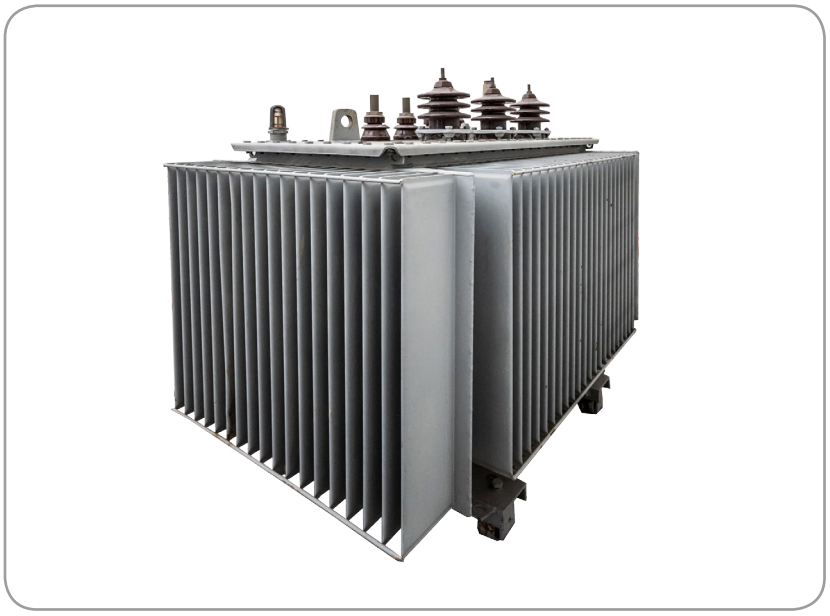
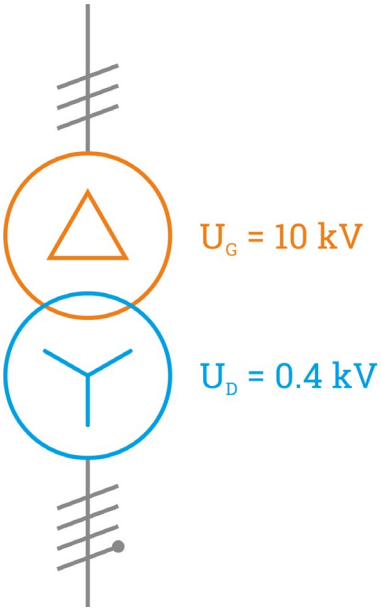
MV/LV transformer testing instructions

