

## Information required for substations and switching stations transformers (Appendix ג' of the Customer Connection Procedure)

	Name	Company	Date	Sign
<b>Customer</b>				
<b>Design body (if applicable)</b>				
<b>Manufacturer</b>				

### Revision Control Table:

Rev	Date	Revision description
01	20-02-2022	1. Added Revision control table 2. Revised information and requirements 3. Added Equipment disqualification clauses 4. Added NOGA required Special Test & NOGA additional requirements

#	Item	Data, Required Value or Applicable Standard for 400 kV system	Data, Required Value or Applicable Standard for 161 kV system	Proposal
1.	<b>SYSTEM DATA</b>			
1.1.	System frequency (definition)	IEC 60050-421, 421-04-03, modified	IEC 60050-421, 421-04-03, modified	
1.1.1.	Rated frequency [Hz]	50	50	
1.1.2.	Range of frequency variation [Hz]	50.5-47.2	50.5-47.2	
1.2.	System voltages (definition)	IEC 60050-421, 421-03-05	IEC 60050-421, 421-03-05	
1.2.1.	Rated system voltage (line to line)	400	161	
1.2.2.	Highest system voltage (line to line)	420	170	
1.3.	Symmetrical short circuit current [kA]	63	50	
1.4.	Methods of the transformer system neutral earthing	Effectively Grounded	Effectively Grounded	
1.5.	Fault duration [sec]	1	1	
1.6.	Earth fault factor (EFF)	1.3	1.3	
1.7.	Line auto reclosing policy	Single-phase single shot 0.8 sec.	Single-phase single shot 0.6 sec.	
2.	<b>CLIMATIC CONDITIONS</b>			
2.1.	Ambient air temperatures according to the worst conditions site	<b>Ambient air temperatures:</b> The temperature values depend on the geographical location where the transformer will be installed. The possibility of interchangeability of transformers between different geographical locations must be considered.		
2.1.1.	Maximum [°C]			
2.1.2.	Minimum [°C]			
2.1.3.	Monthly average of the hottest month [°C]			
2.1.4.	Yearly average $\theta_a$ [°C]			
3.	<b>ENVIRONMENTAL CONDITIONS</b>			
3.1.	Environmental parameters according to	IEC 60721/3-4	IEC 60721/3-4	
3.2.	Severe atmospheric and industrial air pollution, dust, salt spray and sandstorms			

3.3.	Altitude over the sea level up to [m]	1000	1000	
3.4.	Chemically active substances according to	According to Clause 3.2 and ISO 9223	According to Clause 3.2 and ISO 9223	
3.5.	Mechanically active substances according to	IEC 60721-3-3 Table 4: 3S5	IEC 60721-3-3 Table 4: 3S5	
3.6.	Dust (suspension) [mg/m <sup>3</sup> ]	15	15	
3.7.	Dust (sedimentation) rate [mg/m <sup>2</sup> .h]	40	40	
3.8.	Insulator's Pollution levels according to Desert and Coastal types of environments, according to:	IEC 60815-1/ Table 5, E6 E7	IEC 60815-1/ Table 5, E6 E7	
3.9.	Environmental type of pollution	Combination of type A and type B, A-prevalent	Combination of type A and type B, A-prevalent	
3.10.	Site pollution severity (SPS) class	E (very heavy)	E (very heavy)	
3.11.	Non-Soluble Deposit Density (NSDD) [mg/cm <sup>2</sup> ]	2	2	
3.12.	Equivalent Salt Deposit Density (ESDD) [mg/cm <sup>2</sup> ]	0.45	0.45	
4.	<b>SEISMIC QUALIFICATION LEVEL</b>	IEEE Std. 693 Moderate Level	IEEE Std. 693 Moderate Level	
4.1.	Seismicity on the Site: Indicate the adopted value according to the paragraphs:	4.4- 4.5- 4.6	4.4- 4.5- 4.6	
4.2.	The seismic level is determined according to the expected Peak Ground Acceleration ( <b>PGA</b> ) value in the area of the facility defined in:	Israeli Standard 413	Israeli Standard 413	
4.3.	According to standard IEEE 693-2018:			
4.4.	For site with design $PGA \leq 0.1g$ – low seismic level	Low seismic level	Low seismic level	
4.5.	For site with design $0.5g \geq PGA > 0.1g$ – moderate seismic level	Moderate seismic level	Moderate seismic level	
4.6.	For site with design $PGA > 0.5g$ – high seismic level	High seismic level	High seismic level	
5.	<b>ELECTROMAGNETIC ENVIRONMENT</b>			
5.1.	The electronic devices delivered with the transformer shall withstand an electromagnetic environment having the following maximum severity levels according to:	IEC 60255-26	IEC 60255-26	
5.2.	Severity level for electrostatic discharge [kV]	4	4	

