4.	Corrosive sulfur	DIN 51353	Not corrosive
1.2.2.5.	Anti-oxidant inhibitor	IEC 60666	0.08 - 0.40%
1.2.2.6.	Dibenzyl Disulfide (DBDS)	IEC 62697-1	Not detectable (<5 mg/kg)
1.2.2.7.	Metal passivators additives according to:	IEC 60666	Not detectable (<0.05 mg/kg)
1.2.2.8.	2-Furfural content	IEC 61198	Non-detectable (<0.05 mg/kg)
1.2.3.	**Performance**		
1.2.3.1.	Oxidation stability [f]	IEC 61125 (method C) Test duration: 500 h	
1.2.3.2.	Total acidity [f]	IEC 61125	Max. 1.2 mg KOH/g
1.2.3.3.	Sludge [f]	IEC 61125	Max. 0.8%
1.2.3.4.	DDF at 90 °C [f]	IEC 61125	Max. 0.5
1.2.4.	**Health, safety, and environment**		
1.2.4.1.	Flash point	ISO 2719	Min. 135 °C
1.2.4.2.	PCA content	BS 2000 Part 346	Max. 3%
1.2.4.3.	PCB content	IEC 61619	Not detectable (<2 mg/kg)

1.2.4.4.	[a] For bulk supply, [b] For delivery in drums, [c] After laboratory treatment,	[d] Information must be provided [e] At the end of oxidation stability test [f] To be performed at the end of oxidation stability test.

1.3.	**Requirements for Insulation Oil After Filling a New Equipment:**	
	Property	**Requirement**
1.3.1.	Appearance	Clear, free from sediment and suspended matter
1.3.2.	Color (on scale given in ISO 2049)	Max. 2.0
1.3.3.	Breakdown voltage [kV]	>55
1.3.4.	Water content [mg/kg] [g]	< 20
1.3.5.	Acidity [mg KOH/g]	Max. 0.03
1.3.6.	DDF at 90°C and 40 to 60 Hz	Max. 0.015
1.3.7.	Resistivity at 90°C [GΩm]	Min. 60
1.3.8.	Interfacial tension [mN/m]	Min. 35
1.3.9.	Total PCB content [mg/kg] [h]	Not detectable (< 2 total)
1.3.10.	Particles (counting, sizing)	Should be made as baseline for future comparation
1.3.11.	Inhibitor content [h]	-
1.3.12.	Total gas content according to IEC 61181 [i]	< 1%
1.3.13.	DGA according to IEC 61181	-
1.3.14.	[g] The values should be without temperature correction [h] Shall be similar to the value before first filling. [i] By vacuum extraction.	
1.3.15.	The transformer oil COT shall be approved by Purchaser before delivery according to:	IEC 60296

Annex 2: Bushings required profile parameters

	Required Data and Documentation	
	Flat Alternating Sheds	
	The profile parameters shall be according to the following values	



P_1-P_2	> 15 mm
S/P_1	> 0.75
C	> 40 mm
α	7° ≤ α ≤ 14°
D_a	< 300 mm
K_{ad}	1
USCD	53.7 mm/kV
A	> 1500 mm
CF = L/A	3.0 < CF < 4.5
l_1/d_1	2.5 ÷ 4.5
l_2/d_2	2.5 ÷ 4.5

P_1, P_2, S, C, α, ld_1, d_1, ld_2, d_2, D_{s1}, D_{s2}, D_t: see drawing.

$$D_a = \frac{D_{s1} + D_{s2} + 2D_t}{4}$$

L: creepage distance.

A: arcing distance.

Revision Control Table:

Rev	Date	Revision description	Performed by	Approved by
01	18-01-2026	Changes have been made to Annex 2: Operational Experience and Annex 3: RAMS.	Carlos Lisman	Adir Anidgar
02	04-03-2026	Changes were made to the following clauses: • Annex 2 (Operational experience) has been removed from this document and uploaded into Threshold Requirements document on NOGA-ISO website. • Annex 3 (RAMS) – has been removed from this document and uploaded to NOGA-ISO site under "Threshold Requirements."	Carlos Lisman	Adir Anidgar
03	19-04-2026	Include tests for **$U_m \leq 72.5$ kV** (IEC 60076-3, clause 7.3.1) Clause 22.1.7 and sub clauses.	Carlos Lisman	Adir Anidgar
04				