Insulation resistance measurement ● Winding resistance measurement

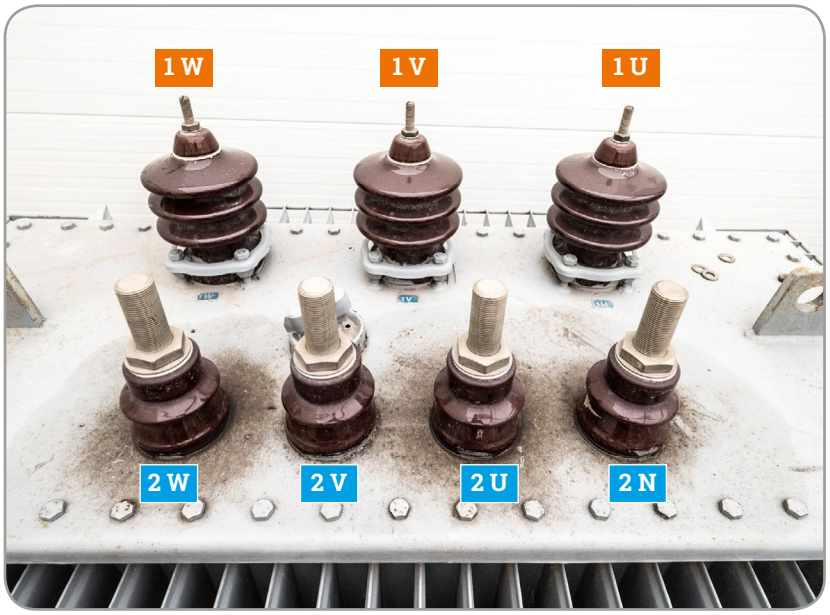
v1.01 | 23.05.2022

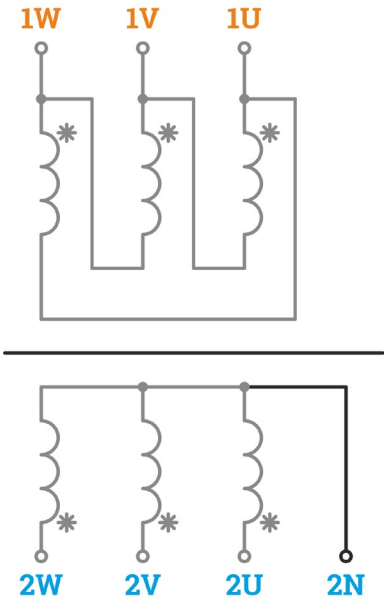
Overview



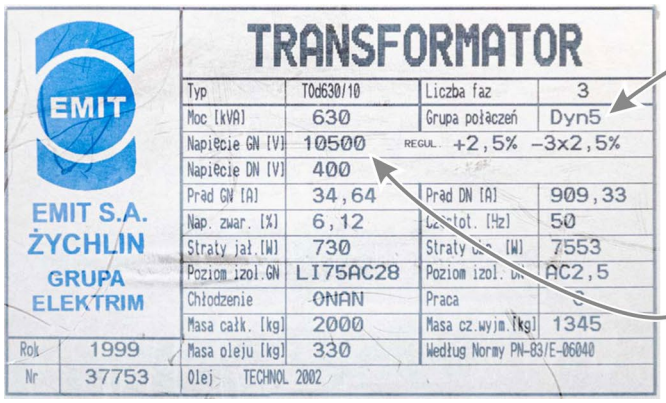


Internal connections





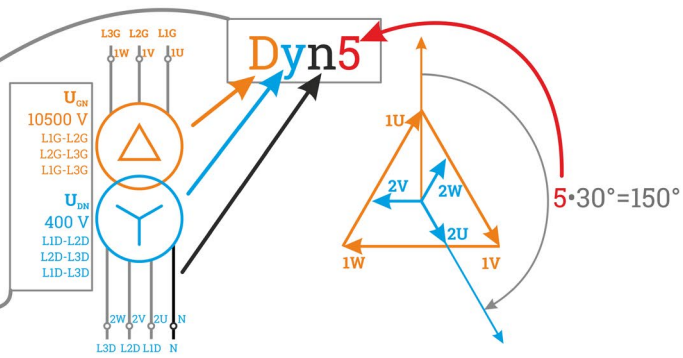
Designations



EMIT S.A.
ŻYCHLIN
GRUPA ELEKTRIM

TRANSFORMATOR

Typ	T0d630/10	Liczba faz	3
Moc [kVA]	630	Grupa połączeń	Dyn5
Napięcie GN [V]	10500	REGUL.	+2,5% -3x2,5%
Napięcie DN [V]	400		
Prąd GN [A]	34,64	Prąd DN [A]	909,33
Nap. zwar. [%]	6,12	Częstot. [Hz]	50
Straty jał. [W]	730	Straty obc. [W]	7553
Poziom izol. GN	LI75AC28	Poziom izol. DN	AC2,5
Chłodzenie	ONAN	Praca	S
Masa całk. [kg]	2000	Masa cz.wyjm. [kg]	1345
Rok 1999	Masa oleju [kg]	330	Według Normy PN-83/E-06040
Nr 37753	Olej TECHNOL 2002		



Key

D	delta connection, high voltage side
Y	star connection, high voltage side
D	zigzag connection, high voltage side
N	neutral conductor, high voltage side
d	delta connection, low voltage side
y	star connection, low voltage side
z	zigzag connection, low voltage side
n	neutral conductor, low voltage side
n•30°	angular displacement of the low voltage side vector in relation to the high voltage side vector
n	hour displacement – multiplication of the angle of 30°
U_{GN}	rated voltage of HV side
U_{DN}	rated voltage of LV side
I_{GN}	rated current of HV side
I_{DN}	rated current of LV side

Insulation resistance measurement

1 Prepare for measurement

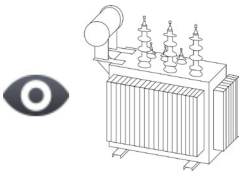
Earth the transformer.

Carefully clean the insulators.

Determine the transformer winding temperature Θ:
- 10–15 hours after filling with oil or de-energisation
- with a thermometer (measurement at the 2/3 of the tank height) or
- using resistance method (measurement of average winding temperature) or
- with a thermal imaging camera.

If it is possible to change voltage at the HV taps, they must be set at all three HV windings. Otherwise balance current causing demagnetisation of the transformer core will flow through the windings.