5.3.	Severity level for radio frequency interference [V/m]	10	10	
5.4.	Severity level for electrical 1 MHz burst disturbance [kV]	2.5	2.5	
5.5.	Severity level for fast transients [kV]	2	2	
6.	<b>GEOMAGNETIC QUALIFICATION LEVEL</b>			
6.1.	Indicate the time duration, that the power transformer is able to withstand the temperature rise caused by a 50 Amps DC current passing through its neutral point, as a result of Geomagnetic Disturbance (GMD) or Electromagnetic pulse (EMP). (min)	The maximum operating time must be indicated for this anomaly.	The maximum operating time must be indicated for this anomaly.	
7.	<b>ACCELERATION DURING TRANSPORT</b>			
7.1.	Typical accelerations expected in transformers during crane loading and transport by rail, road, sea, and air.	The maximum acceleration values allowed in the 3 geometric axes of the transformer (x-y-z) must be indicated by the manufacturer according to the means of transport to be used.	The maximum acceleration values allowed in the 3 geometric axes of the transformer (x-y-z) must be indicated by the manufacturer according to the means of transport to be used.	
7.1.1.	Longitudinal / Transversal / Vertical [m/sec <sup>2</sup> ]			/ /
7.1.2.	A minimum of two impact recorders shall be installed on the transformer during shipment according to:	Section 6.1.3 of IEEE C57-150 (2012)	Section 6.1.3 of IEEE C57-150 (2012)	
8.	<b>FUNCTIONAL SPECIFICATIONS</b>			
8.1.	Rated power [MVA]:			
8.1.1.	Rated power with cooling system [MVA]			
8.1.2.	Rated power without cooling system [MVA]			
8.2.	Cooling method			
8.3.	Connection symbol			
8.4.	Selection of the insulation level according to:	IEC 60071-1 cl. 5 and Table 3	IEC 60071-1 cl. 5 and Table 2	

8.5.	Rated Currents with full operation of cooling system [A]			
8.5.1.	Principal tap (Primary/Secondary) [A]			/
8.5.2.	Maximum tap (Primary/Secondary) [A]			/
8.5.3.	Minimum tap (Primary/Secondary) [A]			/
8.6.	Rated voltages (line to line) [kV]			
8.6.1.	HV			
8.6.2.	LV			
8.6.3.	T			
8.6.4.	HV Neutral [kV] according to	:	<ul style="list-style-type: none"> <li>• IEC 60076-3, Clause 7.4.2</li> <li>• Customer Connection Procedure Clause 6.4.1</li> </ul>	
8.6.5.	Principal tap (Primary/Secondary) [V]			/
8.6.6.	Maximum tap (Primary/Secondary) [V]			/
8.6.7.	Minimum tap (Primary/Secondary) [V]			/
bushings	Short-circuit impedance at 75°C, based on rated power between HV and LV winding terminals, referred to the LV side at:			
8.6.8.	Principal tap		Min. short circuit impedance according to IEC 60076-5	
8.6.9.	Maximum tap			
8.6.10.	Minimum tap			
8.7.	Zero sequence impedance measured at rated frequency by applying a single-phase voltage			
8.7.1.	Principal tap [ohm/phase]			
8.7.2.	Maximum tap [ohm/phase]			
8.7.3.	Minimum tap [ohm/phase]			
8.8.	Maximum guaranteed total sound power level under full load, at rated voltage, rated current and rated frequency with all the cooling sections in operation, according to	99	85	