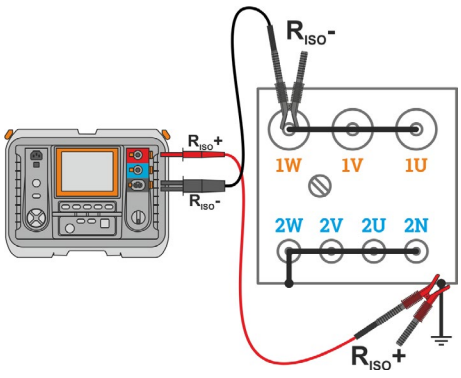
2 Carry out visual inspection



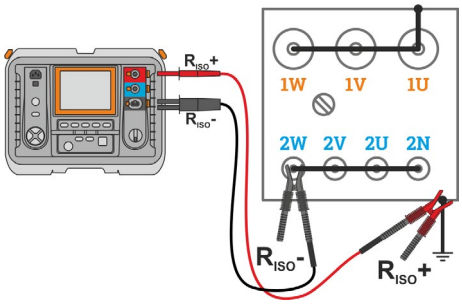
3 Earth the transformer before measurement

4 Connect the meter to the transformer

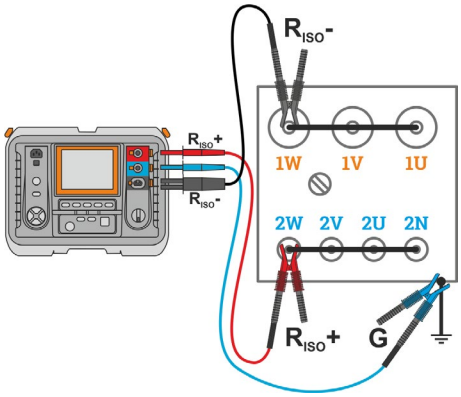
HV winding relative to the LV side and the tank



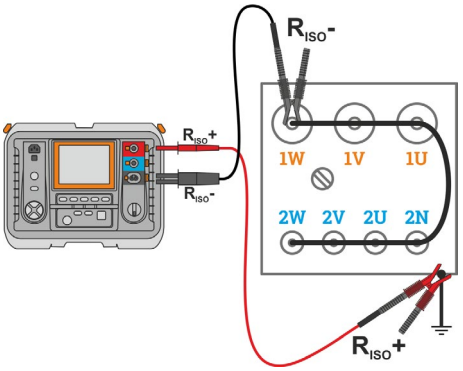
LV winding relative to the HV side and the tank



HV winding relative to the LV side (with shield)



HV+LV relative to the tank earth



5 Enter measurement setpoints

$U_{ISO} \geq 2.5$ kV

Voltage according to the operating and maintenance manual or test voltage from the test carried out by the manufacturer.

measurement time

Depending on the transformer group (I, II, III).

6 Start measurement and read the results

START

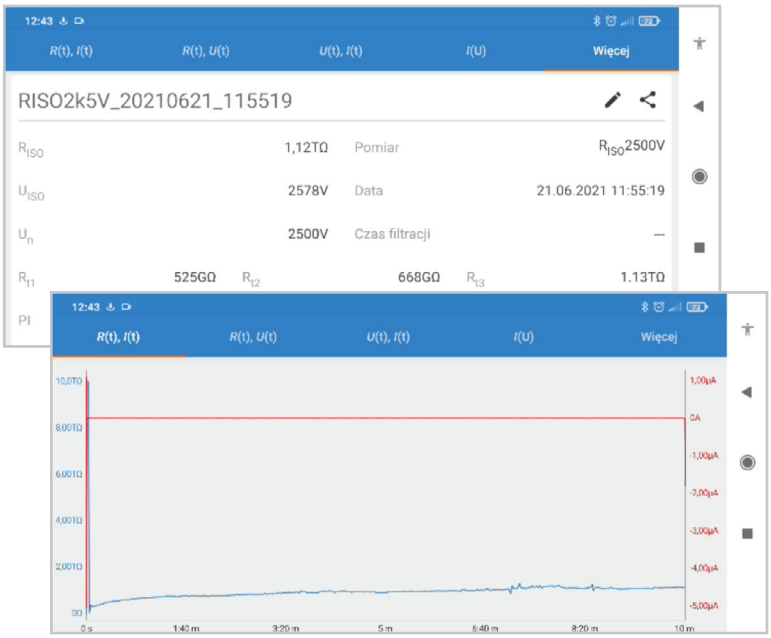
GROUP I
GROUP II

- 15 s → R_{ISO_15s}
- 60 s → R_{ISO_60s}
- 300 s → R_{ISO_300s}

GROUP III

- 60 s → R_{ISO_60s}

Measurement monitoring via mobile app **SONEL MIC MOBILE**



7 Convert the result to reference temperature

Reference temperature is 30°C. Resistance is converted according to the following dependence:

$$R_{ISO(30°C)} = k_1 \cdot R_{ISO(\Theta)}$$

where:

- $R_{ISO(30°C)}$ resistance converted to reference temperature,
- k_1 correction factor depending on winding temperature Θ (step (1)),
- $R_{ISO(\Theta)}$ measured resistance.

The correction factor k_1 can be determined using the following table.

Θ [°C]	0	5	10	15	18	21	24	27	30	33	36	39	42	45	50	55
k_1 [-]	0.25*	0.32*	0.39*	0.50	0.57	0.66	0.76	0.87	1.0	1.14	1.32	1.52	1.74	2.0	2.52*	3.18*

* indicative value

8 Evaluate the results

GROUP I

Insulation resistance between:
- windings and earth $R_{ISO(30°C)} > (1/C) \cdot 1000\ M\Omega$
- windings $R_{ISO(30°C)} \geq (5/C) \cdot 1000\ M\Omega$

where:
- C system capacitance [nF]

GROUP II

Insulation resistance between:
- windings and earth $R_{ISO(30°C)} > 70\ M\Omega$
- windings $R_{ISO(30°C)} \geq 150\ M\Omega$

GROUP III

Insulation resistance between:
- windings and earth $R_{ISO(30°C)} \geq 35\ M\Omega$

GROUP IV

Resistance for transformers:
- $U_n > 10$ kV $R_{ISO(30°C)} > 20\ M\Omega$
- $U_n \leq 10$ kV $R_{ISO(30°C)} > 15\ M\Omega$

...except for cast-resin transformers where:
- HV/LV system, HV/earth > 1000 MΩ
- LV/earth system > 20 MΩ

$$DAR_{standard\ 1} = \frac{R_{ISO\_60s}}{R_{ISO\_30s}}$$

$$DAR_{standard\ 2} = \frac{R_{ISO\_60s}}{R_{ISO\_15s}}$$

$$DAR_{standard\ 3} = \frac{R_{ISO\_300s}}{R_{ISO\_60s}}$$

$\geq$ DAR from acceptance tests

The results should be compared to the historical test reports, including the manufacturer's tests.

9 Set the date for subsequent testing

- In 2 years?
- In 5 years?
- According to the manufacturer's recommendations?
- Specific case? (For example after a month-long downtime.)

Winding resistance measurement

1 Prepare for measurement

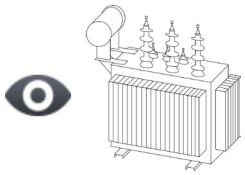
Earth and decouple the transformer.

Carefully clean the transformer terminal at the connection, so that contact resistance has no influence on the measurement result.

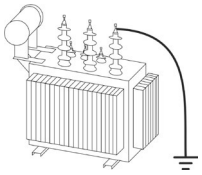
Determine the transformer winding temperature Θ:
- 10–15 hours after filling with oil or de-energisation,
- with a thermometer (measurement at the 2/3 of the tank height) or
- using resistance method (measurement of average winding temperature) or
- with a thermal imaging camera.

Identify the winding material.

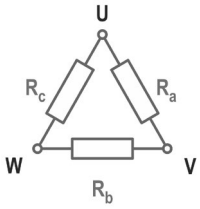
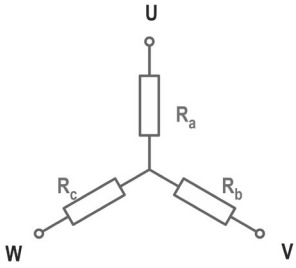
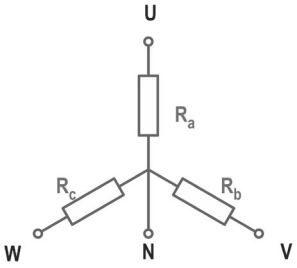
2 Carry out visual inspection