	IEC 60076-10:2016 shall not exceed dB[A]			
8.9.	For information only:			
8.9.1.	No-load harmonics at 100% rated voltage:			
8.9.1.1.	3 <sup>rd</sup> (%)			
8.9.1.2.	5 <sup>th</sup> (%)			
8.9.1.3.	7 <sup>th</sup> (%)			
8.9.2.	No-load harmonics at 110% rated voltage:			
8.9.2.1.	3 <sup>rd</sup> (%)			
8.9.2.2.	5 <sup>th</sup> (%)			
8.9.2.3.	7 <sup>th</sup> (%)			
8.10.	Temperature rise limit according to:	IEC 60076-2 Table 1 and Table 2	IEC 60076-2 Table 1 and Table 2	
8.11.	The responsible for preparing the transformer specification must adapt the temperature rise limits in Table 1 with a correction factor not greater than <b>K = -10</b> (Table 2), considering the provisions of Clause 2.1. In the case in which it is decided to adopt a temperature rise correction greater than K = -10, the design temperatures must be declared and demonstrated by the responsible for preparing the transformer specifications.			
8.12.	Selected K factor:			
8.13.	Top insulation oil no more than [°K]			
8.14.	Average winding temp. rise (by resistance variation) no more than [°K]			
8.15.	Hot-Spot rise limit winding temperature no more than [°K]			
8.16.	Inrush r.m.s. magnetizing current with no residual magnetism at rated voltage (p.u based on full load current) no more than:	7	7	
8.17.	Permissible time the transformer can withstand the following power frequency over-voltages at no-load:			
8.17.1.	135% overvoltage [sec]			
8.17.2.	130% overvoltage [sec]			
8.17.3.	125% overvoltage [sec]			

8.17.4.	120% overvoltage [sec]			
8.17.5.	115% overvoltage [min]			
8.17.6.	110% overvoltage [min]			
8.18.	Max. Overload capability p.u [MVA]according to	IEC 60076-7	IEC 60076-7	
8.19.	Overcurrent capability according to	IEC 60076-7 Table 3	IEC 60076-7 Table 3	
8.19.1.	All associated components of the transformer including bushings, CT's, tap changer, etc. shall withstand the overload and over voltages capabilities			
9.	<b>BUSHINGS</b>			
9.1.	<b>The data required in clauses 9.2 to 9.18 must also be provided for secondary, tertiary, and neutral bushings.</b>			
9.2.	The bushings shall be designed for the service conditions stated in clause 2 & 3 & 4 of this Specification and tested according to	IEC 60137	IEC 60137	
9.3.	Site pollution severity (SPS) class	E (very heavy)	E (very heavy)	
9.4.	Required minimum values of cantilever withstand load applied on the bushings according to	IEC 60137 clause 4.5 (level II)	IEC 60137 clause 4.5 (level II)	
9.5.	Rated voltage [kV]	400	161	
9.6.	Highest phase-to-phase voltage [kV r.m.s.]	420	170	
9.7.	Rated phase-to-earth voltage [kV r.m.s.]	231	93	
9.8.	Maximum phase-to-earth temporary over-voltages the bushings can withstand according to:	IEC 60137 cl. 5.1	IEC 60137 cl. 5.1	
9.9.	Insulation levels according to	IEC 60137 Table 3	IEC 60137 Table 3	
9.10.	Lightning & switching impulse withstand voltage [kV peak]	LI: 1550 SW:1175	750	
9.11.	Power frequency withstand voltage (dry) [kV r.m.s.]	750	355	
9.12.	Power frequency withstand voltage (wet) [kV r.m.s.]	N/A	325	
9.13.	Creepage distance [mm]according to SPS class e and RUSCD= 53.7	13200	5300	

	IEC 60815-3 / 60815-1 at least [mm]:			
9.14.	The bushing profile shall include Alternating Sheds according to:	IEC 60815-3	IEC 60815-3	
9.15.	Arcing distance at least [mm]	3500	1500	
9.16.	Rated current according to:	Clauses 8.18 – 8.19 IEC 60137 Clause 4.2	Clauses 8.18 – 8.19 IEC 60137 Clause 4.2	
9.17.	Rated thermal short-time current (I <sub>th</sub> ) at 2 sec, at least	25 I <sub>r</sub>	25 I <sub>r</sub>	
9.18.	Dynamic short-circuit withstand current	IEC 60076-5	IEC 60076-5	
9.19.	<b>In the case of missing data or the impossibility of achieving adequate quality levels, the bushing may be disqualified for use.</b>			
10.	<b>TAP CHANGER</b>			
10.1.	<b>Applicable standard:</b>	IEC 60214	IEC 60214	
10.2.	Type: On Load / Off Load			
10.3.	Location of installing (Primary/Secondary)			
10.4.	Voltage range (%)			
10.5.	Step voltage			
10.6.	Number of taps above principal position			
10.7.	Number of taps below principal position			
10.8.	<b>In the case of missing data or the impossibility of achieving adequate quality levels, the Tap changer may be disqualified for use.</b>			
11.	<b>Automatic Voltage Regulator (AVR)</b>			
11.1.	An AVR control system for OLTC shall be provided for voltage control and parallel connection.			
11.2.	The AVR must be compatible with the Tap changer and Motor Drive system.			
11.3.	"Local" and "Remote" control mode of the AVR shall be selected from a selector switch or buttons located on the AVR, according to:	IEC 61850		
11.4.	"Automatic" or "Manual" control of the AVR may be selected from the Substation Control System SCS (by communication) or from the dispatch center			



11.5.	Desired value may be selected from the SCS (by communication) or from the dispatch center			
11.6.	The AVR will send back indications according to user requirements			
11.7.	AVR shall include the hardware and software required TCP/IP ETHERNET LAN communication with the SCS according to	IEC 61850		
11.8.	AVR software shall fulfill the CYBER REQUIREMENTS according to:	IEEE C37.240		
11.9.	AVR and all other static equipment shall be protected against shocks, vibrations, and electromagnetic influence according to:	Clause 4 Clause 5		
11.10.	Type test documentation must be provided			
12.	<b>X/R ratio:</b>			
12.1.1.	Principal tap			
12.1.2.	Maximum tap			
12.1.3.	Minimum tap			
12.2.	Voltage drop [kV]			
13.	<b>INSULATION OIL</b>			
13.1.	Insulation oil test according to sub-clause 16.5	Indicate applicable standards	Indicate applicable standards	
13.2.	<b>In the case of missing data or the impossibility of achieving adequate quality levels, the oil may be disqualified for use.</b>			
14.	<b>TRANSFORMER TESTS</b>	All the test according to IEC 60076-1 sub clause 11	All the test according to IEC 60076-1 sub clause 11	
14.1.	<b>Routine tests</b> according to	IEC 60076-1 cl.11	IEC 60076-1 cl.11	
14.1.1.	Measurement of winding resistance according to:	IEC 60076-1 subcl.11.2	IEC 60076-1 subcl.11.2	
14.1.2.	Measurement of voltage ratio and check of phase displacement according to:	IEC 60076-1 subcl.11.3	IEC 60076-1 subcl.11.3	
14.1.3.	Measuring of short-circuit impedance and load losses shall be performed at principal tap and on the highest and lowest tap	IEC 60076-1 subcl.11.4	IEC 60076-1 subcl.11.4	
14.1.4.	Measuring of no-load loss and exciting current, according to	IEC 60076-1 subcl.11.5	IEC 60076-1 subcl.11.5	

14.1.5.	Dielectric Test:	IEC 60076-3 sub clause 7.3.3	IEC 60076-3 sub clause 7.3.2	
14.1.5.1.	Full wave lightning impulse test (LI) [kV peak]	-	IEC 60076-3 cl. 7.3.2.1.a	
14.1.5.2.	Chopped wave lightning impulse test (LIC) [kV peak]	IEC 60076-3 cl. 7.3.3.1.a	-	
14.1.5.3.	Switching impulse test for the line terminal (SI) [kV peak]	IEC 60076-3 cl. 7.3.3.1.b	-	
14.1.5.4.	Line terminal AC withstand voltage test for non-uniformly insulated transformers (LTAC) according to [kV r.m.s]	-	IEC 60076-3 cl. 7.3.2.1.d	
14.1.5.5.	Applied voltage test (AV), according to [kV r.m.s]	IEC 60076-3 cl. 7.3.3.1.c	IEC 60076-3 cl. 7.3.2.1.b	
14.1.5.6.	Induce voltage test & PD (IVPD) [kV r.m.s]	IEC 60076-3 cl. 7.3.3.1.d	IEC 60076-3 cl. 7.3.2.1.e	
14.1.6.	Test on on load tap changer, where appropriate according to:	IEC 60076-1 cl. 11.7	IEC 60076-1 cl. 11.7	
14.1.7.	Leak testing with pressure according to:	IEC 60076-1 cl. 11.8	IEC 60076-1 cl. 11.8	
14.1.8.	Check of ratio and polarity of built in CTs	-	-	
14.1.9.	Check of core and frame insulation according to:	IEC 60076-1 cl. 11.12	IEC 60076-1 cl. 11.12	
14.1.10.	Determination of capacitances windings to earth and between windings	IEC 60076-1 cl. 11.1.2.2 a	IEC 60076-1 cl. 11.1.2.2 a	
14.1.11.	Measurement of d.c. insulation resistance each winding to earth and between windings	IEC 60076-1 cl. 11.1.2.2 b	IEC 60076-1 cl. 11.1.2.2 b	
14.1.12.	Measurement of the dissipation factor (tan $\delta$ ) of the insulation system capacitances	IEC 60076-21 cl. 9.7.6	IEC 60076-21 cl. 9.7.6	
14.1.13.	Measurement of dissolved gasses in dielectric liquid according to:	IEC 61181 & IEC 60567	IEC 61181 & IEC 60567	
14.1.14.	Measurement of non-load loss and current at 90% and 110% of rated voltage according to	IEC 60076-1 cl. 11.5	IEC 60076-1 cl. 11.5	
14.2.	<b>Type test</b> according to:	IEC 60076-1 cl. 11	IEC 60076-1 cl. 11	
14.2.1.	Temperature-rise tests according to:	IEC 60076-2	IEC 60076-2	
14.2.2.	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	IEC 61181 & IEC 60567	
14.2.3.	Determination of transformer sound level with the OLTC on the principal tapping and for each method of cooling according to	IEC 60076-10	IEC 60076-10	

14.2.4.	Measurement of the power taken by the cooling system	-	-	
14.2.5.	Measurement of non-load loss and current at 90% and 110% of rated voltage according to	IEC 60076-1 cl. 11.5	IEC 60076-1 cl. 11.5	
14.3.	<b>Special tests according to</b>	IEC 60076-1-11	IEC 60076-1-11	
	* <b>NOGA required special test in routine and type test transformers</b> ** <b>NOGA required special test in type test transformers only</b>			
14.3.1.	Dielectric special test according to:	IEC 60076-3 cl. 7.3.3	IEC 60076-3 cl. 7.3.2	
14.3.1.1.	* Lightning impulse test on the neutral terminal (LIN)	IEC 60076-3 cl. 7.3.3.2 a	IEC 60076-3 cl. 7.3.2.2 d	
14.3.1.2.	* Line terminal AC withstand voltage test for non-uniformly insulated windings (LTAC)	IEC 60076-3 cl. 7.3.3.2 b	-	
14.3.1.3.	Lightning impulses applied to multiple line terminals simultaneously (LIMT)	IEC 60076-3 cl. 7.3.3.2 c	IEC 60076-3 cl. 7.3.2.2 e	
14.3.1.4.	Switching impulse test (SI)	-	IEC 60076-3 cl. 7.3.2.2 a	
14.3.1.5.	* Chopped wave lightning impulse test (LIC)	-	IEC 60076-3 cl. 7.3.2.2 b	
14.3.1.6.	Line terminal AC withstand voltage test for uniform insulation windings (LTAC)	-	IEC 60076-3 cl. 7.3.2.2 c	
14.3.2.	Winding hot-spot temperature-rise measurement as a part of temperature-rise test according to:	IEC 60076-1 clause 11.1.4 b	IEC 60076-1 clause 11.1.4 b	
14.3.3.	Determination of the transient voltage transfer characteristics according to	IEC 60076-3: 2000 Annex B	IEC 60076-3: 2000 Annex B	
14.3.4.	Short circuit withstand test according to:	IEC 60076-5	IEC 60076-5	
14.3.5.	* Measurement of zero-sequence impedance, according to:	IEC 60076-1 cl. 11.6	IEC 60076-1 cl. 11.6	
14.3.6.	* CT insulation resistance measurement tests shall be performed for each transformer, on the CT terminals block, at [kV r.m.s]	2.5	2.5	
14.3.7.	** Vacuum deflection test according to:	IEC 60076-1 cl. 11.9	IEC 60076-1 cl. 11.9	
14.3.8.	** Pressure deflection test according to:	IEC 60076-1 cl. 11.10	IEC 60076-1 cl. 11.10	
14.3.9.	* Vacuum tightness test according to:	IEC 60076-1 cl. 11.11	IEC 60076-1 cl. 11.11	
14.3.10.	* Measurement of frequency response (SFRA)	IEC 60076-18	IEC 60076-18	
14.3.11.	Check of external coating according to:	ISO 2178 and 2409 or as specified	ISO 2178 and 2409 or as specified	

14.3.12.	Mechanical test or assessment of tank for suitability for transport			
14.4.	<b>NOGA additional requirements</b>			
14.4.1.	If the transformer will be shipped without oil, the Dew Point test shall be provided for each delivered transformer according to:	IEEE Std C57.93-2019	IEEE Std C57.93-2019	
14.4.1.1.	The moisture content in percent of insulation dry weight on each transformer shall not exceed (%)	0.5	1	
14.4.2.	The thermal and dynamic ability to withstand the short-circuit currents shall be demonstrated by calculation according to	IEC 60076-5	IEC 60076-5	
14.5.	<b>At site tests</b>			
14.5.1.	Manufacturer may suggest alternatives for Arrival and On-Site and commissioning tests; however, the final test program shall be agreed between Purchaser and Manufacturer and shall include at least the recommendations of standard IEEE C57.150			
14.5.2.	<b>SAT results approved by manufacturer will be required for commissioning.</b>			
15.	<b>CYBER &amp; INFORMATION SECURITY</b>			
15.1.	Security information of the equipment designing and manufacturing.	Please inform	Please inform	
15.2.	Network and security safeguards of the equipment.	Please inform	Please inform	
16.	<b>REQUIRED ATTACHMENTS</b>			
16.1.	Buchholtz Relay	Type Test certificate according to IEC 60076-22		
16.2.	PRD	Type Test certificate according to IEC 60076-22		
16.3.	Bushings: Primary Secondary, Tertiary (if applicable)	Type Test certificate according to IEC 600137		
16.4.	Tap Changer	Type Test certificate according to IEC 60214		
16.5.	Oil certificates	COT	COT	