3 Earth the transformer.

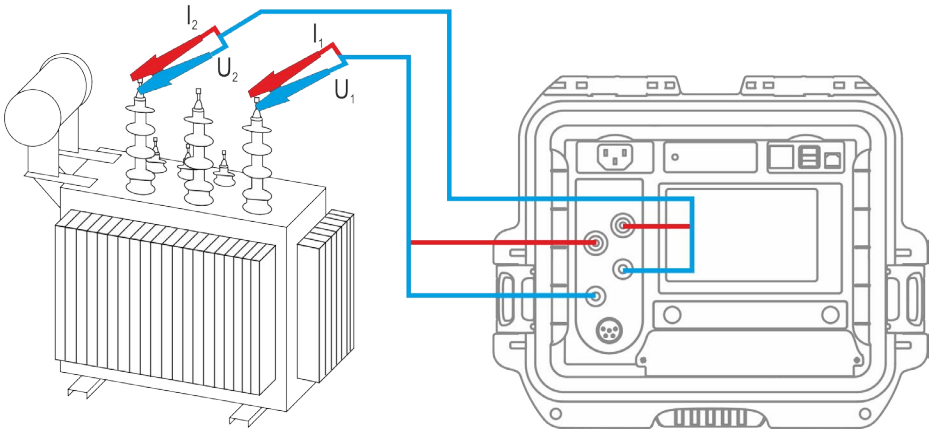


4 Identify the transformer connection system.

Delta	Star without N	Star with N
		

- Resistances with the possibility to be measured: R_{UV}, R_{VW}, R_{UW}, R_{UN}, R_{VN}, R_{WN}.
- Resistances to be determined: R_a, R_b, R_c. In the delta and star without N they should be calculated.

5 Connect the meter to the windings

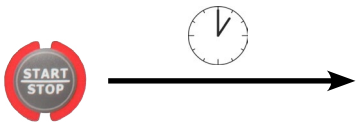


6 Enter measurement setpoints

- Measurement mode
- One-way measurement
- Algorithm
- Maximum measurement current (max. 15% of I_n of the winding)

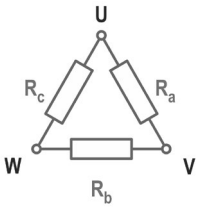
- ☑ Temperature compensation
- Ambient temperature
- Item/winding temperature
- α Winding material or its temperature coefficient α
- ☑ Reference temperature

7 Start measurement and read the results



8 Obtain winding resistance

Delta

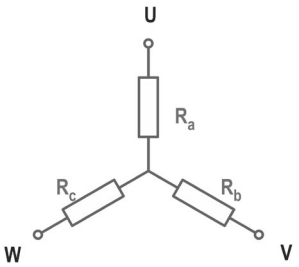


$$R_a = \frac{2 \cdot R_{UV} \cdot R_{WV}}{R_{UV}+R_{VW}-R_{UW}} - \frac{R_{UV}+R_{WV}-R_{UW}}{2}$$

$$R_b = \frac{2 \cdot R_{UW} \cdot R_{WV}}{R_{UW}+R_{VW}-R_{UV}} - \frac{R_{UV}+R_{WV}-R_{UW}}{2}$$

$$R_c = \frac{2 \cdot R_{UW} \cdot R_{UV}}{R_{UW}+R_{UV}-R_{WV}} - \frac{R_{UW}+R_{UV}-R_{WV}}{2}$$

Star without N

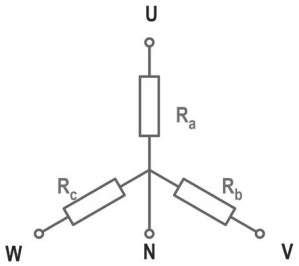


$$R_a = \frac{R_{UV}+R_{WU}-R_{VW}}{2}$$

$$R_b = \frac{R_{UV}+R_{VW}-R_{WU}}{2}$$

$$R_c = \frac{R_{WU}+R_{VW}-R_{UV}}{2}$$

Star with N



$$R_a = R_{UN}$$
$$R_b = R_{VN}$$
$$R_c = R_{WN}$$

Measurements of all transformer windings should be performed on all tap changer steps.

9 Evaluate the results

For each tap the results should meet the following criteria:

$$R_a = (100\% \pm 5\%)\, R_{a\_factory}$$
$$R_b = (100\% \pm 5\%)\, R_{b\_factory}$$
$$R_c = (100\% \pm 5\%)\, R_{c\_factory}$$

$$R_a = (100\% \pm 3\%)\, \frac{R_{a\_factory} + R_{b\_factory} + R_{c\_factory}}{3}$$
$$R_b = (100\% \pm 3\%)\, \frac{R_{a\_factory} + R_{b\_factory} + R_{c\_factory}}{3}$$
$$R_c = (100\% \pm 3\%)\, \frac{R_{a\_factory} + R_{b\_factory} + R_{c\_factory}}{3}$$

10 Set the date for subsequent testing

- In 5 years?
- According to the manufacturer's recommendations?

EMIT | SYSTEM ZAPEWNIENIA JAKOŚCI ISO 9001

PROTOKÓŁ PRÓB TRANSFORMATORA

ZAKŁAD TRANSFORMATORÓW
DZIAŁ KONTROLI JAKOŚCI

Typ	TOd 630/10		Nr fabr.	37 753		Zlecenie	DT040-902553/1
Moc	630	kVA	Rok prod.	1999		Praca	C
Napięcie GN	10 500	V	Grupa poł.	Dyn5		Częstotliwość	50 Hz
Stopnie reg.	+2,5-3x2,5	%	Prąd GN	34,64	A	Temp. otocz.	40 °C
Napięcie DN	400	V	Prąd DN	909,33	A	Chłodzenie	ON-AN
Masa całk.	2 000	kg	Masa cz.wyjm	1 345	kg	Masa oleju	330 kg
Norma	PN - 83/E - 06040		Poziom izol.	LI75AC28/AC2,5		Napięcie zw.	6,12 %

1. Rezystancja uzwojeń [Ω]w temperaturze 20 °C

Uzwojenie	Zaczep	1U1V	1U1W	1V1W	Średnio na fazę
	1	1,59	1,59	1,59	2,38
	2	1,55	1,55	1,55	2,32
GN	3	1,51	1,51	1,51	2,27
	4	1,47	1,47	1,47	2,21
	5	1,43	1,44	1,43	2,15
DN	-	2N2U	2N2V	2N2W	-
	-	0,0011	0,0011	0,0011	0,0011

2. Rezystancja izol. [MΩ]w tem 20 °C

Megaomomierz 2,5 kV

	R_{60}	R_{15}	R_{60}/R_{15}
G-D,Z	15 290	10 670	1,43
D-G,Z	16 540	8 340	1,98

Transf. napełn. olejem Technol 2002

3. Badanie oleju:

Olej spełnia wymagania PN-83/E - 06040

4. Sprawdzenie przekładni i grupy połączeń

Zaczep	1	2	3	4	5
υ_N	26,91	26,25	25,59	24,94	24,28

Δυmax [%]	Stwierdzono grupę połączeń:
0,2	Dyn5

5. Próba wytrzymałości elektrycznej

		GN	DN		Wynik:
5.1 Próba napięciem doprowadzonym	50 Hz ; 60s	28	2,5	kV	*Pozytywny*
5.2 Próba napięciem indukowanym.	Zasilono uzwojenie DN napięciem 2 x U_N; 100Hz; 60s.				*Pozytywny*

6. Próba stanu jałowego Zasilano uzwojenie DN

f	Napięcie				Prąd				Moc
	2U2V	2U2W	2V2W	Średnio	2U	2V	2W	Średnio	Σ
Hz	V	V	V	V	A	A	A	A	W
50	398	401	401	400	4,19	3,30	4,44	3,98	730

					Odchyłka
Straty jałowe gw.	0,800	kW	Straty jałowe zmierzone	0,730 kW	0,00 %
Prąd jałowy gw.	0,40	% In	Prąd jałowy zmierzony	0,44 % In	9,33 %

7. Próba zwarcia pomiarowego: Zasilano uz GN Zwarto uzw. DN υ_{ol} 20 °C

f	Napięcie				Prąd				Moc
	1U1V	1U1W	1V1W	Średnio	1U	1V	1W	Średnio	Σ
Hz	V	V	V	V	A	A	A	A	W
50	531	535	534	533,3	28,80	28,80	28,60	28,73	4490

					Odchyłka
Straty obciążeniowe gw.	6,75	kW	Straty obciążeniowe zm	7,55 kW	11,89 %
Napięcie zwarcia gw.	6,00	%	Napięcie zwarcia zm.	6,12 %	2,06 %

8. Sprawdzenie działania przełącznika zaczepów: Wykonano wg PN-81/E-04070.02 Wynik: *Pozytywny*

9. Badanie szczelności kadzi: Wykonano wg PN-81/E-04070.04 Wynik: *Pozytywny*

UWAGI:

Transformator spełnia wymagania PN - 83/E - 06040

Żychlin, dnia *20 października 1999*

Mierzył: Zatwierdził: