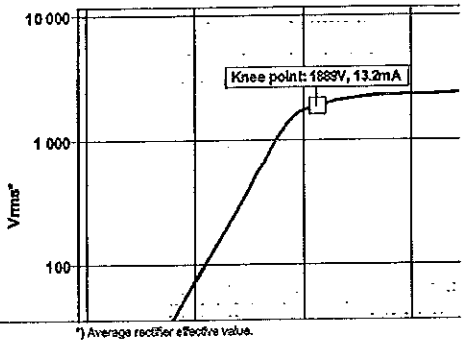
Winding 4S1-4S2

[V]	[mA]
2478.7	1023.3
2459.8	689.2
2411.4	252.8
2379.1	141.4
2206	30.87
2162.3	26.38
2077.5	20.55
1945.8	14.77
1813.8	11.2
1684.8	9.07
1527.4	7.89
1104.1	5.79
874.	4.24
249.	2.27
22	0.43



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part

	R (24 °C)	Rct (75 °C)
P1-P2 range 300A	602.0 μΩ	722.7 μΩ
P1-P2 range 600A	326.0 μΩ	391.3 μΩ
1S1-1S2	0.403 Ω	0.483 Ω
2S1-2S2	6.050 Ω	7.263 Ω
3S1-3S2	0.437 Ω	0.525 Ω
4S1-4S2	9.050 Ω	10.864 Ω

Windings' resistance of voltage part

	R (24 °C)	Rct (75 °C)
A-N	21.70 kΩ	26.049 kΩ
1a-1n	47.150 mΩ	56.600 mΩ
2a-2n	48.550 mΩ	58.281 mΩ
3a-3n	50.200 mΩ	60.262 mΩ
4a-4n	51.800 mΩ	62.182 mΩ
da-dn	114.900 mΩ	137.929 mΩ

Checked by: OG-4 KJ-06 Przasnysz, dn 2013-11-18

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 69	Routine tests report of combined instrument transformer			TYPE: PVA145x Serial no: 2GKP013K1488145	
A-N	Insulation level:	Voltage factor:	Ith 1s [kA]:	Idyn [kA]:	Ioth [A]:	IEC 61869-4
132:√3 kV	145/275/650 kV	1.9/8h	20-20	50-50	225-450	50 Hz

	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
VOLTAGE PART	1a - 1n	0,11:√3	100	1,0	1000
	2a - 2n	0,11:√3	100	1,0	1000
	3a - 3n	0,11:√3	100	1/3P	1000
	4a - 4n	0,11:√3	100	3/3P	1000
	da - dn	0,11:3	200	3,0	450

	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
CURRENT PART	1S1-1S2	5	30	0,2FS 5	150-300/5
	2S1-2S2	1	40	5P 20	150-300/1
	3S1-3S2	5	60	5P 20	150-300/5
	4S1-4S2	1	60	5P 20	150-300/1

List of performed tests:

1. Oil dielectric parameters check before filling (oil after treatment): ☑
   tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,6 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings - P1+P2/A: Up = 275kV / 60s, f = 97Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary - Up = 3 kV/60s ☑
7. Inter-turn overvoltage test for current transformers - lower value (U peak=4,5kV or U peak for Ioth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ☑
10. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.06 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C
- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 78.16 kV, Relative standard deviation = 5.99
  f = 50Hz, oil temp. = 25 °C, measurement with the stirrer, type of electrodes used: partially

Sample	Breakdown voltage [kV]
1	73.7
2	84.3
3	82.8
4	78.4
5	76.9
6	72.8

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the after the power-frequency withstand test on primary
  Stress voltage: 275 kV / 60 s
  Frequency: 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100.5
Level of partial discharge	2 pC	1.2 pC

Remarks: background noise level: 1 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	0.368	450
2S1-2S2	4.29	450
3S1-3S2	1.09	450
4S1-4S2	4.5	310

Determination of voltage part errors (ε U%), (Δφ U min)

1a-1n: 100 VA, 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.164	-0.162	-0.162
Δφ U	-1.3	-1.3	-1.3

1a-1n: 25 VA, 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.016
Δφ U	-1.3	-1.3	-1.3

2a-2n: 100 VA, 1a-1n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.163	-0.162	-0.162
Δφ U	-1.1	-1.1	-1.1

2a-2n: 25 VA, 1a-1n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.015	-0.015
Δφ U	-1.3	-1.3	-1.3

3a-3n: 100 VA, 1a-1n: 100VA; 2a-2n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.254	-0.251	-0.150	-0.148	-0.149	-0.314
Δφ U	-2.1	-1.2	-0.8	-0.8	-0.8	-4.2

3a-3n: 25 VA, 1a-1n: 100VA; 2a-2n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.103	-0.102	-0.004	-0.003	-0.003	-0.170
Δφ U	-2.6	-1.5	-1.1	-1.1	-1.1	-4.6

4a-4n: 100 VA, 1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.261	-0.261	-0.163	-0.162	-0.162	-0.329
Δφ U	-1.0	-0.0	0.4	0.4	0.4	-3.1

1a-1n: 100 VA, 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.116	0.117	0.118
Δφ U	5.1	5.2	5.2

1a-1n: 25 VA, 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.263	0.265	0.265
Δφ U	5.1	5.1	5.2

2a-2n: 100 VA, 1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.118	0.119	0.119
Δφ U	5.3	5.3	5.4

2a-2n: 25 VA, 1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.266	0.267	0.267
Δφ U	5.2	5.2	5.2

3a-3n: 100 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.022	0.027	0.127	0.129	0.129	-0.038
Δφ U	4.8	5.6	5.6	5.6	5.6	2.5

3a-3n: 25 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.172	0.172	0.275	0.278	0.277	0.111
Δφ U	4.4	5.2	5.3	5.3	5.3	2.1

4a-4n: 100 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.007	0.008	0.107	0.106	0.109	-0.060
Δφ U	5.6	6.4	6.4	6.4	6.5	3.3

4a-4n: 25 VA, 1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.099	-0.096	0.001	0.002	0.002	-0.185
Δφ U	-1.9	-1.0	-0.6	-0.6	-0.6	-4.1

da-dn: 200 VA, 1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.177	-0.159	-0.125
Δφ U	16.6	16.1	15.3

4a-4n: 25 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.179	0.178	0.273	0.274	0.275	0.107
Δφ U	4.6	5.4	5.5	5.5	5.5	2.3

da-dn: 50 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	1.053	1.053	1.053
Δφ U	9.7	9.7	9.8

* at 1,9 Un winding da-dn is loaded with 250 VA, p.f. = 0,8

Determination of current part errors (ε I%), Δφ I min)

Ipn (A): 150

1S1-1S2: 30 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.165	-0.113	-0.044	-0.050
Δφ I	4.3	1.7	-0.4	0.9

2S1-2S2: 40 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.141
Δφ I	0.9

4S1-4S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.146
Δφ I	1.3

1S1-1S2: 7.50 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.020	-0.017	0.003	0.007
Δφ I	2.4	1.6	0.4	0.2

3S1-3S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.153
Δφ I	1.7

Ipn (A): 300

1S1-1S2: 30 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.441	-0.110	-0.042	-0.057
Δφ I	17.7	1.8	-0.4	0.7

2S1-2S2: 40 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.140
Δφ I	0.8

4S1-4S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.145
Δφ I	1.2

1S1-1S2: 7.50 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.043	-0.018	0.003	0.004
Δφ I	3.1	2.1	0.5	0.6

3S1-3S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.148
Δφ I	1.7

Current part: Measurements $\varepsilon_I = \pm 0{,}045\ \%$, $\Delta\varphi_I = \pm 2{,}3$ min
Voltage part: Measurements uncertainty: $\varepsilon_U = \pm 0{,}044\ \%$, $\Delta\varphi_U = \pm 2{,}2$ min

Determination of the over current factors:

- instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	Efs [V]	Condition	Assessment
1S1-1S2	2.5	17.84	38.02	U < Efs	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	Ealf [V]	Ie [A]	εc [%]	Condition	Assessment
2S1-2S2	960.83	0.015	0.08	εc ≤ 5%	☑

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3S1-3S2	278.86	0.097	0.1	ε c ≤ 5%	☑
4S1-4S2	1358.83	0.015	0.08	ε c ≤ 5%	☑

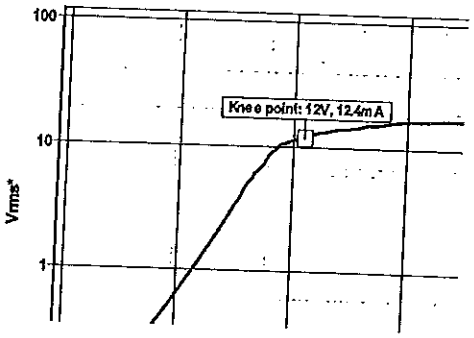
Measurement of capacitance and dielectric dissipation factor - δ
Temperature: 24.2 °C, Frequency: 50

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.23	1404	4.399	0.24	1128	3.572	0.23	276	0.852
63 kV	0.23	1404	27.83	0.24	1129	22.34	0.22	276	5.46
71 kV	0.23	1404	31.36	0.24	1129	25.21	0.22	276	6.156

Core magnetization characteristics:

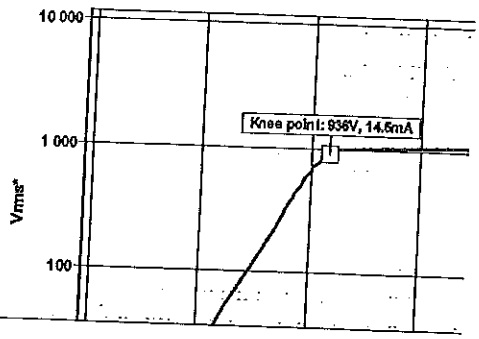
Winding 1S1-1S2

[V]	[mA]
18	3659
16.7	103.41
15.5	48.71
14.4	27.86
13.5	19.69
13	15.84
12.4	12.69
11.8	10.63
11.3	9.23
10.6	7.98
8.4	5.69
6.1	4.69
4	3.37
1.7	1.96
0.1	0.25



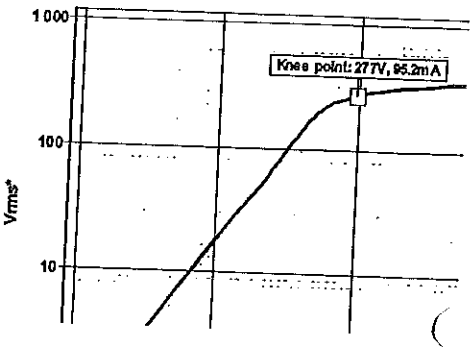
Winding 2S1-2S2

[V]	[mA]
1132.4	1427.9
1127.1	877.7
1104.4	263.7
1029.5	26.54
1000.1	17.54
976.	16.07
948.	14.66
894.	13.85
832	12.48
782.	11.95
612	9.3
442.	7.32
274.	5.42
103.	2.88
10.2	0.68



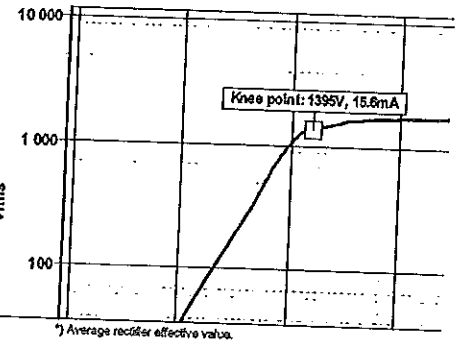
Winding 3S1-3S2

[V]	[mA]
376.	7431
331.	241.6
310.	162
304.	146.8
297.	128
282.	101.48
268.	83.06
253.	72.62
239.	65.23
197.	51.48
163.	41.82
111	33.85
68.8	25.06
28.5	13.39
2.4	2.72



Winding 4S1-4S2

[V]	[mA]
1872.8	2020.9
1734.7	80.36
1627.6	35.01
1534.8	23.91
1509.6	21.62
1451	17.85
1393.2	15.51
1339.3	13.82
1280.7	12.48
1052.2	9.76
832.	8.05
608.	6.47
389.	4.93
168.	2.92
10.3	0.62



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part:

	R (23 °C)	Rct (75 °C)
P1-P2 range 150A	1693.0 μΩ	2267.8 μΩ
P1-P2 range 300A	970.0 μΩ	1168.2 μΩ
1S1-1S2	0.239 Ω	0.287 Ω
2S1-2S2	7.990 Ω	9.623 Ω
3S1-3S2	0.389 Ω	0.468 Ω
4S1-4S2	9.450 Ω	11.381 Ω

Windings' resistance of voltage part:

	R (23 °C)	Rct (75 °C)
A-N	21.30 kΩ	25.653 kΩ
1a-1n	47.010 mΩ	56.617 mΩ
2a-2n	48.480 mΩ	58.387 mΩ
3a-3n	50.000 mΩ	60.218 mΩ
4a-4n	51.700 mΩ	62.255 mΩ
da-dn	34.050 mΩ	41.045 mΩ

Checked by: _____ (OGA KJ-05)

Przasnysz, 2013-12-04

ABB Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59	Routine tests report of combined instrument transformer after lightning impulse			TYP: PVA123a Nr fabr. 2GKP013K1486138	
A – N 110:√3 kV	Insulation level: 126/230/550 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA] 40-63-63	Idyn [kA] 100-158-158	Ith [A]: 100-200-400	IEC 61869-4 50 Hz

CZŁON NAPIĘCIOWY	Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
	1a-1n	0,1:√3	25	0,1	1000
		0,1:√3	25	3,0	1000
	2a-2n	0,1:√3	25	0,1	1000
		0,1:√3	25	3,0	1000
	3a-3n	0,1:√3	25	0,1/3P	1000
		0,1:√3	500	3/3P	1000
	4a-4n	0,1:√3	25	0,1/3P	1000
		0,1:√3	25	3/3P	1000
	da-dn	0,1: 3	100	1	450
		0,1: 3	300	3P	450

CZŁON PRĄDOWY	Uzwojenie	Isn [A]	Sn [VA]	klasa	Przekładnia [A/A]
	1S1-1S2	5	1->5	0,5FS5	50-10-200/5
	2S1-2S2	1	1->2,5	0,5FS10	50-10-200/1
	3S1-3S2	5	10	5P 10	50-10-200/5
	4S1-4S2	1	2.5	5P30	50-10-200/1
		1		PX Ek = 190V Ie <= 0,1A/95 V Rct <= 0,3 Ω Rb = 3,5 Ω Kx = 50 4-2-1/200	50-10-200/1
		1		TPX Kssc = 13 Kid = 14,6 cykl = 0,1s Tp = 0,05 Rct <= 0,3Ω Rb = 1 Ω Ratio error <= 0,5%	50-10-200/1
	5S1-5S2	1	5	5P10	50-10-200/1

List of performer tests

1. Oil dielectric parameters check before filling (oil after tgδ wg IEC 60247, breakdown voltage acc. IEC 60156) ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings – P1+P2/A:Up=184 kV / 60 s,f =97 Hz; N: Up = 3 kV/ 60s, f=50 Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary – Up = 3 kV/60 s ☑
7. Inter-turn overvoltage test for current transformers – lower value (U szczyt. = 4,5 kV lub U szczyt. Przy Ith) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

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Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
  Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage =77,42 kV, Relative standard deviation = 5,64%; f=50 Hz,
  oil temp. = 26 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Próbka	Napięcie przebicia [kV]
1	83.2
2	80.1
3	70.8
4	79.2
5	78.4
6	74.6

Partial discharge measurement

- Measurement according to procedure B
  Stress voltage 184 kV / 60 s
  Frequency 97 Hz

Test voltage	1,2 Um = 151 kV	1,2 Um / √3 = 87.5 kV
Level of partial discharge	1.2 pC	1,2 pC

Remarks: background noise level: 1 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	0.066	400
2S1-2S2	0.307	400
3S1-3S2	0.205	400
4S1-4S2	1.41	400
5S1-5S2	0.736	400

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,1:√3	25	0,1	1000
2a-2n	0,1:√3	25	0,1	1000
3a-3n	0,1:√3	25	0,1/3P	1000
4a-4n	0,1:√3	25	3/3P	1000
da-dn	0,1:3	100	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.036	-0.034	-0.034	
Δφ U	2.1	2.1	2.2	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	0.004	0.006	0.008	
Δφ U	2.0	2.0	2.1	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.026	-0.024	-0.024	
Δφ U	2.2	2.3	2.3	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	0.013	0.015	0.015	
Δφ U	2.1	2.2	2.2	

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.171	-0.109	-0.019	-0.017	-0.017	-0.118
Δφ U	-3.0	0.2	2.4	2.4	2.5	1.0

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.128	-0.068	0.020	0.022	0.022	-0.077
Δφ U	-3.2	-0.0	2.2	2.2	2.2	0.8

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.169	-0.111	-0.023	-0.021	-0.021	-0.120
Δφ U	-2.7	0.5	2.7	2.7	2.8	1.3

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.123	-0.063	0.022	0.024	0.024	-0.075
Δφ U	-3.1	0.1	2.3	2.3	2.4	0.9

da – dn 100 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0.741	-0.739	-0.738
Δφ U	8.9	8.9	9.0

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.035	0.037	0.037
Δφ U	3.5	3.5	3.6

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.076	0.078	0.078
Δφ U	3.4	3.3	3.4

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.045	0.047	0.048
Δφ U	3.6	3.8	3.7

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.085	0.087	0.087
Δφ U	3.5	3.5	3.6

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.097	-0.035	0.053	0.054	0.055	-0.044
Δφ U	-1.6	1.5	3.7	3.7	3.8	2.5

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.054	0.003	0.090	0.092	0.092	-0.007
Δφ U	-1.6	1.4	3.8	3.8	3.6	2.3

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.100	-0.041	0.048	0.048	0.048	-0.050
Δφ U	-1.3	1.8	4.0	4.0	4.0	2.7

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.057	0.002	0.092	0.093	0.094	-0.005
Δφ U	-1.8	1.4	3.6	3.6	3.6	2.3

da – dn 25 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA ,

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0.304	-0.302	-0.302
Δφ U	5.2	5.2	5.3

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,1:√3	25	3,0	1000
2a-2n	0,1:√3	25	3,0	1000
3a-3n	0,1:√3	500	3/3P	1000
4a-4n	0,1:√3	25	3/3P	1000
da-dn	0,1:3	300	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
U	-0.463	-0.461	-0.461	
U	-6.6	-7.1	-6.6	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.424	-0.422	-0.422	
Δφ U	-6.7	-6.7	-6.6	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.455	-0.463	-0.463	
Δφ U	-6.6	-6.6	-6.5	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.425	-0.424	-0.423	
Δφ U	-6.8	-6.7	-6.7	

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1.125	-1.062	-0.970	-0.969	-0.970	-1.219
Δφ U	0.4	3.8	6.2	6.2	6.3	1.7

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.369	-0.309	-0.222	-0.220	-0.220	-0.470
Δφ U	-2.3	0.9	3.2	3.2	3.3	-1.5

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.587	-0.528	-0.437	-0.436	-0.438	-0.673
Δφ U	-11.1	-7.8	-5.5	-5.4	-5.4	-9.8

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	$k_u U_n$
ε U	-0.539	-0.483	-0.394	-0.392	-0.392	-0.628
Δφ U	-11.4	-8.2	-5.9	-5.9	-5.8	-10.2

da – dn 300 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-2.382	-2.274	-2.237	-2.039
Δφ U	12.9	15.2	20.1	14.7

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.037	0.039	0.039
Δφ U	3.4	3.4	3.4

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.076	0.078	0.078
Δφ U	3.3	3.3	3.4

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.047	0.049	0.049
Δφ U	3.5	3.5	3.6

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.086	0.088	0.088
Δφ U	3.4	3.4	3.5

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1.061	-0.997	-0.902	-0.900	-0.901	-1.149
Δφ U	2.1	5.3	7.6	7.7	7.8	3.2

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.299	-0.239	-0.152	-0.150	-0.150	-0.399
Δφ U	-0.8	2.3	4.5	4.5	4.6	-0.0

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.100	-0.037	0.049	0.050	-0.050	-0.202
Δφ U	-1.5	1.7	3.8	3.9	3.9	-0.8

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.052	0.007	0.093	0.095	0.095	-0.159
Δφ U	-1.9	1.3	3.5	3.5	3.5	-1.2

da – dn 75 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA ,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0.725	-0.660	-0.564	-0.560
Δφ U	4.1	7.2	9.5	9.9

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of current part errors (ε I %), (Δφ I min),

Ipn (A): 50

1S1-1S2 5 VA; cosφ = 0,8

	0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.383	-0.232	-0.025	0.132
Δφ I	17.3	7.5	-1.1	-3.3

1S1-1S2 1 VA; cosφ = 0,8

0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
0.295	0.300	0.315	0.333
13.2	8.8	4.9	3.1

2S1-2S2 2,5 VA; cosφ = 1

	0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	0.035	0.008	0.138	0.193
Δφ I	32.8	22.0	7.0	3.9

2S1-2S2 1 VA; cosφ = 1

0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
0.254	0.241	0.276	0.321
18.7	12.7	5.8	3.1

3S1-3S2	
	1,0 In
ε I	0.935
Δφ I	7.4

4S1-4S2	
	1,0 In
ε I	-0.391
Δφ I	14.6

5S1-5S2	
	1,0 In
ε I	0.701
Δφ I	15.5

Ipn (A): 100

1S1-1S2 5 VA; cosφ = 0,8

	0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.743	-0.243	0.021	0.132
Δφ I	37.0	8.3	-0.8	-3.3

1S1-1S2 1 VA; cosφ = 0,8

0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
0.129	0.305	0.317	0.334
29.3	8.9	4.9	3.1

2S1-2S2 2,5 VA; cosφ = 1

	0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	0.027	0.009	0.137	0.191
Δφ I	32.6	22.5	7.1	4.0

2S1-2S2 1 VA; cosφ = 1

0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
0.251	0.237	0.272	0.319
19.0	13.6	6.1	3.0

3S1-3S2	
	1,0 In
ε I	0.912
Δφ I	7.7

4S1-4S2	
	1,0 In
ε I	-0.391
Δφ I	14.5

5S1-5S2	
	1,0 In
ε I	0.707
Δφ I	15.5

Ipn (A): 200

1S1-1S2 5 VA; cosφ = 0,8

	0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-1.099	-0.369	0.144	0.007
Δφ I	53.4	13.3	4.5	0.3

1S1-1S2 1 VA; cosφ = 0,8

0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
-0.438	0.236	0.238	0.271
52.4	15.1	10.2	7.2

2S1-2S2 2,5 VA; cosφ = 1

	0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	0.027	0.005	0.143	0.194
Δφ I	33.4	22.8	6.4	4.0

2S1-2S2 1 VA; cosφ = 1

0,05 I_n	0,2 I_n	1,0 I_n	2,0 I_n
0.250	0.250	0.278	0.314
19.4	12.5	5.7	4.5

3S1-3S2	
	1,0 In
ε I	0.933
Δφ I	7.1

4S1-4S2	
	1,0 In
ε I	-0.392
Δφ I	14.5

5S1-5S2	
	1,0 In
ε I	0.711
Δφ I	15.2

Current part: Measurements uncertainty: $\varepsilon I = \pm 0{,}045\ \%$, $\Delta\varphi I = \pm 2{,}3$ min
Voltage part: Measurements uncertainty: $\varepsilon U = \pm 0{,}044\ \%$, $\Delta\varphi U = \pm 2{,}2$ min

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	2.5	4.36	6.16	$U < E_{FS}$	☑
2S1-2S2	1	9.71	31.07	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Warunek	Assessment
3S1-3S2	21.14	1.154	2.31	$\varepsilon_c < 5\%$	☑
4S1-4S2	219.68	0.123	0.15	$\varepsilon_c < 5\%$	☑
5S1-5S2	52.95	0.129	1.29	$\varepsilon_c < 5\%$	☑

Determination of parameters of class PX core 4S1-4S2:

Ipn [A]	50	100	200
Factor Kx	54.93	54.94	54.94
Turns ratio error [%]	-0.007	-0.003	0.002

Determination of parameters of class TPX core 4S1-4S2:

Ipn [A]	50	100	200
Factor Kssc	13.91	13.91	13.92
Factor Kwf	14.46	14.46	14.46
Current ratio error [%]	-0.225	-0.230	-0.235
Ts [s]	5.498	5.517	5.500
e-peak [%]	1.530	1.529	1.530

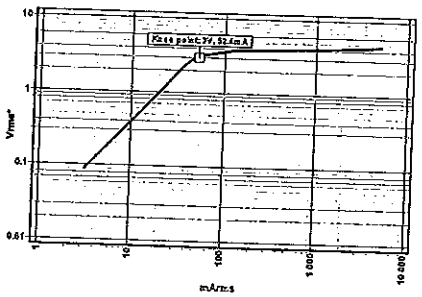
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.25	1379	4.338	0.26	1113	3.493	0.22	266	0.837
63 kV	0.24	1379	27.09	0.25	1113	21.92	0.22	266	5.236
71 kV	0.24	1379	30.62	0.25	1113	24.78	0.22	266	5.909

Core magnetization characteristics:

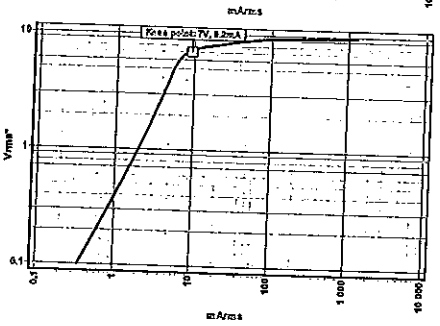
Winding 1S1-1S2

[V]	[mA]
4.8	5057.8
4.3	1790.6
3.8	124.7
3.2	55.39
2.7	42.69
2.2	35.42
1.7	29.05
1	20.79
0.5	12.46
0.1	3.17



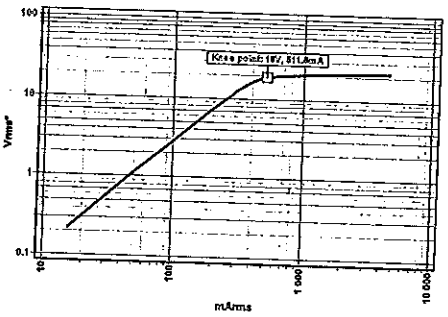
Winding 2S1-2S2

[V]	[mA]
9.8	1309.8
9.6	439.0
9.0	57.87
8.4	25.12
7.8	13.93
7.3	9.77
6.7	7.71
6.1	6.64
5.6	6.22
5	5.64
3.9	4.82
2.7	3.90
1.7	2.85
0.5	1.23
0.1	0.35



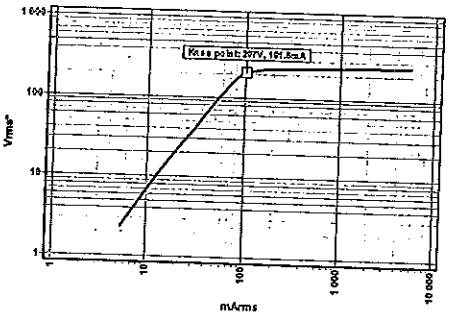
Winding 3S1-3S2

[V]	[mA]
22.5	4634.9
22.0	2540.5
21.5	1365.1
20.6	816.5
19.3	552.6
18.0	458.0
16.4	398.9
15.1	363.5
13.9	333.9
12.5	304.2
9.7	246.6
6.7	188.0
4.1	132.0
1.2	52.98
0.2	15.74



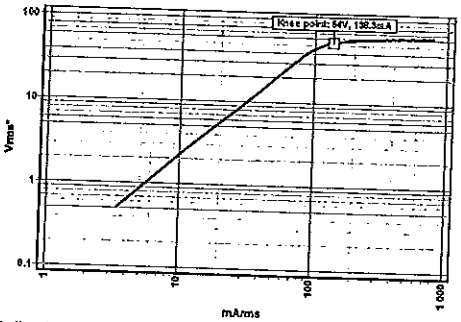
Winding 4S1-4S2

[V]	[mA]
256.8	5481.1
251.7	1665.2
247.3	945.4
240.7	360.0
228.1	158.8
220.4	123.8
207.6	101.98
194.3	91.74
181.6	84.24
165.7	76.94
152.1	72.83
110.0	57.96
67.8	42.39
25.9	23.12
2.3	5.49



Winding 5S1-5S2

[V]	[mA]
63.7	772.4
62.2	428.8
59.6	234.6
57.9	186.5
56.9	166.4
55.2	146.8
52.6	125.8
49.4	112.0
46.6	104.48
38.4	85.51
30.0	69.8
22.1	55.71
13.6	39.17
6.1	18.76
0.5	3.43



Measurement of windings' resistance

Windings' resistance of current part:

	R (23°C)	R ct (75°C)
P1-P2 range 50 A	257.0 μΩ	309.5 μΩ
P1-P2 range 100 A	99.0 μΩ	119.2 μΩ
P1-P2 range 200 A	53.0 μΩ	63.8 μΩ
1S1-1S2	0.046 Ω	0.056 Ω
2S1-2S2	0.504 Ω	0.607 Ω
3S1-3S2	0.023 Ω	0.028 Ω
4S1-4S2	0.204 Ω	0.245 Ω
5S1-5S2	0.301 Ω	0.362 Ω

Windings' resistance of voltage part:

	R (23 °C)	R ct (75°C)
A-N	16.70 kΩ	20.113 kΩ
1a-1n	42.760 mΩ	51.523 mΩ
2a-2n	43.770 mΩ	52.715 mΩ
3a-3n	45.160 mΩ	54.389 mΩ
4a-4n	46.430 mΩ	55.918 mΩ
da-dn	30.970 mΩ	37.299 mΩ

Checked by: .....

Przasnysz, 09.12.2013 r.

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer after lightning impulse			TYPE: PVA145a Serial no: 2GKP013K1486144
A-N 132:√3 kV	Insulation level: 145/275/650 kV	Voltage factor: 1.9/8h	Ith 1s [kA]: 40-40	Idyn [kA]: 100-100	Ith [A]: 450-900	IEC 61869-4 50 Hz

VOLTAGE PART	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
	1a - 1n	0,11:√3	0-> 10	0,1	1000
	2a - 2n	0,11:√3	25	0,1	1000
	3a - 3n	0,11:√3	25	0,1/3P	1000
	4a - 4n	0,11:√3	40	1/3P	1000
	da - dn	0,11	100	1,0	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
	1S1-1S2	5	40	0,2FS 5	300-600/5
	2S1-2S2	1	30	0,5FS 10	300-600/1
	3S1-3S2	5	60	5P 20	300-600/5
	4S1-4S2	1	120	10P 15	300-600/1

List of performed tests:

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings - P1-P2/A: Up = 220kV / 60s, f = 97 Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary - Up = 3 kV/60s ☑
7. Inter-turn overvoltage test for current transformers - lower value (U peak=4,5kV or U peak for Ith) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ☑
10. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.07 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 75.92 kV, Relative standard deviation = 7.19
  f = 50Hz, oil temp. = 20 °C, measurement with the stirrer, type of electrodes used: partially

Sample	Breakdown voltage [kV]
1	81
2	68.2
3	77.5
4	75.3
5	82.2
6	71.3

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the after the power-frequency withstand test on primary
  Stress voltage: 220 kV / 60 s
  Frequency: 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100.8 kV
Level of partial discharge	1.8 pC	1.2 pC

Remarks: background noise level: 1 (measured after voltage switch off).
measuring circuit was calibrated with 5 pC (calibrating

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	1.41	900
2S1-2S2	4.5	550
3S1-3S2	2.15	900
4S1-4S2	4.5	68

Determination of voltage part errors (ε U%), Δφ U min)

1a-1n: 10 VA, 2a-2n: 25VA; 3a-3n: 25VA; 4a-4n: 40VA — p.f. = 1 / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.025	-0.025	-0.026
Δφ U	0.5	0.5	0.6

1a-1n: 0 VA, 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 1

	0,8 Un	1,0 Un	1,2 Un
ε U	0.061	0.061	0.060
Δφ U	2.4	2.4	2.6

1a-1n: 10 VA, 2a-2n: 25VA; 3a-3n: 25VA; 4a-4n: 40VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.009	-0.009	-0.010
Δφ U	0.9	0.9	1.0

1a-1n: 0 VA, 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.077	0.077	0.076
Δφ U	2.8	2.9	2.9

2a-2n: 25 VA, 1a-1n: 10VA; 3a-3n: 25VA; 4a-4n: 40VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.043	-0.042	-0.044
Δφ U	1.3	1.3	1.4

2a-2n: 25 VA, 1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.029	0.029	0.028
Δφ U	2.9	2.9	3.0

2a-2n: 6.25 VA, 1a-1n: 10VA; 3a-3n: 25VA; 4a-4n: 40VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.008	-0.008	-0.007
Δφ U	1.3	1.3	1.3

2a-2n: 6.25 VA, 1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.068	0.068	0.065
Δφ U	2.9	2.9	3.0

3a-3n: 25 VA, 1a-1n: 10VA; 2a-2n: 25VA; 4a-4n: 40VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.117	-0.128	-0.035	-0.035	-0.036	-0.131
Δφ U	0.1	1.1	1.4	1.4	1.5	0.3

3a-3n: 25 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.043	-0.053	0.038	0.038	0.035	-0.059
Δφ U	1.9	2.8	3.0	3.0	3.1	2.1

3a-3n: 6.25 VA, 1a-1n: 10VA; 2a-2n: 25VA; 4a-4n: 40VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.078	-0.087	0.002	0.002	0.001	-0.093
Δφ U	-0.0	1.0	1.3	1.3	1.4	0.3

3a-3n: 6.25 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.006	-0.015	0.073	0.073	0.072	-0.022
Δφ U	1.8	2.7	2.9	3.0	3.0	2.0

4a-4n: 40 VA, 1a-1n: 10VA; 2a-2n: 25VA; 3a-3n: 25VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.128	-0.137	-0.049	-0.049	-0.051	-0.143
Δφ U	0.9	1.9	2.1	2.1	2.2	1.1

4a-4n: 40 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.063	-0.080	0.007	0.007	0.006	-0.085
Δφ U	2.3	3.2	3.3	3.3	3.4	2.4

4a-4n: 10 VA, 1a-1n: 10VA; 2a-2n: 25VA; 3a-3n: 25VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.060	-0.072	0.015	0.014	-0.079	
Δφ U	0.6	1.6	1.8	1.8	1.9	0.6

4a-4n: 10 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.003	-0.013	0.072	0.072	0.070	-0.022
Δφ U	2.0	2.9	3.0	3.0	3.1	2.1

da-dn: 100 VA, 1a-1n: 10VA; 2a-2n: 25VA; 3a-3n: 25VA; 4a-4n: 40VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un	
ε U	-0.757	-0.752	-0.764	-0.761
Δφ U	1.8	1.8	1.8	2.7

da-dn: 25 VA, 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.823	-0.822	-0.822
Δφ U	3.1	3.1	3.2

*at 1,9 Un winding da-dn is loaded with 100 VA, p.f. = 0,8

Determination of current part errors (ε I%), Δφ I min)

Ipn (A): 300

1S1-1S2: 40 VA — p.f. = 0,8 lag. / 1S1-1S2: 10 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.059	-0.047	-0.031	-0.028
Δφ I	0.6	0.1	-0.3	-0.3

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.014	-0.015	-0.014	-0.013
Δφ I	0.1	0.1	0.0	0.0

2S1-2S2: 30 VA — p.f. = 0,8 lag. / 2S1-2S2: 7.50 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.087	-0.065	-0.017	-0.023
Δφ I	2.9	1.3	-0.4	0.5

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	0.006	0.009	0.014	0.016
Δφ I	1.3	0.6	0.2	0.2

3S1-3S2: 60 VA — p.f. = 0,8 lag. / 4S1-4S2: 120 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.109
Δφ I	0.7

	1,0 In
ε I	-0.128
Δφ I	0.9

Ipn (A): 600

1S1-1S2: 40 VA — p.f. = 0,8 lag. / 1S1-1S2: 10 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.060	-0.054	-0.034	-0.031
Δφ I	0.9	0.4	-0.2	-0.2

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.010	-0.017	-0.016	-0.014
Δφ I	0.1	0.3	0.1	0.0

2S1-2S2: 30 VA — p.f. = 0,8 lag. / 2S1-2S2: 7.50 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.083	-0.067	-0.020	-0.040
Δφ I	2.8	1.5	-0.2	1.2

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	0.013	0.010	0.017	0.019
Δφ I	1.0	0.7	0.1	0.1

3S1-3S2: 60 VA — p.f. = 0,8 lag. / 4S1-4S2: 120 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.108
Δφ I	0.7

	1,0 In
ε I	-0.126
Δφ I	0.9

Current part: Measurements uncertainty: $\varepsilon_I = \pm 0{,}045$ %, $\Delta\varphi_I = \pm 2{,}5$ min
Voltage part: Measurements uncertainty: $\varepsilon_U = \pm 0{,}044$ %, $\Delta\varphi_U = \pm 2{,}2$ min

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	Ers [V]	Condition	Assessment
1S1-1S2	2.5	31.35	49.99	U < Ers	☑
2S1-2S2	1	97.33	360.33	U < Ers	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	EALF [V]	Ie [A]	εc [%]	Condition	Assessment
3S1-3S2	282.89	0.135	0.14	εc ≤ 5%	☑
4S1-4S2	1928.96	0.014	0.09	εc ≤ 10%	☑

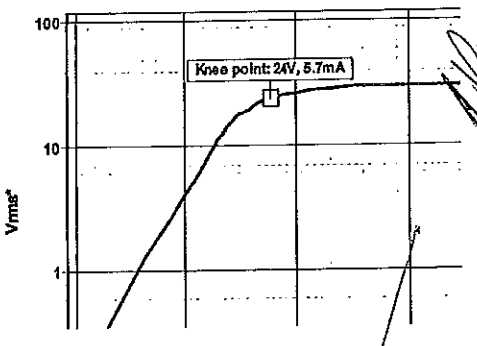
Measurement of capacitance and dielectric dissipation factor - δ
Temperature: 22.5 °C, Frequency: 50

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ [%]	Capacity [pF]	Leak.current [mA]	Tg δ [%]	Capacity [pF]	Leak.current [mA]	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.24	1407	4.423	0.26	1130	3.518	0.22	277	0.87
63 kV	0.25	1407	27.56	0.25	1130	22.41	0.22	277	5.494
71 kV	0.25	1407	31.13	0.25	1130	24.96	0.22	277	8.128

Core magnetization characteristics:

Winding 1S1-1S2

[V]	[mA]
31.5	3069.1
30	48.38
28	15.21
26.8	7.69
25.3	5.76
24.4	5.8
23.7	5.63
22.3	4.6
21	4.17
19.6	3.75
15.4	2.64
11.1	1.95
8.9	1.42
2.6	0.71
0.3	0.16



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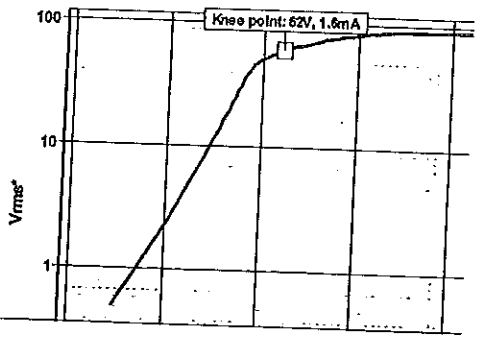
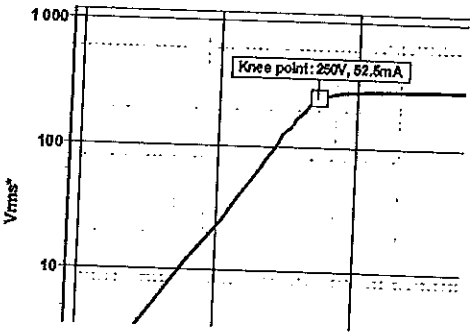
Winding 2S1-2S2

[V]	[mA]
97.9	1134.1
85.6	11.43
79.7	6.6
73.8	3.99
67.9	2.62
65.2	2.08
62.2	1.69
59.3	1.43
56.5	1.24
53.3	1.07
42.1	0.74
30.9	0.58
19.7	0.44
8.3	0.25
0.5	0.03



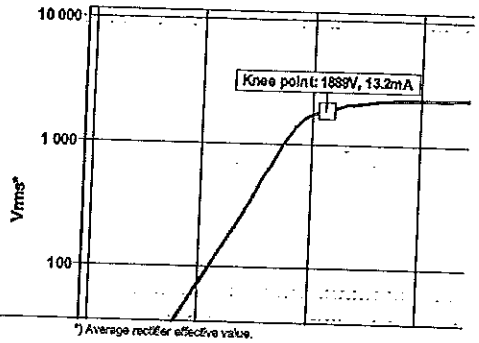
Winding 3S1-3S2

[V]	[mA]
307.	7274
304.	2660.1
290.	314
267.	62.38
261.	57.68
253.	53.51
240.	49.93
228.	47.34
210	44.69
197.	42.95
154.	35.26
111.	27.49
68.8	20.51
25.8	10.79
2.4	2.14



Winding 4S1-4S2

[V]	[mA]
2476.7	1023.3
2459.8	689.2
2411.4	252.6
2379.1	141.4
2206	30.87
2162.3	26.38
2077.5	20.58
1945.8	14.77
1813.8	11.2
1664.8	9.07
1527.4	7.89
1104.1	6.79
674.	4.24
249.	2.27
22	0.43



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part:

	R (24 °C)	Rct (75 °C)
P1-P2 range 300A	602.0 µΩ	722.7 µΩ
P1-P2 range 600A	323.0 µΩ	387.7 µΩ
1S1-1S2	0.395 Ω	0.474 Ω
2S1-2S2	6.010 Ω	7.215 Ω
3S1-3S2	0.429 Ω	0.515 Ω
4S1-4S2	8.790 Ω	10.552 Ω

Windings' resistance of voltage part:

	R (24 °C)	Rct (75 °C)
A-N	21.60 kΩ	25.929 kΩ
1a-1n	47.010 mΩ	56.432 mΩ
2a-2n	48.290 mΩ	57.969 mΩ
3a-3n	50.100 mΩ	60.142 mΩ
4a-4n	51.600 mΩ	61.942 mΩ
da-dn	114.100 mΩ	136.969 mΩ

Checked by: OG-1 KJ-06

Przasnysz, dn 2013-12-20

LABORATORIUM WYSOKICH NAPIĘĆ INSTYTUTU ENERGETYKI

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EWN/145/E/13

ANNEX 3

ANNEX 3 for test report EWN/145/E/13

Lightning impulse test. Impulse 1,2/50 µs, full and chopped:

- Oscillograms of test voltages and detection currents.
- Report No. EWN/145/E/13-1a – 20.11.2013.
- Report No. EWN/145/E/13-1b – 09.11.2013.

HIGH VOLTAGE LABORATORY

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Próba udarem piorunowym 1.2/50us

project: ewn145e13-1a test date 20-11-2013 page 1

Test - object - data

WNR EWN/145/E/13-1a TR-No. 2GKP013K1486144 O.-No. 4500513518

test object	PVA 145a		vector group	-	
output	-	kVA	BIL	650	
voltage	132	kV	frequency	50	Hz

customer ABB Sp. z o. o.
Żegańska 1, 04-713 Warszawa

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	remark
1	-324.7	1.31	47.8		LI: 1A-1N - RW(50.0%)
2	-647.5	1.31	48.1		LI: 1A-1N - FW(100.0%)
3	-373.6	1.32		3.83	LI: 1A-1N - CRW(57.5%)
4	-742	1.34		3.82	LI: 1A-1N - CFW(115.0%)
5	-749.1	1.32		3.78	LI: 1A-1N - CFW(115.0%)
6	-649.9	1.32	48.1		LI: 1A-1N - FW(100.0%)
7	-649.3	1.32	48.1		LI: 1A-1N - FW(100.0%)
8	-649.7	1.32	48.1		LI: 1A-1N - FW(100.0%)
9	-649.2	1.32	48.2		LI: 1A-1N - FW(100.0%)
10	-649.6	1.32	48.2		LI: 1A-1N - FW(100.0%)
11	-649.4	1.31	48.2		LI: 1A-1N - FW(100.0%)
12	-649.3	1.31	48.2		LI: 1A-1N - FW(100.0%)
13	-649.9	1.32	48.2		LI: 1A-1N - FW(100.0%)
14	-649.6	1.32	48.2		LI: 1A-1N - FW(100.0%)
15	-650.9	1.32	48.2		LI: 1A-1N - FW(100.0%)
16	-650.9	1.32	48.2		LI: 1A-1N - FW(100.0%)
17	-650.9	1.32	48.2		LI: 1A-1N - FW(100.0%)
18	-651.2	1.32	48.3		LI: 1A-1N - FW(100.0%)
19	-651.1	1.32	48.2		LI: 1A-1N - FW(100.0%)
20	324.7	1.32	48		LI: 1A-1N - RW(50.0%)
21	648.4	1.32	48.3		LI: 1A-1N - FW(100.0%)
22	650	1.32	48.3		LI: 1A-1N - FW(100.0%)
23	650.2	1.32	48.3		LI: 1A-1N - FW(100.0%)
24	649.7	1.32	48.3		LI: 1A-1N - FW(100.0%)
25	649.4	1.32	48.3		LI: 1A-1N - FW(100.0%)
26	649.2	1.32	48.4		LI: 1A-1N - FW(100.0%)
27	649.3	1.32	48.4		LI: 1A-1N - FW(100.0%)
28	649	1.32	48.4		LI: 1A-1N - FW(100.0%)
29	649.8	1.32	48.4		LI: 1A-1N - FW(100.0%)

A0

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Próba udarem piorunowym 1.2/50us
project: ewn145e13-1a

30	649.1	1.32	48.4		LI: 1A-1N - FW(100.0%)
31	648.9	1.32	48.4		LI: 1A-1N - FW(100.0%)
32	649	1.32	48.4		LI: 1A-1N - FW(100.0%)
33	648.7	1.31	48.4		LI: 1A-1N - FW(100.0%)
34	648.3	1.32	48.4		LI: 1A-1N - FW(100.0%)
35	648.5	1.31	48.4		LI: 1A-1N - FW(100.0%)

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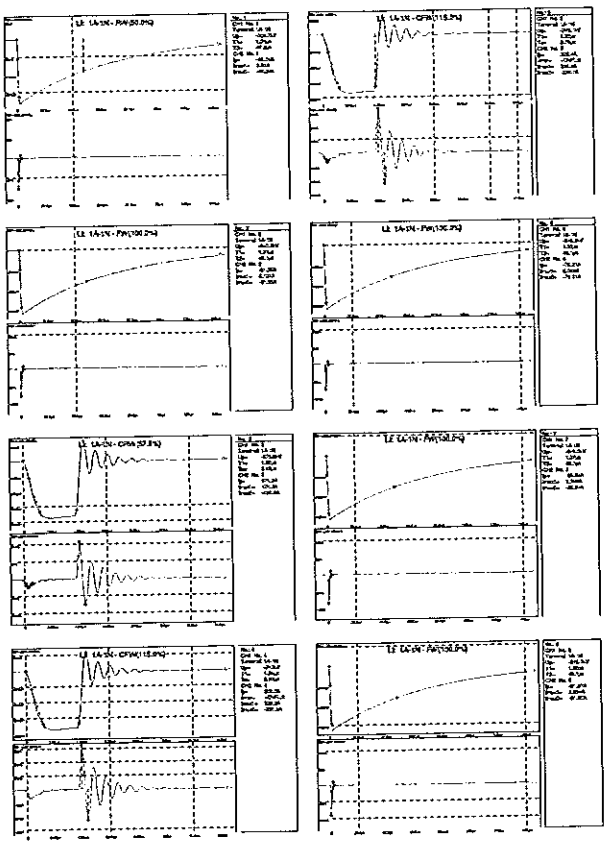
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1a



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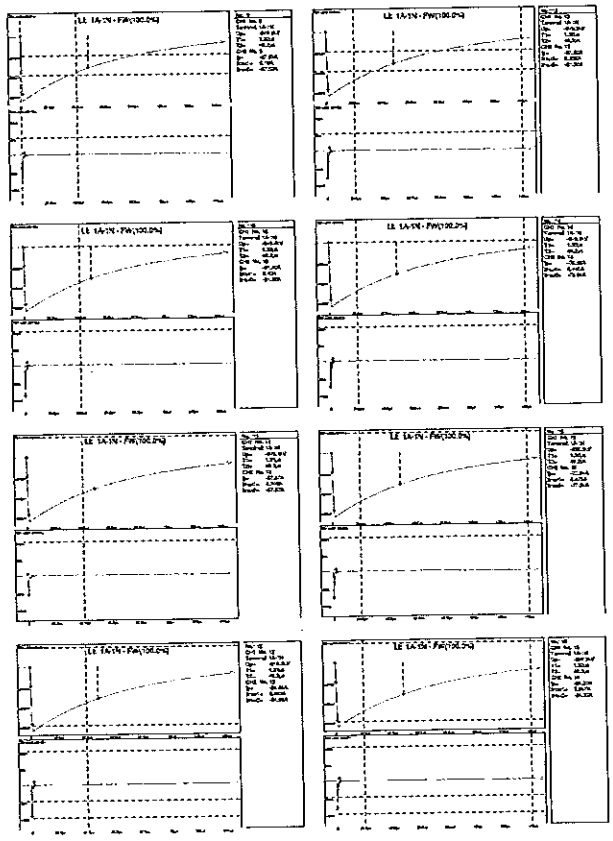
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1a



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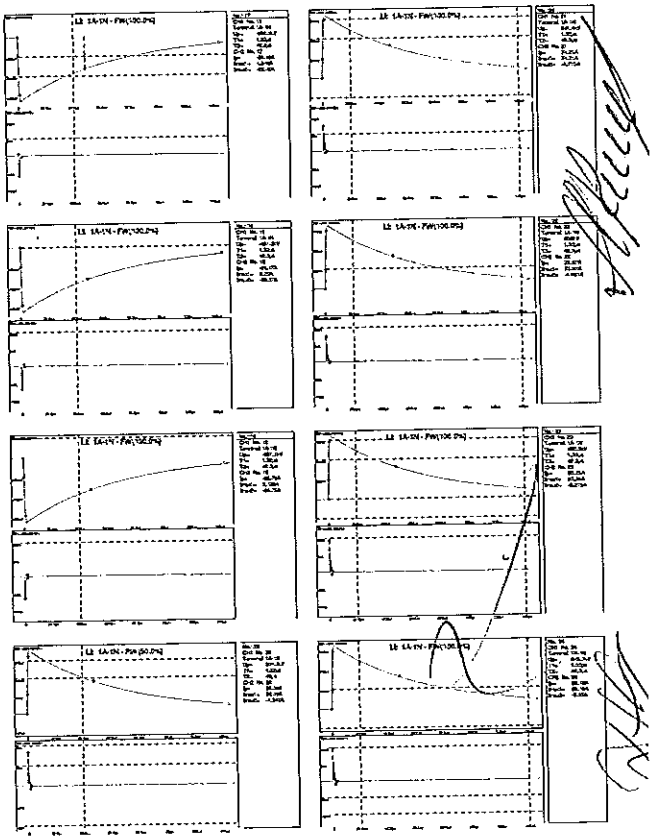
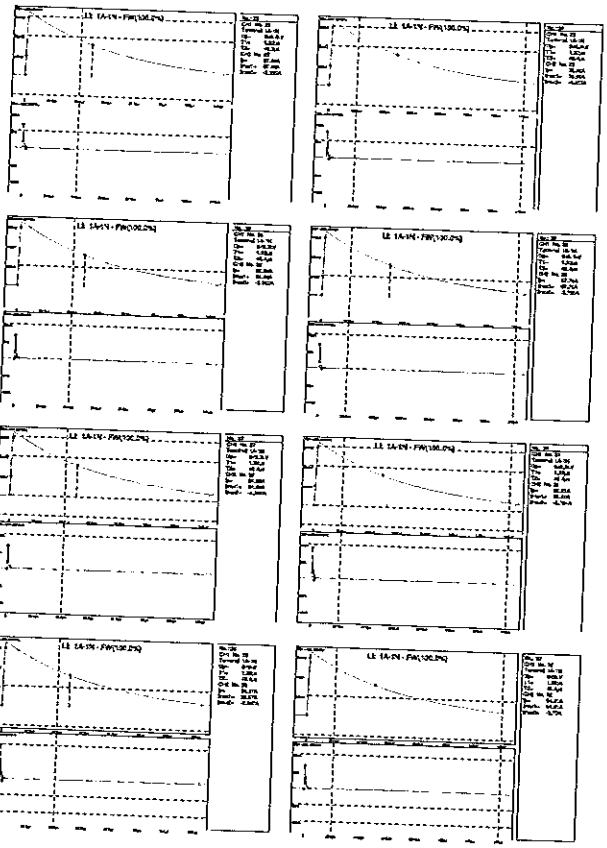
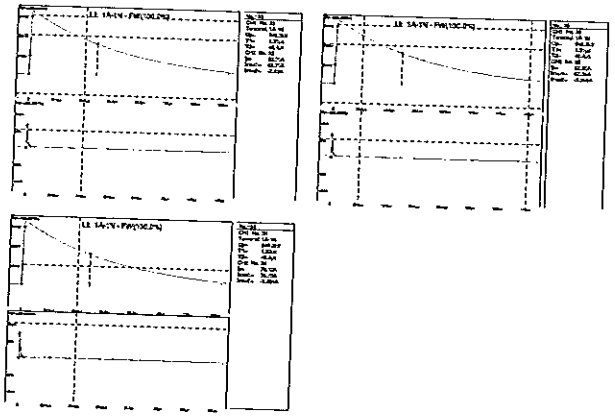
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1a







Test - object - data

WNR	EWN/145/E/13-1b		TR-No. 2GKP013K1486138 O.-No. 4500513518		
test object	PVA 123a		vector group	-	
output	-	kVA	B/L	650	
voltage	110	kV	frequency	50	Hz
customer	ABB Sp. z o. o. Żegańska 1, 04-713 Warszawa				

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	remark
1	-276.3	1.36	50.6		LI: 1A-1N - RW(50.0%)
2	-549.5	1.34	50.5		LI: 1A-1N - FW(100.0%)
3	-317	1.36		3.96	LI: 1A-1N - CRW(57.5%)
4	-633.6	1.35		3.99	LI: 1A-1N - CFW(115.0%)
5	-627.8	1.35		3.97	LI: 1A-1N - CFW(115.0%)
6	-549.8	1.35	50.5		LI: 1A-1N - FW(100.0%)
7	-549.5	1.34	50.5		LI: 1A-1N - FW(100.0%)
8	-549.6	1.34	50.5		LI: 1A-1N - FW(100.0%)
9	-549.5	1.35	50.5		LI: 1A-1N - FW(100.0%)
10	-549.6	1.35	50.5		LI: 1A-1N - FW(100.0%)
11	-549.7	1.35	50.5		LI: 1A-1N - FW(100.0%)
12	-549.5	1.35	50.6		LI: 1A-1N - FW(100.0%)
13	-549.5	1.35	50.5		LI: 1A-1N - FW(100.0%)
14	-549.5	1.35	50.5		LI: 1A-1N - FW(100.0%)
15	-549.5	1.35	50.6		LI: 1A-1N - FW(100.0%)
16	-549.6	1.35	50.6		LI: 1A-1N - FW(100.0%)
17	-549.5	1.35	50.6		LI: 1A-1N - FW(100.0%)
18	-549.3	1.35	50.6		LI: 1A-1N - FW(100.0%)
19	-549.5	1.35	50.6		LI: 1A-1N - FW(100.0%)
20	275.8	1.35	51		LI: 1A-1N - RW(50.0%)
21	552.3	1.35	50.6		LI: 1A-1N - FW(100.0%)
22	552	1.35	50.6		LI: 1A-1N - FW(100.0%)
23	552.6	1.35	50.6		LI: 1A-1N - FW(100.0%)
24	552.3	1.35	50.6		LI: 1A-1N - FW(100.0%)
25	553.5	1.35	50.6		LI: 1A-1N - FW(100.0%)
26	554	1.35	50.6		LI: 1A-1N - FW(100.0%)
27	554.4	1.35	50.7		LI: 1A-1N - FW(100.0%)
28	554.8	1.35	50.6		LI: 1A-1N - FW(100.0%)
29	554.7	1.35	50.7		LI: 1A-1N - FW(100.0%)

30	554.9	1.35	50.6		LI: 1A-1N - FW(100.0%)
31	554.6	1.34	50.6		LI: 1A-1N - FW(100.0%)
32	554.7	1.35	50.7		LI: 1A-1N - FW(100.0%)
33	554.6	1.35	50.7		LI: 1A-1N - FW(100.0%)
34	554.5	1.35	50.7		LI: 1A-1N - FW(100.0%)
35	554.2	1.35	50.7		LI: 1A-1N - FW(100.0%)

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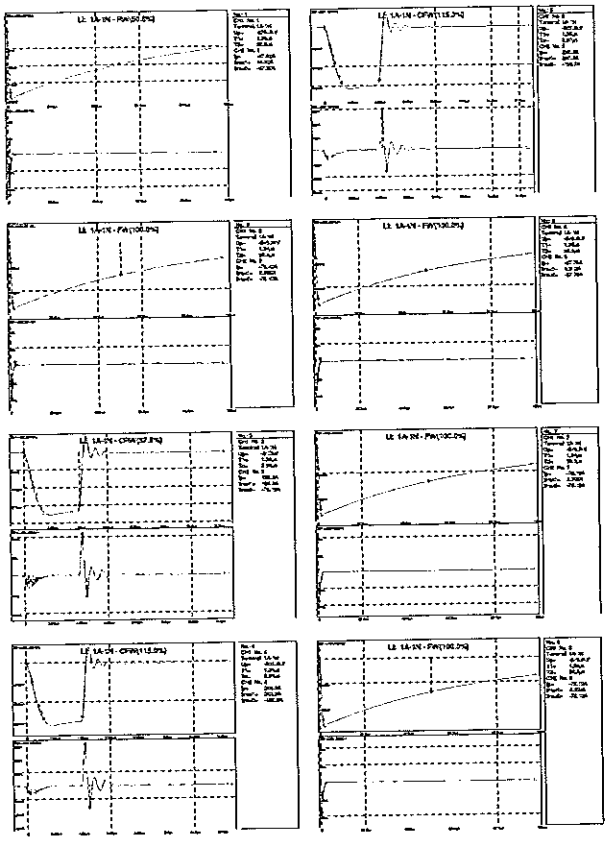
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1b



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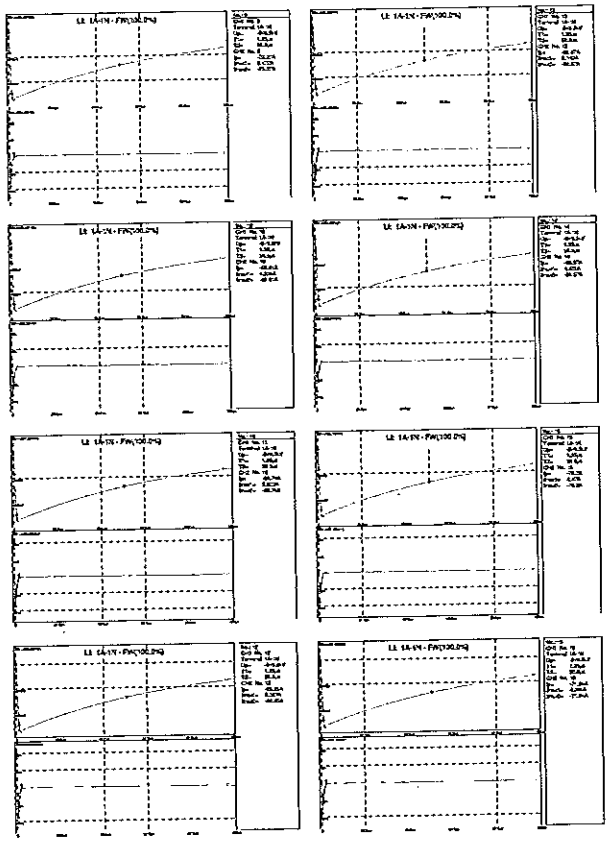
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1b



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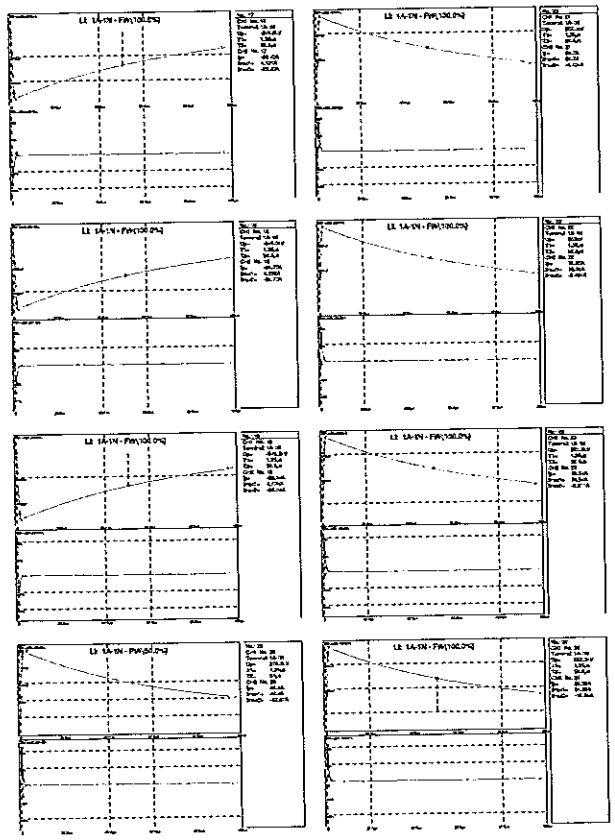
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1b



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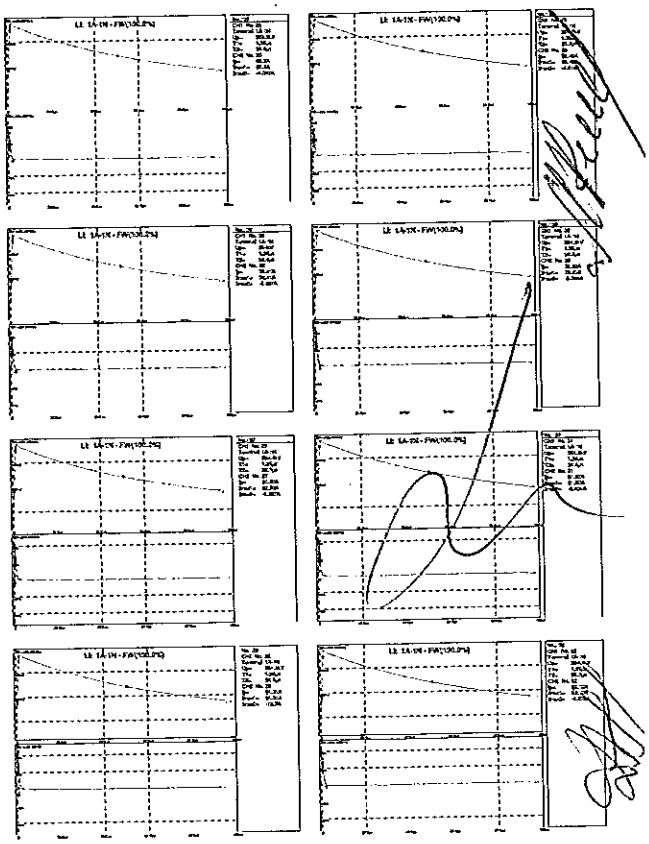
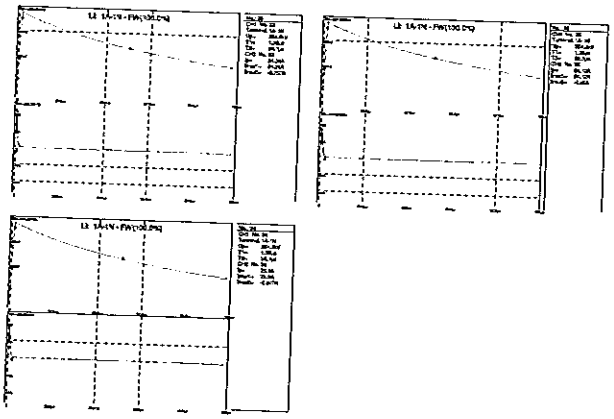
Próba udarem piorunowym 1.2/50us
project: ewn145e13-1b



Próba udarem piorunowym 1.2/50us
project: ewn145e13-1b page 7



ANNEX 4 for test report EWN/145/E/13

Transmitted overvoltage measurement:

- Oscillograms of measured overvoltages transmitted to the secondary windings.

- Report No. EWN/145/E/13-2a – 21.11.2013.
- Report No. EWN/145/E/13-2b – 13.11.2013.

Pomiar przepięć przenoszonych
project: ewn145e13-2a test date 21-11-2013 page 1

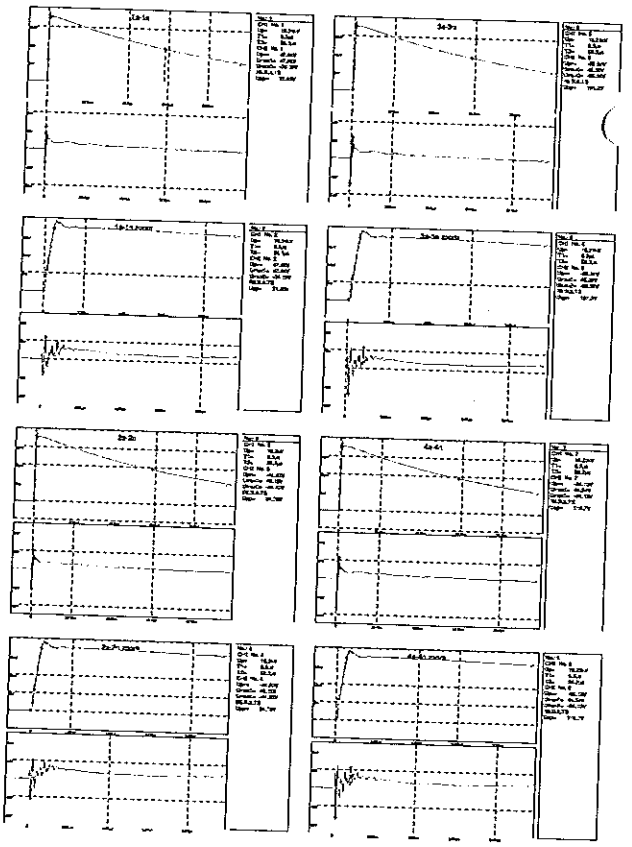
Test - object - data

WNR	EWN/145/E/13-2a	TR-No. 2GKP013K1486144 O.-No. 4500513518		
test object	PVA 145a		vector group	-
output	- kVA		BIL	(19 kV)
voltage	132 kV		frequency	50 Hz
customer	ABB Sp. z o. o. Żegańska 1, 04-713 Warszawa			

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	remark
1	19.24	0.5	58.1		1a-1n
2	19.24	0.5	58.1		1a-1n zoom
3	19.2	0.5	58.2		2a-2n
4	19.2	0.5	58.2		2a-2n zoom
5	19.21	0.5	58.2		3a-3n
6	19.21	0.5	58.2		3a-3n zoom
7	19.23	0.5	58.2		4a-4n
8	19.23	0.5	58.2		4a-4n zoom
9	19.23	0.51	58.1		da-dn
10	19.23	0.51	58.1		da-dn zoom
11	19.23	0.5	58.1		1S1-1S2
12	19.23	0.5	58.1		1S1-1S2 zoom
13	19.23	0.51	58.1		2S1-2S2
14	19.23	0.51	58.1		2S1-2S2 zoom
15	19.25	0.5	58.1		3S1-3S2
16	19.25	0.5	58.1		3S1-3S2 zoom
17	19.19	0.5	58.3		4S1-4S2
18	19.19	0.5	58.3		4S1-4S2 zoom

Pomiar przepięć przenoszonych
project: ewn145e13-2a page 2



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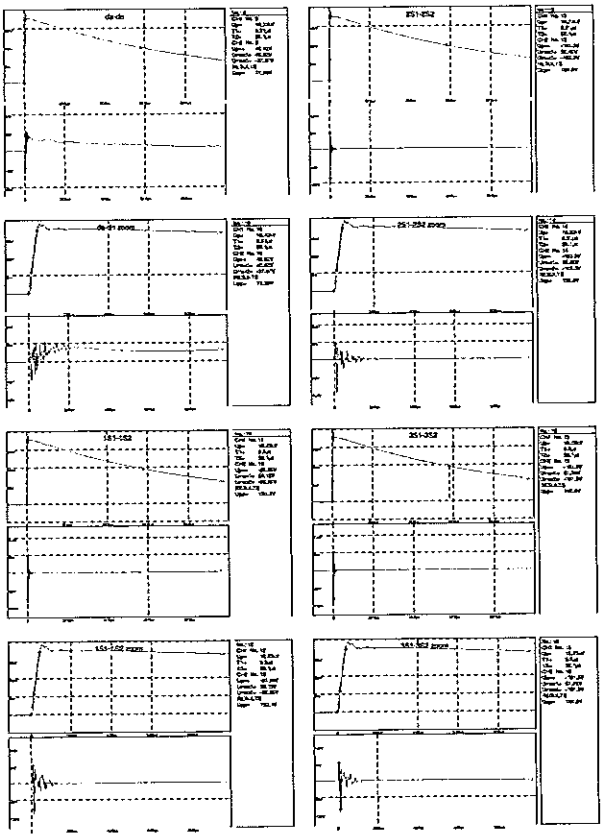
Pomiar przepięć przenoszonych
project : ewn145e13-2a page 3



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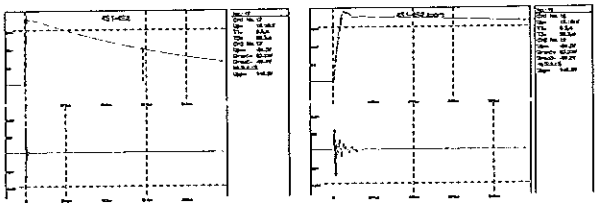
Pomiar przepięć przenoszonych
project : ewn145e13-2a page 4



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Pomiar przepięć przenoszonych
project : ewn145e13-2b test data 13-11-2013 page 1

Test - object - data

WNR	EWN/145/E/13-2b		TR-No. 2GKP013K1486138	O.-No.	4500513518
test object	PVA 123a		vector group	-	
output	-	kVA	BIL	(16 kV)	
voltage	110	kV	frequency	50	Hz

customer ABB Sp. z o. o.
Żegańska 1, 04-713 Warszawa

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	remark
1	16.05	0.51	49.4		1a-1n
2	16.05	0.51	49.4		1a-1n zoom
3	16.06	0.52	49.3		2a-2n
4	16.06	0.52	49.3		2a-2n zoom
5	16.05	0.52	49.4		3a-3n
6	16.05	0.52	49.4		3a-3n zoom
7	16.06	0.52	49.3		4a-4n
8	16.06	0.52	49.3		4a-4n zoom
9	16.05	0.52	49.3		da-dn
10	16.05	0.52	49.3		da-dn zoom
11	16.06	0.53	49.3		1S1-1S2
12	16.06	0.53	49.3		1S1-1S2 zoom
13	16.03	0.52	49.4		2S1-2S2
14	16.03	0.52	49.4		2S1-2S2 zoom
15	16.05	0.52	49.3		3S1-3S2
16	16.05	0.52	49.3		3S1-3S2 zoom
17	16.05	0.53	49.4		4S1-4S2
18	16.05	0.53	49.4		4S1-4S2 zoom
19	16.06	0.53	49.2		5S1-5S2
20	16.06	0.53	49.2		5S1-5S2 zoom

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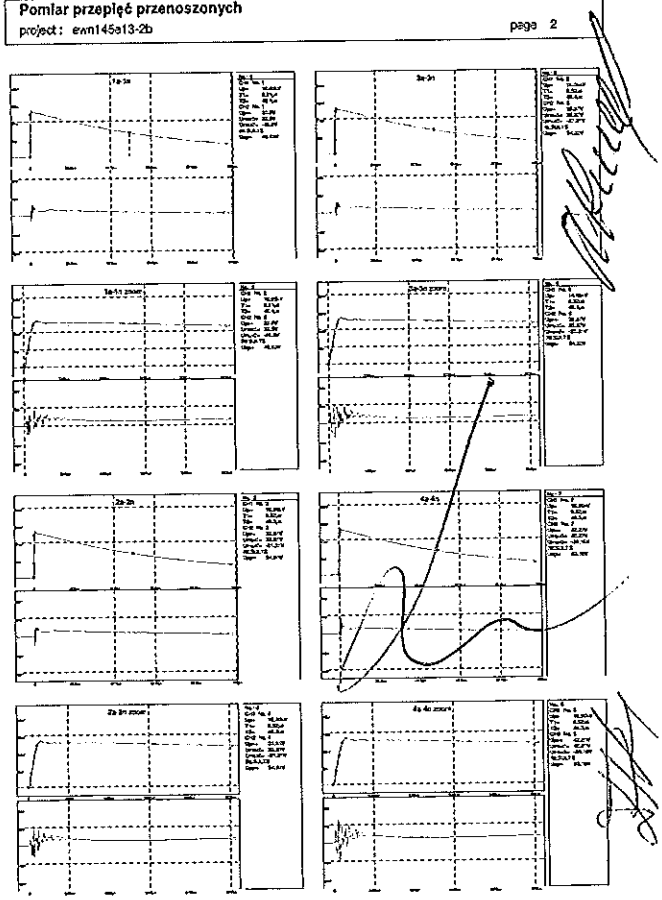
Pomiar przepięć przenoszonych
project : ewn145e13-2b page 2



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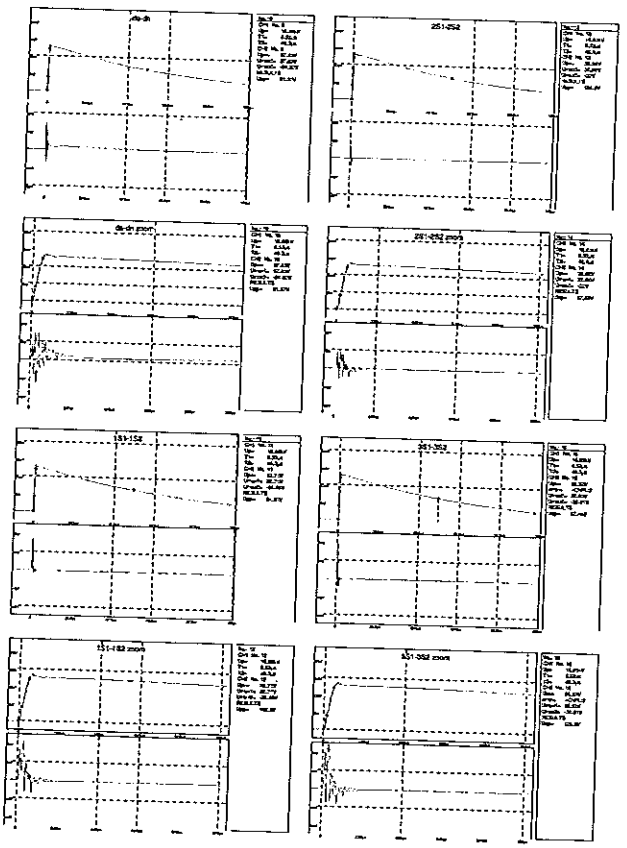
fax: (+4922) 835-80-48, mail: ewn@ien.com.pl

Pomiar przepięć przenoszonych
project: ewn145e13-2b



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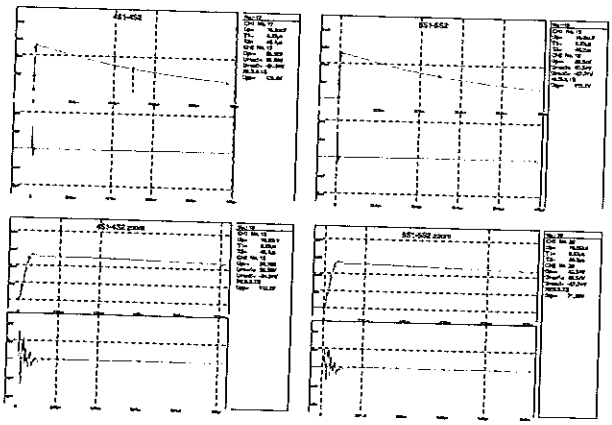
Pomiar przepięć przenoszonych
project: ewn145e13-2b



LABORATRORIES OF THE ELECTROTECHNICAL INSTIUTE
SWITCHGEAR AND CONTROLGEAR TESTING LABORATORY
M. Pożaryskiego 28; 04-703 WARSZAWA, Poland, tel. (+48 22) 812 23 38 fax. (+48 22) 812 04 07

TEST REPORT No. 8281/NZL/NBR/2012

Object of tests:	**Secondary terminal box of HV combined transformer**
Manufacturer:	**ABB Sp. z o.o., ul. Żegańska 1, 04-713 Warszawa Oddział w Przasnyszu, 06-300 Przasnysz/Poland, ul. Leszno 59**
Test performed:	Verification of the degree of protection IP55
Normative document:	PN-EN 60529:2003, EN 60529:1991 + A1:2000, IDT
Ordered by:	**ABB Sp. z o.o., ul. Żegańska 1, 04-713 Warszawa Oddział w Przasnyszu, 06-300 Przasnysz/Poland, ul. Leszno 59**

Contract/Order No.: BSK/579/NZL/2012 on 12.07.2012	Reference number: 504-023826/038
Objects delivered for tests: 09.07.2012	Date of tests completion: 10.07.2012

The test results presented in this report relate only to the samples tested.

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The Switchgear and Controlgear Testing Laboratory of the Electrotechnical Institute is accredited by Polish Centre of Accreditation in accordance with PN-EN ISO/IEC 17025:2005 in the scope of:
testing of low and high voltage alternating and direct current switchgear and controlgear
ACCREDITATION CERTYFICATE No. AB 074

AB 074

Tested by:
Janusz Domański, M.Sc. Eng

Head of the Team of Laboratories IEl:
Robert Franaszek, M.Sc. Eng.

WARSAW, 2012-07-13

This Test Report contains of 7 pages and 1 Annex

CONTENTS

1. Location and time of tests

The tests were performed at Switchgear and Controlgear Testing Laboratory of the Electrotechnical Institute in Warsaw.

Date of tests: 09 and 10 July 2012.

2. Test object

The Manufacturer – **ABB Sp. z o.o., ul. Żegańska 1, 04-713 Warszawa Oddział w Przasnyszu/ Poland** has provided to tests the Secondary terminal box of HV combined transformer.

The technical documentation of the Secondary terminal box of HV combined transformer is given on Annex 1. The name plate of the combined transformer is given on Photo 1.

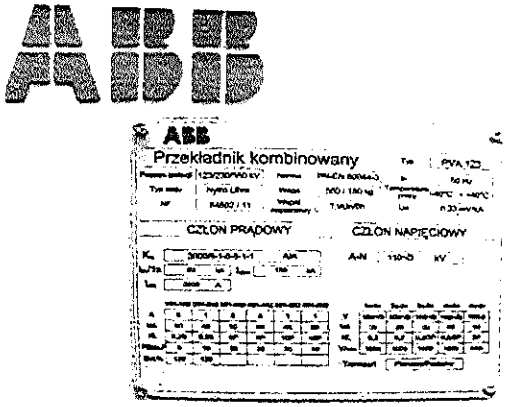


Photo 1 – The nameplate of HV combined transformer

3. Scope of tests

Verification of the degree of protection IP55 according to:

PN-EN 60529:2003	Stopnie ochrony zapewnianej przez obudowy (Kod IP)
EN 60529:1991 + A1:2000, IDT	Degrees of protection provided by enclosures (IP Code)

The test results are given in Table bellow

Item	Test	Requirements acc. to	Testing acc. to	Test result
1	Visual inspection	PN-EN 60529:2003 Clause 11	PN-EN 60529:2003 Clause 11	Positive
2	Verification of the degree of protection IP5X	PN-EN 60529:2003 Clauses 5 and 11	PN-EN 60529:2003 Clauses 13.4 and 13 6	Positive
3	Verification of the degree of protection IPX5	PN-EN 60529:2003 Clauses 6 and 11	PN-EN 60529:2003 Clauses 14 and 14.2.5	Positive

4. Description and the test results

4.1. Visual inspection

Inspection was made according to PN-EN 60529:2003, Clause 11

During inspection were checked:

- overall quality,
- compliance of the implementation with the design documentation and with the identification documents.

Test result of inspection is **positive.**

4.2. Verification of the degree of protection IP55

4.2.1. Verification of the degree of protection against solid foreign objects (IP5X)

Verification of the protection against solid foreign objects, indicated by the first characteristic numeral 5, was performed according to the PN-EN 60529:2003, Clauses 13.4 and 13.5.

The test was performed in the dust chamber type ST 2500 U. Secondary terminal box of HV combined transformer before test in the dust chamber is given on Photo 2. and after test – on Photo 3.

Test conditions during test:

ambient air temperature	–	25 °C
relative humidity	–	60 %
atmospheric pressure	–	1000 hPa
working volume of dust chamber	–	2,5 m^3
duration of test	–	8 h

After test no deposit of talcum powder was observed inside the box.

Test result of IP5X verification is **positive.**

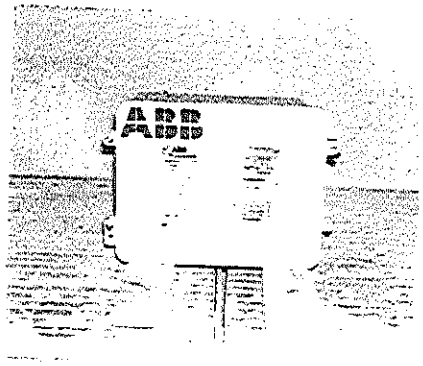


Photo 2 – Secondary terminal box in a dust chamber before IP5X test

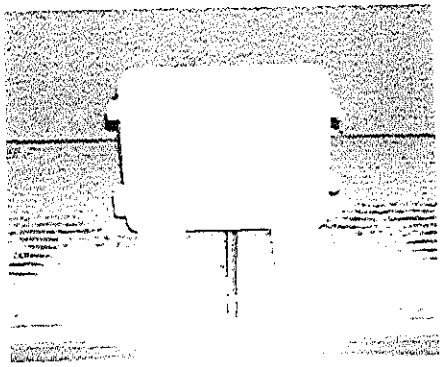


Photo 3 – Secondary terminal box in a dust chamber after IP5X test

4.2.2. Verification of the degree of protection against ingress of water (IPX5)

Verification of the protection against ingress of water, indicated by the first characteristic numeral 5, was performed according to the PN-EN 60529:2003, Clause 14.2.5.

The object under test, mounted as in normal use, was spread from all practicable directions with a stream of water from a standard test nozzle.

Test conditions:

- internal diameter of the nozzle – 6,3 mm
- rate of water flow – 12,5 l/min ± 5%
- distance from nozzle to box enclosure – (2,5 – 3,0) m
- test duration – 3 min

Secondary terminal box of HV combined transformer during IPX5 test is given on Photos 4 and 5.

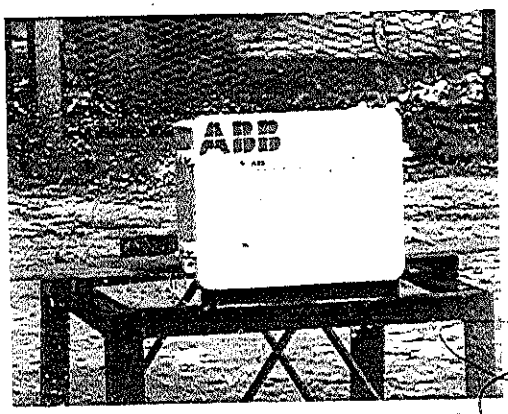


Photo 4 – Secondary terminal box of combined transformer during IPX5 test

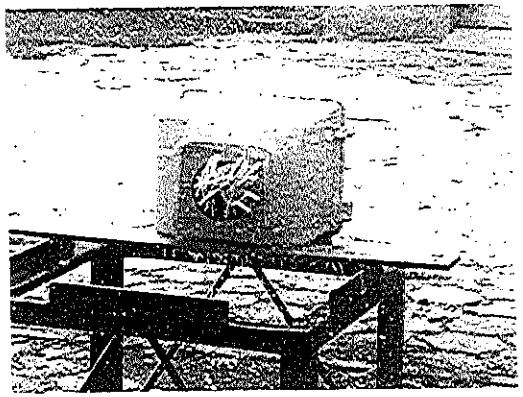


Photo 5 – Secondary terminal box of combined transformer during IPX5 test

After the IPX5 test inside the box was observed only a small amount of water. The water has entered through a vent – see Photo 6. The amount of water and its location does not indicate deterioration in working conditions of combined transformer or impair safety.

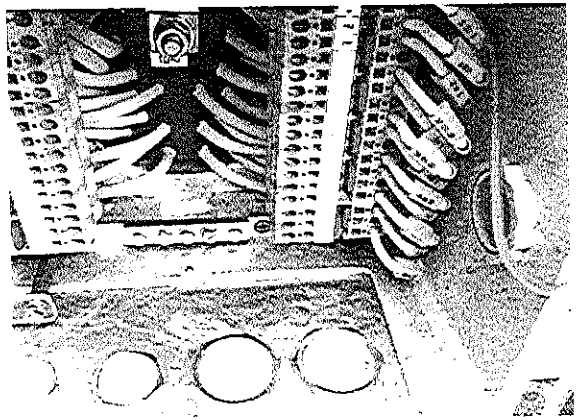


Photo 6 – Secondary terminal box of combined transformer after IPX5 test

The result of IPX5 verification is **positive.**

The verification results of the degree of protection IP55 provided by enclosure of the secondary terminal box of HV combined transformer is **positive.**

Photo 5 – Secondary terminal box of combined transformer during IPX5 test

After the IPX5 test inside the box was observed only a small amount of water. The water has entered through a vent – see Photo 6. The amount of water and its location does not indicate deterioration in working conditions of combined transformer or impair safety.

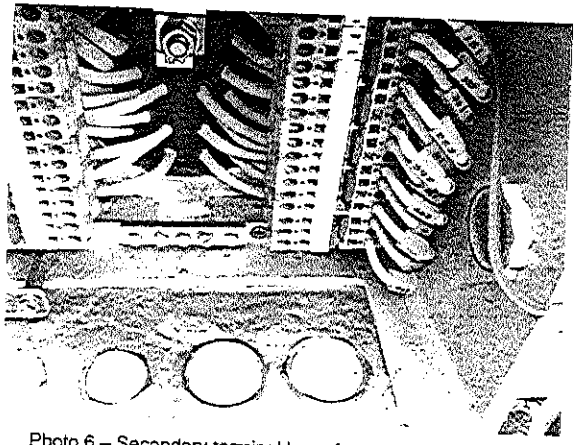


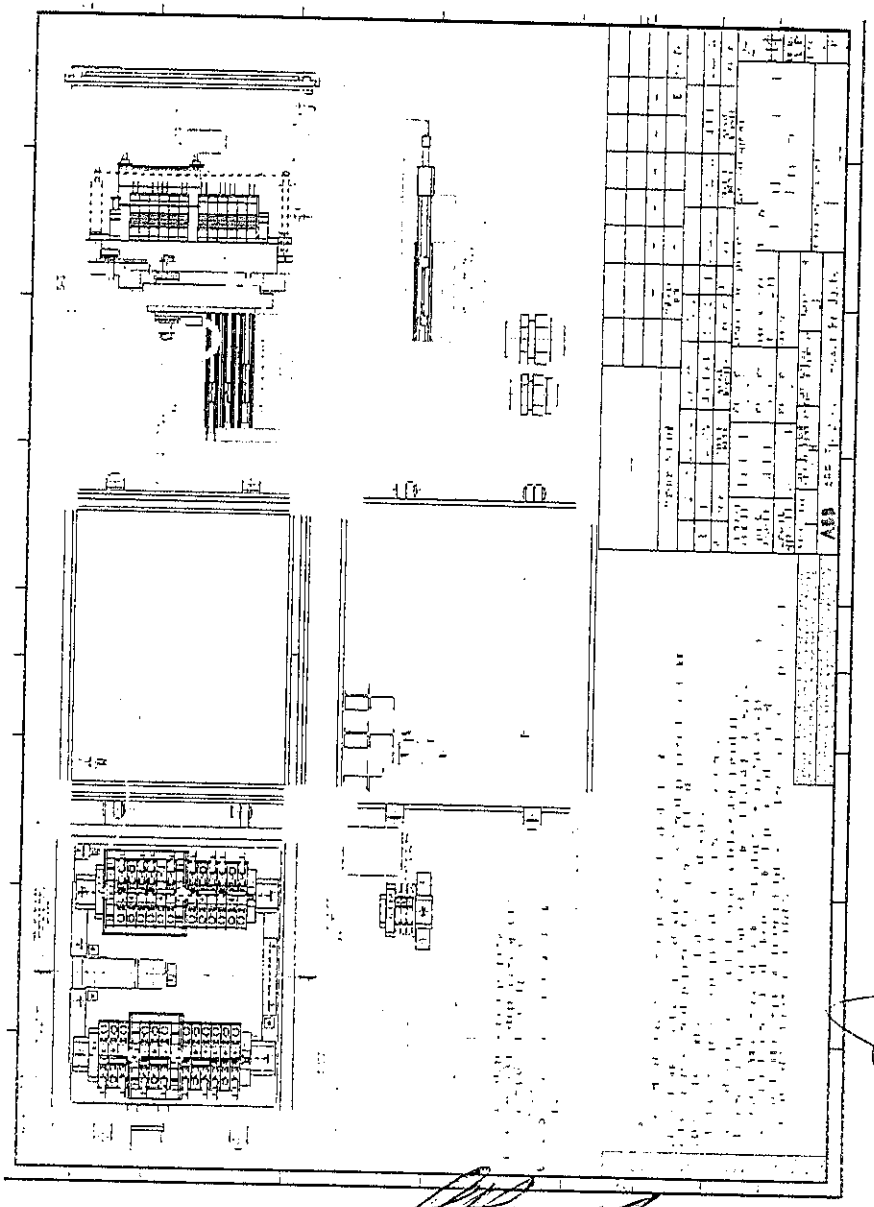
Photo 6 – Secondary terminal box of combined transformer after IPX5 test

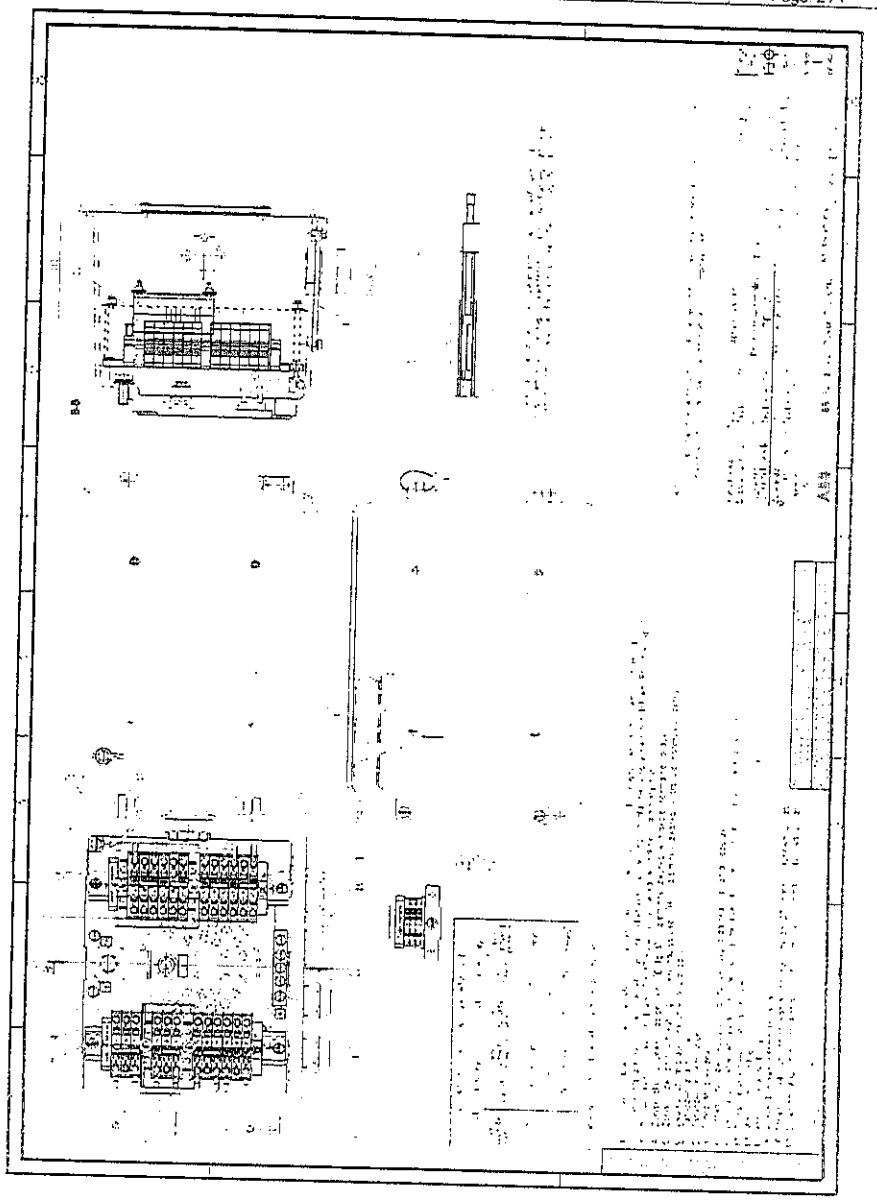
The result of IPX5 verification is **positive.**

The verification results of the degree of protection IP55 provided by enclosure of the secondary terminal box of HV combined transformer is **positive**

5. Conclusion

The secondary terminal box of HV combined transformer, designed according to the drawings No. 2GKK311093R and No. 2GKK614010 complies with the requirements of PN-EN 60529:2003 and EN 60529:1991 +A1:2000, stated for the degree of protection IP55.





INSTYTUT ENERGETYKI
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TEST REPORT No. EWP/35/E/2013-3e

TEST OBJECT:	Combined instrument transformer type PVA 145a
MANUFACTURER:	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
TESTS ORDERED BY:	Institute of Power Engineering High Voltage Department Internal order No. EWN/145/E/13 dated 17.12.2013
TYPE OF TESTS:	**Mechanical impact test**
TEST PROCEDURE:	IEC 61869-1:2007, EN 62262: 2002, IEC 60068-2-75: 1998, PN-EN 61869-1:2009E, PN-EN 62262: 2003E, PN-EN 60068-2-75: 2000P
TEST OBJECT DELIVERED:	28.11.2013
DATE OF TESTS:	21.12.2013
TESTS RESULTS:	Positive for IK7
THE TESTS WERE WITNESSED BY:	-
TEST ENGINEER:	Lidia Gruza M.Sc. Eng.
HEAD OF LABORATORY:	Lidia Gruza M.Sc. Eng.

Warsaw, 3.02.2014

Tests result refers only to the test object.
The Test Report consist tests from and beyond the scope of accreditation (details in sub-cl. 4)
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1. Description of the test object

Test object	Combined instrument transformer
Type	PVA 145a
Serial number	2GKP013K1486144
Manufacturer	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
Year of production	2013
Insulator	Composite Insulator
Number of windings	CT part – 5, CT part –4
Oil type	Nytro Libra
Minimum creepage distance	4495 mm
Insulating oil weight	150 kg
Total weight	540 kg
Dimensions	According to drawing no. 2GKK614123

The laboratory proceeded the identification of test objects on the base of above mentioned documentation (see sub-cl. 3).
The test object is shown in the photograph 1.
The test object was ready for testing by the Customer.

2. Technical data declared by the Manufacturer

Maximum operating voltage	145 kV
Rated frequency	50 Hz
Voltage factor and time	$1{,}9U_n/8h$
Rated continuous thermal current, I_{cth}	450-900 A
Rated short-time thermal current, I_{th}/ 1s	40-40 kA
Rated dynamic current, I_{dyn}	100-100 kA

4. Scope of the tests

Test programme agreed with Orderer comprised of tests:

No.	Kind of test	Tests according the Standard	Location of the test
1.	Mechanical impact test	IEC 61869-1:2007 p. 6.10.6 i p. 7.2.7.2, EN 62262: 2002	EWP

EWP The test was performed in the Institute of Power Engineering, by the High - Current Laboratory.

5. Tests and their results

Combined instrument transformer was installed at the test stand, as it was during normal operation. The test was performed after the temperature-rise test of the tested object. The test procedure was used as defined in IEC 61869-1 sub.-cl. 7.2.7.2. Impact level IK7 was approved for tested combined instrument transformer, according to the requirements given in IEC 61869-1 sub.-cl. 6.10.6 Standard. Test procedure was used according to the IEC 61869-1 sub.-cl. 7.2.7.2 Standard.
The base of tested instrument transformer was protected against moving.
The pendulum – operated impact test apparatus as defined in IEC 60068-2-75 sub.-cl. 4 (Eha test) – was used to carried–out the mechanical test.
Because of the enclosure shape of the parts of the instrument transformer, the pendulum hammer has been used in the form of the steel ball, but the arm was of rope fixed to the unit in according to the Fig. No. D.1 of the EN 6008-2-75: 1997 Standard.
The striking element (the ball) having the mass of 0,5 kg has been dropped to the enclosure from the height of 400 mm ±1%. Simultaneously the tested surface has been protected against secondary strikes (rebounds).
During the test three blows with the energy of 2 J are applied to each point of the enclosure (the weakest points): to the upper tank, lower tank and insulator.
The test was carried-out at the ambient temperature of 15 °C.

5.1. Measuring instruments

The ambient temperature was measured using four mercurial thermometers immersed into tank filled with oil. These thermometers were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor - the accuracy of measurement ± 0,03°C[1].

[1] The expanded uncertainty assigned corresponds to a coverage probability of 95 % and the coverage factor k = 2.

6. Summary

The tested combined instrument transformer type PVA 145a met requirements of the IEC 61869-1:2007 standard for protection of equipment against mechanical impact under normal service conditions for impact level IK7.

7. Opinions and interpretations

None

8. Photographic documentation

Photograph No. 1. View of tested combined instrument transformer on the test stand during preparation for the mechanical impact test.

APPENDIX No. 2.

ABB ABB Sp. z o.o.	Declaration of conformity	ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 091/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486144;**

Place and date of issue of declaration

Przasnysz 13.01.2014

ABB
ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
NIP: 526-030-44-84; PL 5260304484
Regon 010017165
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8921, fax (22) 223 8958
(9)

Referent ds. Realizacji Zamówień
ABB Sp. z o.o.
Oddział w Przasnyszu

Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Lubrecki

(Name) (Signature)

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

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tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/23/E/14 E

TEST OBJECT: Combined instrument transformer type PVA 145a with composite insulator
Serial No. 2GKP013K1486144/13

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: ABB Sp. z o.o., ul. Żegańska 1, 04-713 Warszawa
Order No. 4500554112 z dnia 25.04.2014

TYPE OF TESTS: Short-time current tests
Test for composite error

TESTS PROCEDURE: According to IEC 61869-2:2012

DATE OF TESTS: 12/13.05.2014

TESTS RESULT: Positive for
I_{dyn} = 100 kA, I_{th} = 40 kA, t = 1 s for 300 A terminal

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: Z. Wesołowski – ABB Sp. z o.o.

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 21.05.2014

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1. TEST OBJECT

1.1 Description

Combined instrument transformer type PVA 145a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 145 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with composite insulator immersed with transformer oil.

Combined instrument transformer delivered for the tests wasn't equipped with voltage transformer and current transformer wasn't equipped with 2S1-2S2 winding.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	145 kV
Rated frequency	50 Hz
Rated continuous thermal current	360 A, 720 A
Rated short-time current for 1 s	40 kA
Rated dynamic current	100 kA

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- routine tests report of combined instrument transformer before short-time current test (29.04.2014)
- routine tests report of combined instrument transformer after short-time current test (16.05.2014),
- dimensional drawing combined transformer PVA 123a-145a, No. 2GKK614123 (17.12.2013),
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o (Annex 3 and 4).
The laboratory proceeded the identification of test object on the base of above documentation and the rating plate. Conformity of manufacturing with constructional documentation is stated in manufacturer's declaration, copy of which presents Annex 4.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-2:2012:

- short-time current tests of current transformer acc. to item 7.2.201 of above standard at parameters:

  $I_{dyn} \geq 100$ kA, $I_{th} = 40$ kA, $t_{th} = 1$ s, $I_{th}^2 \times t_{th} \geq 1600$ kA^2×s for 300 A terminal.
- test for composite error acc. to item 7.2.6.203 of above standard with current's transformer burden of about 2,4 Ω (± 5%) connected to 3S1-3S2 windings at parameters:

  $6 > I_{th} \geq 6{,}6$ kA, $t_{th} = 1$ s for 300 A terminal,
- routine test before and after short-time current test made in factory.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests and test for composite error were made in single-phase circuit presented on fig. 1 at dimensions presented on fig.2.
The following quantities were recorded during the tests using digital recorder type HIOKI 8842:
- primary current (with short-circuited all secondary terminals) using laboratory current transformer type CdC class 0,5 with a ratio 50.000/2 A/A (uncertainty of measurement ±0,018% for k = 2),
- secondary currents in 1S1-1S2, 3S1-3S2, 4S1-4S2 windings by means of laboratory toroidal current transformers type IL20a class 0,5 with a ratio 500/5 A/A, 1.000/5 A/A and 2.000/5 A/A (uncertainty of measurement ±0,012% for k = 2),
- voltage drop (U_0) on test object during short-time current tests by means of a resistance-capacitance voltage divider with a bandwidth from 0 to 100 kHz.

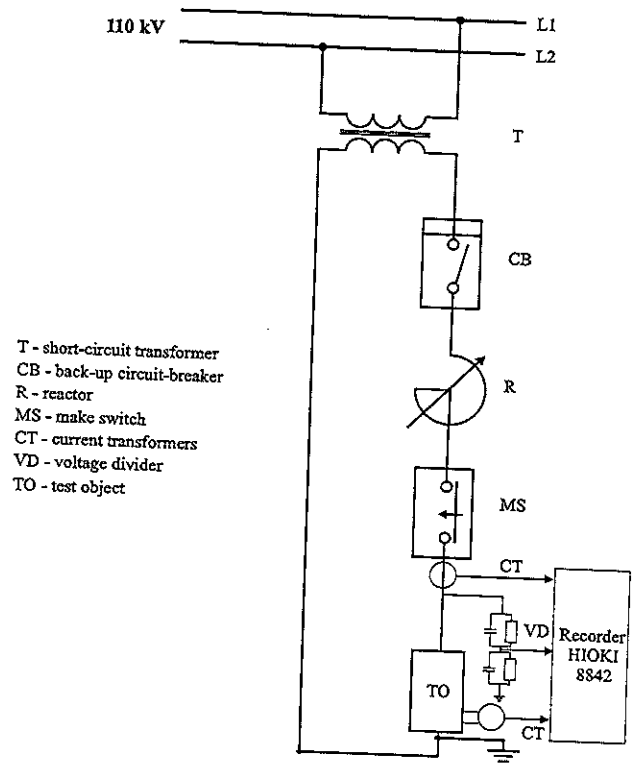


Fig.1. Test and measuring circuits during tests

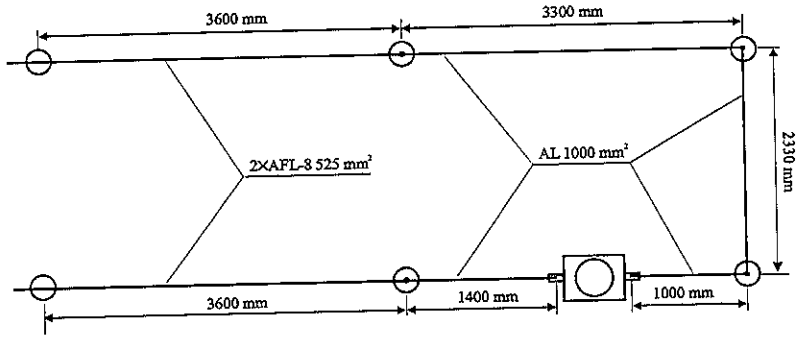


Fig. 2. Configuration of test circuit during tests

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents tables 1 and 2. During the tests the following records were made:
- Nos. 33757, 33758, 33762 – calibration of measuring and test circuit,
- No. 33759 – composite error test,
- Nos. 33763, 33764 – short-time current tests,
  (Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory's archives),
- phot. 1 – current transformer on short-circuit tests stand
  (Annex 2 presents the photograph).

During the composite error test current's transformer burden connected to 3S1-3S2 was $Z = R = 2{,}451\ \Omega$.

Table 1. Results of composite error test for 3S1-3S2 winding

Test No.	I_p	ε_c	t_z	Observations
-	kA	%	s	-
33759	6,32	4,04	0,99	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
I_p – r.m.s. value of the test current (determined from test period without asymmetrical component),
t_z – test duration,

$$\varepsilon_c = \frac{\sqrt{\frac{1}{T}\int_0^T (k_r \cdot i_s - i_p)^2\, dt}}{I_p} \cdot 100\%$$

k_r – rated transformation ratio (300/5 A/A),
i_p – instantaneous value of the primary current,
i_s – instantaneous value of the secondary current,
T – duration of one cycle.

Table 2. Results of short-time current tests

Test No.	i_{peak}	I_t	t_t	$I_t^2 \times t_t$	$I_{1S1\text{-}1S2}$	$I_{3S1\text{-}3S2}$	$I_{4S1\text{-}4S2}$	U_0	Observations
-	kA	kA	s	$(kA)^2 \times s$	A	A	A	V	-
33763	100,24[1)]	40,12	0,08	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33764	71,71	40,12	1,00	1610[2)]	239*	611	126	176	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
i_{peak} – peak value of test current,
I_t – r.m.s. value of test current (determined from test period without asymmetrical component),
t_t – test duration,
$I_{1S1\text{-}1S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{3S1\text{-}3S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{4S1\text{-}4S2}$ – r.m.s. value (determined from test period without asymmetrical component),
U_0 – r.m.s. value of voltage drop (determined from test period without asymmetrical component).
Required : [1)] $i_{peak} \geq 100$ kA,
[2)] $I_t^2 \times t_t \geq 1600\ (kA)^2 \times s$,
* – deformed waveform.

5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-2:2012 the results of tests is positive for:

$I_{dyn} = 100$ kA, $I_{th} = 40$ kA, $t = 1$ s for 300 A terminal of tested combined instrument transformer.

ANNEX 1

Test records

As not numbered pages the following copies of records are given:

33759 – composite error test,
33763, 33764 – short-time current tests.

Denotations:

i – test current,

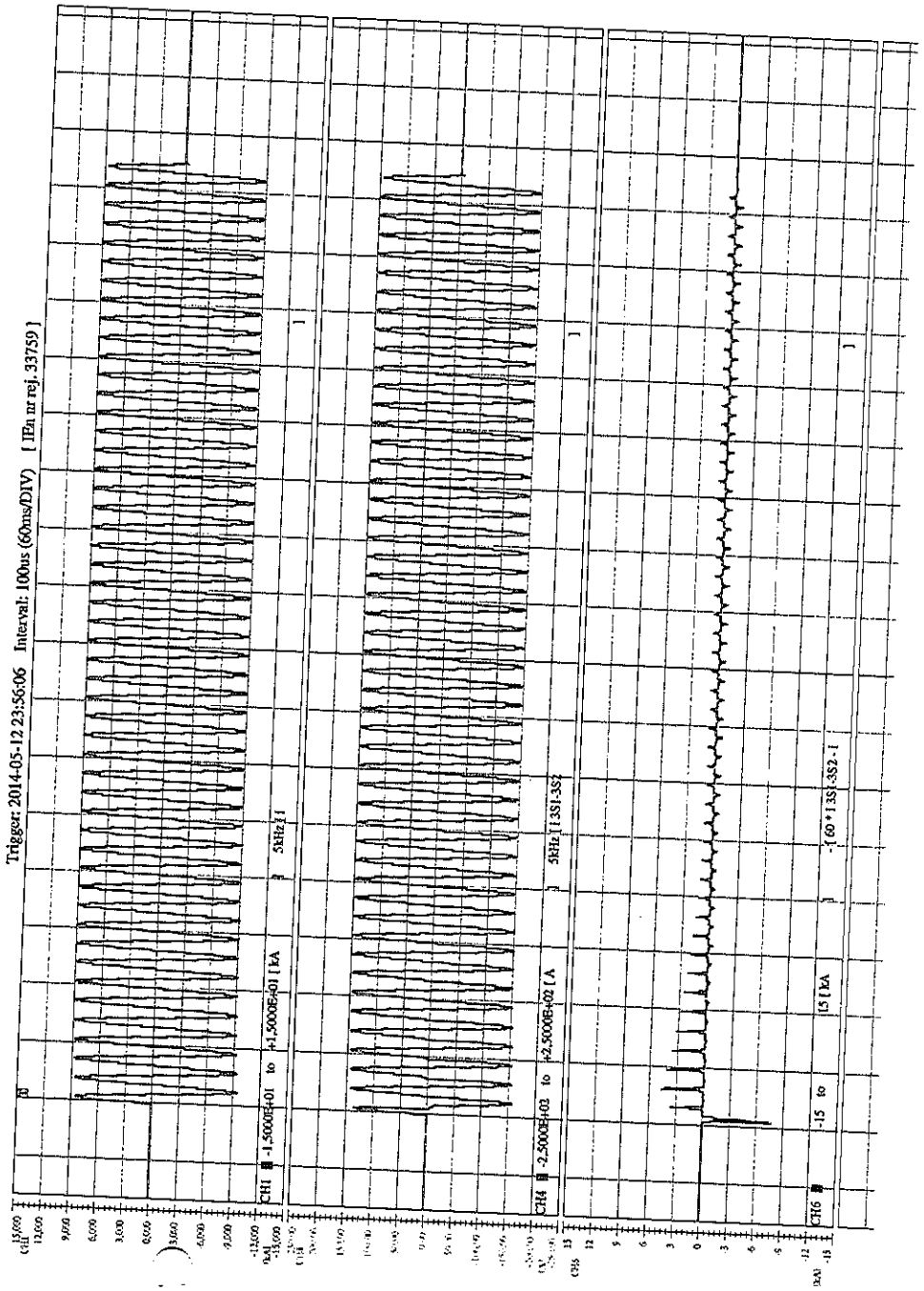
u_0 – voltage drop on test object,

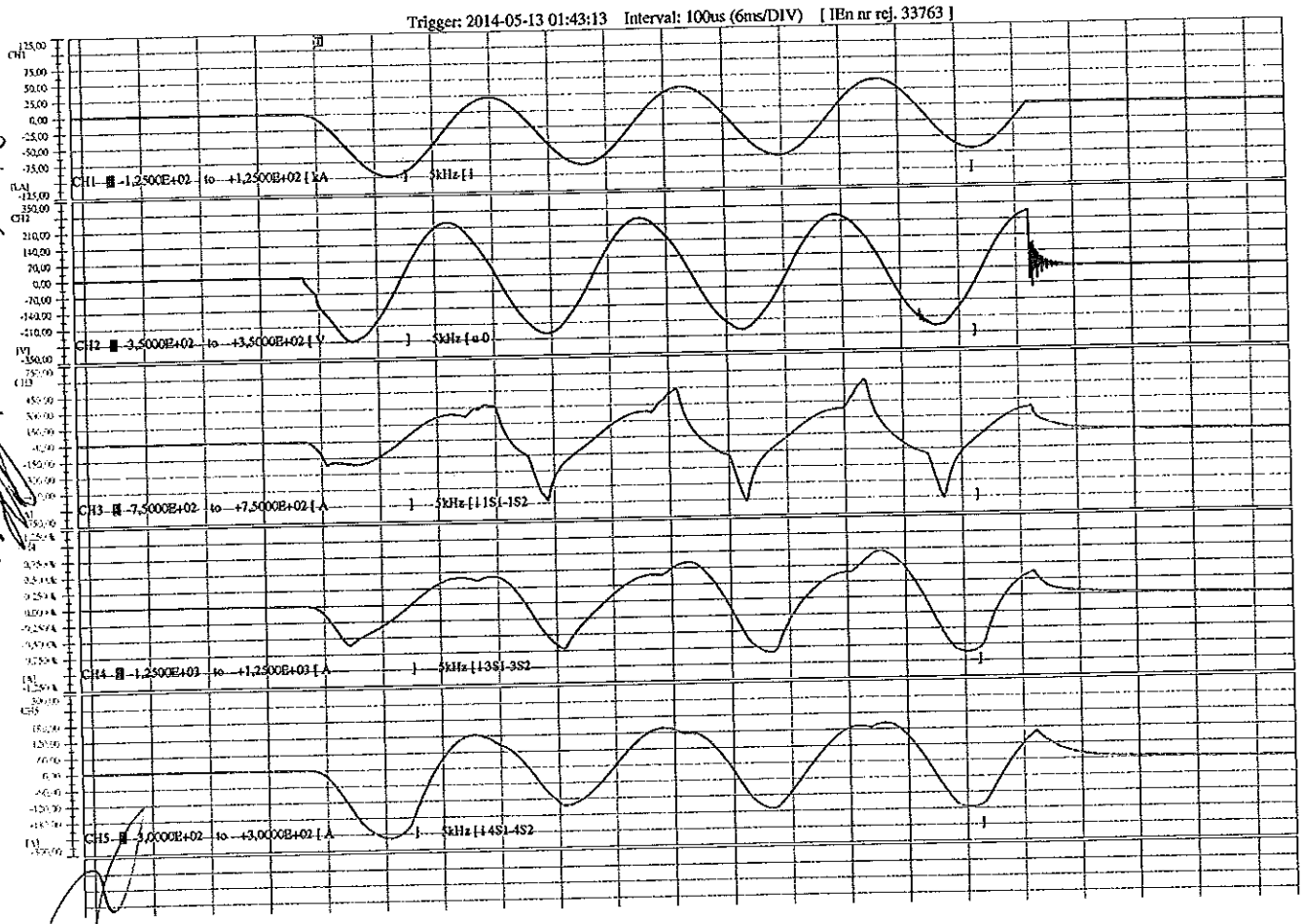
$i_{1S1\text{-}1S2}$ – 1S1-1S2 winding current,

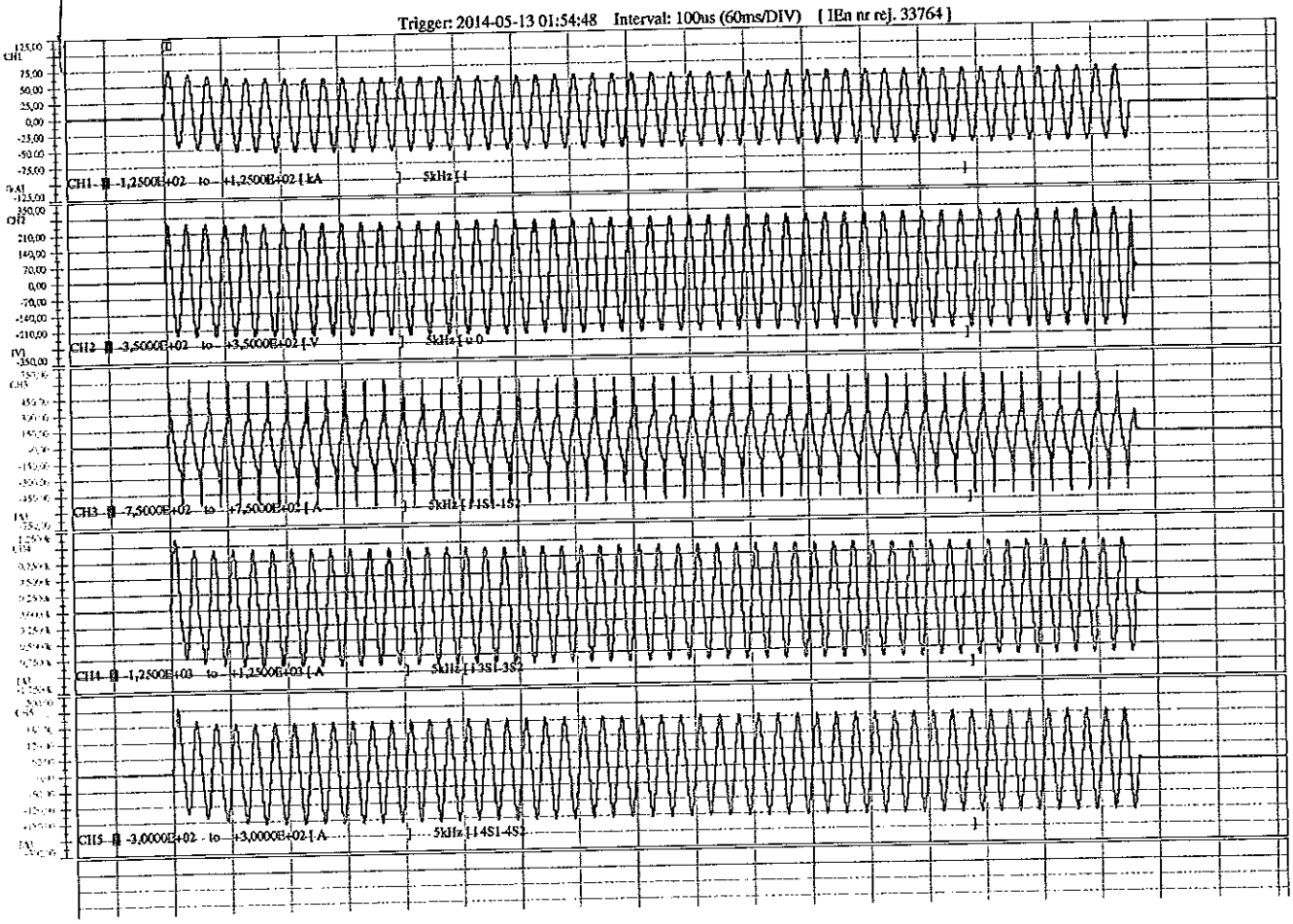
$i_{3S1\text{-}3S2}$ – 3S1-3S2 winding current,

$i_{4S1\text{-}4S2}$ – 4S1-4S2 winding current,

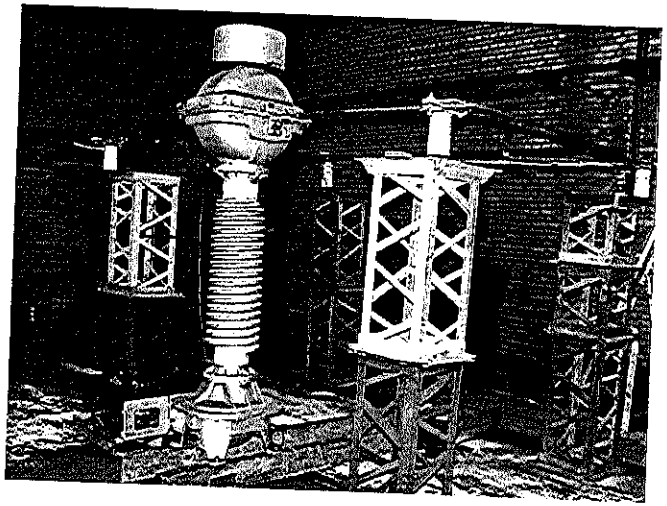
*(60 * $i_{3S1\text{-}3S2}$ – i) – secondary current in 3S1-3S2 winding (including ratio) minus primary current.*




Trigger: 2014-05-13 01:43:13 Interval: 100us (6ms/DIV) [IEn nr rej. 33763]
CH1 -1,2500E+02 to +1,2500E+02 [kA 5kHz [I
CH2 -3,5000E+02 to +3,5000E+02 [V 5kHz [u 0
CH3 -7,5000E+02 to +7,5000E+02 [A 5kHz [I 1S1-1S2
CH4 -1,2500E+03 to +1,2500E+03 [A 5kHz [I 3S1-3S2
CH5 -3,0000E+02 to +3,0000E+02 [A 5kHz [I 4S1-4S2


Trigger: 2014-05-13 01:54:48 Interval: 100us (60ms/DIV) [IEn nr rej. 33764]
CH1 -1,2500E+02 to +1,2500E+02 [kA 5kHz [I
CH2 -3,5000E+02 to +3,5000E+02 [V 5kHz [u 0
CH3 -7,5000E+02 to +7,5000E+02 [A 5kHz [I 1S1-1S2
CH4 -1,2500E+03 to +1,2500E+03 [A 5kHz [I 3S1-3S2
CH5 -3,0000E+02 to +3,0000E+02 [A 5kHz [I 4S1-4S2

ANNEX 2 Photographs taken during the tests



Phot. 1. PVA 145a after short-time current tests

ANNEX 3 Routine test report before and after short-time current tests

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer before short time current test			TYPE: PVA145a Serial no: 2GKP013K1486144	
A-N	Insulation level:	Voltage factor:	Ith 1s [kA]:	Idyn [kA]:	Icth [A]:	IEC 61869-4
132:√3 kV	145/275/650 kV	1.9/8h	40-40	100-100	450-900	50 Hz

VOLTAGE PART *)	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
	1a - 1n	0,11:√3	0->10	0,1	1000
	2a - 2n	0,11:√3	25	0,1	1000
	3a - 3n	0,11:√3	25	0,1/3P	1000
	4a - 4n	0,11:√3	40	1/3P	1000
	da - dn	0,11	100	1,0	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
	1S1-1S2	5	40	0,2FS 5	300-600/5
	2S1-2S2	1	30	0,5FS 10	300-600/1 **)
	3S1-3S2	5	60	5P 20	300-600/5
	4S1-4S2	1	120	10P 15	300-600/1

List of performed tests:

1. Oil dielectric strictures check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings - P1+P2/A: Up = 247,5 kV / 60s, f = 97Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Inter-turn overvoltage test for current transformers - lower value (U peak=4,5kV or U peak for Icth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor - tgδ ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC 60247
  Tg δ = 0.06 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 73.62 kV, Relative standard deviation = 6.98 %;
  f = 50Hz, oil temp. = 28 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	71.3
2	73.8
3	68.9
4	83.6
5	71.7
6	72.4

*) In the combined instrument transformer lack of the voltage part
**) In the current part lack of the core 2S1-2S2

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)

Stress voltage: 275 kV / 60 s
Frequency: 87 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	5 pC	5 pC

Remarks: background noise level: 2.5 (measured after voltage switch off).
measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	1,27	900
3S1-3S2	1,92	900
4S1-4S2	4,5	100

Attention: In the combined instrument transformer lack of the voltage

Attention: IN the combined instrument transformer lack of the voltage part

Determination of current part errors (ε [%], Δφ [min])

Ipn (A): 300

1S1-1S2: 40 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	-0,066	-0,049	-0,032	-0,029
Δφ [	1,1	0,2	-0,3	-0,3

1S1-1S2: 10 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	-0,017	-0,016	-0,016	-0,015
Δφ [	0,4	0,2	0,1	0,1

2S1-2S2: 30 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	-0,065	-0,060	-0,017	-0,027
Δφ [	2,9	1,2	-0,4	0,5

2S1-2S2: 7,50 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	0,009	0,011	0,014	0,016
Δφ [	1,3	0,8	0,3	0,2

3S1-3S2: 60 VA		p.f. = 0,8 lag.
	1,0 In	
ε [	-0,127	
Δφ [	0,6	

4S1-4S2: 120 VA		p.f. = 0,8 lag.
	1,0 In	
ε [	-0,171	
Δφ [	1,0	

Ipn (A): 600

1S1-1S2: 40 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	-0,058	-0,050	-0,032	-0,029
Δφ [	1,0	0,4	-0,2	-0,1

1S1-1S2: 10 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	-0,012	-0,015	-0,014	-0,013
Δφ [	0,1	0,1	0,0	-0,1

2S1-2S2: 30 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	-0,077	-0,060	-0,018	-0,038
Δφ [	2,7	1,3	-0,3	1,1

2S1-2S2: 7,50 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε [	0,017	0,013	0,017	0,018
Δφ [	1,1	0,8	0,2	0,1

3S1-3S2: 60 VA		p.f. = 0,8 lag.
	1,0 In	
ε [	-0,124	
Δφ [	0,6	

4S1-4S2: 120 VA		p.f. = 0,8 lag.
	1,0 In	
ε [	-0,167	
Δφ [	1,0	

Current part: Measurements uncertainty: $\varepsilon_I = \pm 0{,}045$ %, $\Delta\varphi_I = \pm 2{,}3$ min
Voltage part: Measurements uncertainty: $\varepsilon_U = \pm 0{,}044$ %, $\Delta\varphi_U = \pm 2{,}2$ min

Determination of the over current factors:

- instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	EFS [V]	Condition	Assessment
1S1-1S2	2,5	31,14	50,12	U < EFS	☑
2S1-2S2	1	97,04	360,23	U < EFS	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	EALF [V]	Ie [A]	εc [%]	Condition	Assessment

3S1-3S2	284.18	0.185	0.19	$\varepsilon_c \leq 5\%$	☑
4S1-4S2	1940	0.022	0.15	$\varepsilon_c \leq 10\%$	☑

Measurement of capacitance and dielectric dissipation factor - tg δ

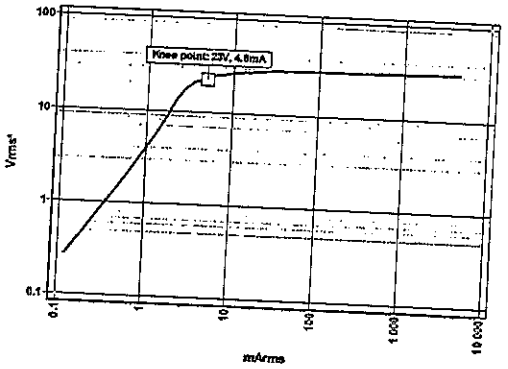
Temperature: 22.5 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.24	1387	4.405	0.25	1110	3.524	0.22	277	0.879
63 kV	0.25	1387	27.46	0.25	1110	21.97	0.22	277	5.481
71 kV	0.25	1387	31.05	0.25	1111	24.79	0.22	277	6.184

Core magnetization characteristics:

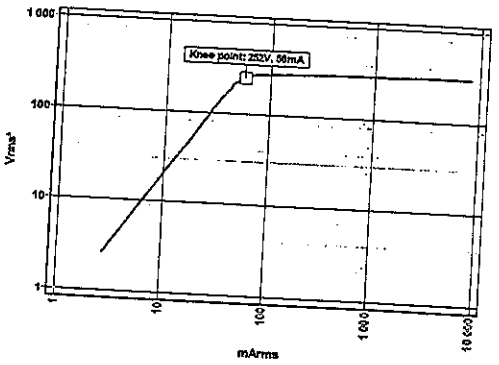
Winding 1S1-1S2

[V]	[mA]
32	4558.2
31.3	2318.3
30.1	41.64
29.4	26.64
27.2	11.05
25.8	7.38
25	6.01
24.2	5.09
22.6	4.35
20.7	3.47
18.7	2.9
15	2.36
9.4	1.73
3.7	0.93
0.3	0.12



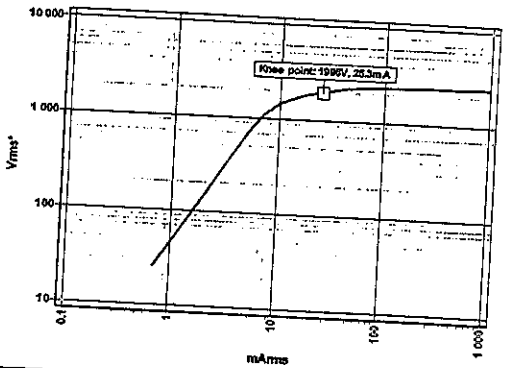
Winding 3S1-3S2

[V]	[mA]
308.5	8138
305.2	2960.3
302.2	1628.8
298.3	679.5
284.4	161.04
276.8	95.13
268.5	68.11
263.4	61.8
244.6	52.54
225.7	47.91
206.8	43.39
150	34.58
92.4	25.35
34.3	13.79
2.6	2.78



Winding 4S1-4S2

[V]	[mA]
2478.1	981.2
2472.2	758.1
2440.5	369.77
2368.9	127.27
2269.8	55.65
2195.4	43.02
2010.7	26.03
1823.9	17.24
1647.4	12.76
1463.9	10.06
1273	8.35
888.2	6.07
517.8	4.32
148.6	2.02
25.3	0.7



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part:

	R (25 °C)	Rct (75 °C)
P1-P2 range 300A	617.0 μΩ	736.2 μΩ
P1-P2 range 600A	311.0 μΩ	372.1 μΩ
1S1-1S2	0.401 Ω	0.479 Ω
2S1-2S2	Ω	Ω
3S1-3S2	0.443 Ω	0.530 Ω
4S1-4S2	9.560 Ω	11.439 Ω

Windings' resistance of voltage part:

	R (24 °C)	Rct (75 °C)
A-N	kΩ	kΩ
1a-1n	mΩ	mΩ
2a-2n	mΩ	mΩ
3a-3n	mΩ	mΩ
4a-4n	mΩ	mΩ
da-dn	mΩ	mΩ

Checked by: OG-4 KJ-06

Przasnysz, 2014-04-29

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer After short time current test			TYPE: PVA145a Serial no: 2GKP013K1486144	
A-N	Insulation level:	Voltage factor:	Ith 1s [kA]:	Idyn [kA]:	Icth [A]:	IEC 61869-4
132:√3 kV	145/275/650 kV	1.9/8h	40-40	100-100	450-900	50 Hz

VOLTAGE PART *)	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
	1a - 1n	0,11:√3	0->10	0,1	1000
	2a - 2n	0,11:√3	25	0,1	1000
	3a - 3n	0,11:√3	25	0,1/3P	1000
	4a - 4n	0,11:√3	40	1/3P	1000
	da - dn	0,11	100	1,0	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
	1S1-1S2	5	40	0,2FS 5	300-600/5 **)
	2S1-2S2	1	30	0,5FS 10	300-600/1
	3S1-3S2	5	60	5P 20	300-600/5
	4S1-4S2	1	120	10P 15	300-600/1

List of performed tests:

1. Oil dielectric strictures check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings - P1+P2/A: Up = 247,5 kV / 60s, f = 97Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Inter-turn overvoltage test for current transformers - lower value (U peak=4,5kV or U peak for Icth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor - tgδ ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC 60247
  Tg δ = 0.08 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 73.62 kV, Relative standard deviation = 6.99 %;
  f = 50Hz, oil temp. = 28 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	71.3
2	73.8
3	68.9
4	83.6
5	71.7
6	72.4

*) In the combined instrument transformer lack of the voltage part
**) In the current part lack of the core 2S1-2S2

Partial discharge measurement

- Measurement according to procedure B

Stress voltage: 247,5 kV / 60 s
Frequency: 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	1.2 pC	1.2 pC

Remarks: background noise level: 1.2 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	1.31	900
3S1-3S2	2	900
4S1-4S2	4.5	100

Attention: In the combined instrument transformer lack of the voltage

Attention: IN the combined instrument transformer lack of the voltage part

Determination of current part errors (ε I%), Δφ I min)

Ipn (A): 300

1S1-1S2: 40 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.061	-0.052	-0.033	-0.029
Δφ I	0.9	0.3	-0.2	-0.3

2S1-2S2: 30 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.085	-0.060	-0.017	-0.027
Δφ I	2.9	1.2	-0.4	0.5

3S1-3S2: 60 VA		p.f. = 0,8 lag.
	1,0 In	
ε I	-0.125	
Δφ I	0.6	

1S1-1S2: 10 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.015	-0.015	-0.014	-0.013
Δφ I	0.3	0.1	0.0	-0.0

2S1-2S2: 7.50 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	0.009	0.011	0.014	0.016
Δφ I	1.3	0.8	0.3	0.2

4S1-4S2: 120 VA		p.f. = 0,8 lag.
	1,0 In	
ε I	-0.170	
Δφ I	1.0	

Ipn (A): 600

1S1-1S2: 40 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.063	-0.054	-0.034	-0.032
Δφ I	1.0	0.4	-0.2	-0.1

2S1-2S2: 30 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.077	-0.060	-0.018	-0.039
Δφ I	2.7	1.3	-0.3	1.1

3S1-3S2: 60 VA		p.f. = 0,8 lag.
	1,0 In	
ε I	-0.123	
Δφ I	0.6	

1S1-1S2: 10 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.013	-0.017	-0.015	-0.013
Δφ I	0.2	0.2	0.1	0.0

2S1-2S2: 7.50 VA				p.f. = 0,8 lag.
	0,05 In	0,2 In	1,0 In	1,5 In
ε I	0.017	0.013	0.017	0.018
Δφ I	1.1	0.8	0.2	0.1

4S1-4S2: 120 VA		p.f. = 0,8 lag.
	1,0 In	
ε I	-0.168	
Δφ I	1.0	

Current part: Measurements uncertainty: $\varepsilon_I = \pm 0{,}045$ %, $\Delta\varphi_I = \pm 2{,}3$ min
Voltage part: Measurements uncertainty: $\varepsilon_U = \pm 0{,}044$ %, $\Delta\varphi_U = \pm 2{,}2$ min

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	EFS [V]	Condition	Assessment
1S1-1S2	2.5	31.39	49.68	U < EFS	☑
2S1-2S2	1	97.04	360.43	U < EFS	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	EALF [V]	Ie [A]	εc [%]	Condition	Assessment

3S1-3S2	282.29	0.143	0.14	$\varepsilon_c \leq 5\%$	☑
4S1-4S2	1934.49	0.022	0.15	$\varepsilon_c \leq 10\%$	☑

Measurement of capacitance and dielectric dissipation factor - tg δ

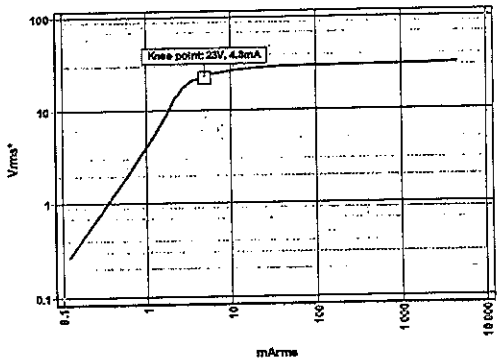
Temperature: 22.5 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.24	1387	4.405	0.25	1110	3.524	0.22	277	0.879
63 kV	0.26	1387	27.46	0.25	1110	21.97	0.22	277	5.481
71 kV	0.25	1387	31.05	0.25	1111	24.79	0.22	277	6.184

Core magnetization characteristics:

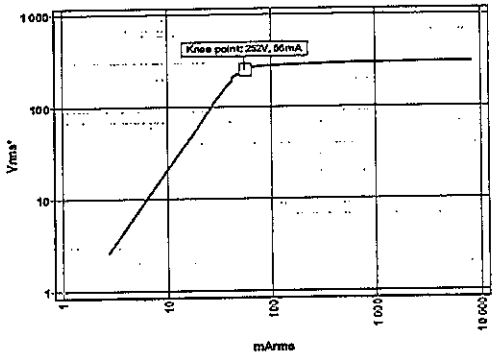
Winding 1S1-1S2

[V]	[mA]
32	4558.2
31.3	2318.3
30.1	41.84
29.4	26.64
27.2	11.05
25.8	7.38
25	6.01
24.2	5.09
22.5	4.35
20.7	3.47
18.7	2.9
15	2.36
9.4	1.73
3.7	0.93
0.3	0.12



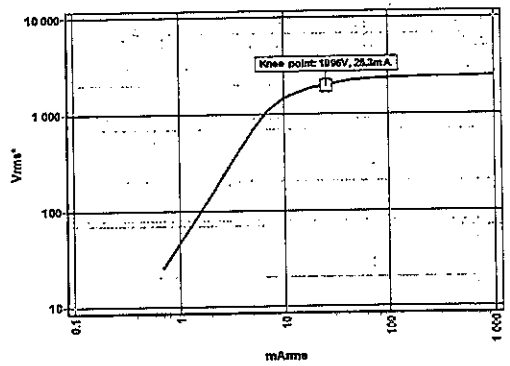
Winding 3S1-3S2

[V]	[mA]
308.5	8136
305.2	2960.3
302.2	1628.8
296.3	679.5
284.4	161.04
276.8	95.13
268.5	68.11
263.4	61.8
244.8	52.54
225.7	47.91
206.8	43.39
150	34.58
92.4	25.35
34.3	13.79
2.6	2.78



Winding 4S1-4S2

[V]	[mA]
2479.1	981.2
2472.2	758.1
2440.5	369.77
2368.9	127.27
2269.8	55.65
2195.4	43.02
2010.7	26.03
1823.9	17.24
1647.4	12.76
1463.9	10.06
1273	8.35
888.2	6.07
517.8	4.32
148.6	2.02
25.3	0.7



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part:

	R (24 °C)	Rct (75 °C)
P1-P2 range 300A	596.0 μΩ	715.5 μΩ
P1-P2 range 600A	313.0 μΩ	375.7 μΩ
1S1-1S2	0.363 Ω	0.459 Ω
2S1-2S2	Ω	Ω
3S1-3S2	0.423 Ω	0.508 Ω
4S1-4S2	9.160 Ω	10.996 Ω

Windings' resistance of voltage part:

	R (24 °C)	Rct (75 °C)
A-N	kΩ	kΩ
1a-1n	mΩ	mΩ
2a-2n	mΩ	mΩ
3a-3n	mΩ	mΩ
4a-4n	mΩ	mΩ
da-dn	mΩ	mΩ

Checked by: ..... OG-4 14-08 .....

Przasnysz, 2014-05-16

ANNEX 4 **Documentations delivered by orderer**

ABB Sp. z o.o.	Declaration of conformity	ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 091/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486144;**

Place and date of issue of declaration

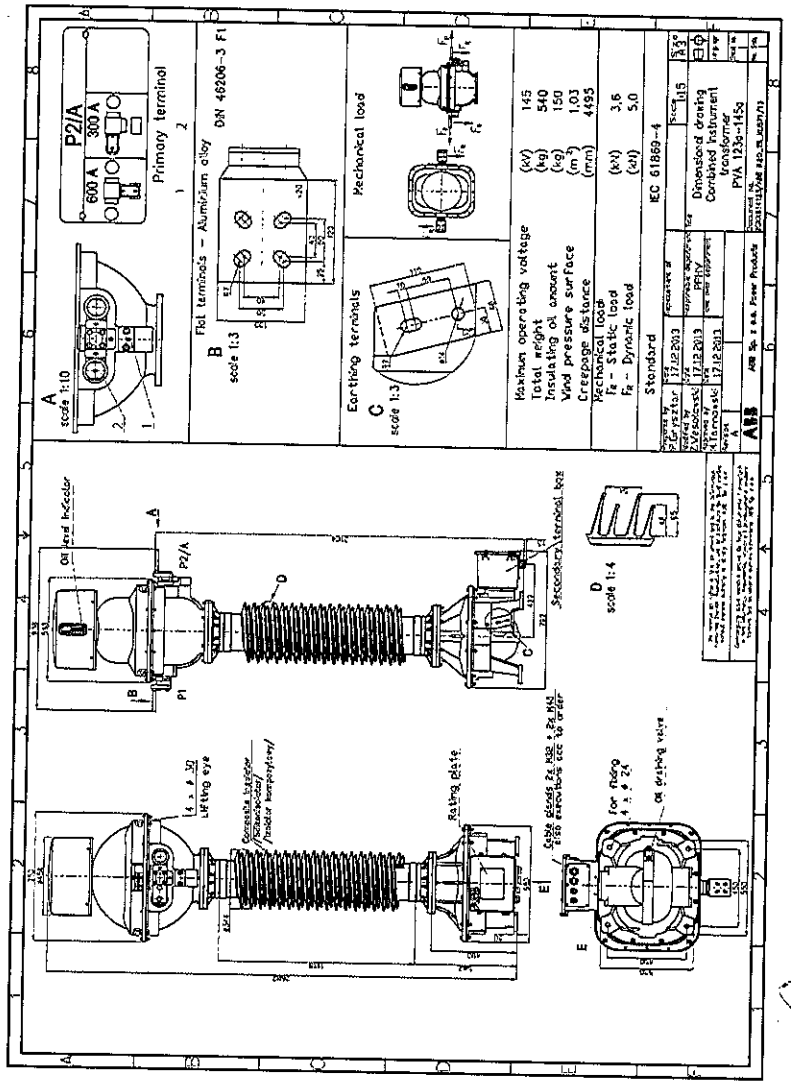
Przasnysz 13.01.2014

ABB
ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
NIP: 526-030-44-64; PL5260304464
Regon 010017166
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8921, fax (22) 223 8958
(9)

Referent ds. Realizacji Zamówień
ABB Sp. z o.o.
Oddział w Przasnyszu

Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Lubocki

(Name) (Signature)



ABB

Combined Instrument Transformer

Type	PVA 145a				
Insulation level	145/275/650 kV	Standard	IEC 61869-4	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	540 / 150 kg	Temp. range	-50°C ⟷ +40°C
S/N	2GKP013K1486144	Voltage factor	1,9Un/8h	Ue	0,2 mV/kA

CURRENT PART

K_n	300-600 / 5-1-5-1 A/A		
I_{th}/1s	40-40 kA	I_{dyn}	100-100 kA
I_{cth}	360-720 A		

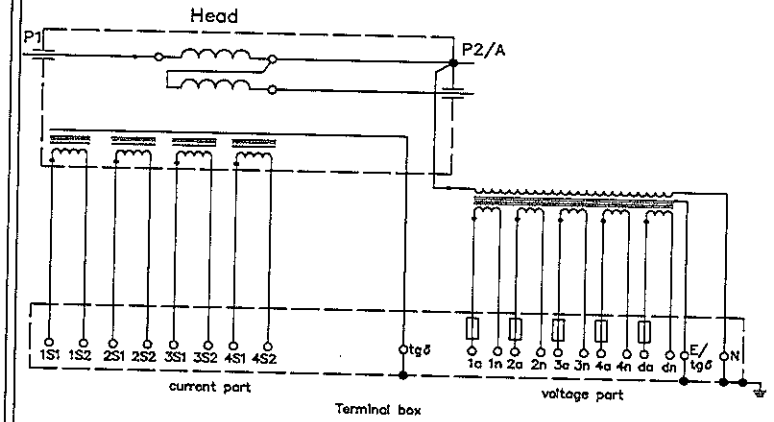
	1S1-1S2	2S1-2S2	3S1-3S2	4S1-4S2	5S1-5S2	6S1-6S2
A	5	1	5	1		
VA	40	30	60	120		
Kl.	0,2	0,5	5P	10P		
FS/ALF	5	10	20	15		
Ext.%	120	120				

VOLTAGE PART

A-N 132:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3	110:√3	110:√3	110
VA	0->10	25	25	40	100
Kl.	0,1	0,1	0,1/3P	1/3P	1,0
VA_{ext}	1000	1000	1000	1000	450

Transportation: Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!
1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ, tgδ MUST BE EARTHED
3. AFTER THREE WINDINGS da - dn ARE CONNECTED IN BROKEN DELTA THE CIRCUIT SHOULD BE EARTHED IN ONE POINT ONLY

INSTYTUT ENERGETYKI
INSTITUTE OF POWER ENGINEERING
LABORATORIUM WIELKOPRĄDOWE
HIGH CURRENT LABORATORY

01-330 Warszawa
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tel./fax 22 836-80-16
e-mail: ewp@ien.com.pl
www.ien.com.pl/ewp

TEST REPORT
NO. EWP/10/E/2014-2E

TEST OBJECT:	Combined instrument transformer type PVA 145a
MANUFACTURER:	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
TESTS ORDERED BY:	Institute of Power Engineering. High Voltage Department Internal order No. EWN/145/E/14 dated 15.01.2014 r.
TYPE OF TESTS:	Temperature-rise test
TEST PROCEDURE:	IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013, IEC 62271-1:2011
TEST OBJECT DELIVERED:	14.01.2014
DATE OF TESTS:	28.01.2014
TESTS RESULTS:	Positive
THE TESTS WERE WITNESSED BY:	-
TEST ENGINEER:	Mariusz SUL M.Sc. Eng.
HEAD OF LABORATORY:	Lidia GRUZA M.Sc. Eng.

Warsaw, 20.02.2014r.

Contents

Report contains 18 numbered pages with:	
2	drawings
1	photograph
3	appendices

Tests result refers only to the test object. The Test Report consist tests from and beyond the scope of accreditation (details in sub-cl. 4). Publishing or reproducing of this report in other version then exact and complete without written permission of laboratory is forbidden.

1.	Description of the test object
Test object	Combined instrument transformer
Type	PVA 145a
Serial number	2GKP013K1486141
Manufacturer	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
Year of production	2013
Insulator	Porcelain insulator
Number of windings	VT part - 5, CT part– 6
Oil type	Nytro Libra
Minimum creepage distance	3640 mm
Insulating oil weight	150 kg
Total weight	620 kg
Dimensions	According to drawing no. 2GKK614120

The laboratory made the identification of test objects on the base of the documentation given in par. 3, appendix no 1. The test object is shown in the photographs No. 1. The object was prepared for testing by the Manufacturer.

2.	Technical data declared by the Manufacturer
Rated voltage	132:√3 kV
Maximum operating voltage	145 kV
Rated frequency	50 Hz
Voltage factor and time	$1{,}9U_n$/8h
Rated continuous thermal current, I_{cth}	3000 A
Rated short-time thermal current, I_{th}/ 1s	63 kA
Rated dynamic current, I_{dyn}	158 kA

VT part, variant 1					
Winding	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
Rated secondary voltage	110:√3 V	110:√3 V	110:√3 V	110:√3 V	110 V
Rated output	25 VA	25 VA	25 VA	25 VA	150 VA
Accuracy class	0,2	0,2	0,2/3P	3/3P	1,0
Thermal limiting output	1000 VA	1000 VA	1000 VA	1000 VA	450 VA

VT part, variant 2					
Winding	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
Rated secondary voltage	110:√3 V	110:√3 V	110:√3 V	110:√3 V	110 V
Rated output	25 VA	25 VA	500 VA	25 VA	400 VA
Accuracy class	3	3	3/3P	3/3P	3P
Thermal limiting output	1000 VA	1000 VA	1000 VA	1000 VA	450 VA

CT part

Winding	Rated secondary current	Rated output	Accuracy class	FS/ALF	Ext.
1S1-1S2	5 A	200 VA	0,2	10	-
2S1-2S2	1 A	100 VA	0,1	5	-
3S1-3S2	1 A	Rb=7Ω, class TPZ 15x7,4, Rct≤6Ω, cykl 100 ms, Tp=50 ms			-
4S1-4S2	5 A	20 VA	5P	60	-
5S1-5S2	1 A	Rb=5Ω, class TPY, 10x13, Rct≤7Ω, Ts=500 ms, cykl 100 ms, Tp=50 ms			
6S1-6S2	1 A	35 VA	5PR	20 Ω	Rct≤8Ω
		Rb=27Ω, class PXR, 1/3000, Ek=700V, Ie≤0,4 A / 350 V, Rct≤8Ω, Kx=20			

3.	Technical documentation of the test object
1.	Drawing no. 2GKK614120 – Dimensional drawing. Combined instrument transformer PVA 123a -145a, ABB Sp. z o.o. Power Products, approved 17.12.2013
2.	Combined transformer verification protocol type PVA 145a, Series No.: 2GKP013K1486141, ABB Sp. z o.o., Przasnysz, 10.12.2013

4. Scope of the tests

Test programme agreed with Orderer comprised of tests:

No.	Kind of test	Tests according the Standard	Location of the test
1.	Temperature-rise tests	IEC 61869-1:2007 p. 6.4 i 7.2.2, IEC 61869-2:2012 p.6.4.1 i 7.2.2.204 IEC 61869-3:2011 p. 6.4.1 i p.7.2.2 IEC 61869-4:2013 p. 6.4.1 i 7.2.2 IEC 62271-1:2011, table no. 3	EWP

EWP – The test was performed in Institute of Power Engineering, by High - Current Laboratory.

5. Tests and their results

Combined transformer was installed at the test stand, as it was during normal operation.
Electric diagram of terminal box of tested combined transformer is given in Fig. 1.
The rated voltage with a required value was applied to the primary voltage winding.
The secondary voltage windings and the residual voltage winding were loaded with the suitable power, according to the test programme given below, which was agreed with the Orderer.
Primary current terminals P1 and P2/A was bridged at the range of 3000 A.
According to Manufacturer's request current in primary current winding was equal to $\mathbf{I_{cth} = 3600\ A}$.
Due to exceeding maximum permissible temperature rise of the terminal P1, current was reduced to **Icth = 3000 A** after five hours of the first stage.
The arrangement of the thermocouples is given in Figure No. 2.
The temperature-rises of windings were measured by the resistance rise method.
During the test, the measurements of loaded windings were made every 1 hour and registered the deflection of oil level indicator.
The resistances of all windings were measured before the tests and after of each stage of tests.
The abstract of the protocol of temperature-rise test is given in Table No. 1.
The summary of test results is given in Table 2.
The temperature-rise of windings were calculated from the formula:

$$\Delta T = \frac{R}{R_0 \alpha} = \frac{R_1 - R_0}{R_0 \cdot 0{,}004}$$

Stage No. 1: Test at the rated load

Test was performed according to the IEC 61869-1 sub-cl. 6.4 and 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and 7.2.2.204; IEC 61869-3 sub-cl. 6.4.1 and 7.2.2; IEC 61869-4 sub-cl. 6.4.1 and 7.2.2. The voltage value 1,2 U_n = 91,5 kV was applied to the P2/A terminal.
The secondary voltage windings were loaded as follows:1a-1n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 2a-2n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 3a-3n ⇒ 500 VA, cos φ = 1, at the voltage 110/√3 V; 4a-4n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V. The winding of residual voltage remained open.
The secondary current windings of the CT were loaded as follows:1S1-1S2 ⇒ 200 VA, cos φ = 1; 2S1-2S2 ⇒ 100 VA, cos φ = 1; 3S1-3S2 ⇒ 7Ω; 4S1-4S2 ⇒ 20 VA, cos φ = 1; 5S1-5S2 ⇒ 5Ω; 6S1-6S2 ⇒ 27Ω.
Terminals P1 and P2/A were short-circuited at the range 3000 A.
The test was performed till reached steady state of the measured temperatures.

Stage No. 2: Test of 8 h

Test was performed according to the IEC 61869-1 sub-cl. 6.4 and 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and 7.2.2.204; IEC 61869-3 sub-cl. 6.4.1 and 7.2.2; IEC 61869-4 sub-cl. 6.4.1 and 7.2.2. The voltage value 1,9 U_n = 144,8 kV was applied to the P2/A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 2a-2n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 3a-3n ⇒ 500 VA at the voltage 110/√3 V; 4a-4n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V.

The residual winding da-dn was loaded by ⇒ 450 VA, cos φ = 1, at the voltage 110 V.
The secondary current windings of the CT were loaded as follows:1S1-1S2 ⇒ 200 VA, cos φ = 1; 2S1-2S2 ⇒ 100 VA, cos φ = 1; 3S1-3S2 ⇒ 7Ω; 4S1-4S2 ⇒ 20 VA, cos φ = 1; 5S1-5S2 ⇒ 5Ω; 6S1-6S2 ⇒ 27Ω.
Terminals P1 and P2/A were short-circuited at the range 3000 A.
The duration of the test was 8 h.

Stage No. 3: Test with thermal limit power

Test was performed according to the IEC 61869-1 sub-cl. 6.4 and 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and 7.2.2.204; IEC 61869-3 sub-cl. 6.4.1 and 7.2.2; IEC 61869-4 sub-cl. 6.4.1 and 7.2.2. The voltage value U_n = 63 kV was applied to the P2/A terminal.
According to Manufacturers request secondary voltage windings (i.e. 1a-1n, 2a-2n, 3a-3n and 4a - 4n) were loaded by limit power 1000 VA at cos φ = 1. The residual winding remained open.
The secondary current windings of the CT were loaded as follows:1S1-1S2 ⇒ 200 VA, cos φ = 1; 2S1-2S2 ⇒ 100 VA, cos φ = 1; 3S1-3S2 ⇒ 7Ω; 4S1-4S2 ⇒ 20 VA, cos φ = 1; 5S1-5S2 ⇒ 5Ω; 6S1-6S2 ⇒ 27Ω.
Terminals P1 and P2/A were short-circuited at the range 3000 A.
The test was performed till reaching the steady state of the measured temperatures.

Measuring instruments

The temperatures were measured by means of type K thermocouples (NiCr – NiAl) with accuracy ± 0,6°C[1].
The ambient temperature was measured using four mercurial thermometers immersed into tank filled with oil. These thermometers were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor- the accuracy of measurement ± 0,03°C[1].
The resistance was measured by means of meter type 2291 manufactured by TETTEX Instruments with accuracy ± 0,01 mΩ[1]

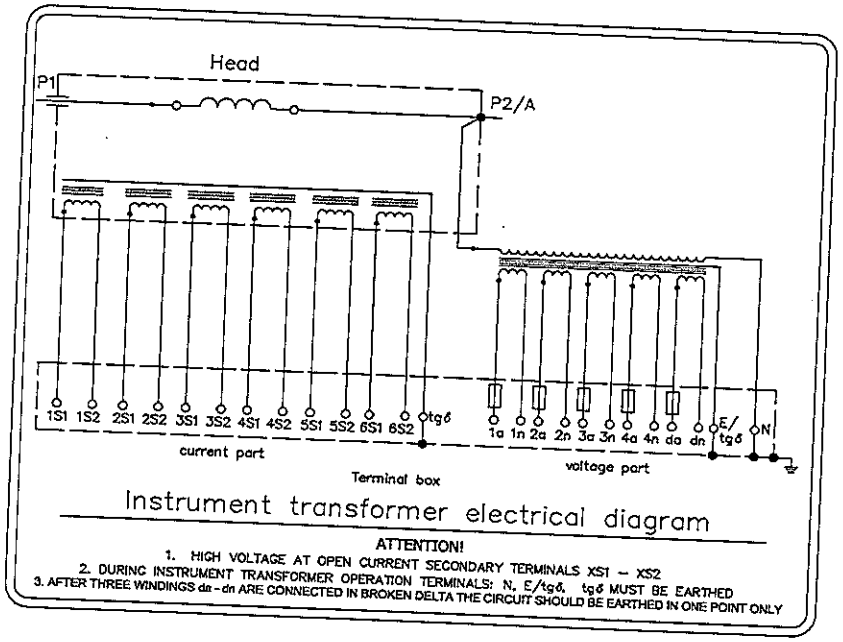

Fig. 1. Electrical diagram of terminal box of tested combined instrument transformer

[1] The expanded uncertainty assigned corresponds to a coverage probability of 95 % and the coverage factor k = 2.

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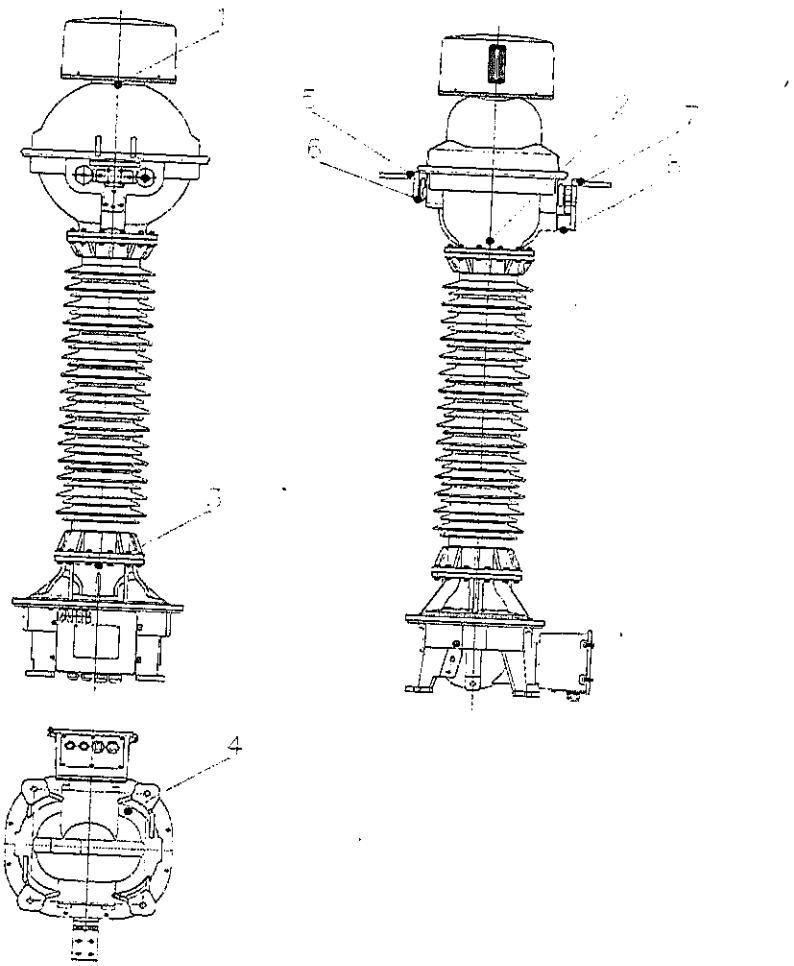

Fig. 2. Arrangement of thermocouples during temperature-rise test:
1 – oil (over current coil), 2 – head (contraction of the flange connecting the head the the insulator), 3 – under the flange of tank lid, 4 – lower tank (placed inside over earthing terminal), 5 – terminal P1, 6 – terminal P1, 7 – terminal P2/A (3000A), 8 – terminal P2/A (3000A).

Table 1. Temperature-rise test results of combined instrument transformer PVA 145a, serial no. 2GKP013K1486141

No. of thermo-couple	Heating time [h] Stage 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ΔT 1, K	-	1,32	2,52	25,25	32,81	38,40	40,65	40,98	41,31	41,45	41,63	41,86	42,76	43,50	43,48	43,65	44,16	44,99	45,86	46,13	45,41	46,08
ΔT 2, K	-	8,02	15,43	20,45	23,95	26,91	27,88	27,98	28,58	29,03	29,48	29,60	30,40	31,38	31,40	31,55	31,86	32,53	33,33	33,55	33,13	33,73
ΔT 3, K	-	0,50	1,30	2,35	2,80	3,27	3,57	3,52	3,75	4,07	4,20	4,17	4,15	4,35	4,45	4,60	5,05	5,50	5,97	6,30	5,67	5,80
ΔT 4, K	-	0,92	2,10	2,77	2,60	3,60	3,65	3,65	4,02	4,10	4,02	4,05	4,07	4,37	4,42	4,45	4,50	5,25	5,67	5,85	5,82	5,37
ΔT 5, K	-	49,45	56,70	62,09	64,63	65,28	57,84	54,36	55,77	55,58	55,28	56,63	56,68	56,75	56,77	56,79	57,28	57,11	57,92	58,60	57,87	57,89
ΔT 6, K	-	48,53	55,28	61,16	63,65	64,58	58,11	54,09	56,33	55,68	55,31	57,21	57,23	57,26	57,36	57,38	57,96	57,70	58,19	58,99	58,31	58,06
ΔT 7, K	-	45,16	52,53	57,53	60,73	62,38	54,46	50,86	52,75	52,21	51,60	53,14	53,14	53,18	53,23	53,26	53,06	52,68	53,41	54,09	53,41	53,84
ΔT 8, K	-	44,38	51,96	58,06	60,65	61,73	55,58	51,89	53,43	52,73	52,48	53,94	54,16	54,33	54,58	54,60	55,06	54,87	55,43	55,60	55,18	54,99
$T_{ot.fl.}$ °C	12,02	12,25	12,37	12,57	12,54	12,60	12,49	12,43	12,74	12,57	12,55	12,51	12,70	12,79	12,87	12,89	13,32	13,26	13,62	13,49	13,17	13,31
$U_{zas.}$ kV	91,5																					
$I_{1S1-1S1}$, A	0,0	6,0	6,0	6,0	6,0	6,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
$I_{P1-P2/A}$, A	0	3604	3617	3612	3617	3621	3018	3011	3024	3015	3012	3021	3018	3022	3019	3017	3015	3009	3020	3015	3020	3014
$R_{1S1-1S2}$ mΩ	437,93	446,24	453,50	461,25	470,06	478,32	485,36	491,88	497,63	502,74	507,23	511,29	514,91	518,04	521,09	523,62	525,89	528,19	530,09	531,90	533,57	535,12
$R_{2S1-2S2}$ Ω	5,2914	5,3854	5,4698	5,5635	5,6682	5,7820	5,8632	5,9481	6,0225	6,0876	6,1456	6,1992	6,2435	6,2834	6,3247	6,3565	6,3860	6,4157	6,4400	6,4598	6,4837	6,5036
$R_{3S1-3S2}$ Ω	4,2316	4,2650	4,3215	4,3986	4,4856	4,5754	4,6536	4,7229	4,7825	4,8354	4,8821	4,9237	4,9624	4,9962	5,0263	5,0531	5,0778	5,1007	5,1205	5,1394	5,1567	5,1730
$R_{4S1-4S2}$ mΩ	570,83	580,91	588,60	598,71	610,04	622,05	630,51	639,52	647,36	654,63	660,72	666,26	671,30	675,69	679,72	683,12	686,34	689,32	691,86	694,30	696,68	698,77
$R_{5S1-5S2}$ Ω	5,5021	5,5537	5,6279	5,7271	5,8411	5,9578	6,0581	6,1482	6,2251	6,2954	6,3547	6,4089	6,4593	6,5027	6,5418	6,5769	6,6085	6,6382	6,6638	6,6886	6,7114	6,7319
$R_{6S1-6S2}$ Ω	5,8177	5,8891	5,9711	6,0785	6,1992	6,3224	6,4226	6,5155	6,5960	6,6687	6,7312	6,7875	6,8403	6,8851	6,9251	6,9620	6,9947	7,0252	7,0521	7,0777	7,1012	7,1232
$R_{P1-P2/A}$ mΩ	0,027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$\Delta T_{1S1-1S2}$, K	-	4,74	8,89	13,31	18,34	23,06	27,08	30,80	34,08	37,00	39,56	41,88	43,95	45,73	47,47	48,92	50,21	51,53	52,61	53,64	54,60	55,48
$\Delta T_{2S1-2S2}$, K	-	4,44	8,43	12,86	17,80	23,18	27,02	31,03	34,54	37,62	40,36	42,89	44,98	46,87	48,82	50,32	51,72	53,12	54,27	55,20	56,33	57,27
$\Delta T_{3S1-3S2}$, K	-	1,97	5,31	9,87	15,01	20,31	24,93	29,03	32,55	35,67	38,43	40,89	43,18	45,17	46,95	48,53	49,99	51,35	52,52	53,63	54,65	55,62
$\Delta T_{4S1-4S2}$, K	-	4,41	7,78	12,21	17,17	22,43	26,14	30,08	33,52	36,70	39,37	41,79	44,00	45,92	47,69	49,18	50,59	51,89	53,01	54,07	55,12	56,03
$\Delta T_{5S1-5S2}$, K	-	2,34	5,72	10,22	15,40	20,71	25,26	29,36	32,85	36,05	38,74	41,20	43,49	45,46	47,24	48,84	50,27	51,62	52,78	53,91	54,95	55,88
$\Delta T_{6S1-6S2}$, K	-	3,07	6,59	11,21	16,39	21,69	25,99	29,99	33,45	36,57	39,26	41,67	43,94	45,87	47,59	49,17	50,58	51,89	53,05	54,15	55,15	56,10
$\Delta T_{P1-P2/A}$, K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Table No. 1, cont.

	Heating time [h] Stage 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R_{1a-1a_n} mΩ	47,062	47,750	48,046	48,251	48,411	48,543	48,629	48,735	48,769	48,841	48,889	48,930	48,963	48,987	49,022	49,031	49,039	49,056	49,059	49,079	49,085	49,087
R_{2a-2a_n} mΩ	48,085	48,657	48,968	49,175	49,340	49,485	49,577	49,686	49,742	49,800	49,847	49,899	49,928	49,960	49,985	50,004	50,019	50,037	50,044	50,063	50,064	50,078
R_{3a-3a_n} mΩ	49,506	50,096	50,405	50,624	50,792	50,935	51,032	51,116	51,183	51,258	51,309	51,355	51,391	51,423	51,455	51,470	51,494	51,505	51,514	51,532	51,527	51,546
R_{4a-4a_n} mΩ	50,724	51,313	51,633	51,860	52,043	52,195	52,290	52,389	52,526	52,614	52,679	52,731	52,769	52,815	52,863	52,877	52,884	52,891	52,911	52,938	52,900	52,915
R_{5a-5a_n} mΩ	110,54	111,79	112,50	113,01	113,43	113,73	114,02	114,25	114,42	114,58	114,70	114,84	114,92	115,00	115,07	115,12	115,17	115,23	115,24	115,28	115,27	115,32
$R_{P2/A-N}$, kΩ	20,63	20,97	21,13	21,16	21,25	21,31	21,34	21,37	21,42	21,48	21,50	21,52	21,59	21,65	21,70	21,75	21,81	21,89	21,96	22,04	22,05	22,07
ΔT_{1a-1a_n}	-	3,65	5,23	6,32	7,17	7,87	8,32	8,89	9,07	9,45	9,71	9,92	10,10	10,23	10,41	10,46	10,50	10,59	10,61	10,71	10,75	10,76
ΔT_{2a-2a_n}	-	2,97	4,59	5,67	6,52	7,28	7,76	8,32	8,61	8,92	9,16	9,43	9,58	9,75	9,88	9,98	10,06	10,15	10,19	10,28	10,29	10,36
ΔT_{3a-3a_n}	-	2,98	4,54	5,65	6,49	7,22	7,71	8,13	8,47	8,85	9,10	9,34	9,52	9,68	9,84	9,92	10,04	10,09	10,14	10,23	10,21	10,30
ΔT_{4a-4a_n}	-	2,90	4,48	5,60	6,50	7,25	7,72	8,21	8,88	9,32	9,64	9,89	10,08	10,31	10,54	10,61	10,65	10,68	10,78	10,91	10,72	10,80
ΔT_{5a-5a_n}	-	2,83	4,43	5,59	6,54	7,21	7,87	8,39	8,78	9,14	9,41	9,72	9,91	10,09	10,25	10,36	10,47	10,61	10,63	10,72	10,70	10,81
$\Delta T_{P2/A-N}$	-	4,12	6,06	6,42	7,51	8,24	8,60	8,97	9,57	10,30	10,54	10,79	11,63	12,36	12,97	13,57	14,30	15,27	16,12	17,09	17,21	17,45
Deflection of the oil level indicator, mm.	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	58

Table No. 1, cont.

No. of thermo-couple	Heating time [h]													
	Stage 2								Stage 3					
	22	23	24	25	26	27	28	29	30	31	32	33	34	
ΔT 1, K	46,16	46,11	45,28	45,76	46,06	46,26	46,70	46,76	45,99	46,33	46,65	46,48	46,91	
ΔT 2, K	33,70	33,55	33,18	33,60	33,53	33,93	34,30	34,18	33,83	34,16	34,53	34,40	34,79	
ΔT 3, K	6,35	7,02	7,11	7,30	7,45	7,62	8,37	9,15	8,22	8,22	7,92	7,90	8,30	
ΔT 4, K	5,92	6,20	6,00	7,05	7,37	8,00	8,12	8,12	6,35	7,27	7,22	7,20	7,52	
ΔT 5, K	57,46	57,09	57,23	58,41	58,01	58,70	56,84	58,53	57,75	58,41	58,28	58,14	58,43	
ΔT 6, K	57,75	57,26	57,73	59,06	61,28	59,19	59,92	59,16	58,38	59,01	59,16	58,94	58,96	
ΔT 7, K	54,36	53,48	54,09	54,89	54,50	55,04	55,48	54,94	53,84	55,87	55,33	54,60	55,16	
ΔT 8, K	55,06	54,77	55,06	55,89	55,87	56,01	56,92	55,84	56,41	57,38	57,58	57,31	57,60	
$T_{el\ śr.}$ °C	13,30	13,24	13,00	13,09	13,10	13,11	13,30	13,33	13,21	13,18	13,21	12,96	13,11	
$U_{zas.}$ kV	144,8								76,2					
$I_{IS1-1S1}$, A	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0	
$I_{P1-P2/A}$, A	3012	3017	3002	3006	3022	3017	3022	3025	3016	3025	3019	3010	3019	
$R_{1S1-1S2}$ mΩ	536,75	537,78	539,23	540,54	541,58	542,61	543,68	544,69	545,21	545,68	546,21	546,76	547,30	
$R_{2S1-2S2}$ Ω	6,5221	6,5366	6,5529	6,5668	6,5781	6,5954	6,6082	6,6206	6,6277	6,6340	6,6409	6,6476	6,6533	
$R_{3S1-3S2}$ Ω	5,1882	5,2007	5,2132	5,2256	5,2366	5,2474	5,2577	5,2677	5,2737	5,2789	5,2841	5,2897	5,2949	
$R_{4S1-4S2}$ mΩ	700,71	702,23	704,05	705,94	707,38	708,72	710,08	711,39	712,10	712,77	713,45	714,22	714,88	
$R_{5S1-5S2}$ Ω	6,7518	6,7675	6,7842	6,8002	6,8145	6,8286	6,8419	6,8549	6,8626	6,8716	6,8765	6,8838	6,8901	
$R_{6S1-6S2}$ Ω	7,1437	7,1598	7,1777	7,1948	7,2094	7,2244	7,2379	7,2515	7,2592	7,2662	7,2734	7,2812	7,2882	
$R_{P1-P2/A}$ mΩ	-	-	-	-	-	-	-	-	-	-	-	-	0,0336	
$\Delta T_{1S1-1S2}$, K	56,41	57,00	57,83	58,58	59,17	59,76	60,37	60,95	61,24	61,51	61,81	62,13	62,44	
$\Delta T_{2S1-2S2}$, K	58,15	58,83	59,60	60,26	60,79	61,61	62,21	62,80	63,14	63,43	63,76	64,08	64,34	
$\Delta T_{3S1-3S2}$, K	56,52	57,25	57,99	58,72	59,37	60,01	60,62	61,21	61,57	61,87	62,18	62,51	62,82	
$\Delta T_{4S1-4S2}$, K	56,88	57,55	58,34	59,17	59,80	60,39	60,99	61,56	61,87	62,16	62,46	62,80	63,09	
$\Delta T_{5S1-5S2}$, K	56,78	57,50	58,26	58,98	59,63	60,27	60,88	61,47	61,82	62,23	62,45	62,78	63,07	
$\Delta T_{6S1-6S2}$, K	56,98	57,67	58,44	59,18	59,80	60,45	61,03	61,61	61,94	62,25	62,55	62,89	63,19	
$\Delta T_{P1-P2/A}$, K	-	-	-	-	-	-	-	-	-	-	-	-	61,11	

Table No. 1, cont.

	Heating time [h]													
	Stage 2								Stage 3					
	22	23	24	25	26	27	28	29	30	31	32	33	34	
R_{1x-1n} mΩ	49,615	49,867	50,069	50,262	50,387	50,487	50,623	50,569	51,360	51,574	51,664	51,787	51,857	
R_{2x-2n} mΩ	50,633	50,904	51,120	51,322	51,462	51,551	51,701	51,652	52,587	52,824	52,945	53,080	53,138	
R_{3x-3n} mΩ	52,124	52,414	52,636	52,860	52,997	53,111	53,216	53,208	54,206	54,466	54,608	54,743	54,826	
R_{4x-4n} mΩ	53,511	53,814	54,052	54,305	54,440	54,565	54,040	54,684	55,603	55,895	56,068	56,216	56,305	
R_{5x-5n} mΩ	116,74	117,44	118,32	118,57	118,90	119,19	119,45	119,45	122,05	122,85	123,27	123,69	123,89	
$R_{P2/A-N}$ kΩ	22,20	22,22	22,24	22,35	22,40	22,52	22,56	22,68	23,34	23,68	23,93	24,10	24,17	
ΔT_{1x-1n}, K	13,56	14,90	15,97	17,00	17,66	18,19	18,92	18,63	22,83	23,97	24,45	25,10	25,47	
ΔT_{2x-2n}, K	13,25	14,66	15,78	16,83	17,56	18,02	18,80	18,55	23,41	24,64	25,27	25,97	26,27	
ΔT_{3x-3n}, K	13,22	14,69	15,81	16,94	17,63	18,20	18,74	18,69	23,73	25,05	25,76	26,45	26,87	
ΔT_{4x-4n}, K	13,74	15,23	16,40	17,65	18,31	18,93	16,34	19,52	24,05	25,49	26,34	27,07	27,51	
ΔT_{5x-5n}, K	14,02	15,61	17,60	18,16	18,91	19,56	20,15	20,15	26,03	27,84	28,79	29,74	30,19	
$\Delta T_{P2/A-N}$, K	19,03	19,27	19,51	20,84	21,45	22,90	23,39	24,84	32,84	36,96	39,99	42,05	42,90	
Deflection of the oil level indicator, mm.	-	-	-	-	-	-	-	65	-	-	-	-	70	

Table No. 2. Temperature-rises [K] given during the tests combined instrument transformer PVA 145a serial no. 2GKP013K1486141

Winding	ΔT after Stage No. 1	ΔT after Stage No. 2	ΔT after Stage No. 3	ΔT_{dop}
1S1-1S2	55,48	60,95	62,44	75 [1), 2), 4)]
2S1-2S2	57,27	62,80	64,34	
3S1-3S2	55,62	61,21	62,82	
4S1-4S2	56,03	61,56	63,09	
5S1-5S2	55,88	61,47	63,07	
6S1-6S2	56,10	61,61	63,19	
P1-P2/A	*Not measured*	*Not measured*	61,11	
1a-1n	10,76	18,63	25,47	75 [1),3), 4)]
2a-2n	10,36	18,55	26,27	
3a-3n	10,30	18,69	26,87	
4a-4n	10,80	19,52	27,51	
da-dn	10,81	20,15	30,19	
P2/A-N	17,45	24,84	42,90	

No.	Location	ΔT after Stage No. 1	ΔT after Stage No. 2	ΔT after Stage No. 3	ΔT_{dop}
1	Oil	46,08	46,76	46,91	55 [1), 2),3), 4)]
2	Head – top part next to terminal	33,73	34,18	34,79	40 [5)]
3	Under the tank lid from side of terminal box	5,80	9,15	8,30	
4	Enclosure of lower tank	5,37	8,12	7,52	
5	Terminal P1	57,89	58,53	58,43	65 [5)]
6	Terminal P1	58,06	59,16	58,96	
7	Terminal P2/A	53,84	54,94	55,16	
8	Terminal P2/A	54,99	55,84	57,60	

[1)] acc. to IEC 61869-1, [2)] wg IEC 61869-2, [3)] acc. to IEC 61869-3, [4)] acc. to IEC 61869-4,
[5)] acc. to IEC 62271-1,
ΔT - temperature-rise; ΔT_{dop} – permitted value in steady state

6. Summary

In tested combined instrument transformer type PVA 145a, with porcelain insulator, as results of temperature rise test with current I_{cth}= **3000 A**:

- in steady state, at the rated load of secondary current and voltage windings (without residual winding), at cos φ = 1 and supply voltage 1,2U_n (Stage No. 1), permitted temperature-rise limits were not exceeded.
The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

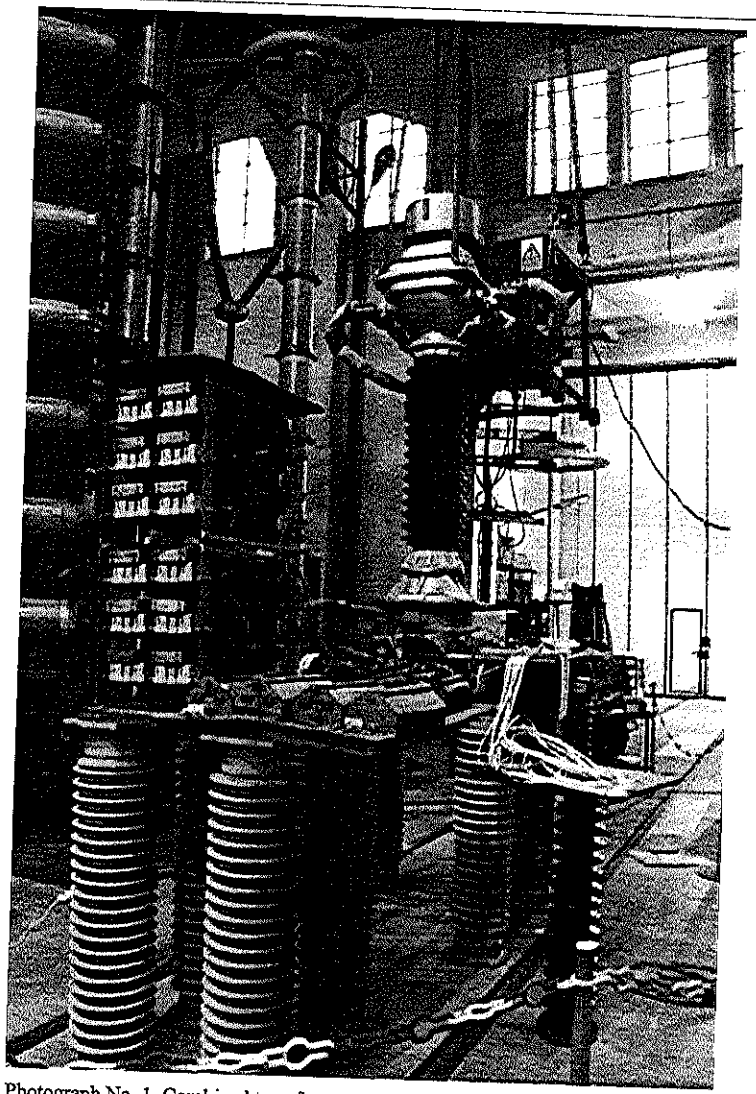
- results of test 8h at supply voltage 1,9U_n and rated load of current and voltage windings at cos φ = 1 and load of residual winding with thermal limit power (Stage No. 2), shows that permitted temperature-rise limits were not exceeded.
The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

- results of test with thermal limit power (Stage No. 3) at rated load of current windings at cos φ = 1 and supply voltage U_n, and at the same time loading of all voltage windings (without residual windings) with thermal limit power, shows that permitted temperature-rise limits were not exceeded.
The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

7. Opinions and interpretations

None

8. Photographic documentation

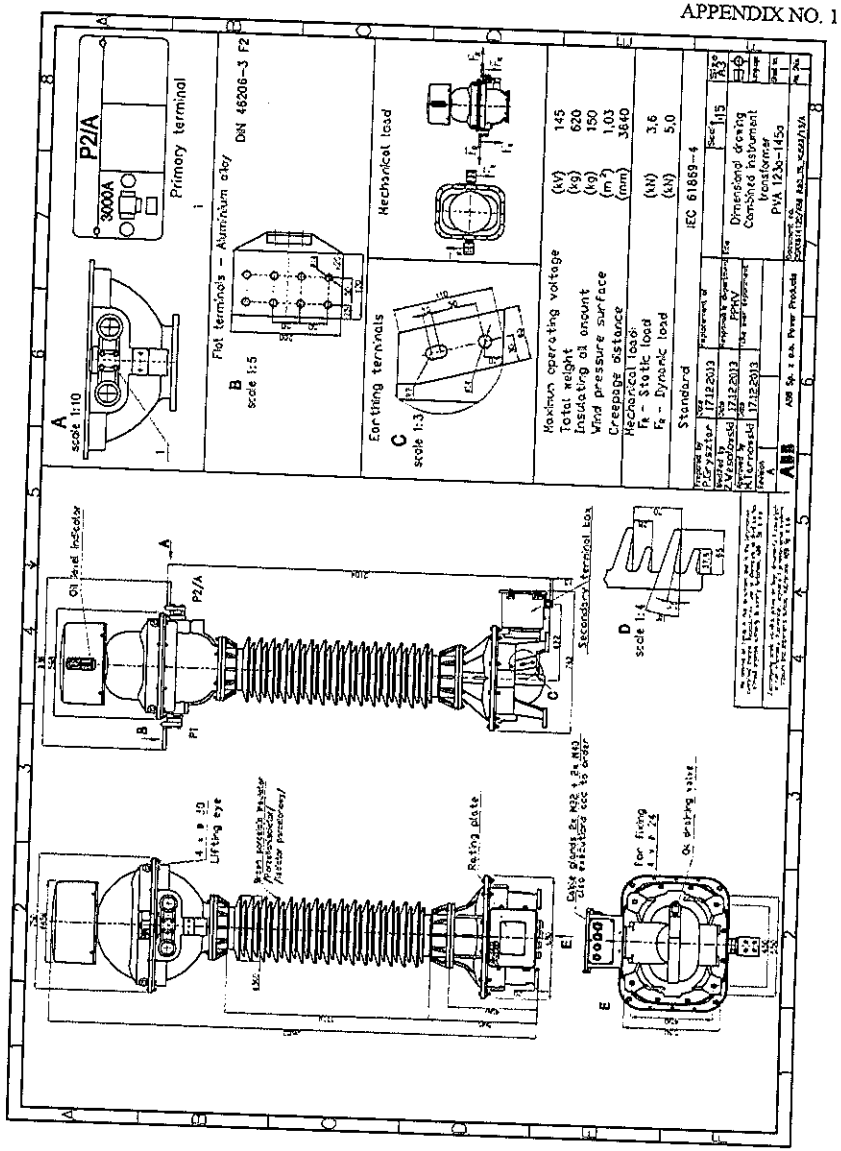


Photograph No. 1. Combined transformer on the test stand during temperature-rise test.

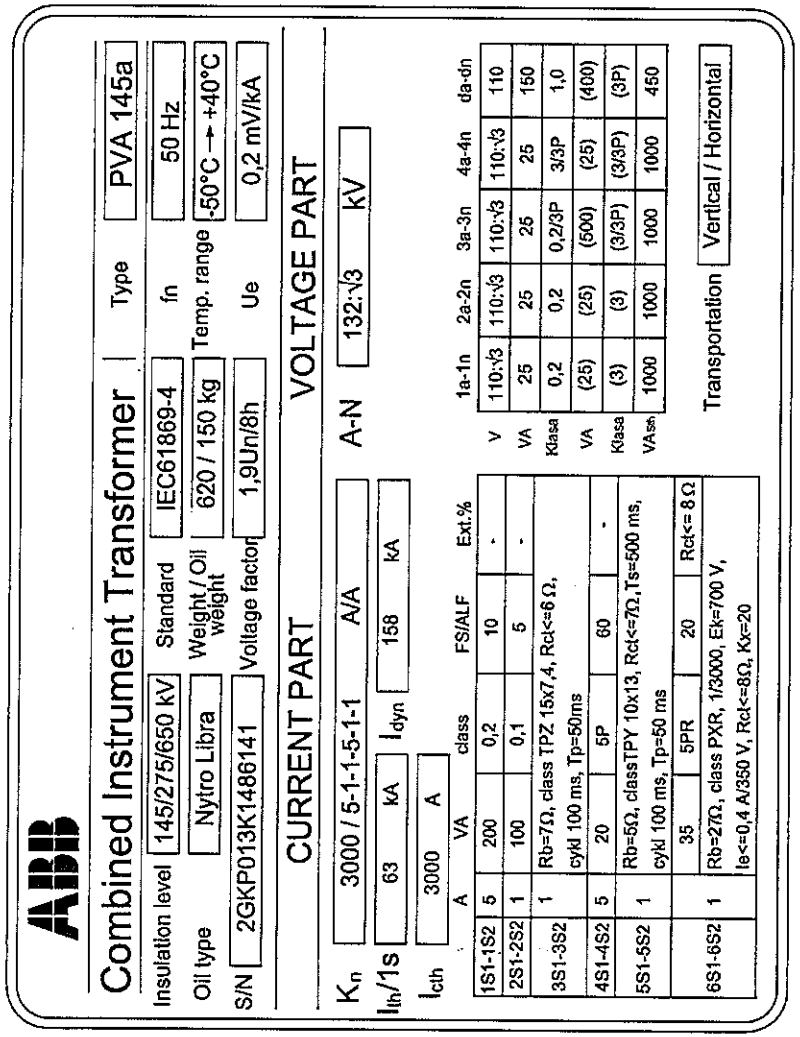
INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY

Test Report No.
EWP/10/E/2014-2E

APPENDIX NO. 1



APPENDIX NO. 2



APPENDIX NO. 3

ABB Sp. z o.o.	Declaration of conformity	ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 090/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486141;**

Place and date of issue of declaration

Przasnysz 13.01.2014

ABB
ABB Sp. z o.o.
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NIP: 526-030-44-84; PL 5260304484
Regon 010017168
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8921, fax (22) 223 8958
(9)

Referent ds. Realizacji Zamówień
ABB Sp. z o.o.
Oddział w Przasnyszu
Małgorzata Gozdziewska

Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Lubecki

(Name) (Signature)

INSTYTUT ENERGETYKI
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TEST REPORT
NO. EWP/35/E/2013-1E

TEST OBJECT:	Combined instrument transformer type PVA 145a
MANUFACTURER:	ABB Sp. z o.o. Power Products 59 Leszno Str. 06-300 Przasnysz, Poland
TESTS ORDERED BY:	Institute of Power Engineering. High Voltage Department Internal order No. EWN/145/E/13 dated 03.12.2013 r.
TYPE OF TESTS:	Temperature-rise test
TEST PROCEDURE:	IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013, IEC 62271-1:2011
TEST OBJECT DELIVERED:	28.11.2013
DATE OF TESTS:	04.12.2013
TESTS RESULTS:	Positive
THE TESTS WERE WITNESSED BY:	-
TEST ENGINEER:	Mariusz SUL M.Sc. Eng.
HEAD OF LABORATORY:	Lidia GRUZA M.Sc. Eng.

Warsaw, 19.02.2014r.

Tests result refers only to the test object. The Test Report consist tests from and beyond the scope of accreditation (details in sub-cl. 4). Publishing or reproducing of this report in other version then exact and complete without written permission of laboratory is forbidden.

Contents

Report contains 18 numbered pages with:	
2	drawings
2	photographs
3	appendices

1.	Description of the test object
Test object	Combined instrument transformer
Type	PVA 145a
Serial number	2GKP013K1486140
Manufacturer	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
Year of production	2013
Insulator	Porcelain insulator
Number of windings	VT part - 5, CT part– 6
Oil type	Nytro Libra
Minimum creepage distance	4495 mm
Insulating oil weight	150 kg
Total weight	620 kg
Dimensions	According to drawing no. 2GKK614121

The laboratory made the identification of test objects on the base of the documentation given in par. 3, appendix no 1. The test object is shown in the photographs No. 1. The object was prepared for testing by the Manufacturer.

2.	Technical data declared by the Manufacturer
Rated voltage	132:√3 kV
Maximum operating voltage	145 kV
Rated frequency	50 Hz
Voltage factor and time	$1{,}9U_n/8h$
Rated continuous thermal current, I_{cth}	1200-2400 A
Rated short-time thermal current, I_{th}/ 1s	63-63 kA
Rated dynamic current, I_{dyn}	158-158 kA

VT part, variant 1					
Winding	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
Rated secondary voltage	110:√3 V	110:√3 V	110:√3 V	110:√3 V	110 V
Rated output	25 VA	25 VA	25 VA	25 VA	150 VA
Accuracy class	0,2	0,2	0,2/3P	3/3P	1,0
Thermal limiting output	1000 VA	1000 VA	1000 VA	1000 VA	450 VA

VT part, variant 2					
Winding	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
Rated secondary voltage	110:√3 V	110:√3 V	110:√3 V	110:√3 V	110 V
Rated output	25 VA	25 VA	500 VA	25 VA	400 VA
Accuracy class	3	3	3/3P	3/3P	3P
Thermal limiting output	1000 VA	1000 VA	1000 VA	1000 VA	450 VA

CT part

Winding	Rated secondary current	Rated output	Accuracy class	FS/ALF	Ext.
1S1-1S2	5 A	100 VA	0,2	10	120 %
2S1-2S2	1 A	70 VA	0,1	5	120 %
3S1-3S2	1 A	35 VA	5P	20	-
4S1-4S2	5 A	15 VA	5P	60	-
5S1-5S2	1 A	Rb=1Ω, class PX, Ek=250 V, Ie≤0,1 A, Rct=7Ω Rb=2Ω, class TPY, 15x13, Rct≤7Ω, Ts=500 ms, cykl 100 ms, Tp=50 ms			
6S1-6S2	1 A	10 VA, class 5PR20, Rct≤8Ω Rb=20Ω, class PXR, 2-1/2000, Ek=500V, Ie≤0,1 A / 250 V, Rct≤5Ω, Kx=20			

3.	Technical documentation of the test object
1.	Drawing no. 2GKK614121 – Dimensional drawing. Combined instrument transformer PVA 123a -145a, ABB Sp. z o.o. Power Products, approved 17.12.2013
2.	Combined transformer verification protocol type PVA 145a, Series No.: 2GKP013K1486140, ABB Sp. z o.o., Przasnysz, 12.11.2013

4.	Scope of the tests

Test programme agreed with Orderer comprised of tests:

No.	Kind of test	Tests according the Standard	Location of the test
1.	Temperature-rise tests	IEC 61869-1:2007 p. 6.4 i 7.2.2, IEC 61869-2:2012 p.6.4.1 i 7.2.2.204 IEC 61869-3:2011 p. 6.4.1 i p.7.2.2 IEC 61869-4:2013 p. 6.4.1 i 7.2.2 IEC 62271-1:2011, table no. 3	EWP

EWP	The test was performed in Institute of Power Engineering, by High - Current Laboratory.

5.	Tests and their results

Combined transformer was installed at the test stand, as it was during normal operation.
Electric diagram of terminal box of tested combined transformer is given in Fig. 1.
The rated voltage with a required value was applied to the primary voltage winding.
The secondary voltage windings and the residual voltage winding were loaded with the suitable power, according to the test programme given below, which was agreed with the Orderer.
Primary current terminals P1 and P2/A was bridged at the range of 2000 A.
According to Manufacturer's request current in primary current winding was equal to $\mathbf{I_{cth} = 2400\ A}$.
The arrangement of the thermocouples is given in Figure No. 2.
The temperature-rises of windings were measured by the resistance rise method.
During the test, the measurements of loaded windings were made every 1 hour and registered the deflection of oil level indicator.
The resistances of all windings were measured before the tests and after of each stage of tests.
The abstract of the protocol of temperature-rise test is given in Table No. 1.
The summary of test results is given in Table 2.

The temperature-rise of windings were calculated from the formula:

$$\Delta T = \frac{R}{R_0 \alpha} = \frac{R_1 - R_0}{R_0 \cdot 0{,}004}$$

Stage No. 1:	Test at the rated load

Test was performed according to the IEC 61869-1 sub-cl. 6.4 and 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and 7.2.2.204; IEC 61869-3 sub-cl. 6.4.1 and 7.2.2; IEC 61869-4 sub-cl. 6.4.1 and 7.2.2. The voltage value 1,2 U_n = 91,5 kV was applied to the P2/A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 2a-2n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 3a-3n ⇒ 500 VA, cos φ = 1, at the voltage 110/√3 V; 4a-4n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V. The winding of residual voltage remained open.
The secondary current windings of the CT were loaded as follows: 1S1-1S2 ⇒ 100 VA, cos φ = 1; 2S1-2S2 ⇒ 70 VA, cos φ = 1; 3S1-3S2 ⇒ 35 VA, cos φ = 1; 5S1-5S2 ⇒ 2Ω; 6S1-6S2 ⇒ 20Ω.
Supply (current control) was applied to the secondary current winding 4S1-4S2.
Terminals P1 and P2/A were short-circuited at the range 2000 A.

The test was performed till reached steady state of the measured temperatures.

Stage No. 2:	Test of 8 h

Test was performed according to the IEC 61869-1 sub-cl. 6.4 and 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and 7.2.2.204; IEC 61869-3 sub-cl. 6.4.1 and 7.2.2; IEC 61869-4 sub-cl. 6.4.1 and 7.2.2. The voltage value 1,9 U_n = 144,8 kV was applied to the P2/A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 2a-2n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V; 3a-3n ⇒ 500 VA at the voltage 110/√3 V; 4a-4n ⇒ 25 VA, cos φ = 1, at the voltage 110/√3 V.

The residual winding da-dn was loaded by ⇒ 450 VA, cos φ = 1, at the voltage 110 V.
The secondary current windings of the CT were loaded as follows: 1S1-1S2 ⇒ 100 VA, cos φ = 1; 2S1-2S2 ⇒ 70 VA, cos φ = 1; 3S1-3S2 ⇒ 35 VA, cos φ = 1; 5S1-5S2 ⇒ 2Ω; 6S1-6S2 ⇒ 20Ω.
Supply (current control) was applied to the secondary current winding 4S1-4S2.
Terminals P1 and P2/A were short-circuited at the range 2000 A.

The duration of the test was 8 h.

Stage No. 3:	Test with thermal limit power

Test was performed according to the IEC 61869-1 sub-cl. 6.4 and 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and 7.2.2.204; IEC 61869-3 sub-cl. 6.4.1 and 7.2.2; IEC 61869-4 sub-cl. 6.4.1 and 7.2.2. The voltage value U_n = 63 kV was applied to the P2/A terminal.
According to Manufacturers request secondary voltage windings (i.e. 1a-1n, 2a-2n, 3a-3n and 4a - 4n) were loaded by limit power 1000 VA at cos φ = 1. The residual winding remained open.
The secondary current windings of the CT were loaded as follows: 1S1-1S2 ⇒ 100 VA, cos φ = 1; 2S1-2S2 ⇒ 70 VA, cos φ = 1; 3S1-3S2 ⇒ 35 VA, cos φ = 1; 5S1-5S2 ⇒ 2Ω; 6S1-6S2 ⇒ 20Ω.
Supply (current control) was applied to the secondary current winding 4S1-4S2. Terminals P1 and P2/A were short-circuited at the range 2000 A.

The test was performed till reaching the steady state of the measured temperatures.

Measuring instruments

The temperatures were measured by means of type K thermocouples (NiCr – NiAl) with accuracy ± 0,6°C[1].
The ambient temperature was measured using four mercurial thermometers immersed into tank filled with oil. These thermometers were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor- the accuracy of measurement ± 0,03°C[1].
The resistance was measured by means of meter type 2291 manufactured by TETTEX Instruments with accuracy ± 0,01 mΩ[1]

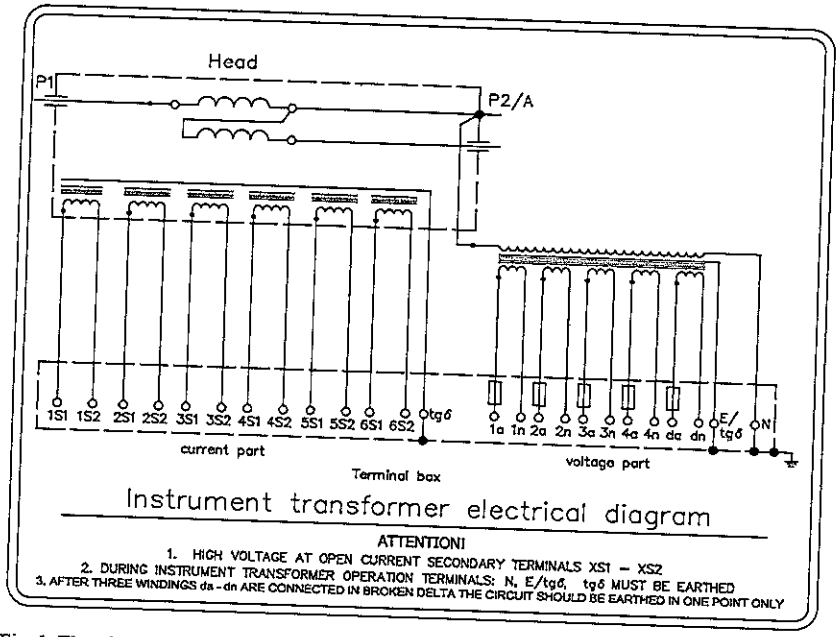

Fig. 1. Electrical diagram of terminal box of tested combined instrument transformer

[1] The expanded uncertainty assigned corresponds to a coverage probability of 95 % and the coverage factor k = 2.

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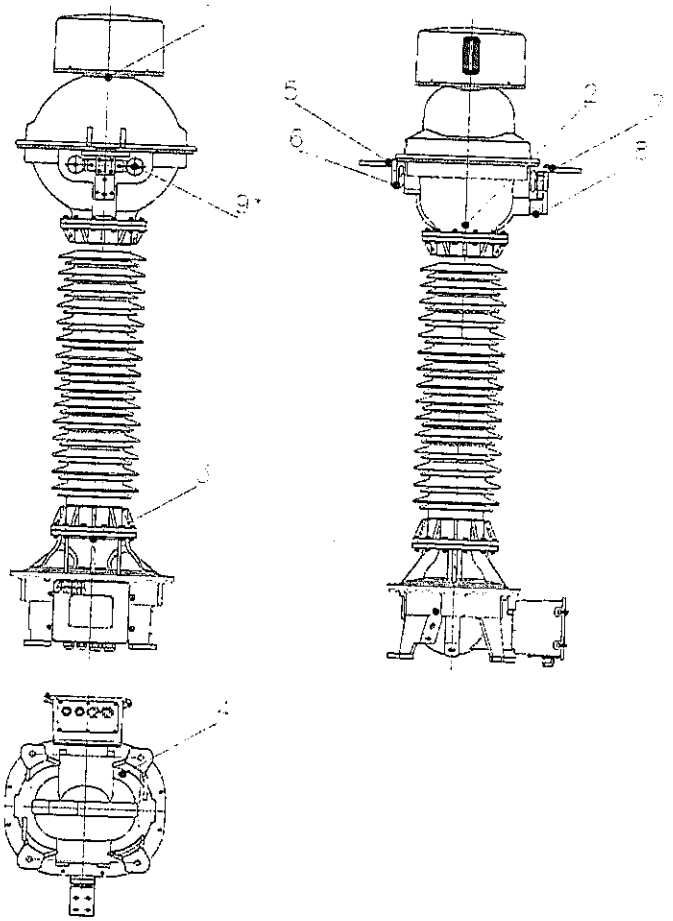


Fig. 2. Arrangement of thermocouples during temperature-rise test:
1 – oil (over current coil), 2 – head (contraction of the flange connecting the head the the insulator), 3 – under the flange of tank lid, 4 – lower tank (placed inside over earthing terminal), 5 – terminal P1, 6 – terminal P1, 7 – terminal P2/A (2000A), 8 – terminal P2/A (2000A), 9 – current path inside the combined instrument transformer.

Table 1. Temperature-rise test results of combined instrument transformer PVA 145a, serial no. 2GKP013K1486140

No. of thermo-couple	Heating time [h] Stage No. 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ΔT 1, K	-	4,30	8,13	11,55	15,95	18,88	21,35	23,13	24,96	26,33	26,96	28,11	28,65	28,98	30,23	30,96	31,51	32,23	32,71	32,33	33,25	33,48
ΔT 2, K	-	5,70	9,30	12,10	14,78	16,63	18,03	19,01	20,30	21,53	22,18	22,88	23,43	23,71	24,48	25,03	25,81	26,15	26,56	26,20	27,23	27,13
ΔT 3, K	-	-0,60	0,00	0,32	0,55	1,05	1,52	1,50	2,00	2,32	1,80	2,05	2,15	1,90	2,05	2,35	2,55	2,02	2,52	2,27	3,00	2,97
ΔT 4, K	-	-1,00	-1,68	-1,68	-1,45	-1,43	-1,55	-1,40	-1,35	-1,10	-2,00	-1,45	-1,28	-1,53	-1,53	-1,43	-1,03	-0,98	-1,10	-1,33	-0,63	-0,65
ΔT 5, K	-	35,41	45,41	47,06	46,06	49,73	45,94	47,19	47,50	48,74	48,48	48,28	49,72	49,26	48,67	48,21	48,16	48,61	49,48	49,89	50,86	51,81
ΔT 6, K	-	37,58	50,85	51,65	50,01	55,31	48,56	50,75	50,80	52,79	51,89	51,79	53,11	52,94	51,96	50,86	53,43	52,96	52,33	53,33	54,76	56,59
ΔT 7, K	-	21,31	27,96	30,11	30,70	33,03	32,21	33,01	33,53	34,63	34,55	34,86	35,63	35,63	35,53	35,35	36,35	36,44	36,01	36,69	37,51	37,56
ΔT 8, K	-	22,28	29,75	31,58	31,93	34,94	33,21	32,28	35,03	36,50	36,43	36,79	37,74	37,71	37,53	37,21	38,83	38,56	38,53	38,98	40,01	40,74
ΔT 9, K	-	18,63	26,13	29,06	30,73	34,21	33,48	35,26	36,43	38,21	38,68	39,33	40,43	40,79	40,91	41,01	40,86	42,46	42,66	43,16	44,40	44,59
$T_{oil\ fp}$ °C	16,83	16,93	17,05	17,15	17,20	17,20	17,15	17,15	17,20	17,30	17,25	17,23	17,30	17,38	17,38	17,38	17,55	17,58	17,45	17,43	17,50	17,50
U_{app}, kV	91,5																					
$I_{451-452}$, A	0	6,33	6,31	6,56	6,58	6,75	6,73	6,84	6,83	6,87	6,89	6,95	7,35	7,11	7,24	7,11	7,42	7,24	7,52	7,47	7,41	7,45
$I_{151-151}$, A	0	6,006	6,008	6,018	6,014	6,039	6,008	6,036	6,015	6,016	6,009	6,005	6,063	6,014	6,023	6,015	6,025	6,006	6,025	6,029	6,01	6,018
$I_{P1-P2/A}$, A	0	2402,4	2403,2	2407,2	2405,6	2415,6	2403,2	2414,4	2406	2406,4	2403,6	2402	2425,2	2405,6	2409,2	2406	2410	2402,4	2410	2411,6	2404	2407,2
$I_{P2/A-N}$, mA	0	10,5	10,5	10,5	10,25	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5
$R_{151-152}$ mΩ	444,21	452,88	458,42	465,52	471,76	478,60	485,03	491,11	497,19	502,42	507,16	511,68	515,94	519,66	523,04	526,13	532,41	535,39	536,17	536,99	542,39	543,23
$R_{251-252}$ Ω	6,0164	6,1404	6,2261	6,3211	6,4117	6,5001	6,5948	6,6847	6,7725	6,8460	6,9125	6,9794	7,0384	7,0905	7,1381	7,1736	7,2834	7,3222	7,3381	7,3344	7,3912	7,3935
$R_{351-352}$ Ω	3,2628	3,3120	3,3582	3,4079	3,4571	3,5099	3,5585	3,6060	3,6532	3,6940	3,7315	3,7659	3,8001	3,8292	3,8552	3,8789	3,9001	3,9198	3,9381	3,9552	3,9706	3,9853
$R_{451-452}$ mΩ	383,11	395,03	400,84	406,72	411,66	418,16	423,71	429,11	434,47	438,99	443,19	447,08	451,73	454,48	457,24	460,30	462,44	464,51	466,63	468,72	470,40	472,32
$R_{551-552}$ Ω	3,5543	3,5920	3,6387	3,6918	3,7463	3,8032	3,8565	3,9082	3,9599	4,0042	4,0456	4,0843	4,1198	4,1523	4,1808	4,2069	4,2299	4,2515	4,2715	4,2899	4,3068	4,3225
$R_{651-652}$ Ω	3,8092	3,8579	3,9096	3,9677	4,0259	4,0869	4,1437	4,1985	4,2536	4,3010	4,3445	4,3846	4,4229	4,4577	4,4880	4,5159	4,5400	4,5629	4,5841	4,6036	4,6216	4,6385
$R_{P1-P2/A}$ mΩ	0,0474	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$\Delta T_{151-152}$, K	-	4,88	8,00	11,99	15,51	19,35	22,97	26,40	29,82	32,76	35,43	37,97	40,37	42,46	44,37	46,10	49,64	51,32	51,75	52,22	55,26	55,73
$\Delta T_{251-252}$, K	-	5,15	8,71	12,66	16,43	20,10	24,03	27,77	31,42	34,47	37,24	40,02	42,47	44,63	46,61	48,09	52,65	54,26	54,92	54,77	57,13	57,22
$\Delta T_{351-352}$, K	-	3,77	7,31	11,12	14,89	18,93	22,66	26,30	29,91	33,04	35,91	38,55	41,17	43,40	45,39	47,21	48,83	50,34	51,74	53,05	54,23	55,36
$\Delta T_{451-452}$, K	-	7,78	11,57	15,41	18,63	22,87	26,49	30,02	33,52	36,46	39,21	41,74	44,78	46,57	48,37	50,37	51,77	53,12	54,50	55,87	56,96	58,21
$\Delta T_{551-552}$, K	-	2,65	5,94	9,67	13,50	17,51	21,26	24,89	28,53	31,64	34,56	37,28	39,78	42,06	44,07	45,90	47,52	49,04	50,45	51,74	52,93	54,03
$\Delta T_{651-652}$, K	-	3,20	6,59	10,40	14,22	18,23	21,95	25,55	29,17	32,28	35,13	37,76	40,28	42,56	44,55	46,38	47,96	49,47	50,86	52,14	53,32	54,43
$\Delta T_{P1-P2/A}$, K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY

Test Report No.
EWP/35/E/2013-1E

Table No. 1, cont.

	Heating time [h] Stage No. 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R_{1a-1a_n} mΩ	47,659	48,146	48,448	50,302	50,810	48,913	49,002	49,076	49,146	49,202	49,251	49,284	49,327	49,357	49,375	49,429	49,424	49,436	49,450	49,463	49,473	49,369
R_{2a-2a_n} mΩ	49,128	49,622	49,937	50,592	50,814	50,430	50,517	50,601	50,680	50,730	50,788	50,821	50,866	50,897	50,920	50,835	50,966	50,980	50,994	51,012	51,020	51,189
R_{3a-3a_n} mΩ	50,125	50,564	50,936	51,156	51,309	51,443	51,551	51,635	51,715	51,775	51,807	51,870	51,901	51,951	51,956	51,987	52,016	52,025	52,042	52,064	52,071	52,098
R_{4a-4a_n} mΩ	51,407	52,004	52,220	52,448	52,602	52,741	52,848	52,928	53,016	53,077	53,108	53,176	53,205	53,255	53,267	53,302	53,322	53,340	53,359	53,377	53,390	53,410
R_{4a-4a_n} mΩ	112,14	113,21	113,98	114,48	114,83	115,17	115,41	115,54	115,81	115,95	116,07	116,18	116,27	116,36	116,78	116,47	116,51	116,55	116,78	116,64	116,66	116,70
$R_{P2/A-N}$, kΩ	21,22	21,56	21,73	21,91	21,91	22,05	22,09	22,01	22,11	22,07	22,15	22,21	22,28	22,41	22,10	22,01	22,03	22,04	22,09	22,12	22,18	22,24
ΔT_{1a-1a_n}	-	2,55	4,14	13,86	16,53	6,58	7,04	7,43	7,80	8,09	8,35	8,52	8,75	8,91	9,00	9,28	9,26	9,32	9,39	9,46	9,52	8,97
ΔT_{2a-2a_n}	-	2,51	4,12	7,45	8,58	6,63	7,07	7,50	7,90	8,15	8,45	8,62	8,84	9,00	9,12	8,69	9,35	9,42	9,50	9,59	9,63	10,49
ΔT_{3a-3a_n}	-	2,19	4,04	5,14	5,91	6,57	7,11	7,53	7,93	8,23	8,39	8,70	8,86	9,11	9,13	9,29	9,43	9,48	9,56	9,67	9,71	9,84
ΔT_{4a-4a_n}	-	2,90	3,95	5,06	5,81	6,49	7,01	7,40	7,82	8,12	8,27	8,60	8,74	8,99	9,05	9,22	9,31	9,40	9,49	9,58	9,64	9,74
ΔT_{4a-4a_n}	-	2,39	4,10	5,22	6,00	6,75	7,29	7,58	8,18	8,49	8,76	9,01	9,21	9,41	10,34	9,65	9,74	9,83	10,34	10,03	10,08	10,17
$\Delta T_{P2/A-N}$	-	4,01	6,01	8,13	8,13	9,78	10,25	9,31	10,49	10,01	10,96	11,66	12,49	14,02	10,37	9,31	9,54	9,66	10,25	10,60	11,31	12,02
Deflection of the oil level indicator, mm	0	0	15	19	23	26	29	30	33	35	37	39	40	41	43	43	44	45	46	47	47	48

Table No. 1, cont.

No. of thermo-couple	Heating time [h]																	
	Stage No. 1			Stage No. 2									Stage No. 3					
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
ΔT 1, K	33,25	34,25	35,06	34,91	34,33	33,49	33,96	33,68	33,18	33,73	34,00	34,41	35,61	35,48	36,75	36,55	37,08
ΔT 2, K	27,05	27,93	28,20	28,38	27,61	27,15	27,23	27,20	26,78	27,08	27,31	28,63	30,19	30,14	31,73	31,33	32,14
ΔT 3, K	2,65	2,92	3,37	3,57	4,02	4,07	5,20	5,40	5,55	5,83	6,08	5,73	5,07	5,10	5,73	5,15	6,05
ΔT 4, K	-0,98	-0,63	-0,33	-0,55	-0,50	-0,93	-0,30	-0,30	-1,18	-0,95	-0,75	-0,20	-0,90	-0,98	-0,65	-0,90	-0,38
ΔT 5, K	51,33	52,01	52,30	49,06	48,43	48,44	49,40	49,96	48,42	49,03	48,34	50,81	51,81	53,29	55,58	54,38	54,98
ΔT 6, K	55,86	55,81	56,57	52,35	51,98	52,62	53,64	54,49	51,61	53,00	52,13	54,91	54,73	56,46	59,53	58,29	58,81
ΔT 7, K	37,49	37,91	38,20	35,54	35,13	35,33	35,41	35,71	35,44	35,25	35,23	37,34	38,41	39,16	40,91	39,85	40,51
ΔT 8, K	40,51	40,93	41,43	39,71	38,98	38,88	39,05	39,56	38,54	38,83	38,76	41,03	41,80	42,68	45,11	44,01	44,63
ΔT 9, K	44,88	45,49	46,03	44,88	44,47	44,35	44,44	45,15	44,25	44,39	44,59	45,58	46,24	47,09	49,04	48,68	48,93
$T_{ot\,8}$, °C	17,58	17,58	17,55	17,55	17,55	17,58	17,60	17,68	17,73	17,75	17,75	17,83	17,90	17,93	18,13	18,13	17,93
U_{zas}, kV	91,5			144,8								76,2					
$I_{451-452}$, A	7,48	7,53	7,51	7,65	7,7	7,65	7,66	7,83	7,73	7,82	8,25	7,68	7,76	7,95	8,3	8,43	8,32
$I_{151-152}$, A	6,024	6,018	6,027	6,01	6,011	6,016	6,017	6,013	6,005	6,001	6,035	6,001	6,003	6,025	6,021	6,015	6,011
$I_{P1-P2/A}$, A	2409,6	2407,2	2410,8	2404	2404,4	2406,4	2406,8	2405,2	2402	2400,4	2414	2400,4	2401,2	2410	2408,4	2406	2404,4
$I_{P2/A-N}$, mA	10,7	10,7	10,7	27	27	27	27	27	27	27	27	50	50	50	50	50	50
$R_{151-152}$ mΩ	544,06	545,76	547,37	549,14	550,33	549,19	549,07	549,49	550,69	551,35	551,94	551,69	552,24	553,16	555,08	556,16	557,23
$R_{251-252}$ Ω	7,4370	7,4762	7,4978	7,5125	7,5395	7,4903	7,4964	7,5156	7,5259	7,5347	7,5361	7,5373	7,5475	7,5664	7,5982	7,6071	7,6237
$R_{351-352}$ Ω	3,9985	4,0121	4,0238	4,0328	4,0412	4,0477	4,0524	4,0585	4,0680	4,0724	4,0777	4,0771	4,0813	4,0873	4,1050	4,1116	4,1176
$R_{451-452}$ mΩ	473,83	475,47	476,73	477,09	478,15	479,02	479,12	480,38	482,33	481,92	482,93	482,26	483,08	484,08	489,66	487,12	487,58
$R_{551-552}$ Ω	4,3380	4,3515	4,3647	4,3754	4,3846	4,3913	4,3971	4,4033	4,4121	4,4181	4,4239	4,4238	4,4278	4,4336	4,4485	4,4592	4,4668
$R_{651-652}$ Ω	4,6539	4,6693	4,6831	4,6943	4,7042	4,7115	4,7174	4,7238	4,7335	4,7400	4,7457	4,7453	4,7498	4,7564	4,7724	4,7840	4,7917
$R_{P1-P2/A}$ mΩ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,0583
$\Delta T_{151-152}$, K	56,20	57,15	58,06	59,05	59,72	59,08	59,01	59,25	59,93	60,30	60,63	60,49	60,80	61,32	62,40	63,01	63,61
$\Delta T_{251-252}$, K	59,03	60,66	61,56	62,17	63,29	61,25	61,50	62,30	62,72	63,09	63,15	63,20	63,62	64,41	65,73	66,10	66,79
$\Delta T_{351-352}$, K	56,37	57,41	58,31	59,00	59,64	60,14	60,50	60,97	61,70	62,03	62,44	62,39	62,71	63,17	64,53	65,04	65,50
$\Delta T_{451-452}$, K	59,20	60,27	61,09	61,33	62,02	62,59	62,65	63,47	64,75	64,48	65,14	64,70	65,24	65,89	69,53	67,87	68,17
$\Delta T_{551-552}$, K	55,12	56,07	57,00	57,75	58,40	58,87	59,28	59,72	60,34	60,76	61,17	61,16	61,44	61,85	62,90	63,65	64,18
$\Delta T_{651-552}$, K	55,44	56,45	57,35	58,09	58,74	59,22	59,61	60,03	60,66	61,09	61,46	61,44	61,73	62,17	63,22	63,98	64,48
$\Delta T_{P1-P2/A}$, K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	57,49

Table No. 1, cont.

	Heating time [h]																	
	Stage No. 1			Stage No. 2									Stage No. 3					
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
R_{1a-1a} mΩ	49,504	49,515	49,524	49,815	50,247	50,439	50,585	50,704	50,809	50,931	50,993	51,710	51,949	52,044	52,185	52,215	52,320
R_{2a-2a} mΩ	51,052	51,066	51,076	51,371	51,841	52,058	52,212	52,342	52,462	52,581	52,644	53,475	53,768	53,874	54,031	54,058	54,186
R_{3a-3a} mΩ	52,109	52,113	52,124	52,424	52,702	53,135	53,298	53,442	53,555	53,693	53,757	54,644	54,972	55,101	55,255	55,307	55,439
R_{4a-4a} mΩ	53,424	53,432	53,454	53,741	54,029	54,503	54,669	54,820	54,945	55,083	55,160	56,152	56,513	56,662	56,834	56,889	57,027
R_{5a-5a} mΩ	116,74	116,79	116,79	117,47	118,94	119,29	119,71	120,05	120,34	120,67	120,85	123,78	124,12	124,52	124,94	125,11	125,40
$R_{P2/A-N}$, kΩ	22,28	22,30	22,31	22,24	22,47	22,70	22,65	22,75	22,80	22,85	23,00	23,50	24,10	24,35	24,50	24,58	24,61
ΔT_{1a-1a}, K	9,68	9,74	9,78	11,31	13,58	14,58	15,35	15,97	16,52	17,16	17,49	21,25	22,50	23,00	23,74	23,90	24,45
ΔT_{2a-2a}, K	9,79	9,86	9,91	11,41	13,81	14,91	15,69	16,36	16,97	17,57	17,89	22,12	23,61	24,15	24,95	25,09	25,74
ΔT_{3a-3a}, K	9,90	9,92	9,97	11,47	12,85	15,01	15,83	16,54	17,11	17,80	18,11	22,54	24,17	24,82	25,59	25,85	26,50
ΔT_{4a-4a}, K	9,81	9,85	9,95	11,35	12,75	15,06	15,86	16,60	17,21	17,88	18,25	23,08	24,83	25,56	26,39	26,66	27,33
ΔT_{5a-5a}, K	10,26	10,37	10,37	11,88	15,16	15,94	16,88	17,63	18,28	19,02	19,42	25,95	26,71	27,60	28,54	28,91	29,56
$\Delta T_{P2/A-N}$, K	12,49	12,72	12,84	12,02	14,73	17,44	16,85	18,03	18,61	19,20	20,97	26,86	33,93	36,88	38,64	39,59	39,94
Deflection of the oil level indicator, mm.	48	49	50	50	52	54	54	55	56	56	57	57	58	59	60	60	60

Table No. 2. Temperature-rises [K] given during the tests combined instrument transformer PVA 145a serial no. 2GKP013K1486140

Winding	ΔT after Stage No. 1	ΔT after Stage No. 2	ΔT after Stage No. 3	ΔT_{dop}
1S1-1S2	58,06	60,63	63,61	75 [1), 2), 4)]
2S1-2S2	61,56	63,15	66,79	
3S1-3S2	58,31	62,44	65,50	
4S1-4S2	61,09	65,14	68,17	
5S1-5S2	57,00	61,17	64,18	
6S1-6S2	57,35	61,46	64,48	
P1-P2/A	*Not measured*	*Not measured*	57,49	
1a-1n	9,78	17,49	24,45	75 [1),3), 4)]
2a-2n	9,91	17,89	25,74	
3a-3n	9,97	18,11	26,50	
4a-4n	9,95	18,25	27,33	
da-dn	10,37	19,42	29,56	
P2/A-N	12,84	20,97	39,94	

No.	Location	ΔT after Stage No. 1	ΔT after Stage No. 2	ΔT after Stage No. 3	ΔT_{dop}
1	Oil	35,06	34,00	37,08	55 [1), 2),3), 4)]
2	Head – top part next to terminal	28,20	27,31	32,14	40 [5)]
3	Under the tank lid from side of terminal box	3,37	6,08	6,05	
4	Enclosure of lower tank	*Inconsistent results, indicating damage of the thermocouple.*			
5	Terminal P1	52,30	48,34	54,98	65 [5)]
6	Terminal P1	56,57	52,13	58,81	
7	Terminal P2/A	38,20	35,23	40,51	
8	Terminal P2/A	41,43	38,76	44,63	
9	Current path inside the combined instrument transformer	46,03	44,59	48,93	75 [1), 2), 4)]

[1)] acc. to IEC 61869-1, [2)] wg IEC 61869-2, [3)] acc. to IEC 61869-3, [4)] acc. to IEC 61869-4, [5)] acc. to IEC 62271-1,

ΔT - temperature-rise; ΔT_{dop} – permitted value in steady state

6. Summary

In tested combined instrument transformer type PVA 145a, with porcelain insulator, as results of temperature rise test with current I_{cth}= **2400 A**:

- in steady state, at the rated load of secondary current and voltage windings (without residual winding), at cos φ = 1 and supply voltage 1,2U_n (Stage No. 1), permitted temperature-rise limits were not exceeded.

The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

- results of test 8 h at supply voltage 1,9U_n and rated load of current and voltage windings at cos φ = 1 and load of residual winding with thermal limit power (Stage No. 2), shows that permitted temperature-rise limits were not exceeded.

The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

- results of test with thermal limit power (Stage No. 3) at rated load of current windings at cos φ = 1 and supply voltage U_n, and at the same time loading of all voltage windings (without residual windings) with thermal limit power, shows that permitted temperature-rise limits were not exceeded.

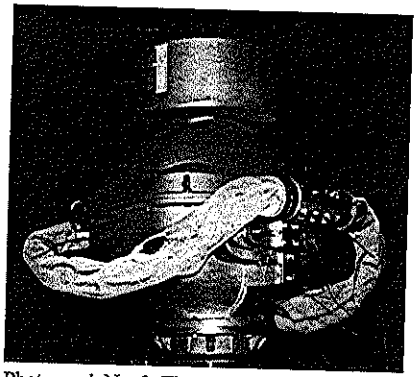
The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

7. Opinions and interpretations

None

8. Photographic documentation

Photograph No. 1. Combined transformer on the test stand during temperature-rise test.

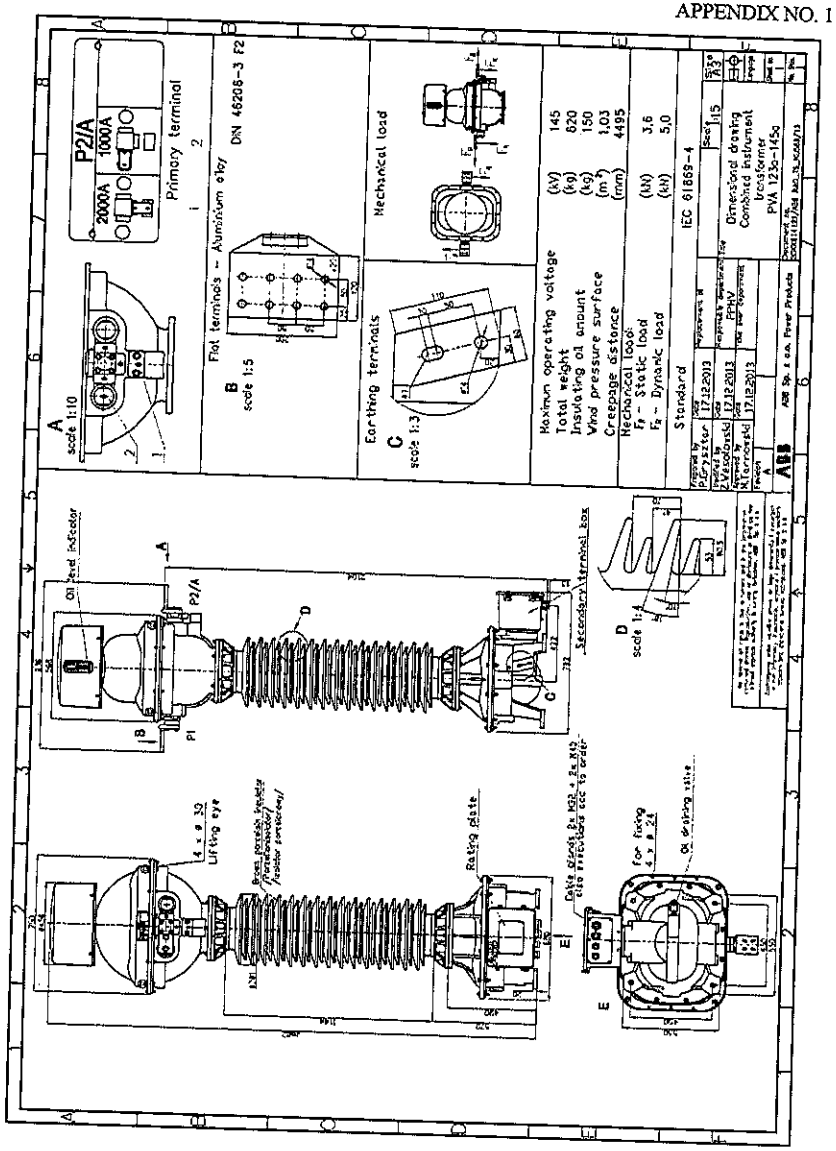


Photograph No. 2. The conductors short-circuiting of P1-P2A terminals.

INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY

Test Report No.
EWP/35/E/2013-1E

APPENDIX NO. 1



APPENDIX NO. 2

ABB

Combined Instrument Transformer

Type: PVA 145a

Insulation level: 145/275/650 kV | Standard: IEC 61869-4 | fn: 50 Hz

Oil type: Nytro Libra | Weight / Oil weight: 620 / 150 kg | Temp.range: -50°C ÷ +40°C

S/N: 2GKP013K1486140 | Voltage factor: 1,9Un/8h | Ue: 0,2 mV/kA

CURRENT PART

K_n 1000-2000 / 5-1-1-5-1-1 A/A

I_{th}/1s 63 - 63 kA I_{dyn} 158 - 158 kA

I_{cth} 1200 - 2400 A

	A	VA	Klasa	FS/ALF	Ext.%
1S1-1S2	5	100	0,2	10	120
2S1-2S2	1	70	0,1	5	120
3S1-3S2	1	35	5P	20	-
4S1-4S2	5	15	5P	60	-
		Rb=1Ω, klasa PX, Ek=250V, Ie<=0,1 A, Rct <=7Ω			
5S1-5S2	1	Rb=2Ω, klasaTPY 15x13, Rct <=7Ω ,Ts=500 ms, cykl 100 ms, Tp=50 ms			
6S1-6S2	1	10 VA, klasa 5PR20, Rct<= 8 Ω			
		Rb=20Ω, klasa PXR, 2-1/2000, Ek=500 V, Ie<=0,1 A / 250 V, Rct<= 5Ω , Kx=20			

VOLTAGE PART

A-N 132:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3	110:√3	110:√3	110
VA	25	25	25	25	150
Klasa	0,2	0,2	0,2/3P	3/3P	1,0
VA	(25)	(25)	(600)	(25)	(400)
Klasa	(3)	(3)	(3/3P)	(3/3P)	(3P)
VAsh	1000	1000	1000	1000	450

Transportation: Vertical/Horizontal

APPENDIX NO. 3

ABB Sp. z o.o.

Declaration of conformity

ABB Sp. z o.o.
Dept. in Przasnysz
POLAND

DECLARATION OF CONFORMITY No. 093/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486140;**

Place and date of issue of declaration

Przasnysz 13.01.2014

ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
NIP: 526-030-44-84; PL 5260304484
Regon 010017165
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8921, fax (22) 223 8958

Dyrektor ds. Realizacji Zamówień
ABB Sp. z o.o.
Oddział w Przasnyszu

Małgorzata Sobczewska

Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu

Krzysztof Łuberski

(Name) (Signature)

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/66/E/13-2 E

TEST OBJECT: Combined transformer type PVA 145a with composite insulator
Serial No. 86142/13

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: Internal order No. EWN/145/E/13 dated 12.11.2013

TYPE OF TESTS: Mechanical tests

TESTS PROCEDURE: According to IEC 61869-1:2007

DATE OF TESTS: 19.11.2013

TESTS RESULT: Positive for
$F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 30.12.2013

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Contents

Report contents:

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1. TEST OBJECT

1.1 Description

Combined transformer type PVA 145a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 145 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with composite insulator immersed with transformer oil.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	145 kV
Rated frequency	50 Hz
Rated static load	3600 N

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing combined instrument transformer PVA 123a-145a, No. 2GKK614123, 17.12.2013,
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o. (Annex 2),

The laboratory proceeded the identification of test object on the base of above documentation and the rating plate.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-1:2007:
- mechanical tests acc. to item 7.4.5 of above standard for F_R = 3600 N of P1 and P2/A 600 A terminals.

During the tests deflection of the combined transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the combined transformer was fixed to the rigid construction of the test stand. Mechanical tests were performed applying the load consecutively to the transformer's P1 and P2/A 600 A terminals as shown on photographs in Annex 1.

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents table 1. The load was increased and released smoothly (30 – 90 s) and was maintained 60 s.

During the tests the following records were made:
- phot. 1 to 24 - combined transformer during mechanical tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3620 N

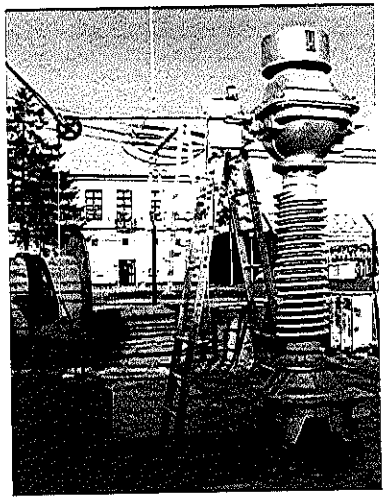
Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	P1	longitudinal	60	During the static load deflection was about 12 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
2	P1	transverse	60	During the static load deflection was about 11 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
3	P1	vertical	60	During the static load deflection was about 3 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
4	P2/A 600 A	longitudinal	60	During the static load deflection was about 13 mm. Residual deflection was about 2 mm. After tests no damage nor oil leak was stated.
5	P2/A 600 A	transverse	60	During the static load deflection was about 12 mm. Residual deflection was about 3 mm. After tests no damage nor oil leak was stated.
6	P2/A 600 A	vertical	60	During the static load deflection was about 4 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.

5. TESTS RESULTS EVALUATION

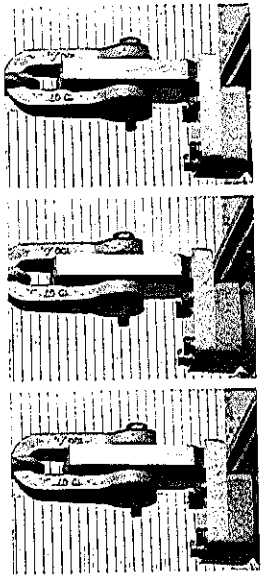
According to criteria given in IEC 61869-1:2007 the results of tests of tested combined transformer is positive for:
- F_R = 3600 N.

ANNEX 1

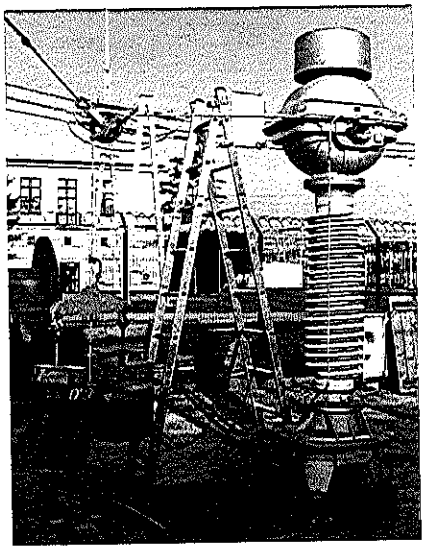
Photographs taken during the tests



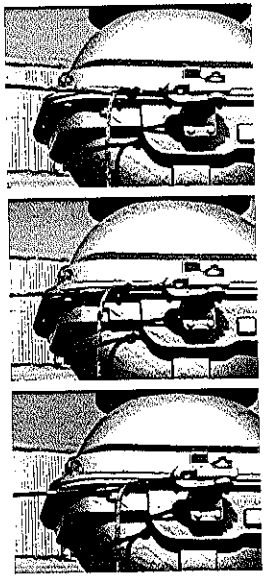
Phot. 1. Longitudinal load of terminal P1



Phot. 2 - 4. Terminal P1 before, during and after longitudinal load



Phot. 5. Transverse load of terminal P1



Phot. 6 - 8. Terminal P1 before, during and after transverse load

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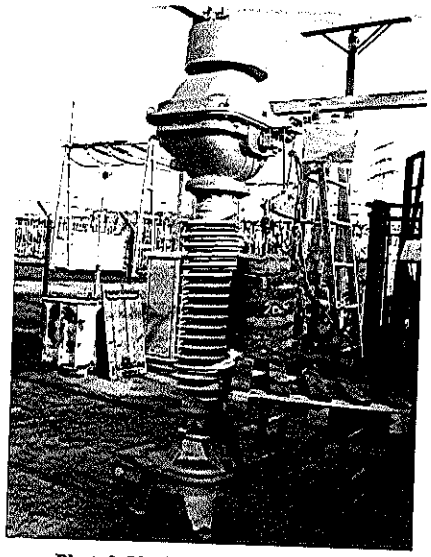
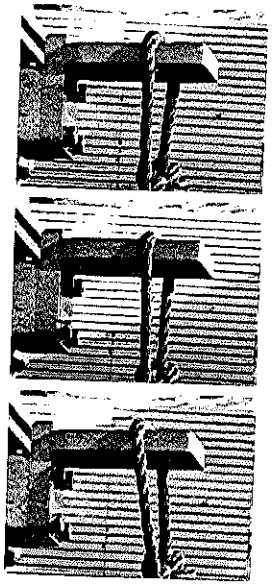
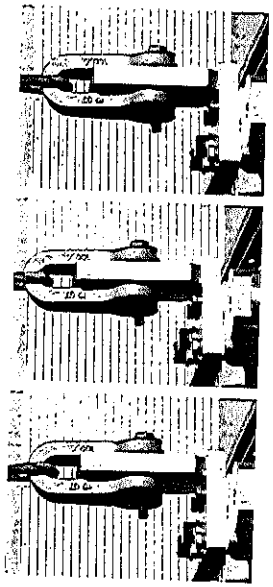


Phot. 9. Vertical load of terminal P1

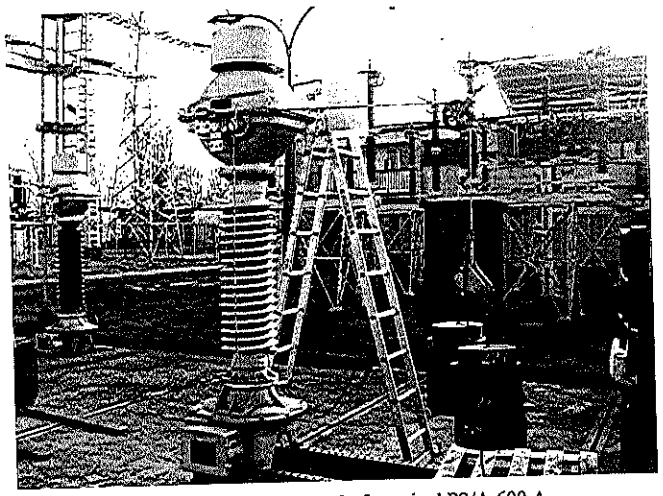


Phot. 10 - 12. Terminal P1 before, during and after vertical load

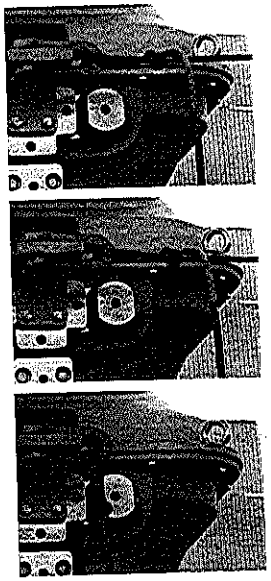
Phot. 13. Longitudinal load of terminal P2/A 600 A



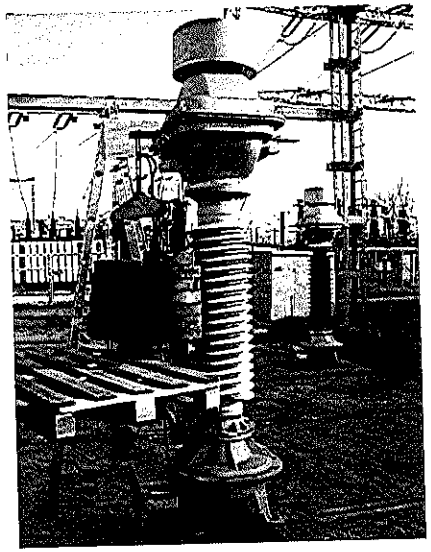
Phot. 14 - 16. Terminal P2/A 600 A before, during and after longitudinal load



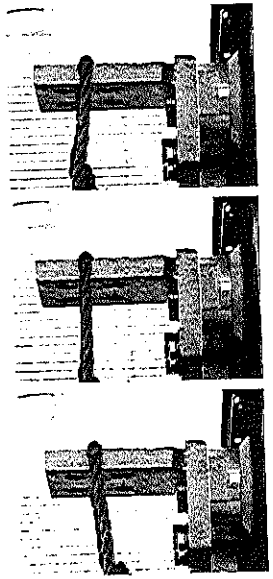
Phot. 17. Transverse load of terminal P2/A 600 A



Phot. 18 – 20. Terminal P2/A 600 A before, during and after transverse load

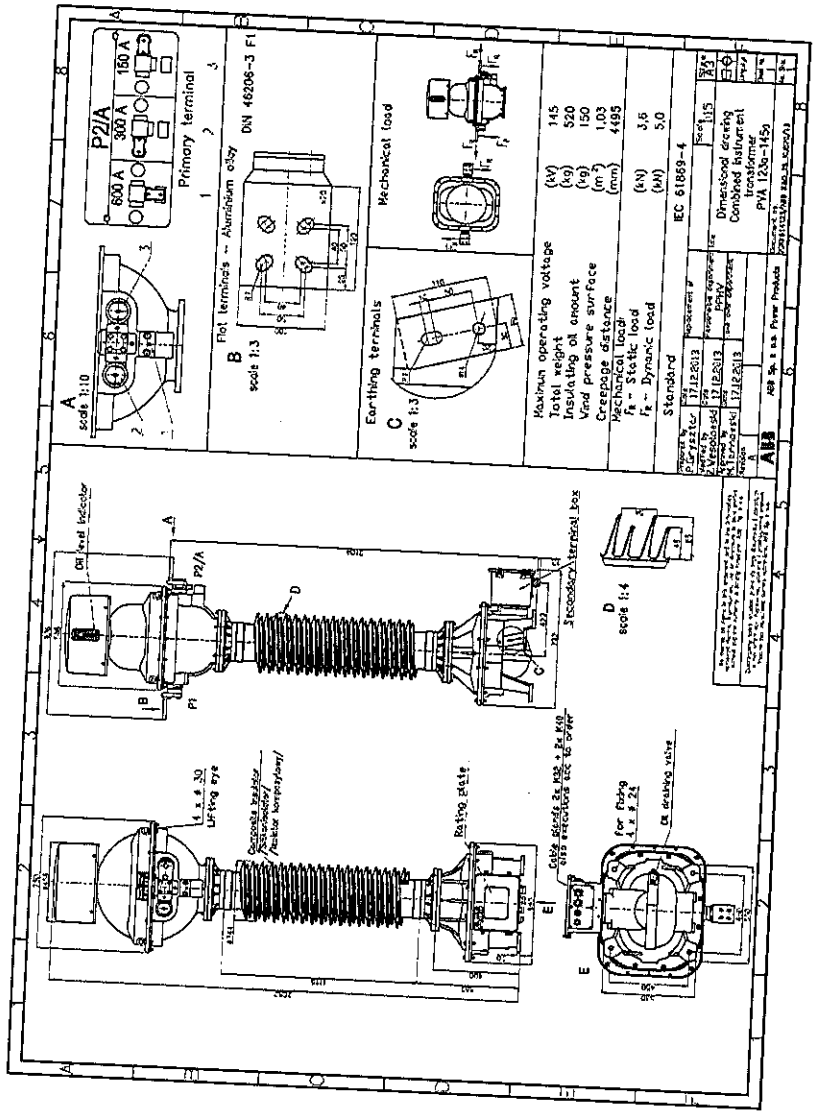


Phot. 21. Vertical load of terminal P2/A 600 A



Phot. 22 – 24. Terminal P2/A 600 A before, during and after vertical load

ANNEX 2 **Documentations delivered by orderer**



ABB

Combined Instrument Transformer

Insulation level	145/275/650kV	Standard	IEC 61869-4	Type	PVA 145a
Oil type	Nytro Libra	Weight / Oil weight	520 / 150 kg	fn	50 Hz
S/N	86142 / 13	Voltage factor	1,9Un/8h	Temp. range	-40°C — +40°C
				Ue	0,2 mV/kA

CURRENT PART

K_n 150-300-600/5-5 A/A

I_{th}/1s 40-40-40 kA I_{dyn} 100-100-100 kA

I_{cth} 180-360-720 A

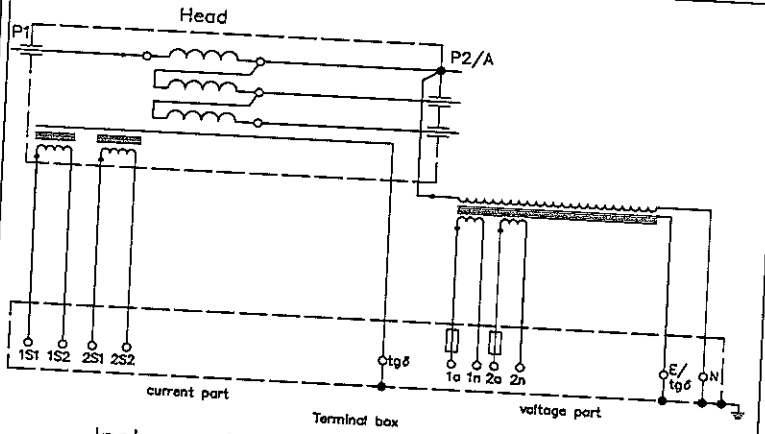
	1S1-1S2	2S1-2S2	3S1-3S2	4S1-4S2	5S1-5S2	6S1-6S2
A	5	5				
VA	30	30				
Class	5P	5P				
FS/ALF	20	20				
Ext.%						

VOLTAGE PART

A-N 132:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3			
VA	25	25			
Class	0,5	0,5/3P			
VA$_{sm}$	1000	1000			

Transportation Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!
1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ, tgδ MUST BE EARTHED

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/66/E/13-1 E

TEST OBJECT: Combined transformer type PVA 145a with porcelain insulator
Serial No. 86143/13

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: Internal order No. EWN/145/E/13 dated 12.11.2013

TYPE OF TESTS: Mechanical tests

TESTS PROCEDURE: According to IEC 61869-1:2007

DATE OF TESTS: 18.11.2013

TESTS RESULT: Positive for
F_R = 3600 N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 30.12.2013

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Contents

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1. TEST OBJECT

1.1 Description

Combined transformer type PVA 145a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 145 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with porcelain insulator immersed with transformer oil.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	145 kV
Rated frequency	50 Hz
Rated static load	3600 N

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing combined instrument transformer PVA 123a-145a, No. 2GKK614121, 17.12.2013,
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o. (Annex 2),

The laboratory proceeded the identification of test object on the base of above documentation and the rating plate.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-1:2007:
- mechanical tests acc. to item 7.4.5 of above standard for F_R = 3600 N of P1 and P2/A 300 A terminals.

During the tests deflection of the combined transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the combined transformer was fixed to the rigid construction of the test stand. Mechanical tests were performed applying the load consecutively to the transformer's P1 and P2/A 300 A terminals as shown on photographs in Annex 1.

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents table 1. The load was increased and released smoothly (30 – 90 s) and was maintained 60 s.

During the tests the following records were made:
- phot. 1 to 24 - combined transformer during mechanical tests.

(Annex 1 presents the photographs)

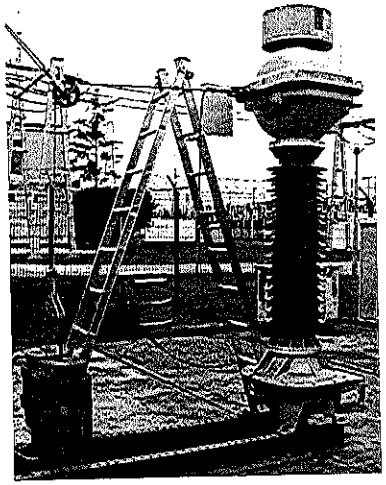
Table 1. Results of static load withstand tests at F = 3620 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	P1	longitudinal	60	During the static load deflection was about 7 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
2	P1	transverse	60	During the static load deflection was about 6 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
3	P1	vertical	60	During the static load deflection was about 3 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
4	P2/A 300 A	longitudinal	60	During the static load deflection was about 6 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
5	P2/A 300 A	transverse	60	During the static load deflection was about 6 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.
6	P2/A 300 A	vertical	60	During the static load deflection was about 2 mm. Residual deflection was about 1 mm. After tests no damage nor oil leak was stated.

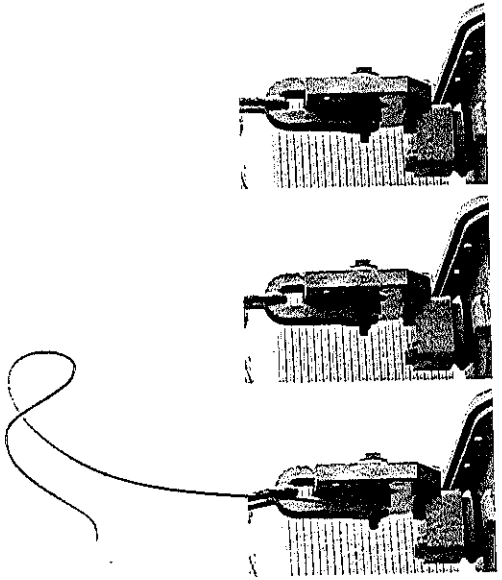
5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-1:2007 the results of tests of tested combined transformer is positive for:
- F_R = 3600 N.

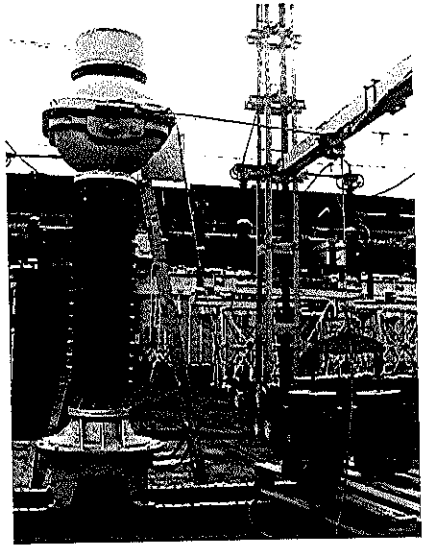
ANNEX 1 **Photographs taken during the tests**



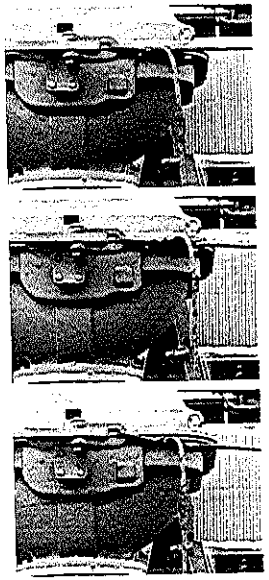
Phot. 1. Longitudinal load of terminal P1



Phot. 2 - 4. Terminal P1 before, during and after longitudinal load



Phot. 5. Transverse load of terminal P1



Phot. 6 - 8. Terminal P1 before, during and after transverse load

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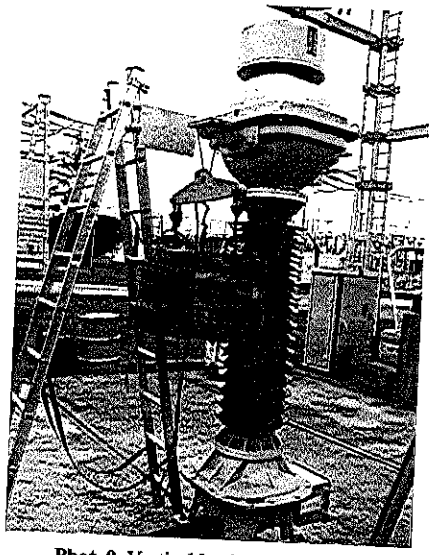
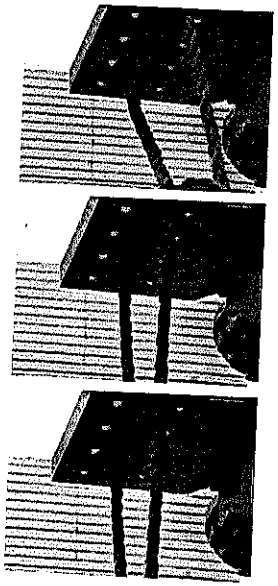
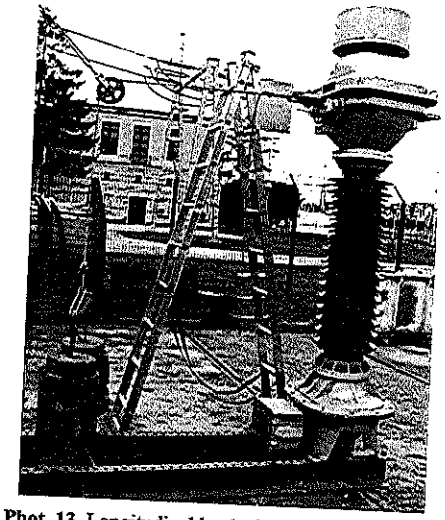


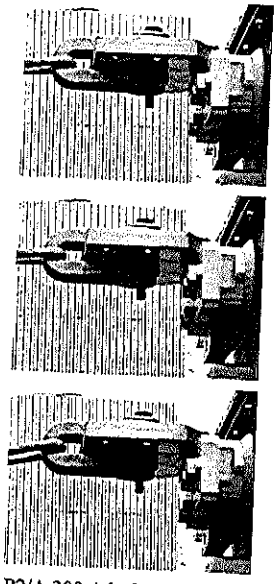
Phot. 9. Vertical load of terminal P1



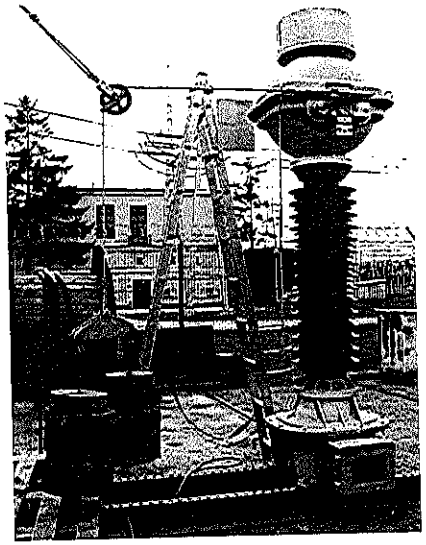
Phot. 10 - 12. Terminal P1 before, during and after vertical load



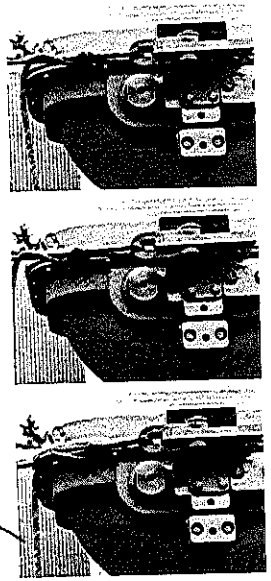
Phot. 13. Longitudinal load of terminal P2/A 300 A



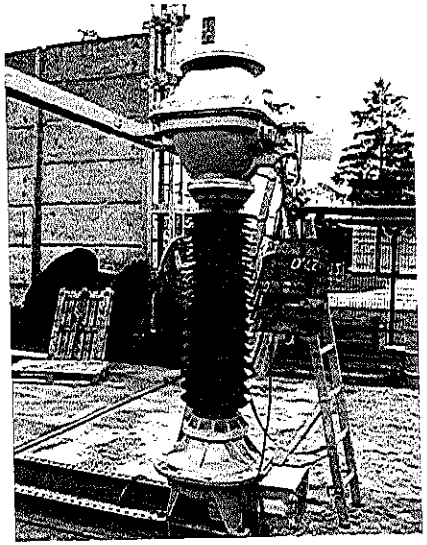
Phot. 14 - 16. Terminal P2/A 300 A before, during and after longitudinal load



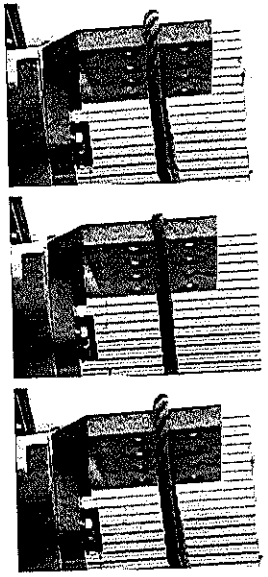
Phot. 17. Transverse load of terminal P2/A 300 A



Phot. 18 – 20. Terminal P2/A 300 A before, during and after transverse load

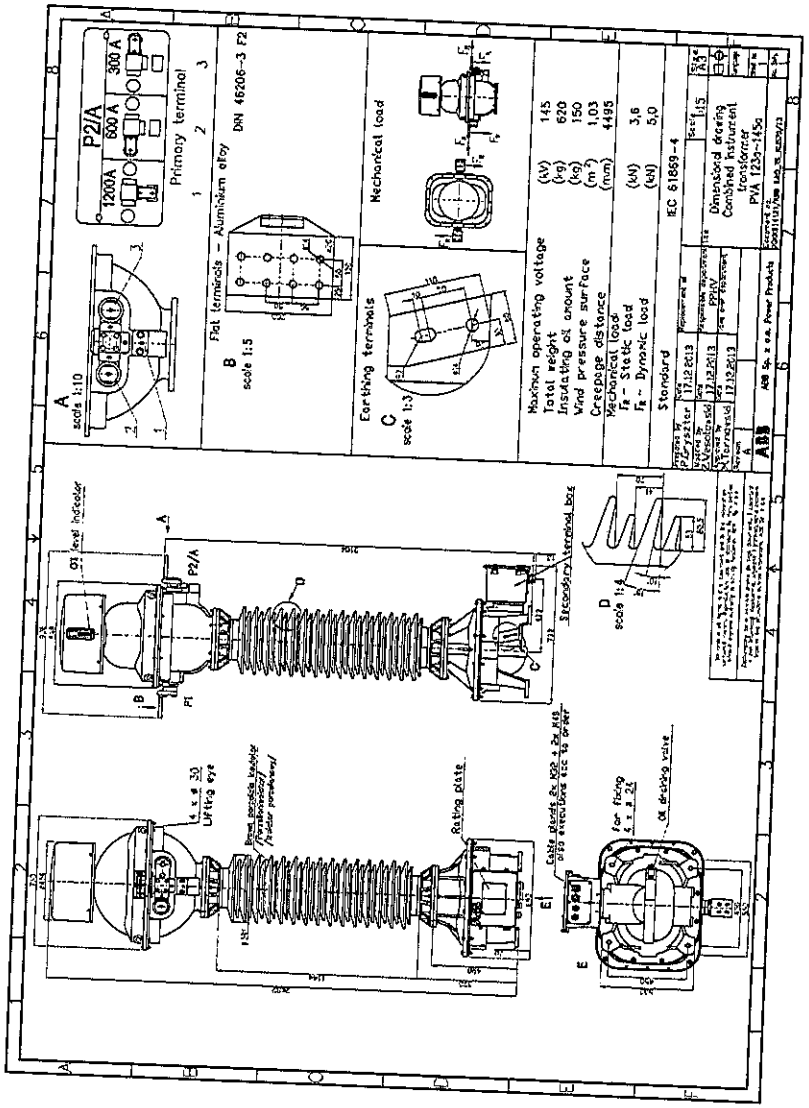


Phot. 21. Vertical load of terminal P2/A 300 A



Phot. 22 – 24. Terminal P2/A 300 A before, during and after vertical load

ANNEX 2 **Documentations delivered by orderer**



ABB

Combined Instrument Transformer

Insulation level	145/275/650 kV	Standard	IEC 61869-4	Type	PVA 145a
Oil type	Nytro Libra	Weight / Oil weight	600 / 180 kg	fn	50 Hz
S/N	86143 / 13	Voltage factor	1,9Un/8h	Temp. range	-40°C ÷ +40°C
				Ue	0,2 mV/kA

CURRENT PART

K_n 150-300-600/5-5 A/A

$I_{th}/1s$ 40-40-40 kA I_{dyn} 100-100-100 kA

I_{cth} 180-360-720 A

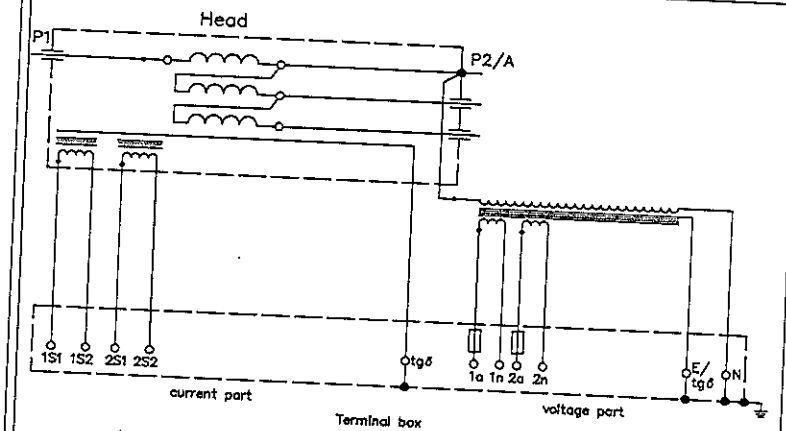
	1S1-1S2	2S1-2S2	3S1-3S2	4S1-4S2	5S1-5S2	6S1-6S2
A	5	5				
VA	30	30				
Class	5P	5P				
FS/ALF	20	20				
Ext.%						

VOLTAGE PART

A-N 132:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3			
VA	25	25			
Class	0,5	0,5/3P			
VA_{sth}	1000	1000			

Transportation Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!
1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ, tgδ MUST BE EARTHED

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/71/E/13-3 E

TEST OBJECT: Combined instrument transformer type PVA 123a with composite insulator
Serial No. 2GKP013K1486138

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: Internal order No. EWN/145/E/13 dated 12.12.2013

TYPE OF TESTS: Short-time current tests
Test for composite error
Short-circuit withstand capability test

TESTS PROCEDURE: According to IEC 61869-2:2012 and IEC 61869-3:2011

DATE OF TESTS: 16/17.12.2013

TESTS RESULT: Positive for
I_{dyn} = 158 kA, I_{th} = 63 kA, t = 1 s for 100 A terminal
I_{dyn} = 100 kA, I_{th} = 40 kA, t = 1 s for 50 A terminal
63,5 kV at short-circuit in secondary circuits of VT

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: M. Tarnowski, Z. Wesołowski – ABB Sp. z o.o.

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 29.01.2014

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1. TEST OBJECT

1.1 Description

Combined instrument transformer type PVA 123a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 126 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with composite insulator immersed with transformer oil.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	126 kV		
Rated frequency	50 Hz		
Terminal	50 A	100 A	200 A
Rated continuous thermal current	100 A	200 A	400 A
Rated short-time current for 1 s	40 kA	63 kA	63 kA
Rated dynamic current	100 kA	158 kA	158 kA

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing combined transformer PVA 123a-145a, No. 2GKK614122 (17.12.2013),
- routine tests report of combined instrument transformer (12.11.2013),
- routine tests report of combined instrument transformer after short-time current test (24.01.2013),
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o (Annex 3 and 4).
The laboratory proceeded the identification of test object on the base of above documentation and the rating plate. Conformity of manufacturing with constructional documentation is stated in manufacturer's declaration, copy of which presents Annex 4.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-2:2012 and IEC 61869-3:2011:

- short-time current tests of current transformer acc. to item 7.2.201 of above standard at parameters:
  $I_{dyn} \geq 158$ kA, $I_{th} = 63$ kA, $t_{th} = 1$ s, $I_{th}^2 \times t_{th} \geq 3969$ kA^2×s for 100 A terminal.
  $I_{dyn} \geq 100$ kA, $I_{th} = 40$ kA, $t_{th} = 1$ s, $I_{th}^2 \times t_{th} \geq 1600$ kA^2×s for 50 A terminal.
- test for composite error acc. to item 7.2.6.203 of above standard with current's transformer burden of about 2,5 Ω connected to 4S1-4S2 windings at parameters:
  $4{,}4 > I_{th} \geq 4$ kA, $t_{th} = 1$ s for 50 A terminal,
- short-circuit withstand capability test acc. to item 7.2.301 of above standards at parameters:
  $U_p \geq 63{,}5$ kV, $t_p = 1$ s.
- routine test before and after short-time current test made in factory.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests and test for composite error were made in one-phase circuit presented on fig. 1 at dimensions presented on fig.2. Short-circuit withstand capability test were made in one phase circuit presented on fig. 3.
The following quantities were recorded during short-time current tests and test for composite error using digital recorder type HIOKI 8842:
- primary current (with short-circuited all secondary terminals) during short-time current tests using laboratory current transformer type CdC class 0,5 with a ratio 50.000/2 A/A (uncertainty of measurement ±0,018% for k = 2),
- secondary currents in -1S2, 3S1-3S2 and 4S1-4S2 windings by means of laboratory toroidal current transformers type IL20a class 0,5 with a ratio 1.000/5 A/A, 2.000/5 A/A and 5.000/5 A/A (uncertainty of measurement ±0,012% for k = 2),.
- voltage drop (U_0) on test object during short-time current tests by means of a resistance-capacitance voltage divider with a bandwidth from 0 to 100 kHz.

The following quantities were recorded during short-circuit withstand capability tests using digital recorder type HIOKI 8842:
- primary voltage and current, secondary current in short-circuited windings: 1a-1n (next 4a-4n and da-dn) during short-circuit withstand capability tests of voltage transformer using:
  - inductive voltage transformer type U110a class 0,5 with a ratio 110/√3/0,1/√3 kV/kV for primary voltage measurement,
  - laboratory current transformer type GE 4461 class 0,2 with a ratio 5/5 A/A for primary current measurement (uncertainty of measurement ±0,013% for k = 2),
  - laboratory current transformer type IL 20a class 0,5 with a ratio 2.000/5 A/A for secondary currents measurements (uncertainty of measurement ±0,012% for k = 2).

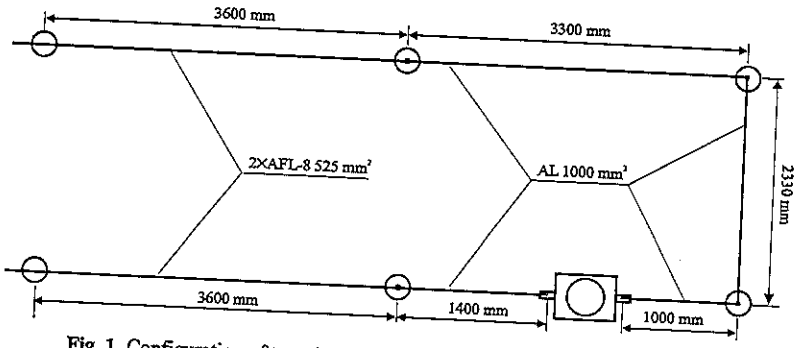
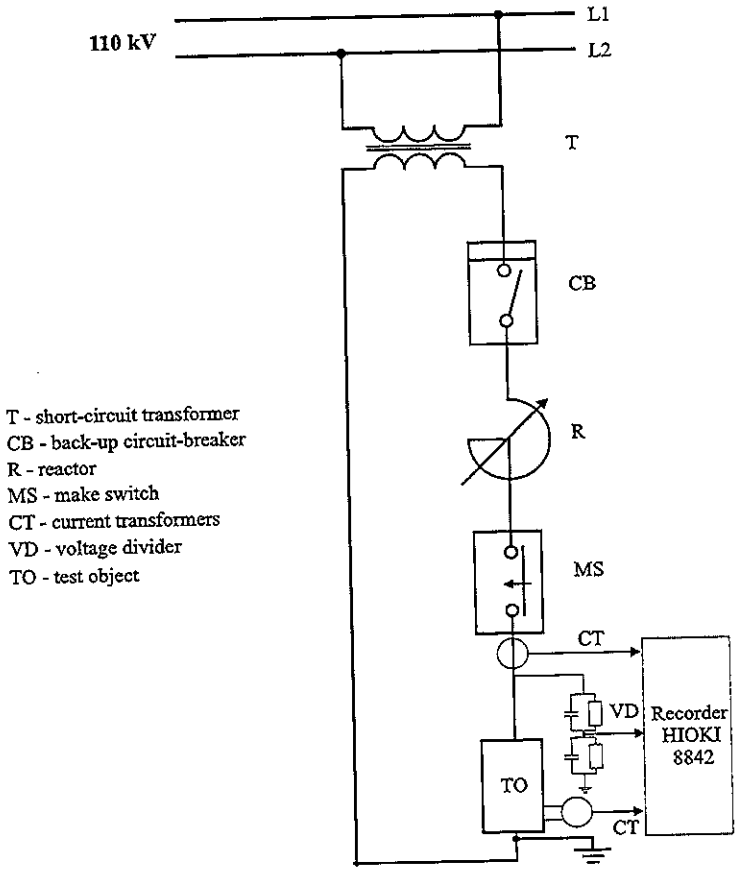
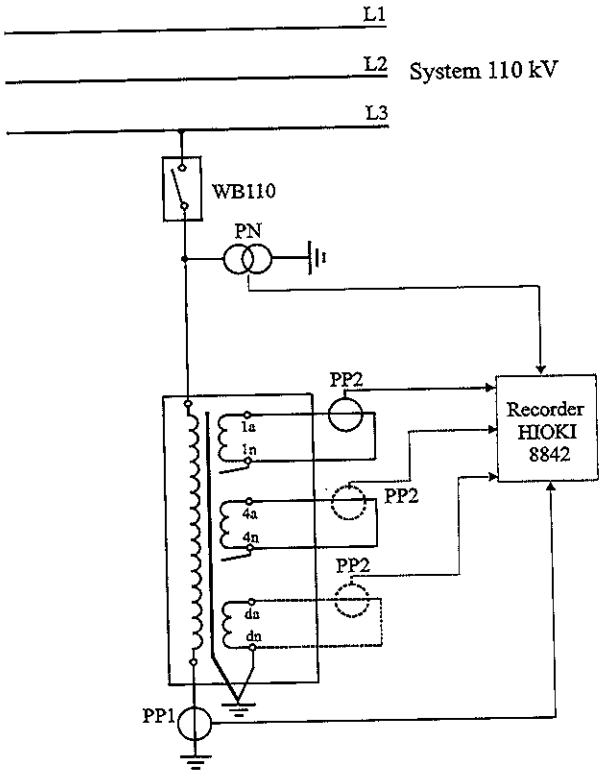


Fig. 1. Configuration of test circuit during tests during short-time current tests



T - short-circuit transformer
CB - back-up circuit-breaker
R - reactor
MS - make switch
CT - current transformers
VD - voltage divider
TO - test object

Fig. 2. Test and measuring circuits during short-time current tests



WB110 - back-up circuit-breaker
PN - voltage transformer
PP1, PP2 - current transformers

Fig. 3. Test and measuring circuits during short-circuit withstand capability tests

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4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents tables 1, 2 and 3.
During the tests the following records were made:
- Nos. 33089, 33090, 33092, 33093 – short-time current tests,
- No. 33095 – composite error test,
- No. 33096, 33097, 33098 – short-circuit withstand capability test,
  (Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory's archives),
- phot. 1, 2 – current transformer on the tests stand
  (Annex 2 presents the photograph).

Table 1. Results of short-time current tests

Test No.	i_{peak}	I_z	t_z	$I_z^2 \times t_z$	$I_{1S1-1S2}$	$I_{3S1-3S2}$	$I_{4S1-4S2}$	U_0	Observations
-	kA	kA	s	$(kA)^2 \times s$	A	A	A	V	-
33089	111,81	64,74	0,97	4066[2)]	256*	1517*	649	38	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33090	158,43[1)]	64,74	0,06	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33092	102,68[3)]	40,54	0,08	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33093	66,92	40,54	1,02	1676[4)]	269*	1556*	811	60	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
i_{peak} – peak value of test current,
I_z – r.m.s. value of test current (determined from test period without asymmetrical component),
t_z – test duration,
$I_{1S1-1S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{3S1-3S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{4S1-4S2}$ – r.m.s. value (determined from test period without asymmetrical component),
U_0 – r.m.s. value (determined from test period without asymmetrical component).
Required : [1)] $i_{peak} \geq 158$ kA,
[2)] $I_z^2 \times t_z \geq 3969\ (kA)^2 \times s$,
[3)] $i_{peak} \geq 100$ kA,
[4)] $I_z^2 \times t_z \geq 1600\ (kA)^2 \times s$.
* - waveform deformed.

During the composite error test current's transformer burden connected to 4S1-4S2 was 2,4 Ω.

Table 2. Results of composite error test for 4S1-4S2 winding

Test No.	I_p	ε_c	t_z	Observations
-	kA	%	s	-
33095	4,31	0,98	1,02	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
I_p – r.m.s. value of the test current (determined from test period without asymmetrical component),
t_z – test duration,

$$\varepsilon_c = \frac{\sqrt{\frac{1}{T}\int_0^T \left(k_r \cdot i_s - i_p\right)^2 dt}}{I_p} \cdot 100\%$$

k_r – rated transformation ratio (50/1 A/A),
i_p – instantaneous value of the primary current,
i_s – instantaneous value of the secondary current,
T – duration of one cycle.

Table 3. Results of short-circuit withstand capability tests

Test No.	Terminals	U_z	I_{PS}	I_{SS}	t_z	Observations
-	-	kV	A	A	s	-
33096	1a – 1n	65,0[1)]	0,73	804	1,00	Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.
33097	4a – 4n	65,0[1)]	0,72	796	1,00	Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.
33098	da - dn	65,0[1)]	0,42	795	1,00	Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.

Legend:
U_z - test voltage
I_{PS} - r.m.s. value of primary side test current
I_{SS} - r.m.s. value of secondary side test current
t_z - test duration
[1)] - required $U_z \geq 63,5$ kV

5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-2:2012 and IEC 61869-3:2011 the results of tests is positive for:

- $I_{dyn} = 158$ kA, $I_{th} = 63$ kA, $t = 1$ s for 100 A,
- $I_{dyn} = 100$ kA, $I_{th} = 40$ kA, $t = 1$ s for 50 A,
- 63,5 kV at short-circuit in secondary circuits of voltage transformer.

ANNEX 1 **Test records**

As not numbered pages the following copies of records are given:

33089, 33090, 33092, 33093 – short-time current tests,
33095 – composite error test,
33096, 33097, 33098 – short circuit withstand capability test.

Denotations:

i – test current,

u_0 – voltage drop on test object,

$i_{1S1\text{-}1S2}$ – 1S1-1S2 winding current,

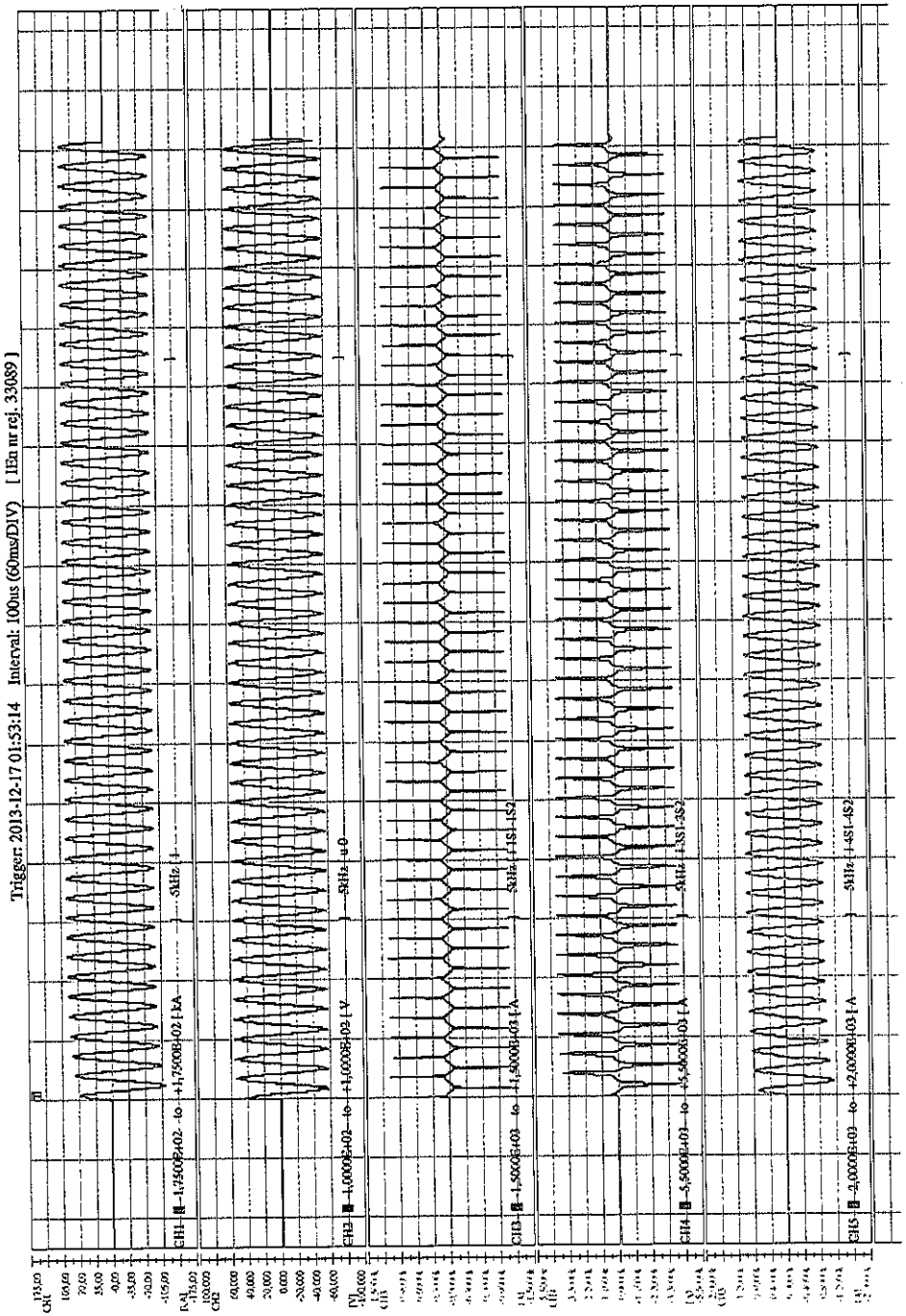
$i_{3S1\text{-}3S2}$ – 3S1-3S2 winding current,

$i_{4S1\text{-}4S2}$ – 4S1-4S2 winding current.

u_z –test voltage during voltage transformer tests,

i_N – test current on primary side of VT,

$i_{1a\text{-}1n}$, $i_{4a\text{-}4n}$, $i_{da\text{-}dn}$ – test current on secondary side of VT.



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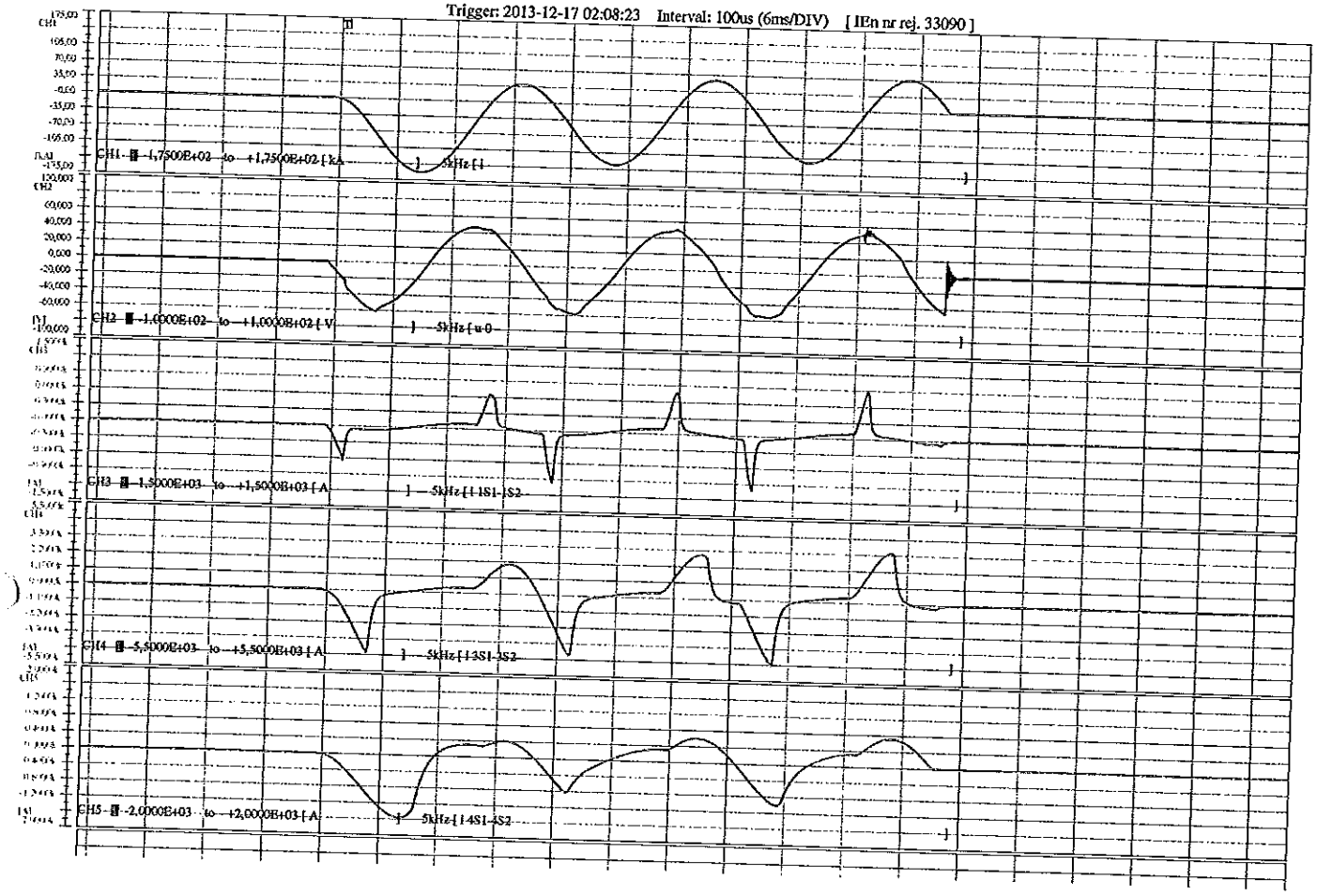
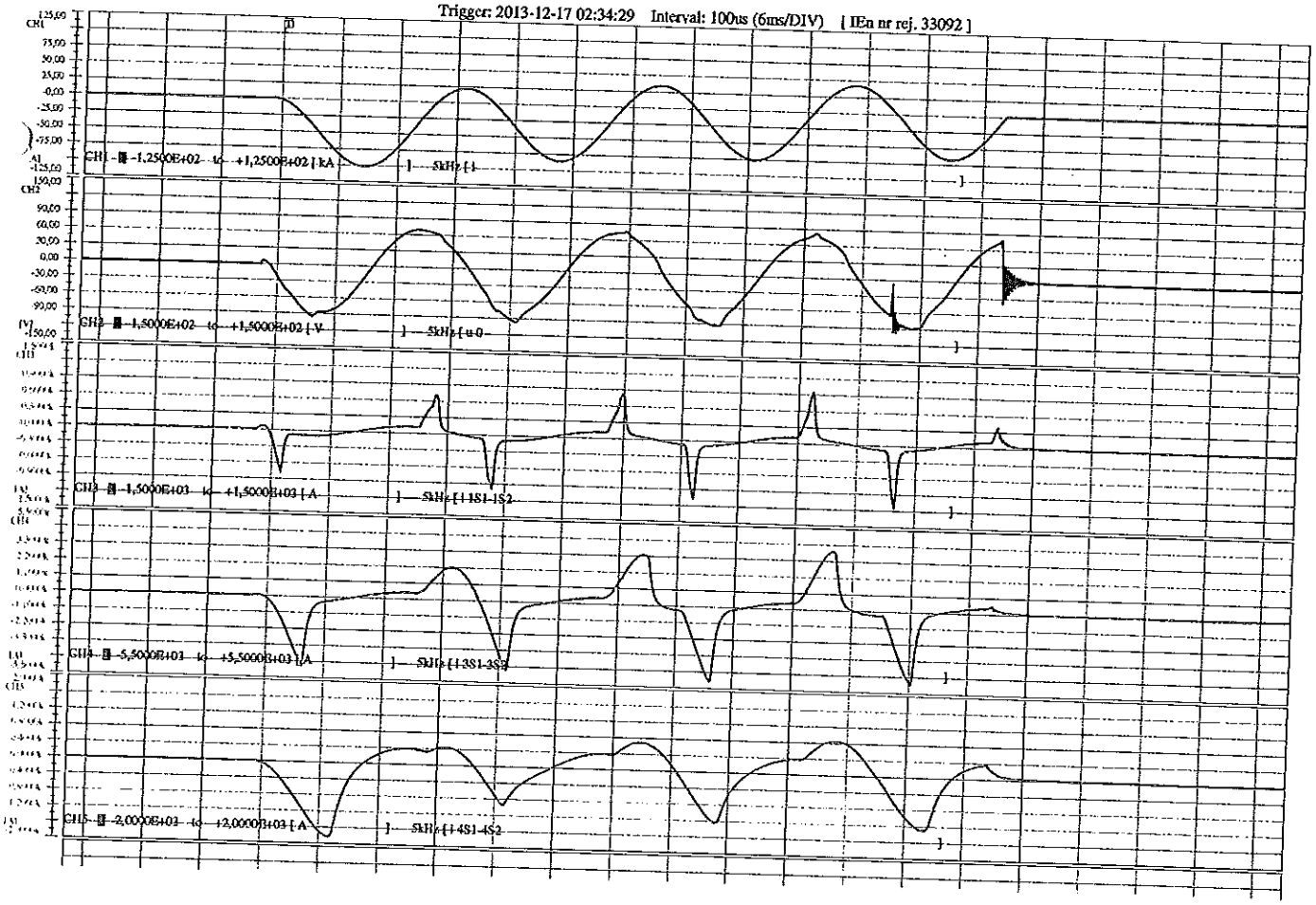
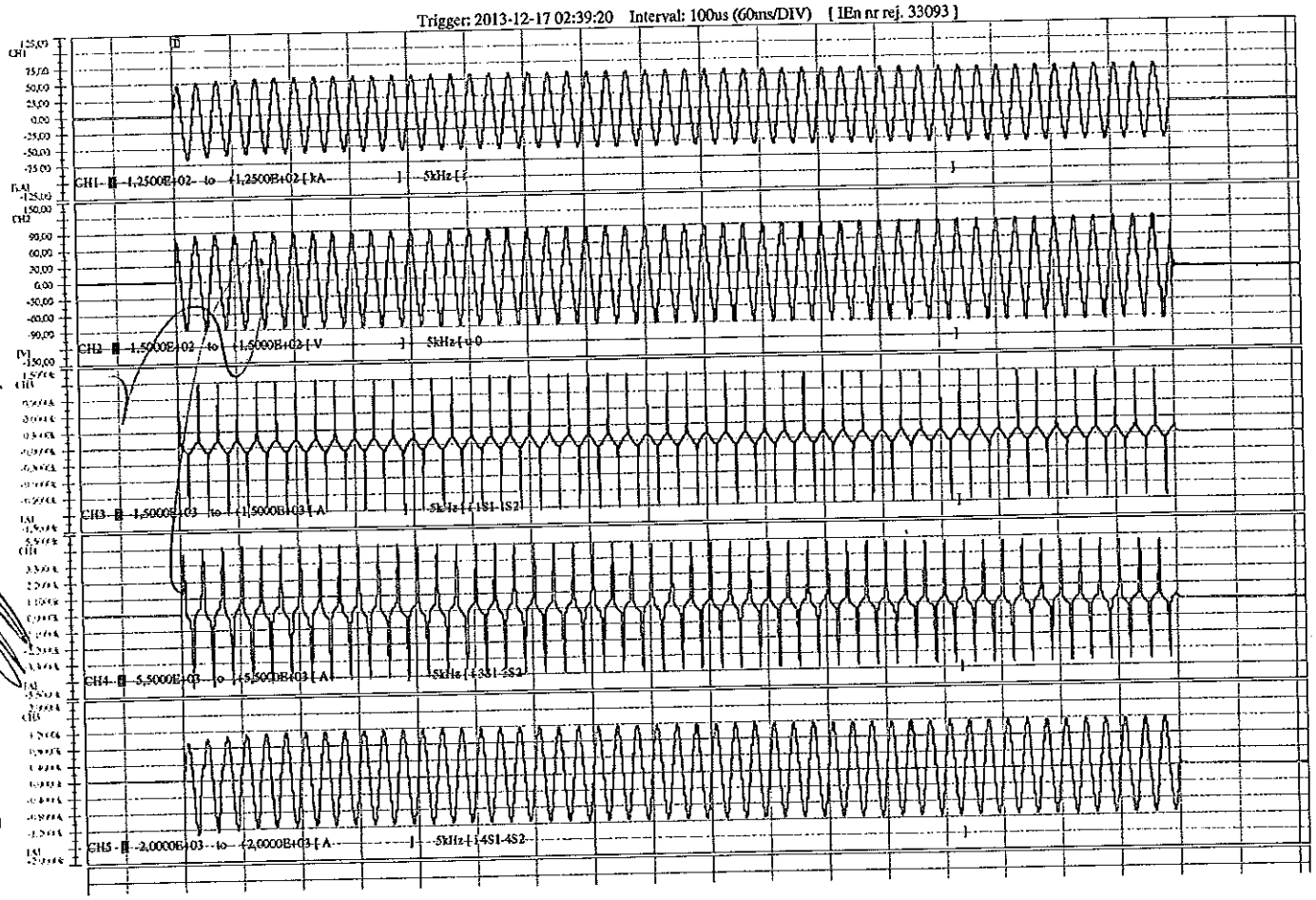
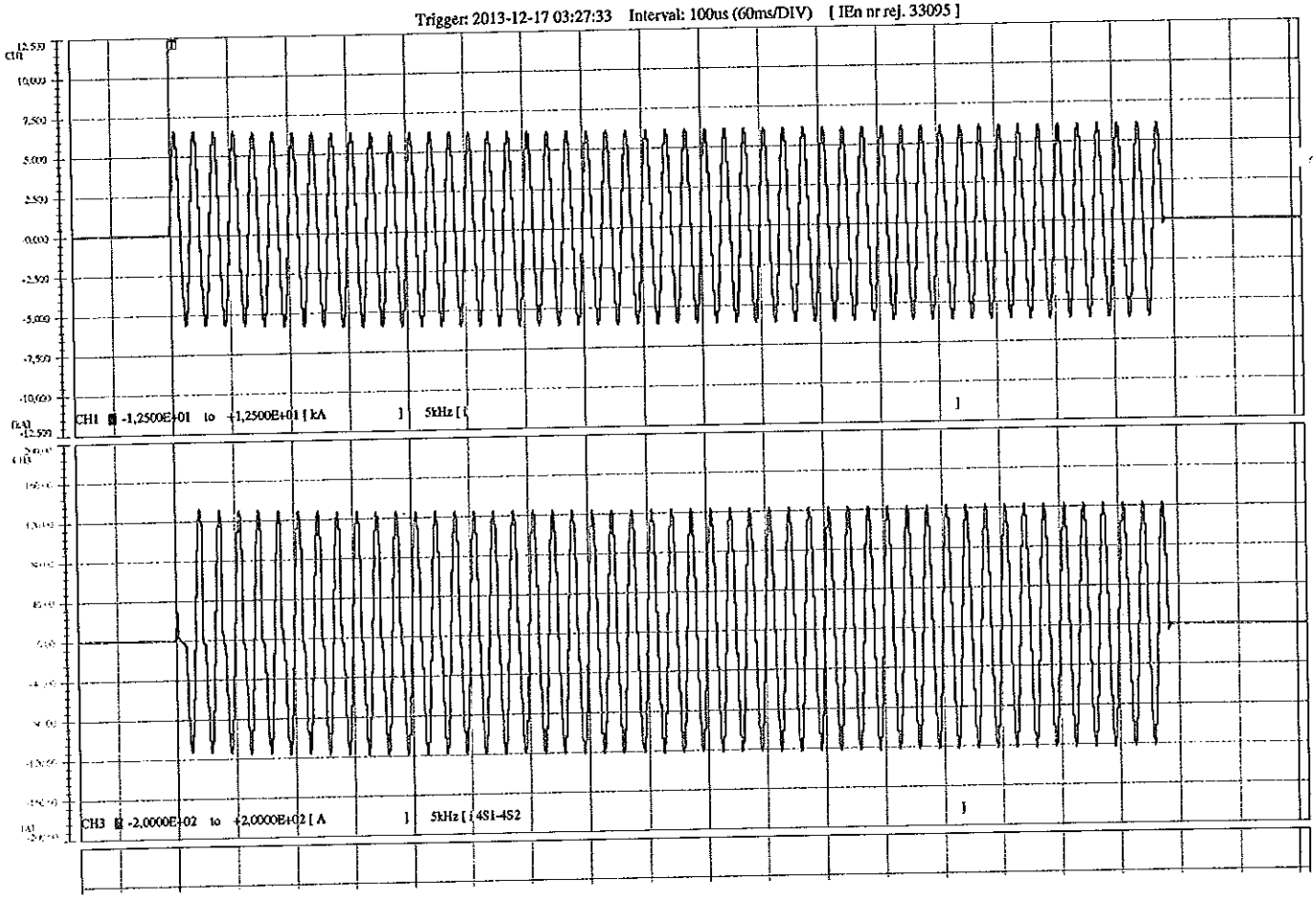
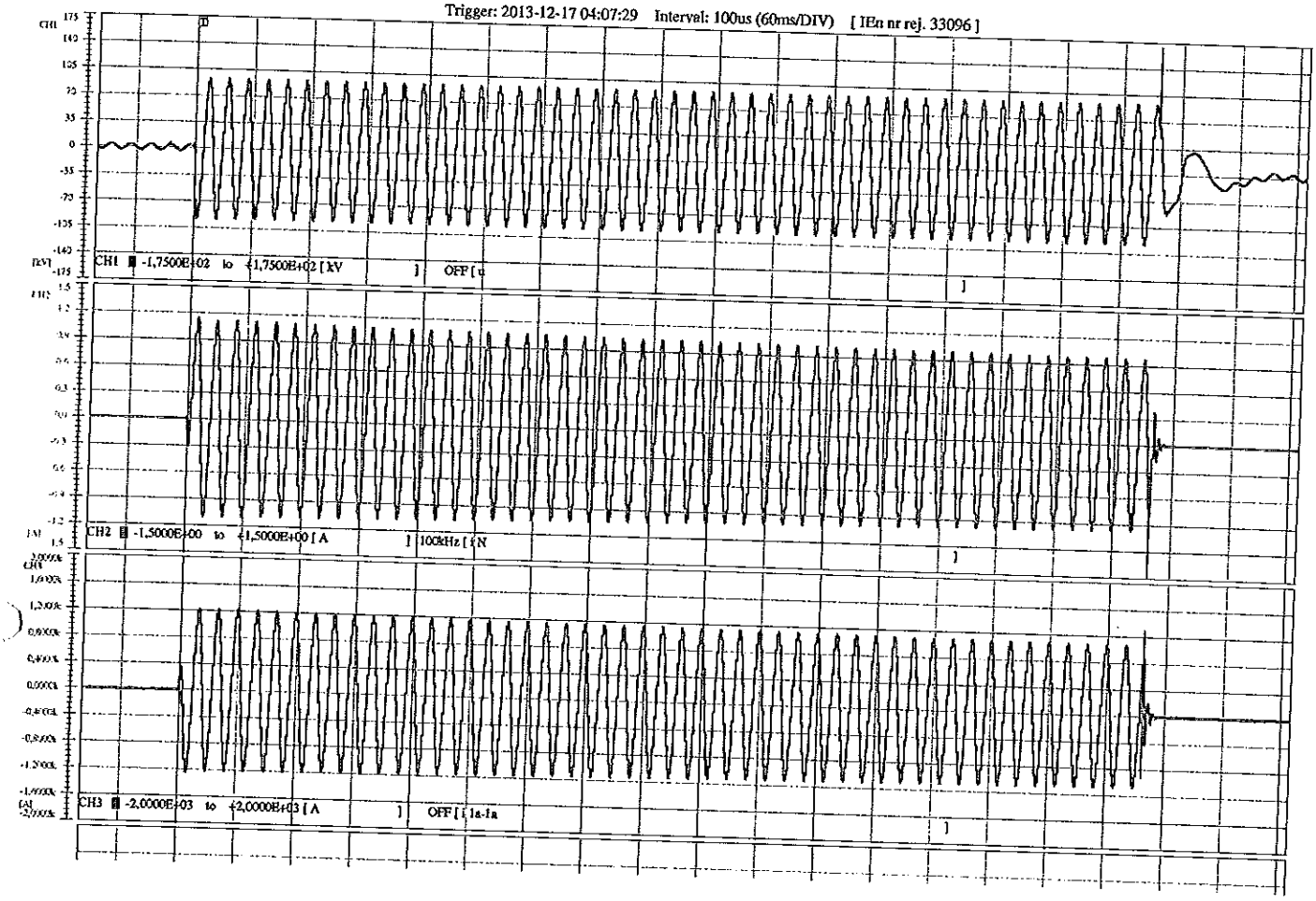
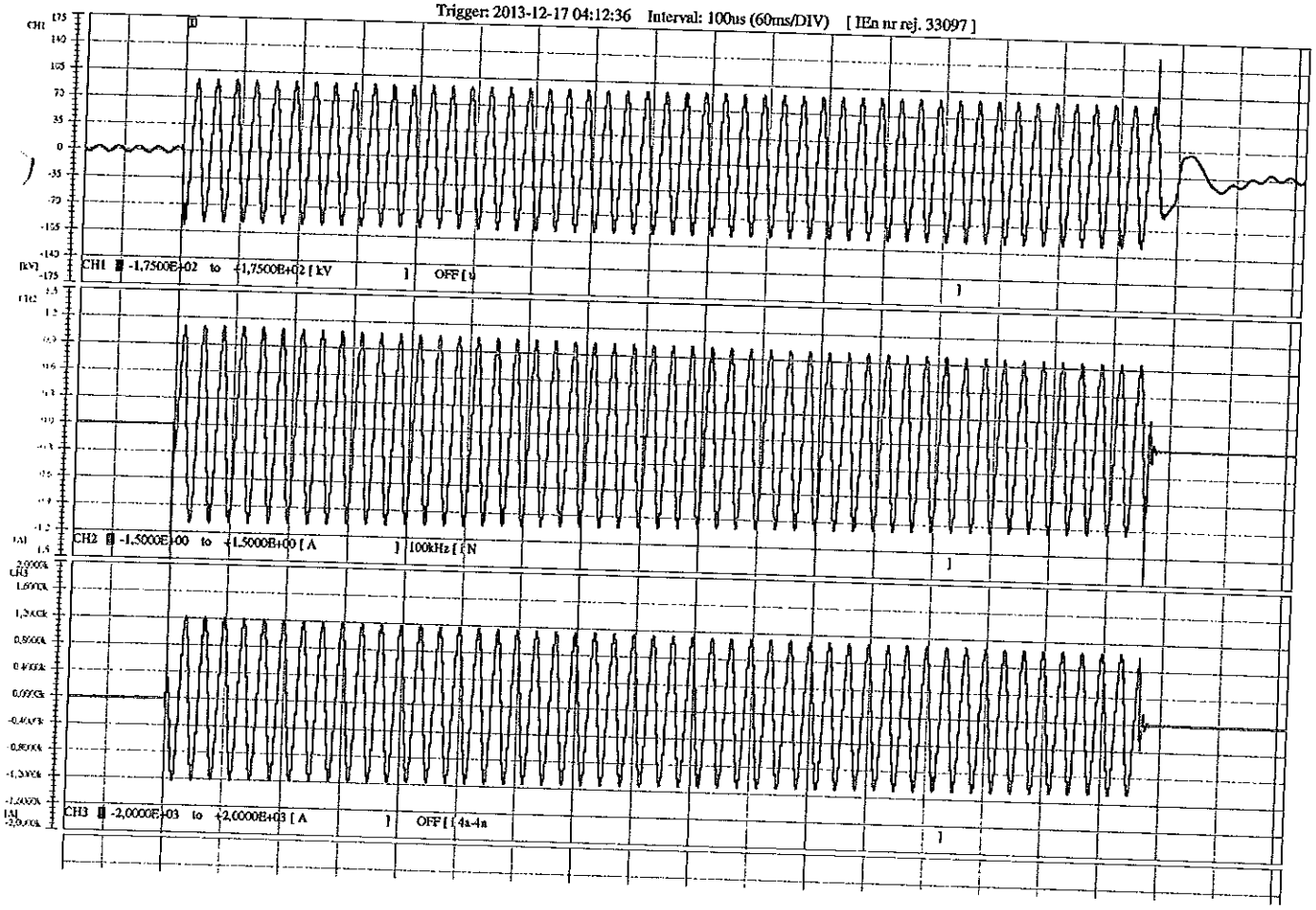

Trigger: 2013-12-17 02:08:23 Interval: 100us (6ms/DIV) [IEn nr rej. 33090]
CH1 -1,7500E+02 to +1,7500E+02 [kA 5kHz [I
CH2 -1,0000E+02 to +1,0000E+02 [V 5kHz [u 0
CH3 -1,5000E+03 to +1,5000E+03 [A 5kHz [I 1S1-1S2
CH4 -5,5000E+03 to +5,5000E+03 [A 5kHz [I 3S1-3S2
CH5 -2,0000E+03 to +2,0000E+03 [A 5kHz [I 4S1-4S2

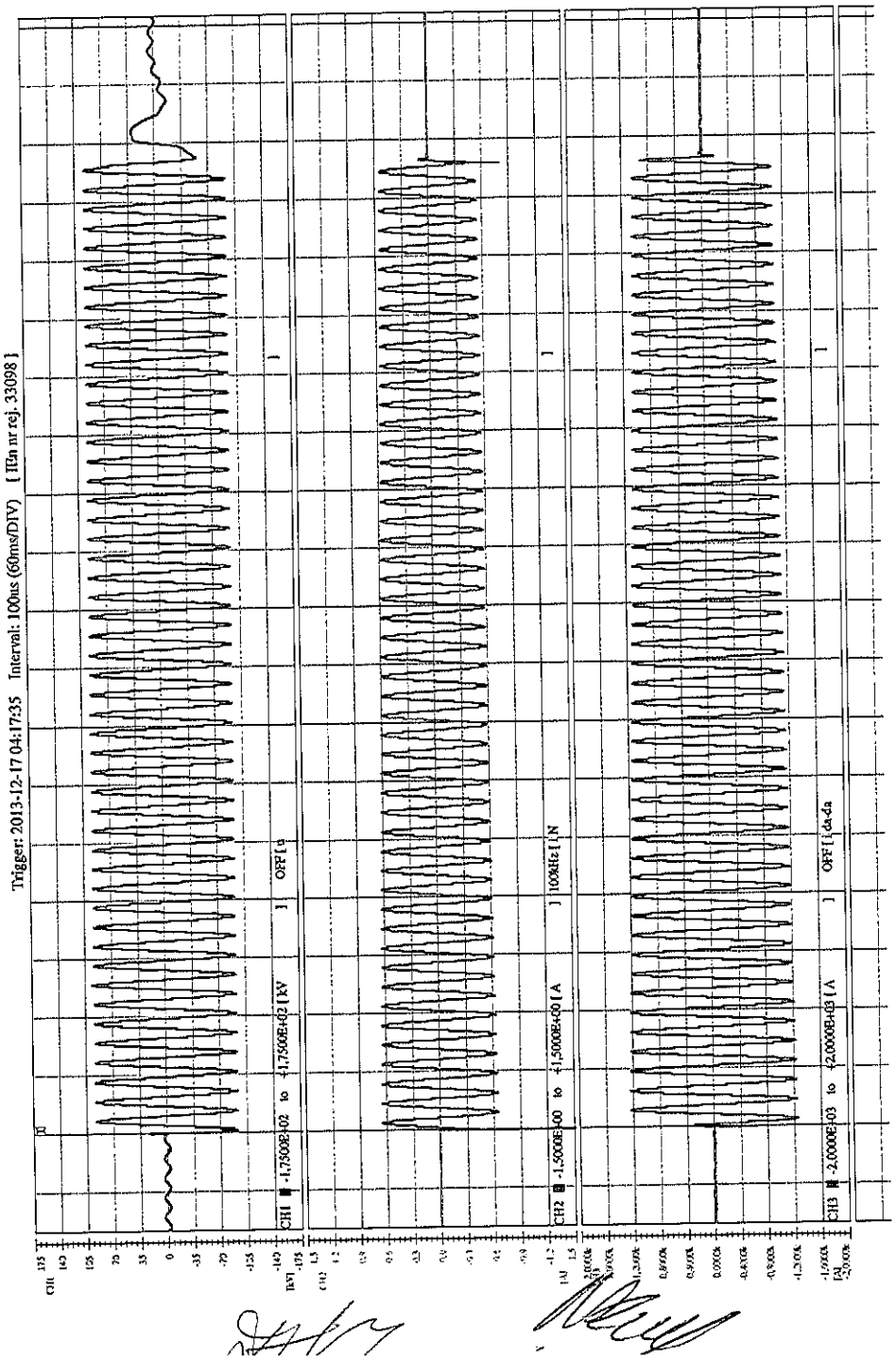

Trigger: 2013-12-17 02:34:29 Interval: 100us (6ms/DIV) [IEn nr rej. 33092]
CH1 -1,2500E+02 to +1,2500E+02 [kA 5kHz [I
CH2 -1,5000E+02 to +1,5000E+02 [V 5kHz [u 0
CH3 -1,5000E+03 to +1,5000E+03 [A 5kHz [I 1S1-1S2
CH4 -5,5000E+03 to +5,5000E+03 [A 5kHz [I 3S1-3S2
CH5 -2,0000E+03 to +2,0000E+03 [A 5kHz [I 4S1-4S2


Trigger: 2013-12-17 02:39:20 Interval: 100us (60ms/DIV) [IEn nr rej. 33093]
CH1 -1,2500E+02 to +1,2500E+02 [kA] 5kHz [
CH2 -1,5000E+02 to +1,5000E+02 [V] 5kHz [0
CH3 -1,5000E-03 to +1,5000E+03 [A] 5kHz [1S1-1S2
CH4 -5,5000E-03 to +5,5000E+03 [A] 5kHz [3S1-3S2
CH5 -2,0000E+03 to +2,0000E+03 [A] 5kHz [4S1-4S2

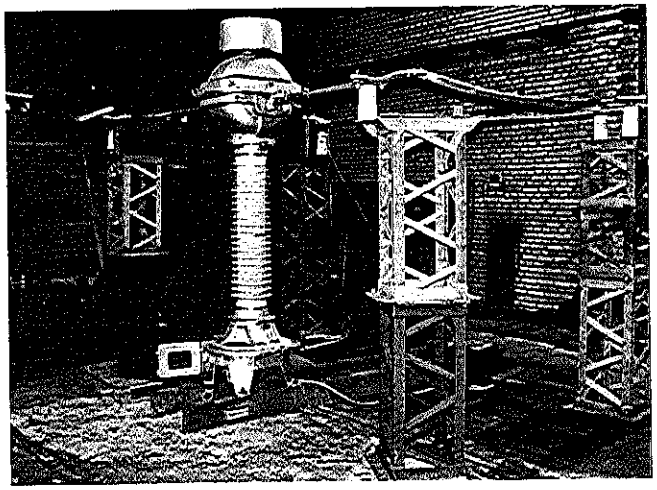

Trigger: 2013-12-17 03:27:33 Interval: 100us (60ms/DIV) [IEn nr rej. 33095]
CH1 -1,2500E+01 to +1,2500E+01 [kA] 5kHz [
CH3 -2,0000E+02 to +2,0000E+02 [A] 5kHz [4S1-4S2


Trigger: 2013-12-17 04:07:29 Interval: 100us (60ms/DIV) [IEn nr rej. 33096]
CH1 -1,7500E+02 to +1,7500E+02 [kV] OFF [u
CH2 -1,5000E+00 to +1,5000E+00 [A] 100kHz [N
CH3 -2,0000E+03 to +2,0000E+03 [A] OFF [Ia-In

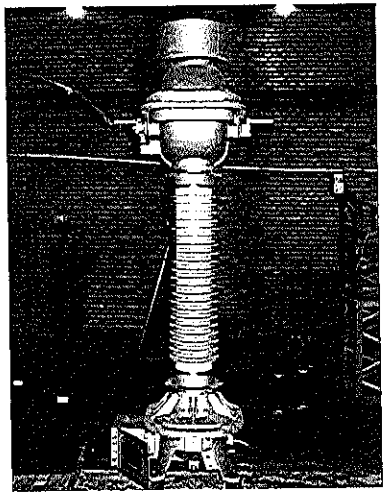

Trigger: 2013-12-17 04:12:36 Interval: 100us (60ms/DIV) [IEn nr rej. 33097]
CH1 -1,7500E+02 to +1,7500E+02 [kV] OFF [u
CH2 -1,5000E+00 to +1,5000E+00 [A] 100kHz [N
CH3 -2,0000E+03 to +2,0000E+03 [A] OFF [Ia-In



ANNEX 2 **Photographs taken during the tests**



Phot. 1. PVA 123a after short-time current tests



Phot. 2. PVA 123a after short circuit withstand capability test.

ANNEX 3 Routine test report before and after short-time current tests

ABB Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer			TYP: PVA123a Nr fabr. 2GKP013K1486138	
A – N 110:√3 kV	Insulation level: 126/230/550 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA] 40-40-40	Idyn [kA] 100-100-100	Icth [A]: 180-360-720	IEC 61869-4 50 Hz

VOLTAGE PART	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
	1a-1n	0,1:√3	25	0,1	1000
		0,1:√3	25	3,0	1000
	2a-2n	0,1:√3	25	0,1	1000
		0,1:√3	25	3,0	1000
	3a-3n	0,1:√3	25	0,1/3P	1000
		0,1:√3	500	3/3P	1000
	4a-4n	0,1:√3	25	0,1/3P	1000
		0,1:√3	25	3/3P	1000
	da-dn	0,1: 3	100	1	450
		0,1: 3	300	3P	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	class	Przekładnia [A/A]
	1S1-1S2	5	1->5	0,5FS5	50-10-200/5
	2S1-2S2	1	1->2.5	0,5FS10	50-10-200/1
	3S1-3S2	5	10	5P 10	50-10-200/5
	4S1-4S2	1	2.5	5P80	50-10-200/1
		1		PX Ek=190V Ie-<=0,1A/95 V Rct<=0,3Ω Rb=3,5 Ω Kx=50 4-2-1/200	50-10-200/1
		1		TPX Kssc= 13 Ktd= 14,6 cykl = 0,1s Tp= 0,05 Rct<=0,3Ω Rb=1 Ω Ratio error <=0.5%	50-10-200/1
	5S1-5S2	1	5	5P10	50-10-200/1

List of performer tests

1. Oil dielectric parameters check before filling (oil after tgδ wg IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings – P1+P2/A;Up=230 kV / 60 s,f =97 Hz; N; Up = 3 kV/ 60s, f=50 Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary – Up = 3 kV/60 s ☑
7. Inter-turn overvoltage test for current transformers– lower value (U szczyt. = 4,5 kV lub U szczyt. Przy Icth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
  Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage =77,42 kV, Relative standard deviation = 5,84%; f=50 Hz, oil temp. = 26 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	83.2
2	80.1
3	70.8
4	79.2
5	76.4
6	74.8

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)
Stress voltage 230 kV / 60 s
Frequency 97 Hz

Test voltage	1,2 Um = 151 kV	1,2 Um / √3 = 87,5 kV
Level of partial discharge	2 pC	1,5 pC

Remarks: background noise level: 1 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	0.086	400
2S1-2S2	0.307	400
3S1-3S2	0.205	400
4S1-4S2	1.41	400
5S1-5S2	0.736	400

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Uen [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,1:√3	25	0,1	1000
2a-2n	0,1:√3	25	0,1	1000
3a-3n	0,1:√3	25	0,1/3P	1000
4a-4n	0,1:√3	25	3/3P	1000
da-dn	0,1: 3	100	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.037	-0.035	-0.035	
Δφ U	2.2	2.2	2.3	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0.004	0.005	0.005	
Δφ U	2.1	2.1	2.2	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.027	-0.025	-0.025	
Δφ U	2.3	2.3	2.4	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0.013	0.014	0.015	
Δφ U	2.1	2.2	2.2	

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.171	-0.109	-0.020	-0.018	-0.017	-0.117
Δφ U	-3.0	0.2	2.4	2.5	2.5	1.1

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.128	-0.066	0.019	0.021	0.021	-0.078
Δφ U	-3.2	-0.0	2.2	2.2	2.3	0.9

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.170	-0.109	-0.024	-0.023	-0.023	-0.122
Δφ U	-2.7	0.5	2.8	2.8	2.8	1.4

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.125	-0.065	0.021	0.023	0.023	-0.077
Δφ U	-3.0	0.1	2.4	2.4	2.4	1.0

da – dn 100 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA , cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0.741	-0.739	-0.738
Δφ U	8.9	8.9	9.0

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.035	0.037	0.037
Δφ U	3.6	3.6	3.6

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.075	0.077	0.077
Δφ U	3.4	3.5	3.5

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.044	0.046	0.047
Δφ U	3.7	3.7	3.8

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.084	0.086	0.086
Δφ U	3.5	3.5	3.6

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.094	-0.037	0.050	0.052	0.053	-0.046
Δφ U	-1.4	1.7	3.7	3.8	3.8	2.5

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.054	0.003	0.060	0.062	0.092	-0.007
Δφ U	-1.6	1.4	3.6	3.6	3.6	2.3

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.101	-0.041	0.045	0.047	0.047	-0.052
Δφ U	-1.2	1.9	4.0	4.0	4.1	2.7

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.054	0.002	0.090	0.092	0.092	-0.007
Δφ U	-1.4	1.5	3.6	3.6	3.7	2.4

da – dn 25 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA ,

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0.304	-0.302	-0.302
Δφ U	5.2	5.2	5.3

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Uen [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,1:√3	25	3,0	1000
2a-2n	0,1:√3	25	3,0	1000
3a-3n	0,1:√3	500	3/3P	1000
4a-4n	0,1:√3	25	3/3P	1000
da-dn	0,1: 3	300	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.517	-0.515	-0.516	
Δφ U	-7.1	-7.1	-7.0	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.476	-0.476	-0.475	
Δφ U	-7.2	-7.2	-7.1	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.511	-0.509	-0.509	
Δφ U	-7.1	-7.1	-7.0	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.470	-0.470	-0.469	
Δφ U	-7.3	-7.3	-7.2	

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1.151	-1.089	-0.996	-0.995	-0.993	-1.245
Δφ U	1.9	4.9	7.2	7.3	7.3	2.7

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.383	-0.318	-0.230	-0.228	-0.227	-0.478
Δφ U	-1.9	1.2	3.5	3.5	3.6	-1.1

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.595	-0.537	-0.448	-0.445	-0.443	-0.699
Δφ U	-10.7	-7.5	-5.1	-5.1	-5.1	-9.7

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.265	-0.203	-0.113	-0.112	-0.11	-0.367
Δφ U	-4.5	-1.2	1.1	1.1	1.1	-3.6

da – dn 300 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA , cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-1.229	-1.172	-1.072	-1.089
Δφ U	-5.8	-2.4	0.7	0.9

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.035	0.037	0.037
Δφ U	3.6	3.6	3.6

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.075	0.077	0.077
Δφ U	3.5	3.5	3.5

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.045	0.046	0.047
Δφ U	3.7	3.7	3.8

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.084	0.086	0.086
Δφ U	3.5	3.5	3.6

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1.080	-1.019	-0.926	-0.924	-0.924	-1.175
Δφ U	3.3	6.3	8.5	8.5	8.7	4.1

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.305	-0.247	-0.158	-0.156	-0.155	-0.407
Δφ U	-0.5	2.7	4.8	4.8	4.9	0.3

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.097	-0.040	0.047	0.049	-0.049	-0.205
Δφ U	-1.2	1.9	4.0	4.0	4.1	-0.6

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.053	0.007	0.091	0.093	0.094	-0.161
Δφ U	-1.5	1.5	3.6	3.7	3.7	-0.9

da – dn 75 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA ,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0.731	-0.868	-0.572	-0.584
Δφ U	4.5	7.7	9.8	10.2

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

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Determination of current part errors (ε I %), (Δφ I min).

Ipn (A): 50

	1S1-1S2 5 VA; cosφ = 0,8				1S1-1S2 1 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.432	-0.235	-0.018	0.127	0.264	0.299	0.314	0.328
Δφ I	19.5	7.5	-1.0	-3.1	15.8	8.9	4.9	3.4
	2S1-2S2 2.5 VA; cosφ = 1				2S1-2S2 1 VA; cosφ = 1			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	0.024	-0.011	0.132	0.194	0.252	0.251	0.283	0.316
Δφ I	33.2	23.1	7.4	4.3	19.3	11.6	5.5	4.6

3S1-3S2	
	1,0 In
ε I	0.896
Δφ I	8.3

4S1-4S2	
	1,0 In
ε I	-0.394
Δφ I	14.4

5S1-5S2	
	1,0 In
ε I	0.709
Δφ I	15.4

Ipn (A): 100

	1S1-1S2 5 VA; cosφ = 0,8				1S1-1S2 1 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.393	-0.277	0.007	0.132	0.294	0.303	0.314	0.329
Δφ I	17.7	9.3	-0.4	-3.3	13.3	8.9	4.9	3.3
	2S1-2S2 2.5 VA; cosφ = 1				2S1-2S2 1 VA; cosφ = 1			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	0.025	0.013	0.136	0.194	0.249	0.244	0.277	0.315
Δφ I	33.1	20.8	6.4	5.2	19.0	12.4	5.7	4.1

3S1-3S2	
	1,0 In
ε I	0.880
Δφ I	8.4

4S1-4S2	
	1,0 In
ε I	-0.402
Δφ I	14.7

6S1-6S2	
	1,0 In
ε I	0.711
Δφ I	15.1

Ipn (A): 200

	1S1-1S2 5 VA; cosφ = 0,8				1S1-1S2 1 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.581	-0.280	0.010	0.013	0.084	0.282	0.305	0.270
Δφ I	27.7	9.6	-0.7	0.2	25.8	11.2	5.2	7.5
	2S1-2S2 2.5 VA; cosφ = 1				2S1-2S2 1 VA; cosφ = 1			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	0.002	-0.002	0.132	0.192	0.237	0.257	0.281	0.313
Δφ I	36.4	22.8	6.8	4.8	20.7	11.8	5.6	4.6

3S1-3S2	
	1,0 In
ε I	0.880
Δφ I	8.9

4S1-4S2	
	1,0 In
ε I	-0.393
Δφ I	14.4

5S1-5S2	
	1,0 In
ε I	0.705
Δφ I	15.4

Current part: Measurements uncertainty: **ε I = ±0,045 %, Δφ I = ±2,3 min**
Voltage part: Measurements uncertainty: **ε U = ±0,044 %, Δφ U = ±2,2 min**

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E FS [V]	Condition	Assessment
1S1-1S2	2.5	4.32	6.22	$U < E_{FS}$	☑
2S1-2S2	1	9.63	31.35	$U < E_{FS}$	☑

- granicznego dokładności (ALF) – próba błędu złożonego ε_c rdzeni zabezpieczeniowych

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Condition	Assessment
3S1-3S2	21.18	1.176	2.35	ε_c < 5%	☑
4S1-4S2	220.64	0.124	0.16	ε_c < 5%	☑
5S1-5S2	53.08	0.129	1.29	ε_c < 5%	☑

Determination of parameters of class PX core 4S1-4S2:

Ipn (A)	50	100	200
Factor Kx	53.85	54.87	54.87
Turns ratio error [%]	-0.009	-0.003	0.002

Determination of parameters of class TPX core 4S1-4S2:

Ipn (A)	50	100	200
Factor Kssc	13.41	13.87	13.86
Factor Ktd	14.45	14.46	14.46
Current ratio error [%]	-0.232	-0.230	-0.235
Ts [s]	5.319	5.511	5.500
ε-peak [%]	2.36	1.57	1.55

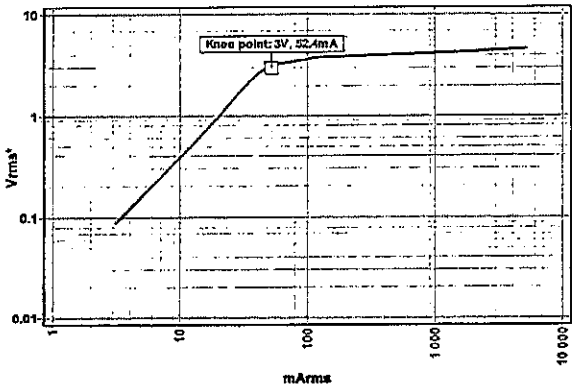
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Capacity	Capacity	Leak current	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.24	1383	4.36	0.25	1116	3.532	0.23	266	0.836
63 kV	0.24	1383	27.54	0.24	1116	22.21	0.22	266	5.297
71 kV	0.24	1383	30.9	0.24	1117	24.98	0.22	266	5.963

Core magnetization characteristics:

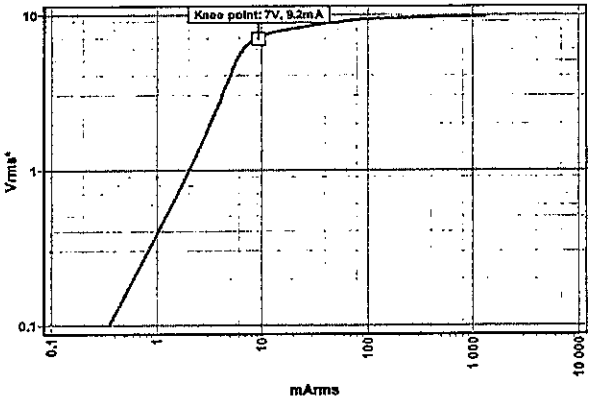
Winding 1S1-1S2

[V]	[mA]
4.5	5292
4.3	2108.3
3.8	135.6
3.2	55.41
2.7	42.37
2.2	35
1.6	28.78
1	20.73
0.5	12.12
0.1	3.25



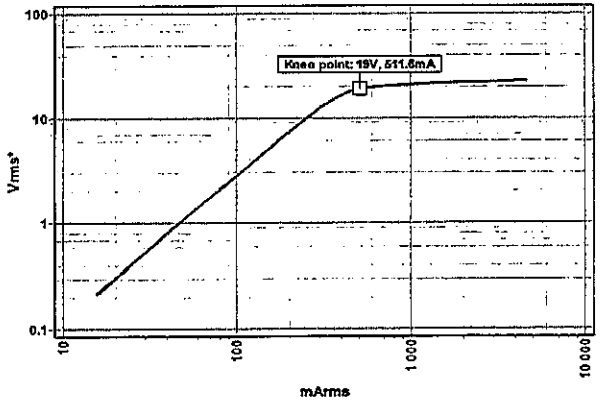
Winding 2S1-2S2

[V]	[mA]
9.7	1224.3
9.5	413.6
8.9	53.1
8.4	26.71
7.8	14.58
7.2	9.49
6.7	7.87
6.1	6.93
5.5	6.19
5	5.66
3.8	4.75
2.8	3.93
1.7	2.85
0.5	1.23
0.1	0.32



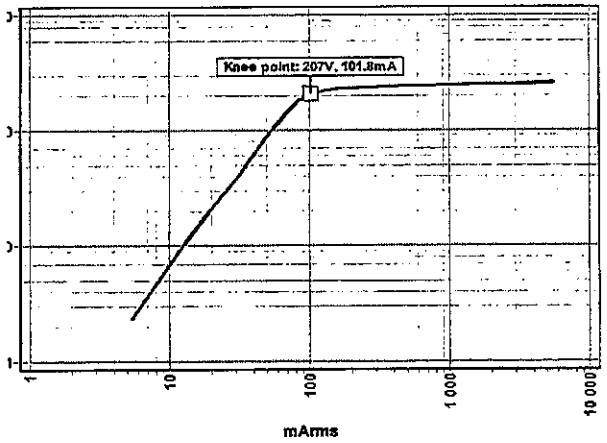
Winding 3S1-3S2

[V]	[mA]
22	2714.7
21.4	1328.1
20.6	814.6
19.2	555.1
17.8	444.8
16.5	398.7
15	358.4
13.8	329.9
12.3	297
10.9	268.9
9.6	243.4
6.7	186.1
4.1	130.9
1.2	51.58
0.2	13.46



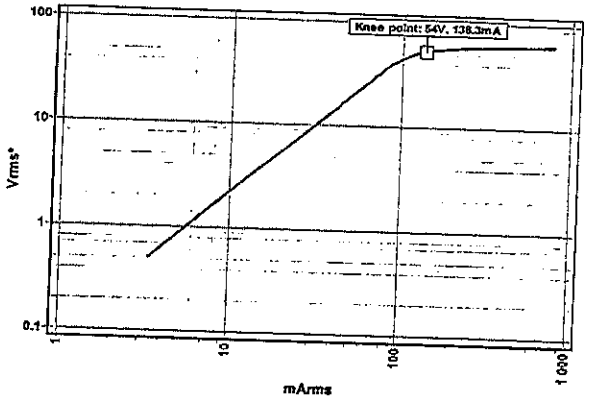
Winding 4S1-4S2

[V]	[mA]
256.5	5777
251.1	1957.8
248.2	1141.9
241.4	449.8
234	217
229.3	168.1
220.6	123.9
207.3	100.74
194.2	90.53
178.1	81.76
152.6	72.53
109.8	58.59
67.7	43.23
25.2	23
1.8	4.79



Winding 5S1-5S2

[V]	[mA]
64.5	1117.4
62.8	589.9
60.2	267.2
58.6	204.4
57.1	169.8
56.1	156
52.9	127.3
50.3	114.1
47.6	105.77
39	87.24
30.5	71.18
22	56.3
13.7	40.21
5.1	19.51
0.5	3.51



Measurement of windings' resistance

Windings' resistance of current part:

	R (23°C)	R ct (75°C)
P1-P2 range 50 A	266.0 µΩ	320.4 µΩ
P1-P2 range 100 A	100.0 µΩ	120.4 µΩ
P1-P2 range 200 A	47.0 µΩ	56.6 µΩ
1S1-1S2	0.048 Ω	0.058 Ω
2S1-2S2	0.527 Ω	0.635 Ω
3S1-3S2	0.024 Ω	0.029 Ω
4S1-4S2	0.214 Ω	0.257 Ω
5S1-5S2	0.315 Ω	0.380 Ω

Windings' resistance of voltage part:

	R (24.9°C)	R ct (75°C)
A-N	17.30 kΩ	20.835 kΩ
1a-1n	44.120 mΩ	53.136 mΩ
2a-2n	45.150 mΩ	54.377 mΩ
3a-3n	46.680 mΩ	56.220 mΩ
4a-4n	48.050 mΩ	57.869 mΩ
da-dn	31.900 mΩ	38.419 mΩ

Checked by: OG-4 KJ-06

Przasnysz. 12.11.2013 r.

AEB Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer after short time current test			TYP: PVA123a Nr fabr. 2GKP013K1486138	
A – N 110:√3 kV	Insulation level: 126/230/550 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA] 40-63-63	Idyn [kA] 100-158-158	Icth [A]: 100-200-400	IEC 61869-4 50 Hz

CZŁON NAPIĘCIOWY	Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
	1a-1n	0,1:√3	25	0,1	1000
		0,1:√3	25	3,0	1000
	2a-2n	0,1:√3	25	0,1	1000
		0,1:√3	25	3,0	1000
	3a-3n	0,1:√3	25	0,1/3P	1000
		0,1:√3	500	3/3P	1000
	4a-4n	0,1:√3	25	0,1/3P	1000
		0,1:√3	25	3/3P	1000
	da-dn	0,1: 3	100	1	450
		0,1: 3	300	3P	450

CZŁON PRĄDOWY	Uzwojenie	Isn [A]	Sn [VA]	klasa	Przekładnia [A/A]
	1S1-1S2	5	1->5	0,5FS5	50-10-200/5
	2S1-2S2	1	1->2,5	0,5FS10	50-10-200/1
	3S1-3S2	5	10	5P 10	50-10-200/5
		1	2,5	5P80	50-10-200/1
	4S1-4S2	1		PX Ek = 190V Ie <= 0,1A/95 V Rct <= 0,3 Ω Rb = 3,5 Ω Kx = 60 4-2-1/200	50-10-200/1
		1		TPX Kssc = 13 Ktd = 14,6 cykl = 0,1s Tp = 0,05 Rct <= 0,3Ω Rb = 1 Ω Ratio error <= 0.5%	50-10-200/1
	5S1-5S2	1	5	5P10	50-10-200/1

List of performer tests

1. Oil dielectric parameters check before filling (oil after tgδ wg IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings – P1+P2/A:Up=230 kV / 60 s,f =97 Hz; N; Up = 3 kV/ 60s, f=50 Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary – Up = 3 kV/60 s ☑
7. Inter-turn overvoltage test for current transformers– lower value (U szczyt. = 4,5 KV lub U szczyt. Przy Icth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
  Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage =77,42 kV, Relative standard deviation = 5,64%; f=50 Hz, oil temp. = 26 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Próbka	Napięcie przebicia [kV]
1	83.2
2	80.1
3	70.8
4	79.2
5	76.4
6	74.8

Partial discharge measurement

- Measurement according to procedure B
Stress voltage 230 kV / 60 s
Frequency 97 Hz

Test voltage	1,2 Um = 151 kV	1,2 Um / √3 = 87.5 kV
Level of partial discharge	1.2 pC	1,2 pC

Remarks: background noise level: 1 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	0.09	400
2S1-2S2	0.3	400
3S1-3S2	0.192	400
4S1-4S2	1.31	400
5S1-5S2	0.704	400

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,1:√3	25	0,1	1000
2a-2n	0,1:√3	25	0,1	1000
3a-3n	0,1:√3	25	0,1/3P	1000
4a-4n	0,1:√3	25	3/3P	1000
da-dn	0,1: 3	100	1	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.036	-0.034	-0.034	
Δφ U	2.1	2.1	2.2	

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.036	0.038	0.038
Δφ U	3.5	3.5	3.5

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0.003	0.005	0.005	
Δφ U	2.0	2.1	2.1	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.075	0.076	0.077
Δφ U	3.5	3.5	3.6

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.030	-0.026	-0.026	
Δφ U	2.3	2.3	2.3	

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.042	0.044	0.044
Δφ U	3.6	3.6	3.7

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0.009	0.011	0.011	
Δφ U	2.1	2.1	2.2	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0.061	0.063	0.063
Δφ U	3.5	3.5	3.6

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.167	-0.107	-0.020	-0.018	-0.017	-0.117
Δφ U	-3.0	0.1	2.4	2.4	2.5	1.0

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.097	-0.035	0.053	0.054	0.055	-0.044
Δφ U	-1.5	1.6	3.7	3.7	3.8	2.5

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.120	-0.065	0.020	0.022	0.022	-0.078
Δφ U	-3.2	-0.1	2.2	2.2	2.2	0.8

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.052	0.006	0.092	0.094	0.094	-0.006
Δφ U	-1.7	1.4	3.5	3.5	3.6	2.3

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.176	-0.115	-0.028	-0.026	-0.026	-0.125
Δφ U	-2.7	0.5	2.7	2.8	2.8	1.4

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.111	-0.048	0.035	0.038	0.039	-0.055
Δφ U	-1.3	1.8	4.0	4.0	4.0	2.7

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0.122	-0.066	0.019	0.021	0.021	-0.079
Δφ U	-3.0	0.1	2.3	2.3	2.4	0.9

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0.058	0.002	0.057	0.059	0.059	-0.008
Δφ U	-1.7	1.5	3.6	3.6	3.7	2.3

da – dn 100 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA , cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0.741	-0.739	-0.738
Δφ U	8.9	8.9	9.0

da – dn 25 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA ,

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0.304	-0.302	-0.302
Δφ U	5.2	5.2	5.3

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of current part errors (ε I %), (Δφ I min),

Ipn (A): 50

	1S1-1S2 5 VA; cosφ = 0,8				1S1-1S2 1 VA; cosφ = 0,8			
	0,05In	0,2 In	1,0 In	2,0 In	0,05In	0,2 In	1,0 In	2,0 In
ε I	-0.383	-0.232	-0.025	0.132	0.295	0.300	0.315	0.333
Δφ I	17.3	7.5	-1.1	-3.3	13.2	8.8	4.9	3.1
	2S1-2S2 2.5 VA; cosφ = 1				2S1-2S2 1 VA; cosφ = 1			
	0,05In	0,2 In	1,0 In	2,0 In	0,05In	0,2 In	1,0 In	2,0 In
ε I	0.035	0.008	0.138	0.193	0.254	0.241	0.276	0.321
Δφ I	32.6	22.0	7.0	3.9	18.7	12.7	5.8	3.1

3S1-3S2	
	1,0 In
ε I	0.935
Δφ I	7.4

4S1-4S2	
	1,0 In
ε I	-0.391
Δφ I	14.6

5S1-5S2	
	1,0 In
ε I	0.701
Δφ I	15.5

Ipn (A): 100

	1S1-1S2 5 VA; cosφ = 0,8				1S1-1S2 1 VA; cosφ = 0,8			
	0,05In	0,2 In	1,0 In	2,0 In	0,05In	0,2 In	1,0 In	2,0 In
ε I	-0.743	-0.243	0.021	0.132	0.129	0.305	0.317	0.334
Δφ I	37.0	8.3	-0.8	-3.3	29.3	8.9	4.9	3.1
	2S1-2S2 2.5 VA; cosφ = 1				2S1-2S2 1 VA; cosφ = 1			
	0,05In	0,2 In	1,0 In	2,0 In	0,05In	0,2 In	1,0 In	2,0 In
ε I	0.027	0.009	0.137	0.191	0.251	0.237	0.272	0.319
Δφ I	32.6	22.5	7.1	4.0	19.0	13.6	6.1	3.0

3S1-3S2	
	1,0 In
ε I	0.912
Δφ I	7.7

4S1-4S2	
	1,0 In
ε I	-0.391
Δφ I	14.5

5S1-5S2	
	1,0 In
ε I	0.707
Δφ I	15.5

Ipn (A): 200

	1S1-1S2 5 VA; cosφ = 0,8				1S1-1S2 1 VA; cosφ = 0,8			
	0,05In	0,2 In	1,0 In	2,0 In	0,05In	0,2 In	1,0 In	2,0 In
ε I	-0.493	-0.316	-0.083	0.068	0.158	0.277	0.280	0.294
Δφ I	23.6	11.4	2.9	-1.4	21.6	12.4	7.8	6.3
	2S1-2S2 2.5 VA; cosφ = 1				2S1-2S2 1 VA; cosφ = 1			
	0,05In	0,2 In	1,0 In	2,0 In	0,05In	0,2 In	1,0 In	2,0 In
ε I	0.023	0.039	0.143	0.194	0.249	0.251	0.279	0.321
Δφ I	32.8	19.1	6.4	4.0	19.0	12.4	5.7	3.3

3S1-3S2	
	1,0 In
ε I	0.933
Δφ I	7.1

4S1-4S2	
	1,0 In
ε I	-0.392
Δφ I	14.5

5S1-5S2	
	1,0 In
ε I	0.711
Δφ I	15.2

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Current part: Measurements uncertainty: **ε I = ±0,045 %, Δφ I = ±2,3 min**
Voltage part: Measurements uncertainty: **ε U = ±0,044 %, Δφ U = ±2,2 min**

Determination of the over current factors:

- instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	2.5	4.29	6.22	$U < E_{FS}$	☑
2S1-2S2	1	9.64	31.28	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Warunek	Assessment
3S1-3S2	21.14	1.156	2.31	$\varepsilon_c < 5\%$	☑
4S1-4S2	220.32	0.127	0.16	$\varepsilon_c < 5\%$	☑
5S1-5S2	53.95	0.129	1.29	$\varepsilon_c < 5\%$	☑

Determination of parameters of class PX core 4S1-4S2:

Ipn (A)	50	100	200
Factor Kx	54.93	54.94	54.94
Turns ratio error [%]	-0.007	-0.003	0.002

Determination of parameters of class TPX core 4S1-4S2:

Ipn (A)	50	100	200
Factor Kssc	13.91	13.91	13.92
Factor Ktd	14.46	14.46	14.46
Current ratio error [%]	-0.225	-0.230	-0.235
Ts [s]	5.498	5.517	5.500
ε-peak [%]	1.530	1.529	1.530

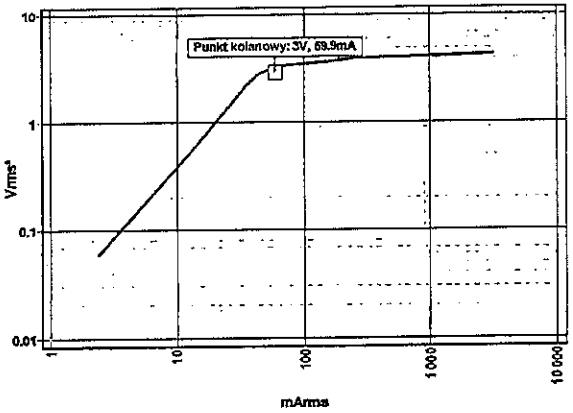
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ [%]	Capacity [pF]	Leak current [mA]	Tg δ [%]	Capacity [pF]	Leak current [mA]	Tg δ [%]	Capacity [pF]	Leak current [mA]
10 kV	0.23	1378	4.32	0.24	1111	3.459	0.22	266	0.833
63 kV	0.23	1378	27.22	0.24	1112	21.93	0.22	266	5.252
71 kV	0.23	1378	30.77	0.24	1112	24.82	0.22	268	5.939

Core magnetization characteristics:

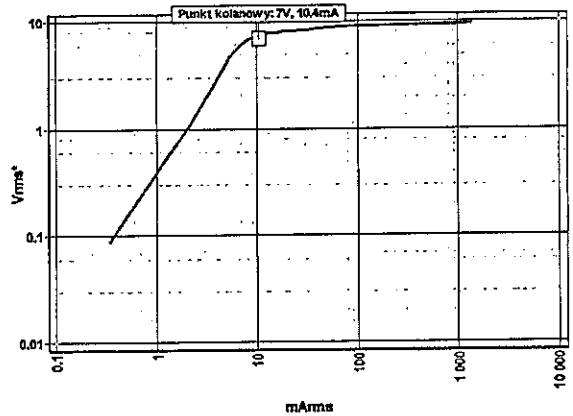
Winding 1S1-1S2

[V]	[mA]
4.4	3146.5
4.0	261.1
3.4	61.75
2.8	43.85
2.3	35.91
1.7	28.93
1.1	20.93
0.5	12.27
0.1	2.41



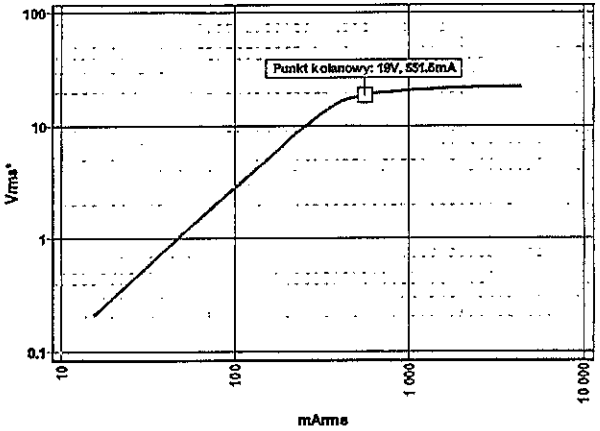
Winding 2S1-2S2

[V]	[mA]
9.7	1371.9
9.5	396.7
9.0	57.91
8.4	27.12
8.1	18.63
7.5	11.18
6.9	8.3
6.3	7.18
5.8	6.44
5.1	5.79
4.0	4.92
2.8	3.98
1.7	2.9
0.6	1.28
0.1	0.34



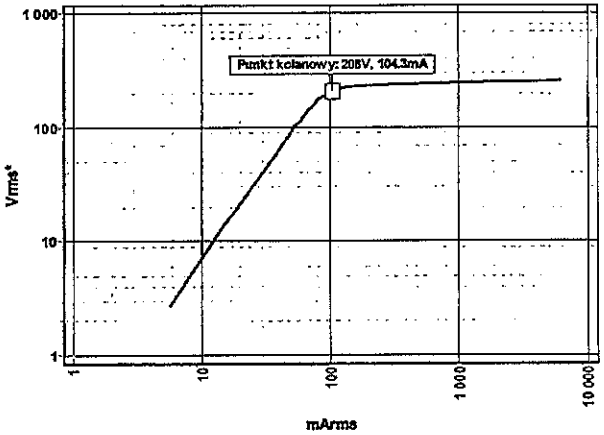
Winding 3S1-3S2

[V]	[mA]
22.4	4318.6
21.9	2020.1
21.0	1039.6
19.8	607.5
18.2	472.7
16.9	411.5
15.3	366.6
14.0	333.9
12.7	305.3
11.3	276.6
9.7	245.5
7.0	192.1
4.0	128.2
1.3	55.24
0.2	15.55



Winding 4S1-4S2

[V]	[mA]
256.9	6035
252.7	2439.3
248.4	1129.5
243.5	554.3
228.8	165.1
223.8	137.5
215.6	113.2
202.1	97.48
185.6	85.34
171.9	78.69
158.4	73.91
114.0	58.23
70.8	42.85
26.9	23.1
2.7	5.8



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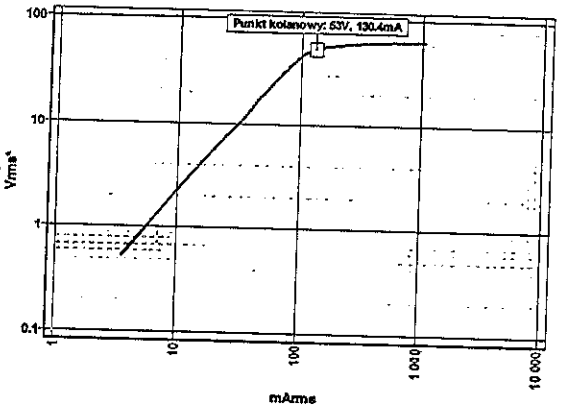
Winding 5S1-5S2

[V]	[mA]
64.4	1044.4
62.8	543.6
60.1	257.6
57.8	183.6
56.5	159.5
54.8	141.4
51.9	121.5
48.8	109.27
45.9	101.74
40.2	88.35
31.7	72.18
22.9	56.64
14.2	39.95
5.4	19.35
0.5	3.56



Measurement of windings' resistance

Windings' resistance of current part:

	R (23°C)	R ct (75°C)
P1-P2 range 50 A	276.0 µΩ	333.7 µΩ
P1-P2 range 100 A	119.0 µΩ	142.9 µΩ
P1-P2 range 200 A	66.0 µΩ	79.2 µΩ
1S1-1S2	0.048 Ω	0.057 Ω
2S1-2S2	0.523 Ω	0.628 Ω
3S1-3S2	0.023 Ω	0.028 Ω
4S1-4S2	0.212 Ω	0.254 Ω
5S1-5S2	0.313 Ω	0.376 Ω

Windings' resistance of voltage part:

	R (23.°C)	R ct (75°C)
A-N	17.30 kΩ	20.767 kΩ
1a-1n	44.060 mΩ	52.891 mΩ
2a-2n	44.960 mΩ	53.971 mΩ
3a-3n	46.460 mΩ	55.772 mΩ
4a-4n	47.940 mΩ	57.549 mΩ
da-dn	31.600 mΩ	37.934 mΩ

Checked by: ... OG-4 KJ-06

Przasnysz. 24.01.2014 r.

ANNEX 4 **Documentations delivered by orderer**

ABB Sp. z o.o.	Declaration of conformity	ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 001/2014 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 123a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486138;**

Place and date of issue of declaration

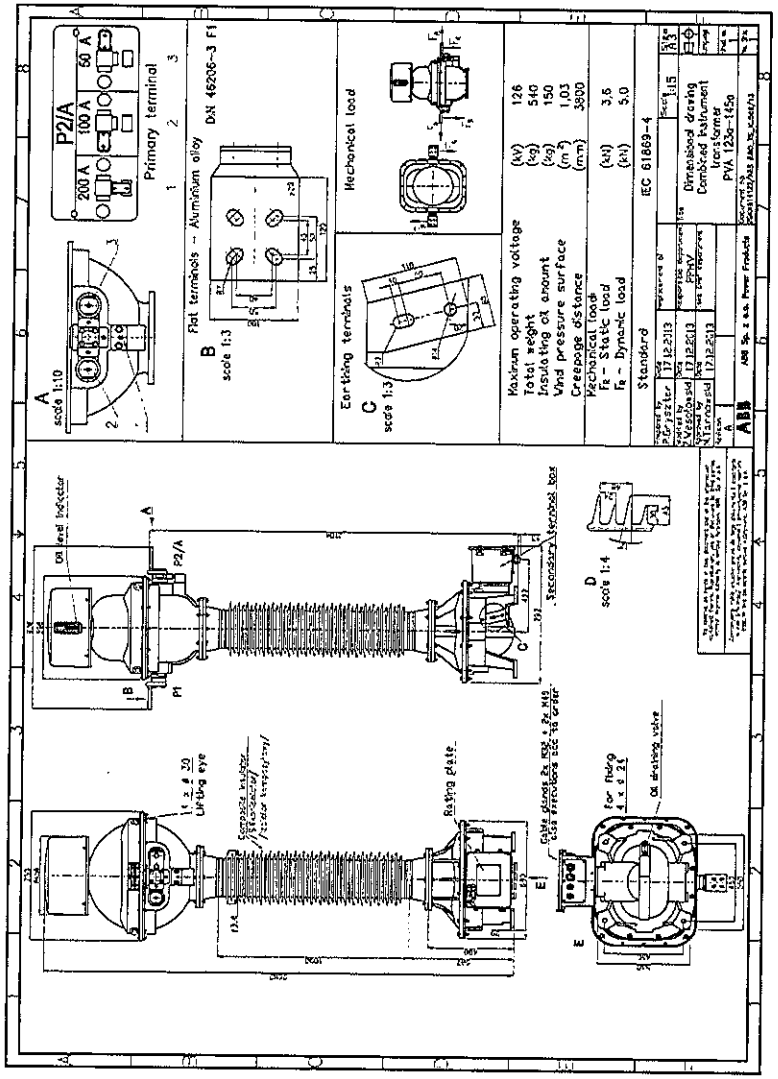
Przasnysz 13.01.2014

ABB
ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
NIP: 526-030-44-64; PL 526030464
Regon 010017168
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8921, fax (22) 223 8958
(9)

Referent ds. Realizacji Zam...
ABB Sp. z o.o.
Oddział w Przasnyszu
Małgorzata ...

Kierownik ds. Zapewnienia ...
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof ...

(Name) (Signature)



ABB

Combined Instrument Transformer

Type	PVA 123a				
Insulation level	126/230/550 kV	Standard	IEC 61869-4	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	540 / 150 kg	Temp. range	-50°C — +40°C
S/N	2GKP013K1486138	Voltage factor	1,9Un/8h	Ue	0,2 mV/kA

CURRENT PART

K_n 50-100-200 / 5-1-5-1-1 A/A

$I_{th}/1s$ 40 - 63 - 63 kA I_{dyn} 100 - 158 - 158 kA

I_{cth} 100 - 200 - 400 A

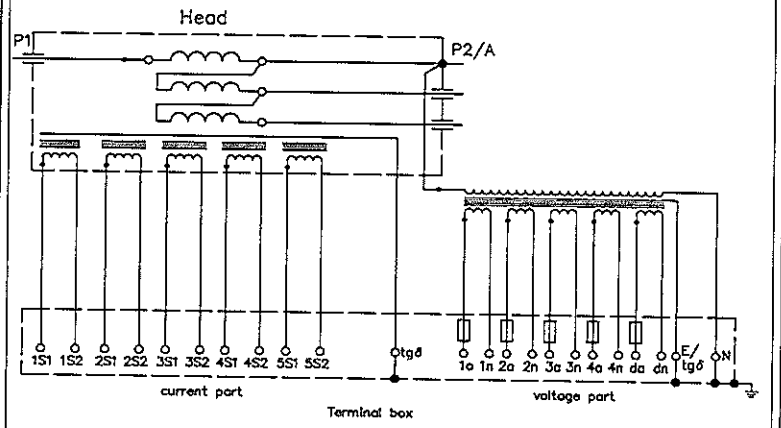
	A	VA	class	FS/ALF	Ext%
1S1-1S2	5	1 -> 5	0,5	5	200
2S1-2S2	1	1 -> 2,5	0,5	10	200
3S1-3S2	5	10	5P	10	-
4S1-4S2	1	2,5	5P	80	-
		Rb=3,5Ω,class PX, 4-2-1/200, Ek=190 V, Ie<=0,1 A / 95 V, Rct<=0,3Ω, Kx=50			
		Rb=1Ω, classTPX 13x14,6, Rct <=0,3Ω , cykl 100 ms, Tp=50 ms			
5S1-5S2	1	5	5P	10	-
6S1-6S2					

VOLTAGE PART

A-N 110:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	100:√3	100:√3	100:√3	100:√3	100:3
VA	25	25	25	25	100
Klasa	0,1	0,1	0,1/3P	0,1/3P	1,0
VA	(25)	(25)	(500)	(25)	300)
Klasa	(3)	(3)	(3/3P)	(3/3P)	(3P)
VAzn	1000	1000	1000	1000	450

Transportation Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!

1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ, tgδ MUST BE EARTHED
3. AFTER THREE WINDINGS da - dn ARE CONNECTED IN BROKEN DELTA THE CIRCUIT SHOULD BE EARTHED IN ONE POINT ONLY

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INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/74/E/13 E

TEST OBJECT: Combined instrument transformer type PVA 145a with porcelain insulator
Serial No. 2GKP013K1486140

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: Internal order No. EWN/145/E/13 dated 09.12.2013

TYPE OF TESTS: Short-time current tests
Test for composite error

TESTS PROCEDURE: According to IEC 61869-2:2012

DATE OF TESTS: 10/11.12.2013

TESTS RESULT: Positive for
I_{dyn} = 158 kA, I_{th} = 63 kA, t = 1 s for 1000 A terminal

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: M. Tarnowski, Z. Wesołowski – ABB Sp. z o.o.

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 30.12.2013

Publishing or reproducing of this report in other version than exact and complete without permission in writing from the laboratory is forbidden.

Contents

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numbered pages	30
records (pages not numbered)	3
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1. TEST OBJECT

1.1 Description

Combined instrument transformer type PVA 145a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 132 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with porcelain insulator immersed with transformer oil.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	132 kV
Rated frequency	50 Hz
Rated continuous thermal current	1000 A, 2000 A
Rated short-time current for 1 s	63 kA
Rated dynamic current	158 kA

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing combined transformer PVA 123a-145a, No. 2GKK614121 (17.12.2013),
- routine tests report of combined instrument transformer (12.11.2013),
- routine tests report of combined instrument transformer after short-time current test (20.12.2013),
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o (Annex 3 and 4).
The laboratory proceeded the identification of test object on the base of above documentation and the rating plate. Conformity of manufacturing with constructional documentation is stated in manufacturer's declaration, copy of which presents Annex 4.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-2:2012:

- short-time current tests of current transformer acc. to item 7.2.201 of above standard at parameters:

  $I_{dyn} \geq 158$ kA, $I_{th} = 63$ kA, $t_{th} = 1$ s, $I_{th}^2 \times t_{th} \geq 3969$ kA^2×s for 1000 A terminal.
- test for composite error acc. to item 7.2.6.203 of above standard with current's transformer burden of about 10 Ω connected to 6S1-6S2 windings at parameters:

  $20 > I_{th} \geq 21$ kA, $t_{th} = 1$ s for 1000 A terminal,
- routine test before and after short-time current test made in factory.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests and test for composite error were made in one-phase circuit presented on fig. 1 at dimensions presented on fig.2.
The following quantities were recorded during the tests using digital recorder type HIOKI 8842:
- primary current (with short-circuited all secondary terminals) during short-time current tests using laboratory current transformer type CdC class 0,5 with a ratio 50.000/2 A/A (uncertainty of measurement ±0,018% for k = 2),
- secondary currents in 1S1-1S2, 4S1-4S2 windings by means of laboratory toroidal current transformers type IL20a class 0,5 with a ratio 2.000/5 A/A (uncertainty of measurement ±0,012% for k = 2) and secondary currents in 5S1-5S2, 6S1-6S2 by shunt 25 A/300 mV class 0,5 (uncertainty of measurement ±0,33 % for k = 2).
- voltage drop (U_0) on test object during short-time current tests by means of a resistance-capacitance voltage divider with a bandwidth from 0 to 100 kHz.

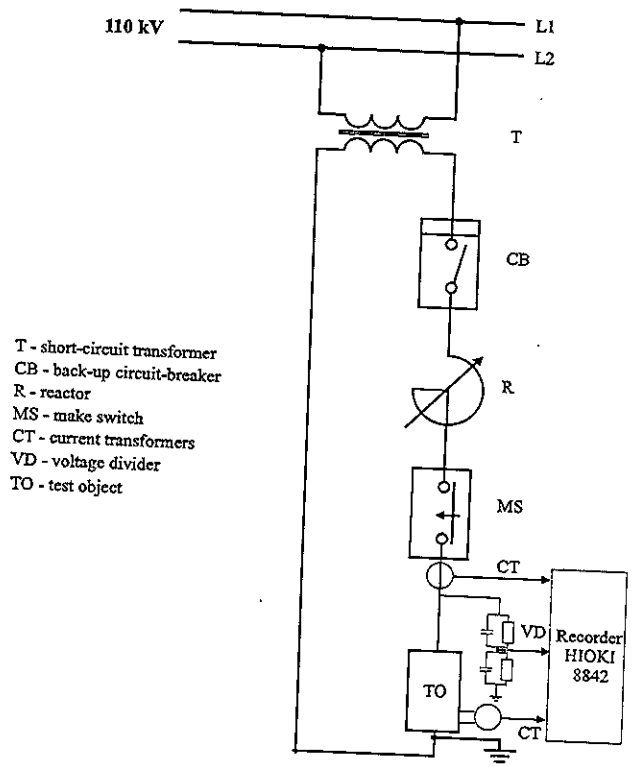


Fig.1. Test and measuring circuits during tests

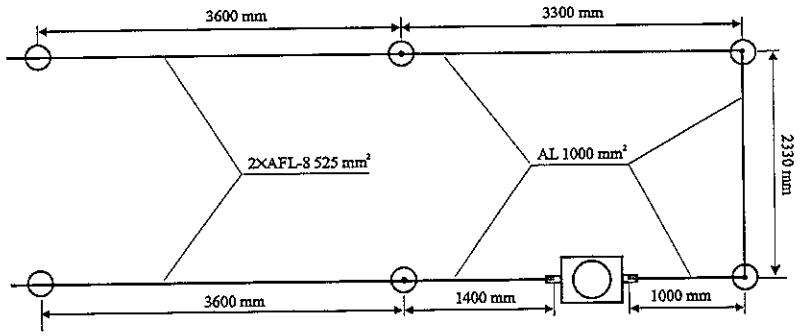


Fig. 2. Configuration of test circuit during tests

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents tables 1 and 2.
During the tests the following records were made:
- No. 33059 – calibration of measuring and test circuit,
- Nos. 33061, 33063 – short-time current tests,
- No. 33067 – composite error test,
  (Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory's archives),
- phot. 1 – current transformer on short-circuit tests stand
  (Annex 2 presents the photograph).

Table 1. Results of short-time current tests

Test No.	i_{peak}	I_z	t_z	$I_z^2 \times t_z$	$I_{1S1-1S2}$	$I_{4S1-4S2}$	$I_{5S1-5S2}$	U_0	Observations
-	kA	kA	s	$(kA)^2 \times s$	A	A	A	V	-
33061	159,60[1)]	64,22	0,06	–	–	–*	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33063	103,26	64,22	1,00	4124[2)]	329	–*	64	33	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
i_{peak} – peak value of test current,
I_z – r.m.s. value of test current (determined from test period without asymmetrical component),
t_z – test duration,
$I_{1S1-1S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{4S1-4S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{5S1-5S2}$ – r.m.s. value (determined from test period without asymmetrical component),
U_0 – r.m.s. value (determined from test period without asymmetrical component).
Required : [1)] $i_{peak} \geq 158$ kA,
[2)] $I_z^2 \times t_z \geq 3969$ $(kA)^2 \times s$,
* – no record (short-circuiting wire was damaged during tests).

During the composite error test current's transformer burden connected to 6S1-6S2 was 10,3 Ω.

Table 2. Results of composite error test for 6S1-6S2 winding

Test No.	I_p	ε_c	t_z	Observations
-	kA	%	s	-
33067	20,34	1,81	1,00	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
I_p – r.m.s. value of the test current (determined from test period without asymmetrical component),
t_z – test duration,

$$\varepsilon_c = \frac{\sqrt{\frac{1}{T}\int_0^T (k_r \cdot i_s - i_p)^2 dt}}{I_p} \cdot 100\%$$

k_r – rated transformation ratio (1000/1 A/A),
i_p – instantaneous value of the primary current,
i_s – instantaneous value of the secondary current,
T – duration of one cycle.

5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-2:2012 the results of tests is positive for:

I_{dyn} = 158 kA, I_{th} = 63 kA, t = 1 s for 1000 A terminal of tested combined instrument transformer.

ANNEX 1

Test records

As not numbered pages the following copies of records are given:

33061, 33063 – short-time current tests,
33067 – composite error test.

Denotations:

i – test current,

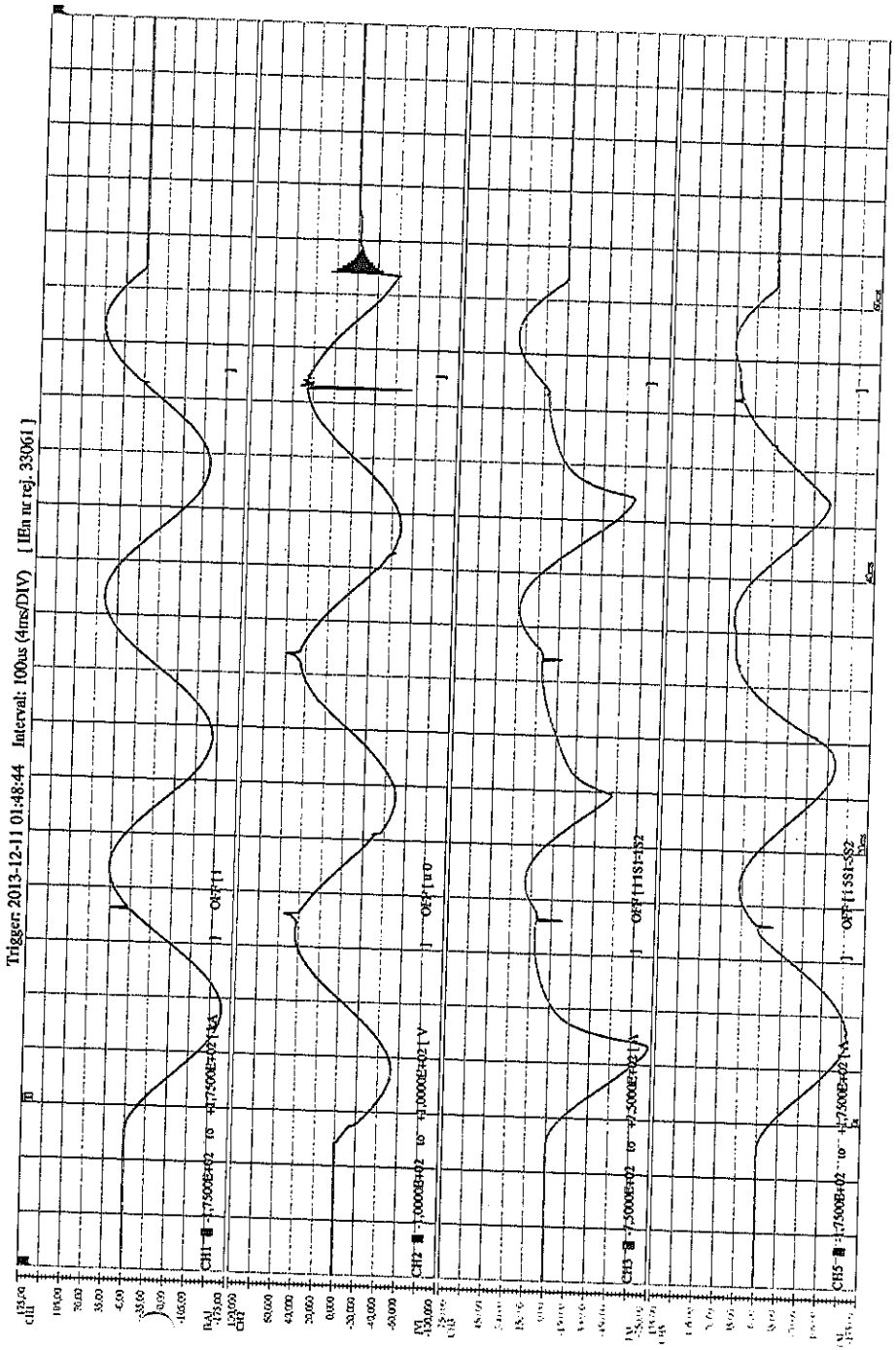
u_0 – voltage drop on test object,

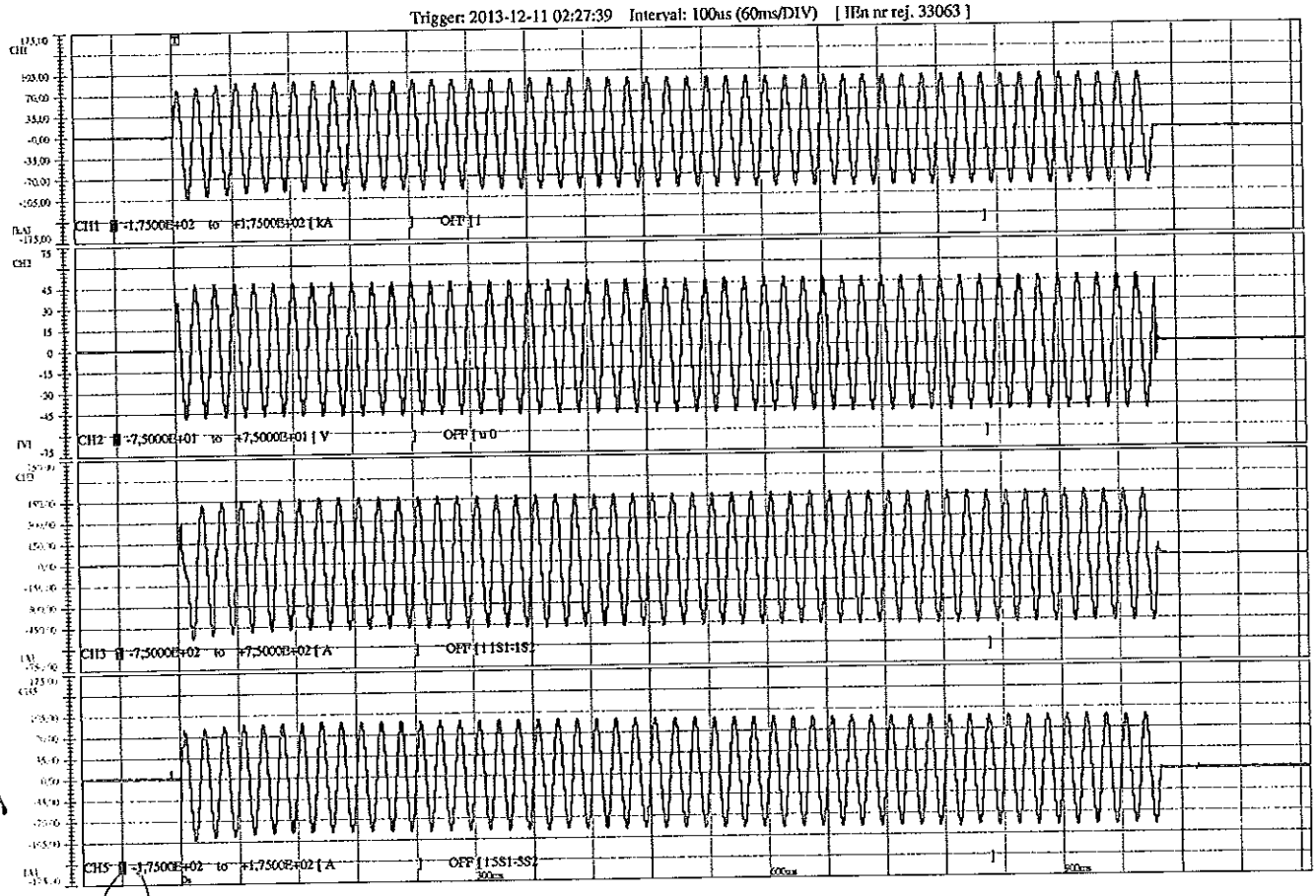
$i_{1S1-1S2}$ – 1S1-1S2 winding current,

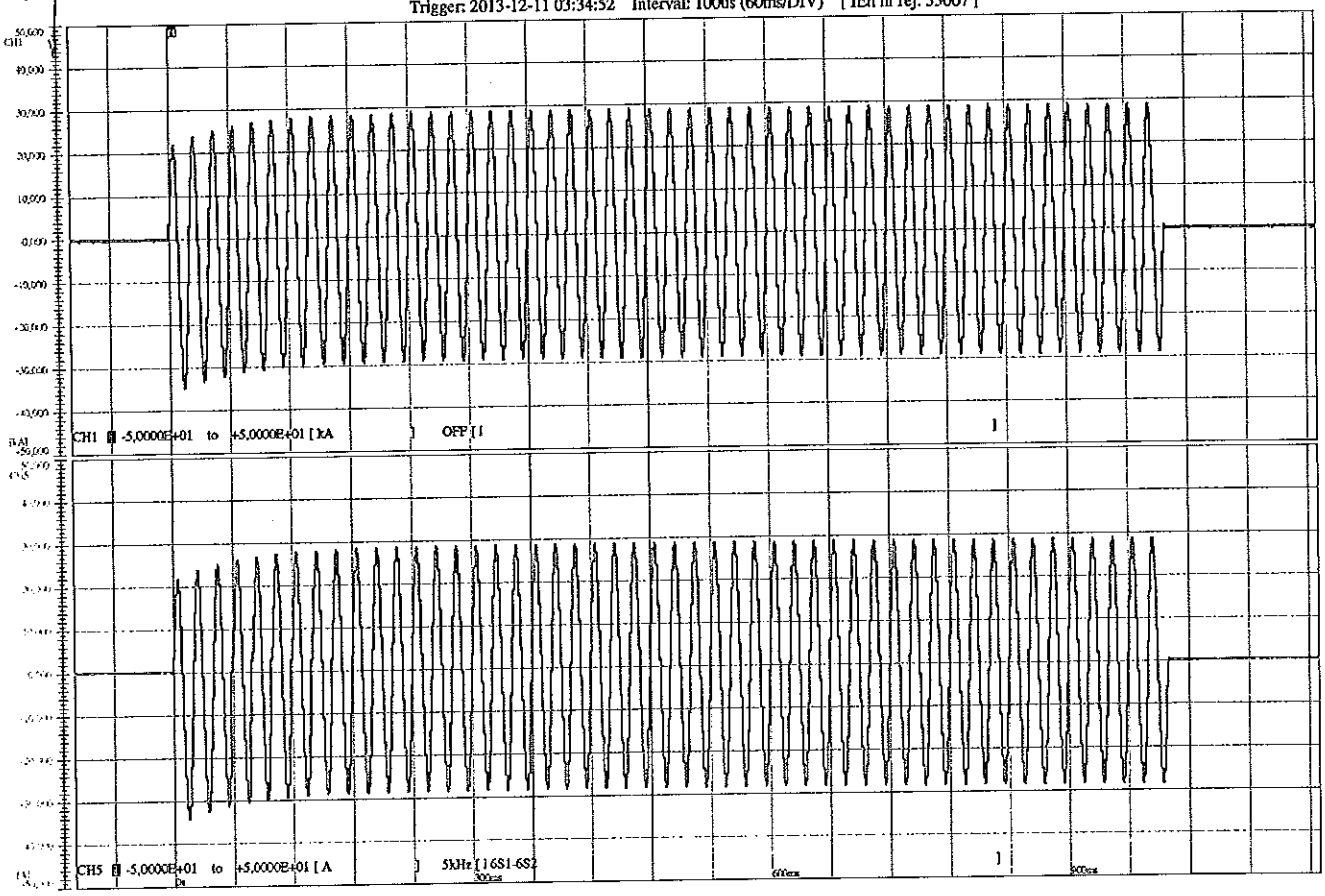
$i_{4S1-4S2}$ – 4S1-4S2 winding current,

$i_{5S1-5S2}$ – 5S1-5S2 winding current,

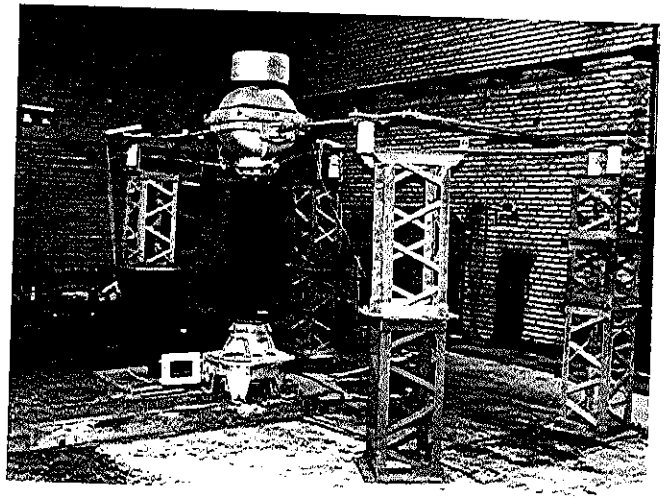
$i_{6S1-6S2}$ – 6S1-6S2 winding current.




Trigger: 2013-12-11 02:27:39 Interval: 100us (60ms/DIV) [IEn nr rej. 33063]
CH1 -1,7500E+02 to +1,7500E+02 [kA] OFF [1
CH2 -7,5000E+01 to +7,5000E+01 [V] OFF [u 0
CH3 -7,5000E+02 to +7,5000E+02 [A] OFF [1 1S1-1S2
CH5 -1,7500E+02 to +1,7500E+02 [A] OFF [1 5S1-5S2


Trigger: 2013-12-11 03:34:52 Interval: 100us (60ms/DIV) [IEn nr rej. 33067]
CH1 -5,0000E+01 to +5,0000E+01 [kA] OFF [1
CH5 -5,0000E+01 to +5,0000E+01 [A] 5kHz [1 6S1-6S2

ANNEX 2 Photographs taken during the tests



Phot. 1. PVA 145a after short-time current tests

ANNEX 3 Routine test report before and after short-time current tests

AEE Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer			TYP: PVA145a Nr fabr. 2GKP013K1488140	
A – N 132:$\sqrt{3}$ kV	Insulation level: 145/275/650 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA] 63-63	Idyn [kA] 158-158	Icth [A]: 1200-2400	IEC 61869-4 50 Hz

VOLTAGE PART	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
	1a-1n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	2a-2n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	3a-3n	0,11:√3	25	0,2/3P	1000
		0,11:√3	500	3/3P	1000
	4a-4n	0,11:√3	25	3/3P	1000
		0,11:√3	25	3/3P	1000
	da-dn	0,11	150	1	450
		0,11	400	3P	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	class	Ratio
	1S1-1S2	5	100	0,2FS10	1000-2000/5
	2S1-2S2	1	70	0,1FS5	1000-2000/1
	3S1-3S2	5	35	5P 20	1000-2000/5
	4S1-4S2	5	15	5P 60	1000-2000/5
				PX Ek = 250V Ie <= 0,1A / 125 Rct <= 7Ω Rb = 1 Ω	
	5S1-5S2	1		TPY Kssc = 15 Ktd = 13 Cykl = 0,1s Tp = 0,05 s Rb = 2 Ω K_R <= 10%	1000-2000/1
			30	5P30	
	6S1-6S2	1	10	5PR20 Rct<=8Ω	1000-2000/1
				PXR 2-1/2000 Kx=20 Ek=500V Ie<=0,1A Rct<=5,0 Ω Rb=20 Ω	

List of performer tests

1. Oil dielectric parameters check before filling (oil after tg5 wg IEC 60247, breakdown voltage acc. IEC 60156
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings ☑
   – P1+P2/A;Up=275 kV / 60 s,f =97 Hz; N; Up = 3 kV/ 60s, f=50 Hz
5. Partial discharge ☑
6. Power-frequency withstand test on secondary ☑
   – Up = 3 kV/60 s ☑

7. Inter-turn overvoltage test for current transformers– lower value ☑
(U szczyt. = 4,5 kV lub U szczyt. Przy Ith) / 60s
8. Determination of errors ☑
9. . Determination of the over current factors: FS,ALF ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

☐

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
Mean breakdown voltage =77,42 kV, Relative standard deviation = 5,64%; f=50 Hz, oil temp. = 26 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	83,2
2	80,1
3	70,8
4	79,2
5	76,4
6	74,8

Partial discharge measurement
- Measurement according to procedure A (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)
Stress voltage: 275 kV / 60 s
Frequency: 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	1,8 pC	1,3 pC

Remarks: background noise level: 1 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	4,5	2050
2S1-2S2	4,5	42,5
3S1-3S2	4,5	12
4S1-4S2	4,5	1100
5S1-5S2	1,47	2400
6S1-6S2	4,5	1900

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Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	0,2	1000
2a-2n	0,11:√3	25	0,2	1000
3a-3n	0,11:√3	25	0,2/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	150	1	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,021	-0,021	-0,021	
Δφ U	3,1	3,1	3,2	

1a – 1n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,052	0,053	0,052
Δφ U	4,8	4,8	4,9

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0,017	0,017	0,016	
Δφ U	3,1	3,1	3,2	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,089	0,090	0,089
Δφ U	4,8	4,8	4,9

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,017	-0,017	-0,017	
Δφ U	3,2	3,2	3,3	

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,059	0,059	0,059
Δφ U	4,8	4,8	4,9

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0,020	0,021	0,020	
Δφ U	3,2	3,2	3,2	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,097	0,097	0,097
Δφ U	4,8	4,8	4,9

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,097	-0,100	-0,008	-0,008	-0,009	-0,141
Δφ U	1,8	2,9	3,3	3,3	3,4	1,4

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,023	-0,026	0,064	0,065	0,064	-0,069
Δφ U	3,7	4,7	4,9	4,9	5,0	3,1

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,054	-0,059	0,029	0,030	0,029	-0,103
Δφ U	1,8	2,8	3,2	3,2	3,3	1,3

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,011	0,011	0,101	0,102	0,101	-0,032
Δφ U	3,6	4,6	4,8	4,8	4,9	3,0

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,096	-0,097	-0,008	-0,007	-0,008	-0,818
Δφ U	2,1	3,2	3,6	3,6	3,6	-17,4

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,024	-0,027	0,062	0,063	0,063	-0,070
Δφ U	3,9	4,9	5,1	5,1	5,2	3,3

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,051	-0,055	0,033	0,033	0,033	-0,778
Δφ U	2,0	3,0	3,4	3,4	3,4	-17,6

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,016	0,015	0,103	0,104	0,103	-0,030
Δφ U	3,8	4,7	4,9	4,9	5,0	3,0

da – dn 100 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,611	-0,795	-0,821	-0,854
Δφ U	21,1	11,8	3,8	4,6

da – dn 25 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,288	-0,492	-0,525	-0,535
Δφ U	24,4	11,9	4,9	5,1

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	3,0	1000
2a-2n	0,11:√3	25	3,0	1000
3a-3n	0,11:√3	500	3/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	400	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,467	-0,467	-0,468	
Δφ U	-7,2	-7,2	-7,1	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,430	-0,430	-0,429	
Δφ U	-7,2	-7,2	-7,1	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,511	-0,509	-0,509	
Δφ U	-7,1	-7,1	-7,0	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,430	-0,430	-0,430	
Δφ U	-7,2	-7,2	-7,2	

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1,029	-1,030	-0,933	-0,933	-0,932	-1,307
Δφ U	3,3	4,3	4,8	4,8	4,9	-6,3

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,295	-0,296	-0,204	-0,203	-0,204	-0,585
Δφ U	2,1	3,2	3,6	3,6	3,7	-7,6

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,533	-0,535	-0,442	-0,441	-0,441	-0,818
Δφ U	-7,8	-6,6	-6,2	-6,2	-6,1	-17,4

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,490	-0,494	-0,401	-0,400	-0,400	-0,778
Δφ U	-7,8	-6,7	-6,3	-6,3	-6,3	-17,6

da – dn 400 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA , cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-1,654	-1,727	-1,673	-1,692
Δφ U	-1,5	-2,9	-3,6	-2,6

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,052	0,053	0,052
Δφ U	4,8	4,8	4,9

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,089	0,090	0,089
Δφ U	4,8	4,8	4,9

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,045	0,046	0,047
Δφ U	3,7	3,7	3,8

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,094	0,095	0,094
Δφ U	4,8	4,8	4,9

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,963	-0,958	-0,863	-0,862	-0,861	-1,238
Δφ U	5,1	6,1	6,5	6,5	6,6	-4,6

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,224	-0,226	-0,134	-0,133	-0,133	-0,513
Δφ U	3,9	5,0	5,2	5,3	5,3	-6,9

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,025	-0,026	0,062	0,063	0,063	-0,317
Δφ U	3,9	4,9	5,1	5,1	5,2	-6,3

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,017	0,015	0,103	0,104	0,103	-0,275
Δφ U	3,7	4,7	4,9	4,9	5,0	-6,3

da – dn 75 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA ,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,625	-0,682	-0,630	-0,635
Δφ U	9,2	7,1	5,3	6,0

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of current part errors (ε I %), (Δφ I min),
Ipn (A): 1000

1S1-1S2 100 VA; cosφ = 0,8				
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0,303	-0,138	-0,017	-0,006
Δφ I	8,6	5,0	1,9	1,6

1S1-1S2 25 VA; cosφ = 0,8			
0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
-0,006	0,097	0,146	0,150
5,8	3,1	1,6	1,5

2S1-2S2 70 VA; cosφ = 0,8				
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0,078	-0,056	-0,009	-0,015
Δφ I	1,5	0,4	-0,6	-0,2

2S1-2S2 17,50 VA; cosφ = 0,8			
0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
0,018	0,010	0,023	0,026
0,6	0,6	-0,0	-0,1

3S1-3S2: 35 VA cosφ = 0,8	
	1,0 In
ε I	-0,138
Δφ I	1,0

4S1-4S2: 15 VA cosφ = 0,8	
	1,0 In
ε I	-0,036
Δφ I	0,6

5S1-5S2: 30 VA cosφ = 0,8	
	1,0 In
ε I	-2,510
Δφ I	118,1

6S1-6S2: 15 VA cosφ = 0,8	
	1,0 In
ε I	-0,974
Δφ I	20,8

Ipn (A): 2000

1S1-1S2 100 VA; cosφ = 0,8				
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0,302	-0,138	-0,018	-0,006
Δφ I	8,6	4,9	1,8	1,6

1S1-1S2 25 VA; cosφ = 0,8			
0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
0,005	0,098	0,146	0,151
5,6	3,1	1,5	1,4

2S1-2S2 70 VA; cosφ = 0,8				
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0,096	-0,071	-0,027	-0,047
Δφ I	2,3	0,9	0,1	1,2

2S1-2S2 17,50 VA; cosφ = 0,8			
0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
0,009	-0,003	0,008	0,014
1,2	1,2	0,6	0,3

3S1-3S2: 35 VA cosφ = 0,8	
	1,0 In
ε I	-0,138
Δφ I	0,9

4S1-4S2: 15 VA cosφ = 0,8	
	1,0 In
ε I	-0,037
Δφ I	0,5

5S1-5S2: 30 VA cosφ = 0,8	
	1,0 In
ε I	-2,510
Δφ I	117,8

6S1-6S2: 15 VA cosφ = 0,8	
	1,0 In
ε I	-0,974
Δφ I	20,8

Current part: Measurements uncertainty: **ε I = ±0,045 %, Δφ I = ±2,3 min**
Voltage part: Measurements uncertainty: **ε U = ±0,044 %, Δφ U = ±2,2 min**

Determination of the over current factors:

- instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	5	153.33	422.24	$U < E_{FS}$	☑
2S1-2S2	0.5	157.46	531.29	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Condition	Assessment
3S1-3S2		0.02	0.1	ε_c < 5%	☑
4S1-4S2	383.35	0.123	0.04	ε_c < 5%	☑
5S1-5S2		1.298	4.33	ε_c < 5%	☑
6S1-6S2	877.45	0.227	1.14	ε_c < 5%	☑

Determination of parameters of class PX: core 4S1-4S2

4S1-4S2		
Ipn (A)	1000	2000
Factor Kx	38.39	37.18

Determination of parameters of class TPY core 5S1-5S2:

Ipn (A)	1000	2000
Factor Kssc	15.78	15.41
Factor Ktd	12.78	12.75
Factor Kr [%]	0	0
Current ratio error [%]	-0.164	-0.167
Ts [s]	0.4446	0.4369
ε-peak [%]	9.44	9.67

Determination of parameters of class PXR core 6S1-6S2:

Ipn (A)	1000	2000
Factor Kx	26.89	26.68
Factor Kr [%]	3	3

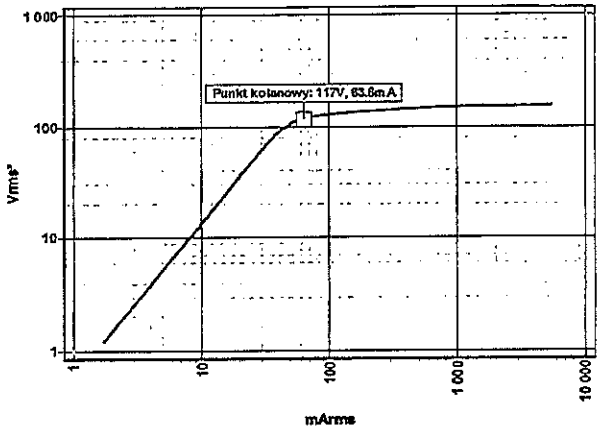
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.24	1418	4.464	0.25	1141	3.587	0.22	276	0.87
63 kV	0.24	1418	27.97	0.24	1141	22.51	0.22	276	5.452
71 kV	0.24	1418	31.67	0.24	1142	25.51	0.22	276	6.173

Core magnetization characteristics:

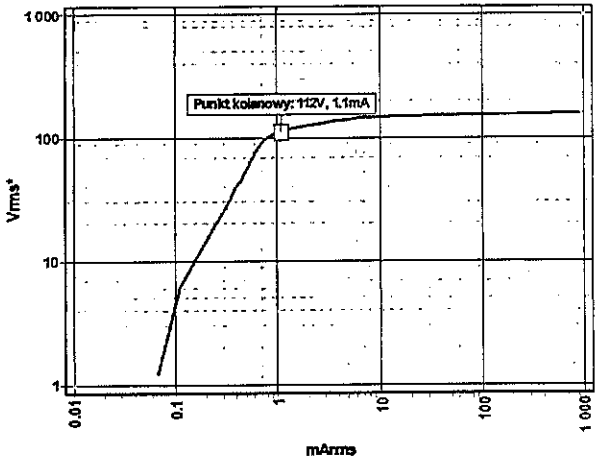
Winding 1S1-1S2

[V]	[mA]
153.7	5351.9
147.9	1328.8
138.4	230.4
132.6	126.3
129.2	100.62
123	74.91
115.7	60.14
109.5	52.58
103.2	47.64
90.8	40.94
71.3	33.03
51.6	25.9
31.8	18.59
12	9.22
1.2	1.77



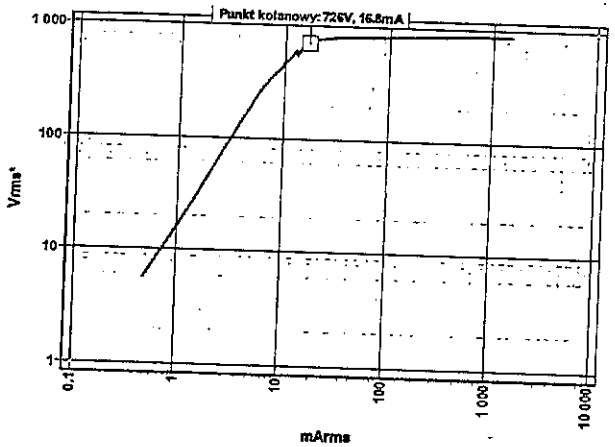
Winding 2S1-2S2

[V]	[mA]
159.5	908.5
146.9	8.19
136.8	3.68
127	1.99
123.3	1.67
117	1.27
110.7	1.02
103.3	0.86
97.1	0.76
91	0.7
71.4	0.57
51.8	0.47
32.1	0.35
12.3	0.18
1.2	0.07



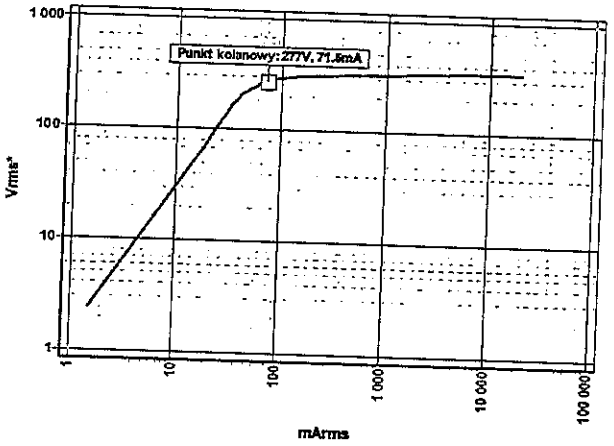
Winding 3S1-3S2

[V]	[mA]
899	1522.2
860.1	155.7
798.6	27.5
755.6	19.04
740.5	17.96
728.7	16.93
696.4	15.62
670.4	14.51
644.9	14.27
529.5	11.19
417.4	8.65
307.1	6.43
195.3	4.74
83.2	2.81
5.7	0.47



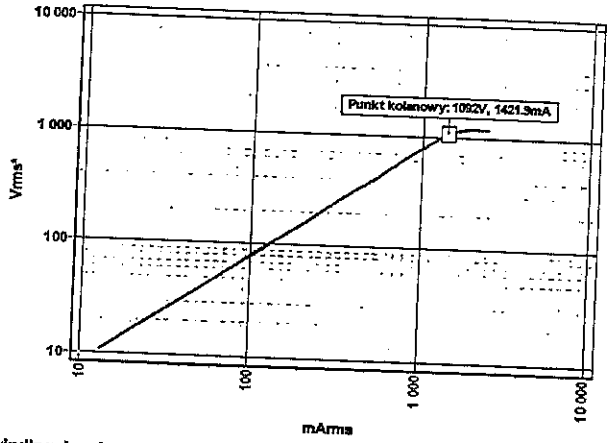
Winding 4S1-4S2

[V]	[mA]
358	20011
325.1	385.9
304.4	118.8
295.9	96.74
288	82.97
283	77.06
268.7	62.67
253	55.37
240.1	49.93
196.6	39.03
154	31.55
110.8	24.6
68.8	17.9
26.3	9
2.4	1.5



Winding 5S1-5S2

[V]	[mA]
1201.7	2415
1181.1	1753.8
1160.8	1591.9
1134.3	1500.1
1113.1	1455.9
1084.1	1408.2
1053.8	1363.1
1027.3	1326
917.3	1177
757.2	968.7
598.5	765.3
435.7	557.9
271.4	348
104.7	135
10.9	13.35



Measurement of windings' resistance

Windings' resistance of current part:

	R (23°C)	R ct (75°C)
P1-P2 range 1000 A	90.0 µΩ	108.4 µΩ
P1-P2 range 2000 A	41.0 µΩ	49.4 µΩ
1S1-1S2	0.455 Ω	0.548 Ω
2S1-2S2	6.390 Ω	7.696 Ω
3S1-3S2	3.353 Ω	4.038 Ω
4S1-4S2	0.392 Ω	0.472 Ω
5S1-5S2	3.648 Ω	4.391 Ω
6S1-6S2	3.924 Ω	4.726 Ω

Windings' resistance of voltage part:

	R (24,9°C)	R ct (75°C)
A-N	21.70 kΩ	26.135 kΩ
1a-1n	47.300 mΩ	56.966 mΩ
2a-2n	48.710 mΩ	58.664 mΩ
3a-3n	50.200 mΩ	60.459 mΩ
4a-4n	51.800 mΩ	62.386 mΩ
Da-dn	114.100 mΩ	137.417 mΩ

Checked by: OG-4 KJ-06

Przasnysz, 12.11.2013 r.

ABB Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer after short time current test			TYP: PVA145a Nr fabr. 2GKP013K1486140	
A – N 132:$\sqrt{3}$ kV	Insulation level: 145/275/650 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA] 63-63	Idyn [kA] 158-158	Icth [A]: 1200-2400	IEC 61869-4 50 Hz

	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
VOLTAGE PART	1a-1n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	2a-2n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	3a-3n	0,11:√3	25	0,2/3P	1000
		0,11:√3	500	3/3P	1000
	4a-4n	0,11:√3	25	3/3P	1000
		0,11:√3	25	3/3P	1000
	da-dn	0,11	150	1	450
		0,11	400	3P	450

	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
CURRENT PART	1S1-1S2	5	100	0,2FS10	1000-2000/5
	2S1-2S2	1	70	0,1FS5	1000-2000/1
	3S1-3S2	1	35	5P 20	1000-2000/1
	4S1-4S2	5	16	5P 60	1000-2000/5
				PX Ek = 250V Ie <= 0,1A / 125 V Rct <= 0,5 Ω Rb = 1 Ω	
	5S1-5S2	1		TPY Kssc = 15 Ktd = 13 Cykl = 0,1s Tp = 0,05 s Rb = 2 Ω K_R <= 10%	1000-2000/1
			30	5P30	
	6S1-6S2	1	10	5PR20 Rct <= 8Ω	1000-2000/1
				PXR 2-1/2000 Kx = 20 Ek = 500V Ie <= 0,1A / 250 V Rct <= 5,0 Ω Rb = 20 Ω	

List of performer tests

1. Oil dielectric parameters check before filling (oil after tgδ wg IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings – P1+P2/A;Up=247,5 kV / 60 s,f =97 Hz; N; Up = 3 kV/ 60s, f=50 Hz ☑

5. Partial discharge ☑
6. Power-frequency withstand test on secondary – Up = 3 kV/60 s ☑
7. Inter-turn overvoltage test for current transformers– lower value (U szczyt. = 4,5 kV lub U szczyt. Przy Icth) / 60s ☑
8. Determination of errors ☑
9. . Determination of the over current factors: FS, ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
  Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage =77,42 kV, Relative standard deviation = 5,64%; f=50 Hz, oil temp. = 26 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	83,2
2	80,1
3	70,8
4	79,2
5	76,4
6	74,8

Partial discharge measurement

- Measurement according to procedure B
Stress voltage 247,5 kV / 60 s
Frequency 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	1,8 pC	1,2 pC

Remarks: background noise level: 1 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	4,5	2050
2S1-2S2	4,5	400
3S1-3S2	4,5	135
4S1-4S2	4,5	1100
5S1-5S2	1,47	2400
6S1-6S2	4,5	1750

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
1a-1n	0,11:√3	25	0,2	1000
2a-2n	0,11:√3	25	0,2	1000
3a-3n	0,11:√3	25	0,2/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	150	1	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,020	-0,019	-0,020	
Δφ U	3,1	3,2	3,2	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0,018	0,018	0,018	
Δφ U	3,1	3,2	3,3	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,012	-0,011	-0,012	
Δφ U	3,2	3,2	3,3	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	0,026	0,026	0,025	
Δφ U	3,2	3,2	3,3	

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,098	-0,099	-0,007	-0,006	-0,007	-0,144
Δφ U	1,9	3,0	3,3	3,3	3,4	1,2

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,054	-0,058	0,030	0,031	0,030	-0,109
Δφ U	1,8	2,9	3,2	3,2	3,3	1,2

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,091	-0,097	-0,006	-0,005	-0,006	-0,142
Δφ U	2,2	3,3	3,6	3,6	3,6	1,5

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,052	-0,055	0,034	0,035	0,034	-0,101
Δφ U	2,2	3,1	3,4	3,4	3,4	1,3

da – dn 150 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,921	-0,926	-0,839	-0,842
Δφ U	2,9	4,1	4,6	5,5

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,052	0,053	0,052
Δφ U	4,8	4,8	4,9

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,090	0,091	0,090
Δφ U	4,8	4,8	4,9

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,060	0,061	0,060
Δφ U	4,9	4,9	4,9

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,098	0,099	0,098
Δφ U	4,8	4,8	4,9

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,023	-0,026	0,064	0,065	0,064	-0,089
Δφ U	3,7	4,7	4,9	4,9	5,0	2,9

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,011	0,011	0,101	0,102	0,101	-0,032
Δφ U	3,5	4,6	4,8	4,9	4,9	2,8

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,025	-0,025	0,064	0,065	0,064	-0,071
Δφ U	3,9	4,9	5,1	5,1	5,2	3,1

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,017	0,014	0,104	0,105	0,104	-0,031
Δφ U	3,7	4,7	4,9	4,9	5,0	2,9

da – dn 37,5 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,602	-0,610	-0,522	-0,523
Δφ U	3,9	5,0	5,2	6,1

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	3,0	1000
2a-2n	0,11:√3	25	3,0	1000
3a-3n	0,11:√3	500	3/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	400	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,459	-0,459	-0,461	
Δφ U	-7,4	-7,4	-7,3	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,422	-0,422	-0,423	
Δφ U	-7,4	-7,4	-7,3	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,453	-0,453	-0,454	
Δφ U	-7,4	-7,4	-7,4	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,416	-0,416	-0,417	
Δφ U	-7,4	-7,4	-7,4	

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1,031	-1,031	-0,934	-0,932	-0,933	-1,280
Δφ U	3,0	4,1	4,7	4,7	4,8	-2,0

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,295	-0,295	-0,205	-0,203	-0,205	-0,555
Δφ U	2,2	3,3	3,7	3,7	3,7	-3,2

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,515	-0,522	-0,435	-0,435	-0,435	-0,790
Δφ U	-8,9	-7,4	-6,3	-6,3	-6,3	-13,0

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,478	-0,483	-0,394	-0,394	-0,394	-0,746
Δφ U	-9,1	-7,7	-6,6	-6,6	-6,5	-13,2

da – dn 400 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-1,790	-1,790	-1,726	-1,874
Δφ U	-5,3	-4,0	-1,9	-3,0

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,053	0,053	0,053
Δφ U	4,8	4,8	4,8

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,090	0,091	0,090
Δφ U	4,8	4,8	4,9

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,061	0,062	0,061
Δφ U	4,8	4,8	4,9

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,099	0,099	0,099
Δφ U	4,8	4,8	4,9

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,956	-0,857	-0,862	-0,861	-0,860	-1,208
Δφ U	4,7	5,8	6,3	6,3	6,4	-0,3

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,224	-0,225	-0,133	-0,132	-0,133	-0,481
Δφ U	4,0	5,0	5,3	5,3	5,3	-1,5

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,026	-0,027	0,062	0,063	0,063	-0,286
Δφ U	3,9	4,9	5,1	5,1	5,2	-1,8

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,017	0,016	0,104	0,105	0,104	-0,244
Δφ U	3,7	4,7	4,9	4,9	5,0	-1,9

da – dn 75 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,717	-0,725	-0,637	-0,637
Δφ U	4,3	5,3	5,6	6,6

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of current part errors (ε I %), (Δφ I min),

Ipn (A): 1000

1S1-1S2 100 VA; cosφ = 0,8					1S1-1S2 25 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0.302	-0.135	-0.014	-0.003	-0.011	0.098	0.148	0.152
Δφ I	8.6	4.9	1.9	1.7	5.9	3.1	1.8	1.5
2S1-2S2 70 VA; cosφ = 0,8					2S1-2S2 17.50 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0.072	-0.053	-0.006	-0.013	0.019	0.010	0.023	0.027
Δφ I	1.4	0.4	-0.6	-0.2	0.6	0.7	0.1	0.0

3S1-3S2: 35 VA cosφ = 0,8		4S1-4S2: 15 VA cosφ = 0,8	
	1,0 In		1,0 In
ε I	-0.138	ε I	-0.034
Δφ I	1.0	Δφ I	0.6

5S1-5S2: 30 VA cosφ = 0,8		6S1-6S2: 15 VA cosφ = 0,8	
	1,0 In		1,0 In
ε I	-2.510	ε I	-0.815
Δφ I	119.2	Δφ I	14.9

Ipn (A): 2000

1S1-1S2 100 VA; cosφ = 0,8					1S1-1S2 25 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0.302	-0.136	-0.016	-0.005	-0.003	0.098	0.147	0.151
Δφ I	8.6	4.9	1.8	1.6	5.8	3.1	1.8	1.5
2S1-2S2 70 VA; cosφ = 0,8					2S1-2S2 17,50 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n	0,05I_n	0,2 I_n	1,0 I_n	1,2 I_n
ε I	-0.072	-0.053	-0.008	-0.004	0.021	0.012	0.024	0.027
Δφ I	1.5	0.4	-0.6	-0.7	0.5	0.5	-0.1	-0.1

3S1-3S2: 35 VA cosφ = 0,8		4S1-4S2: 15 VA cosφ = 0,8	
	1,0 In		1,0 In
ε I	-0.138	ε I	-0.035
Δφ I	1.0	Δφ I	0.6

5S1-5S2: 30 VA cosφ = 0,8		6S1-6S2: 15 VA cosφ = 0,8	
	1,0 In		1,0 In
ε I	-2.510	ε I	-0.820
Δφ I	118.1	Δφ I	14.9

Current part: Measurements uncertainty: **ε I = ±0,045 %, Δφ I = ±2,3 min**
Voltage part: Measurements uncertainty: **ε U = ±0,044 %, Δφ U = ±2,2 min**

Determination of the over current factors:

- instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	5	153.48	422.08	$U < E_{FS}$	☑
2S1-2S2	0.5	157.29	530.14	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Uzwojenie	E_{ALF} [V]	Ie [A]	ε_c [%]	Condition	Assessment
3S1-3S2		0.02	0.1	$\varepsilon_c < 5\%$	☑
4S1-4S2	363.63	0.123	0.04	$\varepsilon_c < 5\%$	☑
5S1-5S2		1.296	4.32	$\varepsilon_c < 5\%$	☑
6S1-6S2	876.63	0.097	0.49	$\varepsilon_c < 5\%$	☑

Determination of parameters of class PX core 4S1-4S2:

4S1-4S2		
Ipn (A)	1000	2000
factor Kx	38.67	38.64

Determination of parameters of class TPY core 5S1-5S2:

Ipn (A)	1000	2000
factor Kssc	15.81	15.81
factor Ktd	12.78	12.78
factor Kr [%]	0	0
Błąd przekładni prądowej [%]	-0.124	-0.127
Ts [s]	0.4452	0.4453
ε-peak [%]	9.423	9.421

Determination of parameters of class PXR core 6S1-6S2:

Ipn (A)	1000	2000
factor Kx	26.64	26.64
factor Kr [%]	3	3

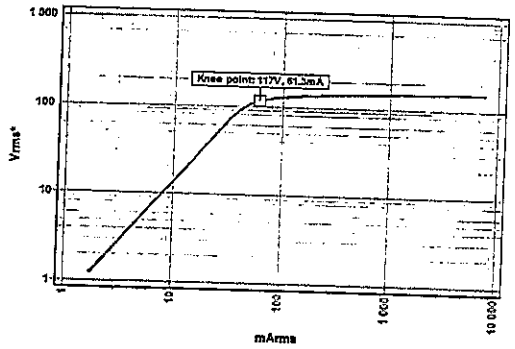
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.23	1417	4.448	0.24	1140	3.585	0.22	276	0.868
63 kV	0.23	1417	28.01	0.24	1141	22.57	0.22	276	5.468
71 kV	0.23	1417	31.75	0.24	1141	25.54	0.22	276	6.195

Core magnetization characteristics:

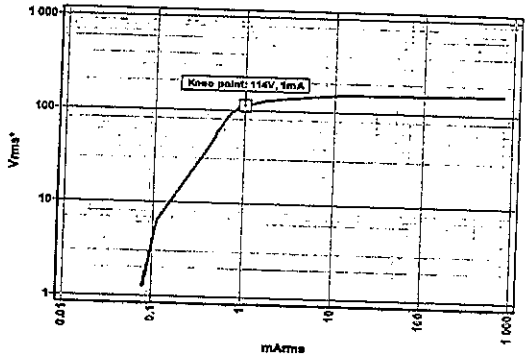
Winding 1S1-1S2

[V]	[mA]
154.8	7322.0
147.9	1271.5
138.4	221.3
128.4	93.4
124.6	77.93
118.5	63.60
111.3	53.86
104.5	46.16
98.3	44.30
92.1	41.06
72.1	33.06
52.1	25.86
32.2	18.69
12.2	9.32
1.2	1.79



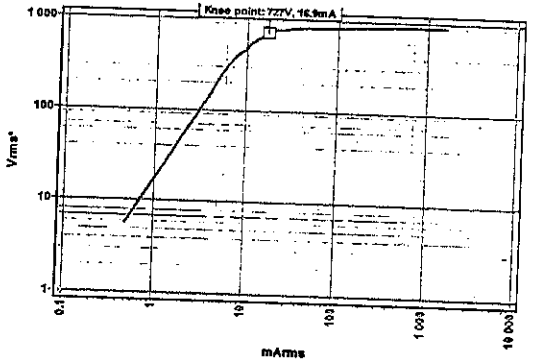
Winding 2S1-2S2

[V]	[mA]
158.7	762.3
149.2	10.39
139.8	4.24
129.2	2.06
125.4	1.64
119.2	1.21
111.8	0.95
105.4	0.83
99.0	0.75
92.8	0.7
72.8	0.58
52.7	0.47
32.6	0.35
12.5	0.18
1.3	0.08



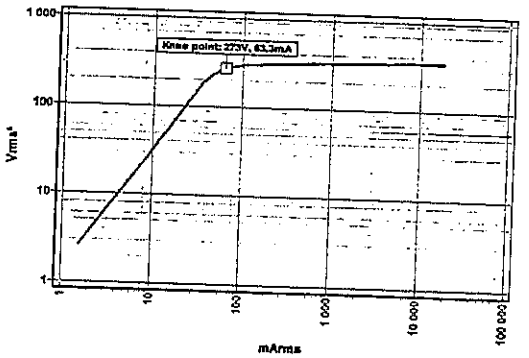
Winding 3S1-3S2

[V]	[mA]
900.2	1567.4
800.2	27.88
769.4	20.32
758.0	19.38
741.3	17.54
725.8	16.86
711.9	16.64
682.3	15.75
655.2	14.63
538.0	10.97
423.5	8.48
310.9	6.22
198.3	4.63
84.1	2.73
5.8	0.48



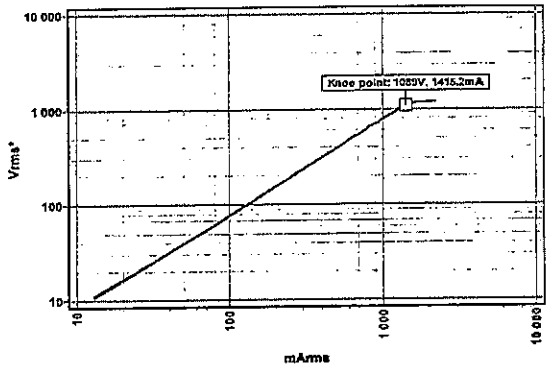
Winding 4S1-4S2

[V]	[mA]
355.1	17673
328.8	525.6
303.0	109.9
300.7	100.86
292.6	83.50
284.2	72.44
271.3	61.54
257.7	54.20
241.0	47.48
199.9	38.64
157.3	31.17
112.8	24.22
69.8	17.44
26.0	8.64
2.6	1.55



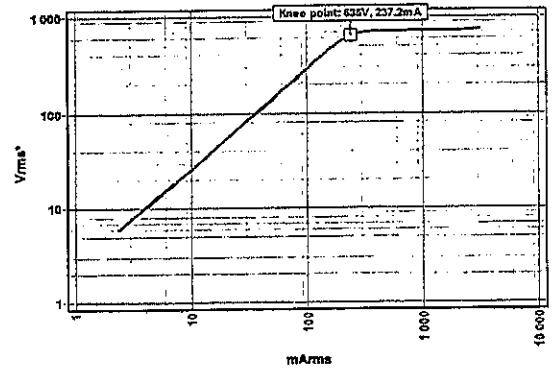
Winding 5S1-5S2

[V]	[mA]
1197.8	2177.8
1187.4	1848.3
1146.9	1535.8
1119.4	1462.7
1095.9	1425.8
1066.0	1380.4
1035.9	1334.2
1015.6	1303.8
935.2	1197.2
768.6	980.6
605.3	772.0
442.4	564.4
275.3	351.7
106.4	136.8
10.8	13.12



Winding 6S1-6S2

[V]	[mA]
733.8	3054.6
670.3	271.9
659.0	257.7
643.5	243.5
627.0	231.6
614.9	224.1
600.2	216.0
567.3	200.2
485.6	167.1
399.5	136.7
313.1	107.81
226.7	78.97
140.0	49.67
53.7	19.82
5.9	2.37



Measurement of windings' resistance

Windings' resistance of current part:

	R (23°C)	R ct (75°C)
P1-P2 zakres 1000 A	145.0 µΩ	173.5 µΩ
P1-P2 zakres 2000 A	77.0 µΩ	92.1 µΩ
1S1-1S2	0.455 Ω	0.544 Ω
2S1-2S2	6.200 Ω	7.418 Ω
3S1-3S2	3.352 Ω	4.011 Ω
4S1-4S2	0.395Ω	0.473 Ω
5S1-5S2	3.710 Ω	4.439 Ω
6S1-6S2	3.909 Ω	4.677 Ω

Windings' resistance of voltage part:

	R (24.9°C)	R ct (75°C)
A-N	21.60 kΩ	25.844 kΩ
1a-1n	46.940 mΩ	56.164 mΩ
2a-2n	48.610 mΩ	58.162 mΩ
3a-3n	49.930 mΩ	59.741 mΩ
4a-4n	51.500 mΩ	61.620 mΩ
Da-dn	113.700 mΩ	136.042 mΩ

Checked by: .....OG-4 KJ-06.....

Przasnysz. 20.12.2013 r.

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ANNEX 4 **Documentations delivered by orderer**

ABB Sp. z o.o.	Declaration of conformity	ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 093/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486140;**

Place and date of issue of declaration

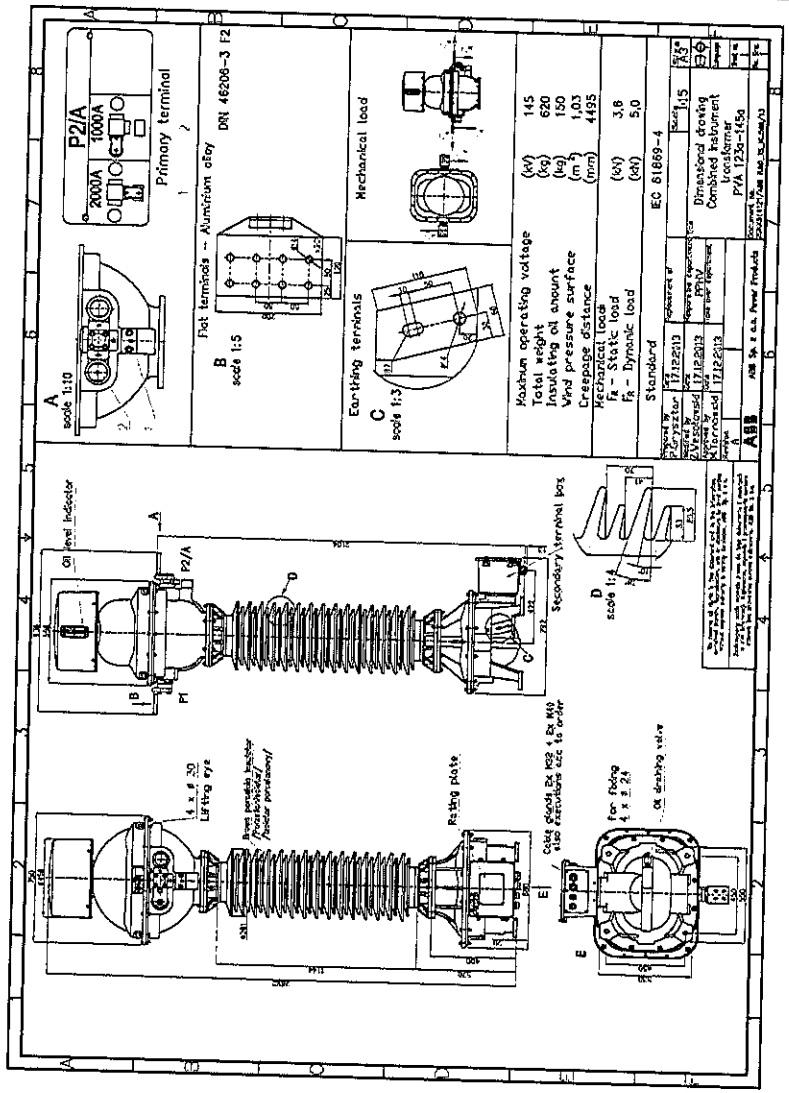
Przasnysz 13.01.2014

ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
NIP: 526-030-44-84; PL 526304484
Regon 010017163
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8921, fax (22) 223 8958

Kierownik ds. Zaopatrzenia Małgorzata Oddziewska
ABB Sp. z o.o.
Oddział w Przasnyszu

Krzysztof Łubocki

(Name) (Signature)



ABB

Combined Instrument Transformer

Type	PVA 145a				
Insulation level	145/275/650 kV	Standard	IEC 61869-4	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	620 / 150 kg	Temp.range	-50°C — +40°C
S/N	2GKP013K1486140	Voltage factor	1,9Un/8h	Ue	0,2 mV/kA

CURRENT PART

K_n 1000-2000 / 5-1-1-5-1-1 A/A

$I_{th}/1s$ 63 - 63 kA I_{dyn} 158 - 158 kA

I_{cth} 1200 - 2400 A

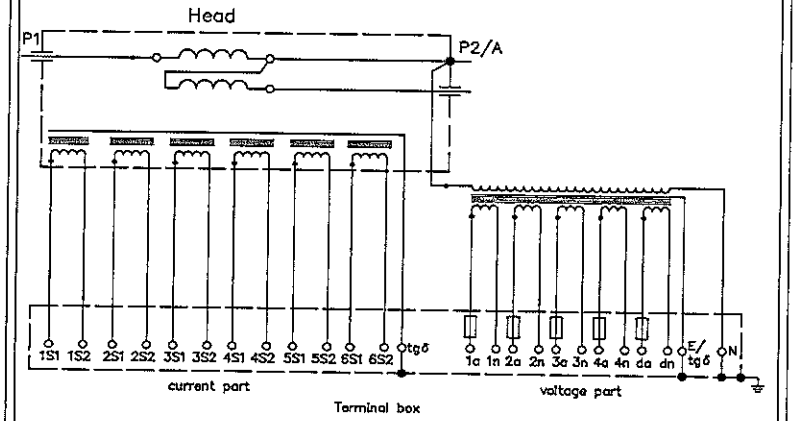
	A	VA	Klasa	FS/ALF	Ext.%
1S1-1S2	5	100	0,2	10	120
2S1-2S2	1	70	0,1	5	120
3S1-3S2	1	35	5P	20	-
4S1-4S2	5	15	5P	60	-
		Rb=1Ω, klasa PX, Ek=250V, Io<=0,1 A, Rct <=7Ω			
5S1-5S2	1	Rb=2Ω, klasaTPY 15x13, Rct <=7Ω ,Ts=500 ms, cykl 100 ms, Tp=50 ms			
6S1-6S2	1	10 VA, klasa 5PR20, Rct<= 8 Ω			
		Rb=20Ω, klasa PXR, 2-1/2000, Ek=500 V, Io<=0,1 A / 250 V, Rct<= 5Ω , Kx=20			

VOLTAGE PART

A-N 132:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3	110:√3	110:√3	110
VA	25	25	25	25	150
Klasa	0,2	0,2	0,2/3P	3/3P	1,0
VA	(25)	(25)	(500)	(25)	(400)
Klasa	(3)	(3)	(3/3P)	(3/3P)	(3P)
VAth	1000	1000	1000	1000	450

Transportation Vertical/Horizontal



Instrument transformer electrical diagram

ATTENTION!

1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ, tgδ MUST BE EARTHED
3. AFTER THREE WINDINGS da - dn ARE CONNECTED IN BROKEN DELTA THE CIRCUIT SHOULD BE EARTHED IN ONE POINT ONLY

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/71/E/13-1 E

TEST OBJECT: Combined instrument transformer type PVA 145a with porcelain insulator
Serial No. 2GKP013K1486141

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: Internal order No. EWN/145/E/13 dated 12.12.2013

TYPE OF TESTS: Short-time current tests

TESTS PROCEDURE: According to IEC 61869-2:2012 and client instructions

DATE OF TESTS: 12/13.12.2013

TESTS RESULT: Positive for:
I_{dyn} = 158 kA, I_{th} = 63 kA, t = 1 s
and
I_{dyn} = 100 kA (no. of tests = 3) , I_{th} = 40 kA, t = 3 s

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: M. Tarnowski, Z. Wesołowski – ABB Sp. z o.o.

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 15.01.2014

Publishing or reproducing of this report in other version than exact and complete without permission in writing from the laboratory is forbidden.

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figures	2
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1. TEST OBJECT

1.1 Description

Combined instrument transformer type PVA 145a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 145 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with porcelain insulator immersed with transformer oil.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	145 kV
Rated frequency	50 Hz
Rated continuous thermal current	3000 A
Rated short-time current for 1 s	63 kA
Rated dynamic current	158 kA

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing combined transformer PVA 123a-145a, No. 2GKK614120 (17.12.2013),
- routine tests report of combined instrument transformer (10.12.2013),
- routine tests report of combined instrument transformer after short-time current test (03.01.2014),
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o (Annex 3 and 4).
The laboratory proceeded the identification of test object on the base of above documentation and the rating plate. Conformity of manufacturing with constructional documentation is stated in manufacturer's declaration, copy of which presents Annex 4.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-2:2012 and client instructions:

- short-time current tests of current transformer acc. to item 7.2.201 of above standard at parameters:
  $I_{dyn} \geq 158$ kA for 3000 A terminal,
  $I_{dyn} \geq 100$ kA for 3000 A terminal,
  $I_{dyn} \geq 100$ kA for 3000 A terminal,
  $I_{th} = 63$ kA, $t_{th} = 1{,}21$ s, $I_{th}^2 \times t_{th} \geq 4800$ kA^2×s for 3000 A terminal.
- routine test before and after short-time current test made in factory.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests was made in one-phase circuit presented on fig. 1 at dimensions presented on fig.2. The following quantities were recorded during the tests using digital recorder type HIOKI 8842:
- primary current (with short-circuited all secondary terminals) during short-time current tests using laboratory current transformer type CdC class 0,5 with a ratio 50.000/2 A/A (uncertainty of measurement ±0,018% for k = 2),
- secondary currents in 1S1-1S2 winding by means of laboratory toroidal current transformers type IL20a class 0,5 with a ratio 1.000/5 A/A (uncertainty of measurement ±0,012% for k = 2) and secondary currents in 3S1-3S2, 6S1-6S2 by by means of current transformer type GE 4461 class 0,2 with a ratio 50/5 A/A (uncertainty of measurement ±0,013% for k = 2).
- voltage drop (U_0) on test object during short-time current tests by means of a resistance-capacitance voltage divider with a bandwidth from 0 to 100 kHz.

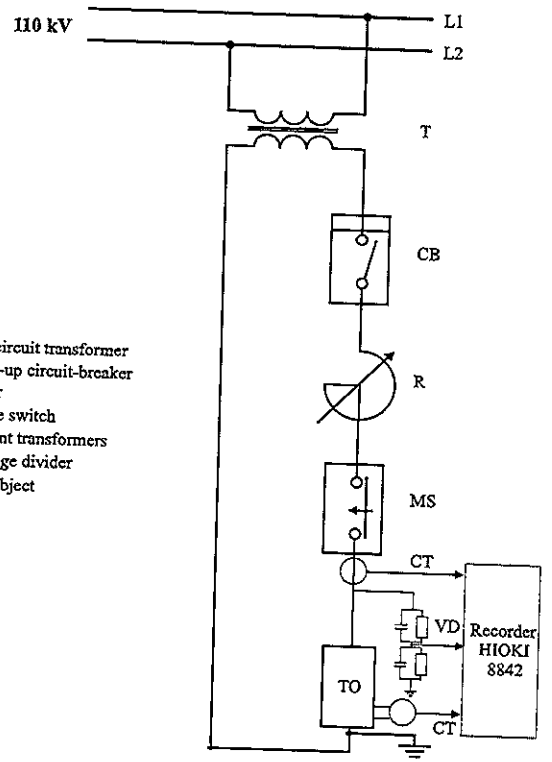

Fig.1. Test and measuring circuits during tests

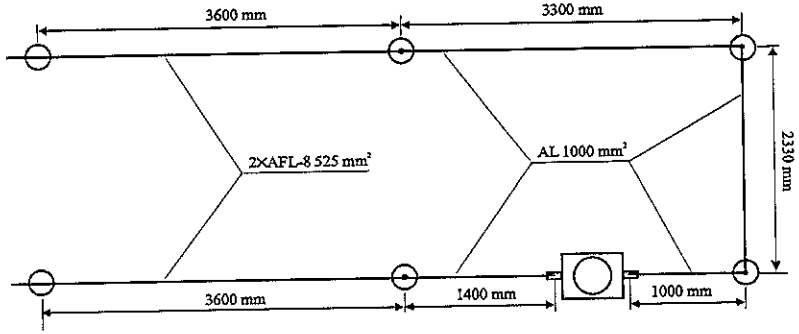

Fig. 2. Configuration of test circuit during tests

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents tables 1 and 2.
During the tests the following records were made:
- Nos. 33070, 33072, 33086 – calibration of measuring and test circuit,
- Nos. 33071, 33073, 33074, 33087 – short-time current tests,
  (Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory's archives),
- phot. 1 – current transformer on short-circuit tests stand
  (Annex 2 presents the photograph).

Table 1. Results of short-time current tests

Test No.	i_{peak}	I_z	t_z	$I_z^2 \times t_z$	$I_{1S1-1S2}$	$I_{3S1-3S2}$	$I_{6S1-6S2}$	U_0	Observations
-	kA	kA	s	$(kA)^2 \times s$	A	A	A	V	-
33071	160,18[1)]	64,31	0,06	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33073	103,06[2)]	40,30	0,06	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33074	101,51[2)]	40,29	0,06	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33087	96,07	64,86	1,15	4838[3)]	109	21	21	21	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
i_{peak} – peak value of test current,
I_z – r.m.s. value of test current (determined from test period without asymmetrical component),
t_z – test duration,
$I_{1S1-1S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{3S1-3S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{6S1-6S2}$ – r.m.s. value (determined from test period without asymmetrical component),
U_0 – r.m.s. value (determined from test period without asymmetrical component).
Required : [1)] $i_{peak} \geq 158$ kA,
[2)] $i_{peak} \geq 100$ kA,
[3)] $I_z^2 \times t_z \geq 4800\ (kA)^2 \times s$.

5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-2:2012 the results of tests is positive for:
$I_{dyn} = 158$ kA, $I_{th} = 63$ kA, $t = 1$ s
and
$I_{dyn} = 100$ kA (no. of tests = 3), $I_{th} = 40$ kA, $t = 3$ s for 3000 A terminal of tested combined instrument transformer.

Thermal ability to withstand short circuit during tests was $I_z^2 \times t_z > 4800\ (kA)^2 \times s$ (the same value is required for $I_{th} = 40$ kA and $t = 3$ s).

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ANNEX 1

Test records

As not numbered pages the following copies of records are given:

33071, 33073, 33074, 33087 – short-time current tests,

Denotations:

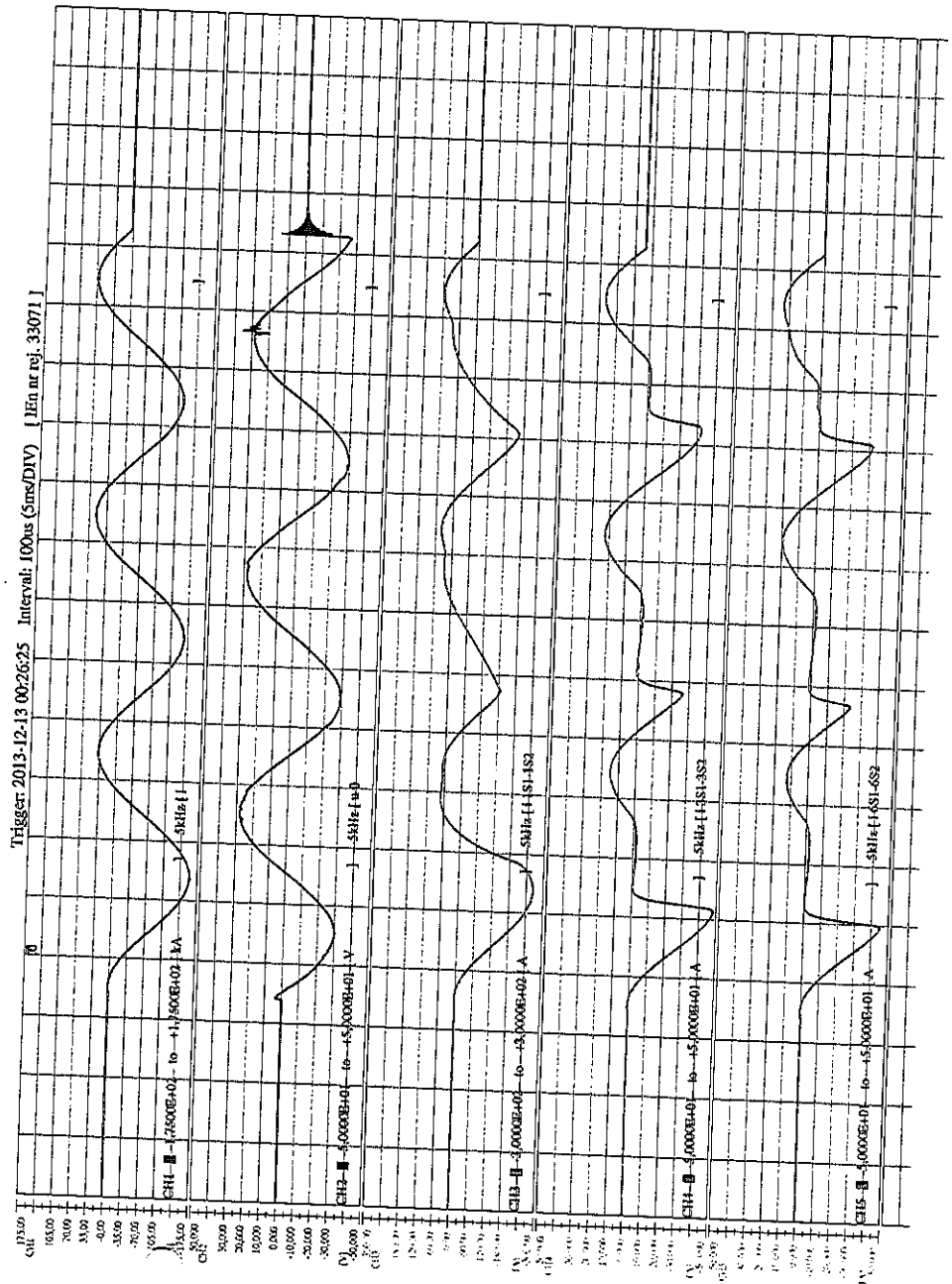
i – test current,

u_0 – voltage drop on test object,

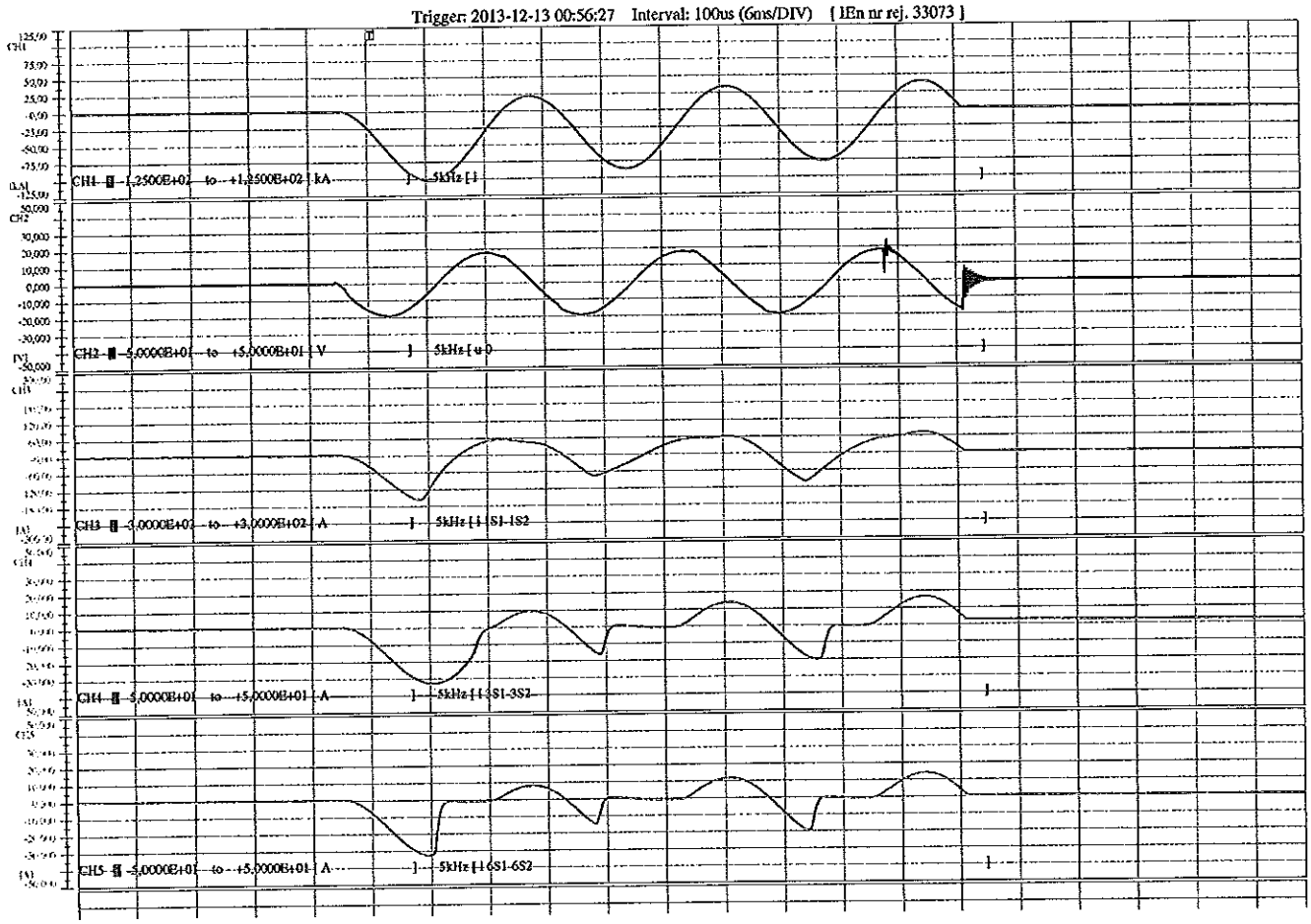
$i_{1S1-1S2}$ – 1S1-1S2 winding current,

$i_{3S1-3S2}$ – 3S1-3S2 winding current,

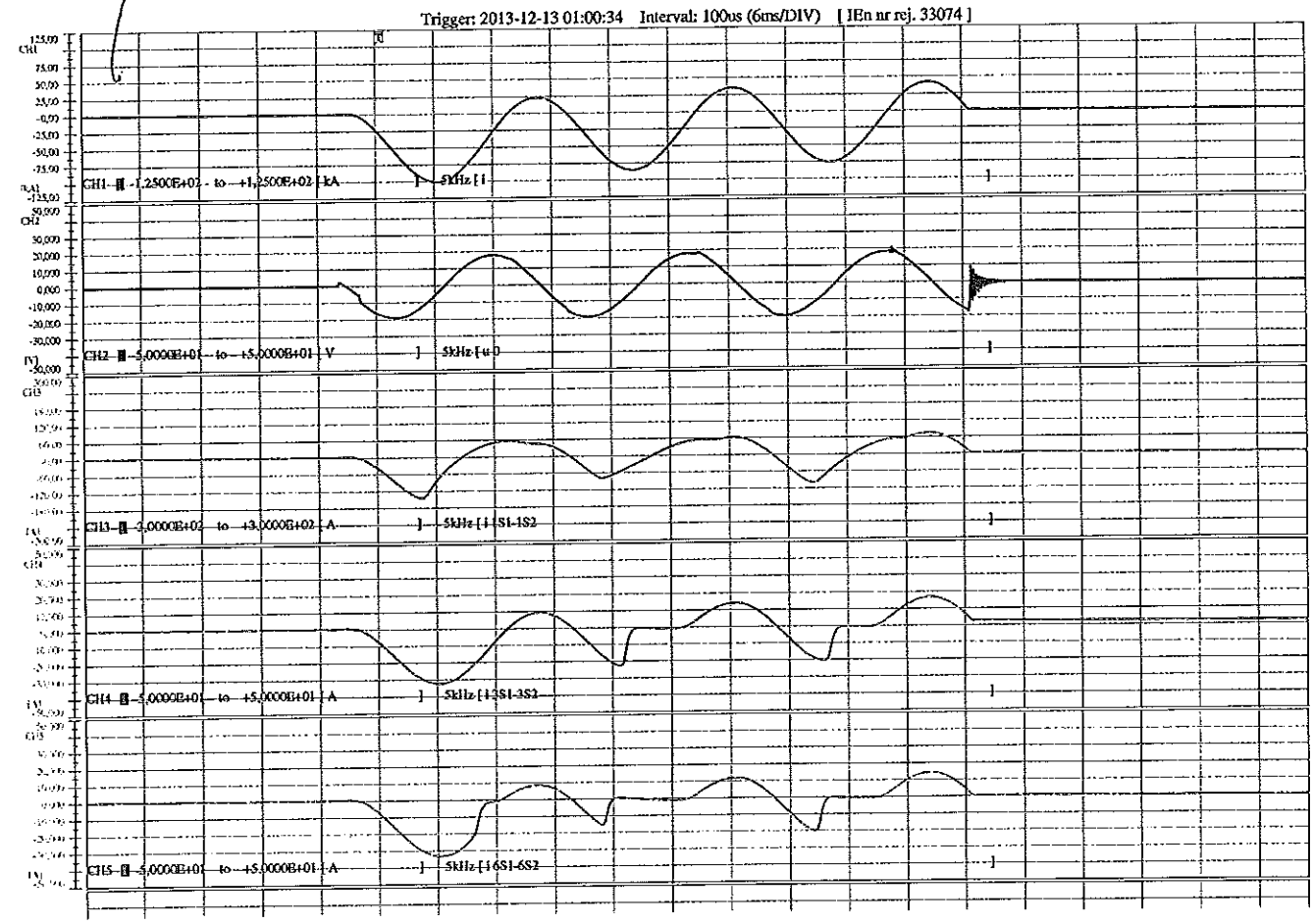
$i_{6S1-6S2}$ – 6S1-6S2 winding current.



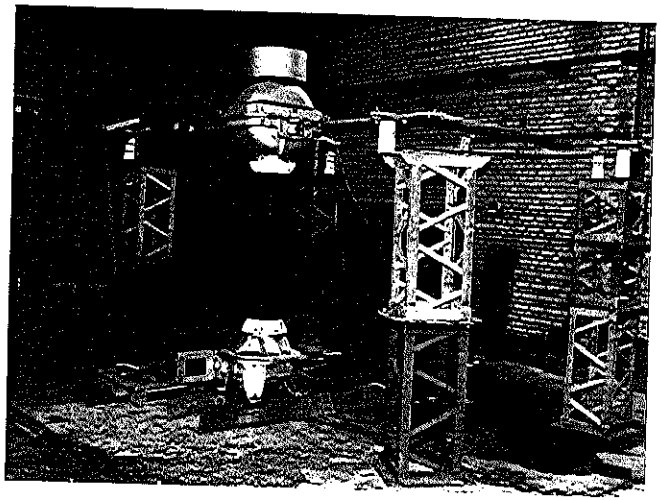
Trigger: 2013-12-13 00:56:27 Interval: 100us (6ms/DIV) [IEn nr rej. 33073]



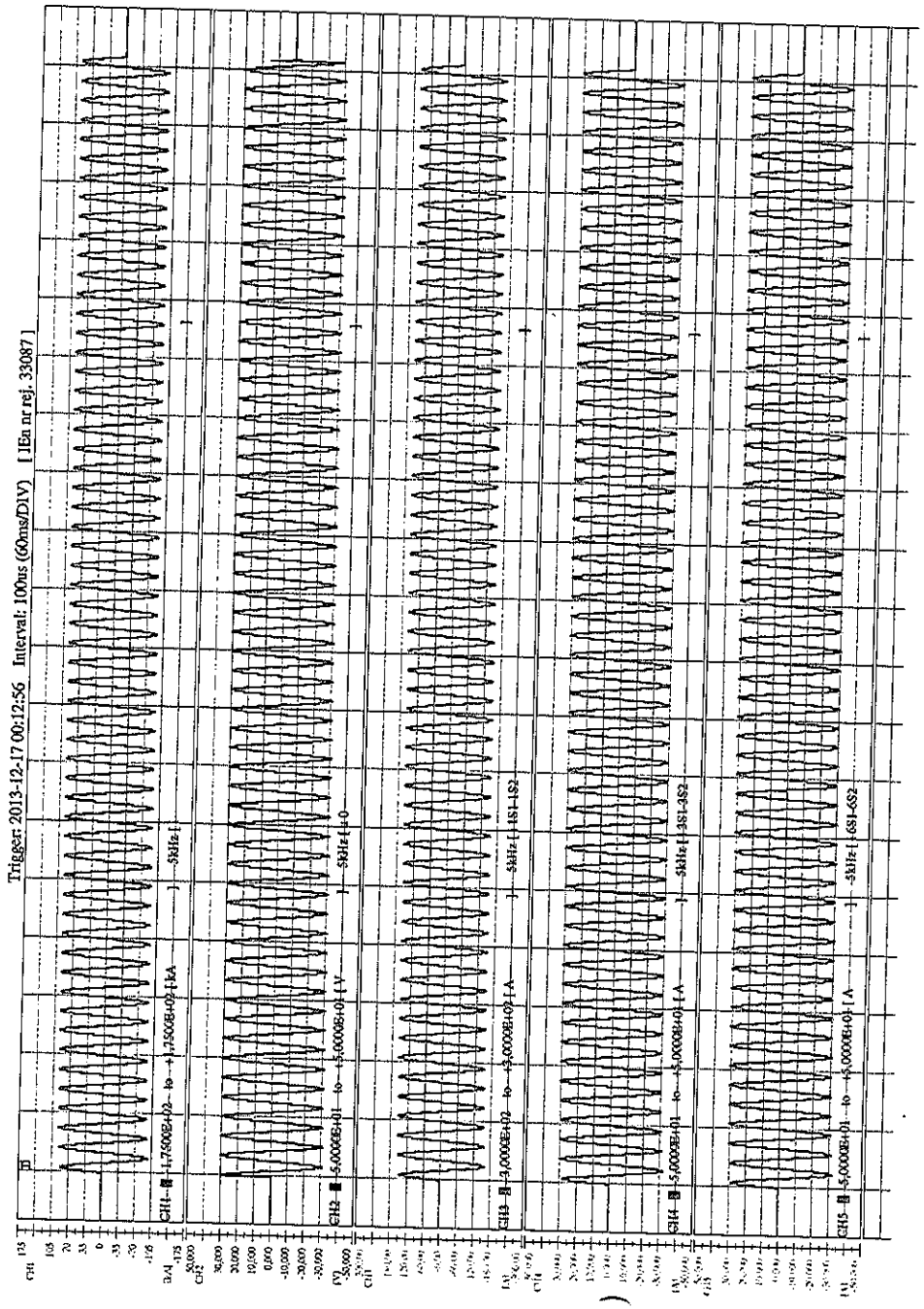
Trigger: 2013-12-13 01:00:34 Interval: 100us (6ms/DIV) [IEn nr rej. 33074]



ANNEX 2 **Photographs taken during the tests**



Phot. 1. PVA 145a after short-time current tests



ANNEX 3 Routine test report before and after short-time current tests

ABB Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer			TYP: PVA145a Nr fabr. 2GKP013K1486141	
A – N	Insulation level: 145/275/650 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA]	Idyn [kA]	Icth [A]:	IEC 61869-4
132:√3 kV			63	158	3600	50 Hz

VOLTAGE PART	Winding	Usn [kV]	Sn [VA]	klasa	Sth [VA]
	1a-1n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	2a-2n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	3a-3n	0,11:√3	25	0,2/3P	1000
		0,11:√3	600	3/3P	1000
	4a-4n	0,11:√3	25	3/3P	1000
		0,11:√3	25	3/3P	1000
	da-dn	0,11	150	1	450
		0,11	400	3P	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	klasa	Ratio [A/A]
	1S1-1S2	5	200	0,2FS10	3000/5
	2S1-2S2	1	100	0,1FS5	3000/1
	3S1-3S2	1		TPZ Rb = 7 Ω Kssc = 15 Ktd = 7,4 Rct <= 6 Ω Tp = 50 ms Cykl 100 ms	3000/1
	4S1-4S2	5	20	5P60	3000/5
	5S1-5S2	1		TPY Rb = 5 Ω Kssc= 10 Ktd= 13 Rct <= 7 Ω Ts = 500 ms Tp = 60 ms cykl = 100 ms	3000/1
	6S1-6S2	1	35	5PR20	3000/1
				PXR Rb = 27 Ω 1/3000 Ek = 700 V Ie <= 0,4A / 350 V Rct <= 8 Ω Kx = 20	3000/1

List of performer tests

1. Oil dielectric parameters check before filling (oil after tgδ wg IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings – P1+P2/A;Up=275 kV / 60 s,f =97 Hz; N; Up = 3 kV/ 60s, f=50 Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary – Up = 3 kV/60 s ☑

7. Inter-turn overvoltage test for current transformers– lower value (U szczyt. = 4,5 kV lub U szczyt. Przy Icth) / 60s ☑
8. Determination of errors ☑
9. . Determination of the over current factors: FS, ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
    Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
  Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage =78,15 kV, Relative standard deviation = 5,99%; f=50 Hz, oil temp. = 25 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	73.7
2	84.3
3	82.8
4	78.4
5	76.9
6	72.8

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)
Stress voltage 275 kV / 60 s
Frequency 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100.5 kV
Level of partial discharge	1.6 pC	1.2pC

Remarks: background noise level: 1 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	4.5	1400
2S1-2S2	4.5	320
3S1-3S2	0.448	3600
4S1-4S2	4.5	1000
5S1-5S2	3.2	3800
6S1-6S2	4.5	2100

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	0,2	1000
2a-2n	0,11:√3	25	0,2	1000
3a-3n	0,11:√3	25	0,2/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	150	1	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,078	-0,077	-0,079	
Δφ U	3,7	3,7	3,8	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,040	-0,040	-0,041	
Δφ U	3,7	3,7	3,8	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,071	-0,070	-0,072	
Δφ U	3,8	3,8	3,8	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,034	-0,034	-0,034	
Δφ U	3,7	3,7	3,8	

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,114	-0,132	-0,060	-0,060	-0,051	-0,192
Δφ U	2,5	3,6	3,9	3,8	3,9	1,9

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,075	-0,096	-0,023	-0,022	-0,024	-0,155
Δφ U	2,4	3,6	3,8	3,8	3,8	1,8

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,124	-0,145	-0,072	-0,072	-0,073	-0,200
Δφ U	2,8	4,0	4,2	4,2	4,2	2,2

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,075	-0,097	-0,025	-0,025	-0,026	-0,158
Δφ U	2,6	3,8	4,0	4,0	4,0	2,0

da – dn 100 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,937	-0,864	-0,857
Δφ U	4,5	4,7	5,6

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,008	-0,006	-0,007
Δφ U	5,3	5,3	5,4

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,031	0,032	0,031
Δφ U	5,3	5,3	5,4

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,001	0,001	0,000
Δφ U	5,4	5,4	5,5

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,038	0,038	0,037
Δφ U	5,4	5,4	5,4

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,040	-0,061	0,012	0,012	0,011	-0,121
Δφ U	4,3	5,4	5,5	5,5	5,5	3,6

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,002	-0,024	0,049	0,049	0,048	-0,084
Δφ U	4,2	5,3	5,4	5,4	5,5	3,5

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,044	-0,070	0,002	0,003	0,002	-0,130
Δφ U	4,6	5,7	5,7	5,7	5,8	3,8

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,008	-0,031	0,044	0,043	0,042	-0,088
Δφ U	4,4	5,4	5,5	5,5	5,5	3,6

da – dn 25 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,635	-0,563	-0,564
Δφ U	5,6	5,7	6,6

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	3,0	1000
2a-2n	0,11:√3	25	3,0	1000
3a-3n	0,11:√3	500	3/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	400	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,520	-0,520	-0,521	
Δφ U	-6,7	-6,7	-6,6	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,483	-0,482	-0,483	
Δφ U	-6,7	-6,6	-6,6	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,517	-0,518	-0,518	
Δφ U	-6,7	-6,6	-6,6	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,481	-0,480	-0,482	
Δφ U	-6,7	-6,7	-6,6	

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1,035	-1,057	-0,978	-0,978	-0,980	-1,324
Δφ U	3,8	4,9	5,2	5,3	5,4	-1,5

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,308	-0,330	-0,256	-0,256	-0,257	-0,605
Δφ U	2,9	4,1	4,2	4,2	4,3	-2,7

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,544	-0,566	-0,490	-0,490	-0,491	-0,837
Δφ U	-7,2	-6,9	-5,5	-5,5	-5,1	-12,4

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,497	-0,521	-0,448	-0,447	-0,449	-0,795
Δφ U	-7,2	-6,0	-5,7	-5,7	-5,6	-12,7

da – dn 300 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-1,778	-1,803	-1,802	-1,738
Δφ U	-4,9	-3,5	-0,2	-1,8

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,006	-0,006	-0,007
Δφ U	5,3	5,3	5,4

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,031	0,032	0,031
Δφ U	5,3	5,3	5,3

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,004	-0,003	-0,005
Δφ U	5,4	5,4	5,5

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,084	0,086	0,086
Δφ U	5,4	5,4	5,4

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,965	-0,987	-0,912	-0,911	-0,912	-1,254
Δφ U	5,6	6,6	6,8	6,8	6,9	0,2

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,238	-0,259	-0,185	-0,184	-0,186	-0,534
Δφ U	4,7	5,7	5,8	5,8	5,9	-1,0

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,046	-0,085	0,009	0,009	0,008	-0,336
Δφ U	4,8	5,8	5,7	5,7	5,8	-1,1

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,005	-0,022	0,050	0,051	0,050	-0,297
Δφ U	4,4	5,4	5,5	5,5	5,5	-1,4

da – dn 75 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,729	-0,753	-0,684	-0,685
Δφ U	4,9	6,1	6,2	7,1

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of current part errors (ε I %), (Δφ I min),

Ipn (A): 3000

1S1-1S2 200 VA; cosφ = 0,8					1S1-1S2 50 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.283	-0.134	-0.039	-0.030	-0.019	0.056	0.092	0.095
Δφ I	6.5	3.3	1.0	0.8	3.9	1.9	1.0	0.9
2S1-2S2 100 VA; cosφ = 1					2S1-2S2 25 VA; cosφ = 1			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.039	-0.030	0.000	0.002	0.023	0.015	0.018	0.019
Δφ I	0.6	0.1	-0.6	-0.6	-0.1	0.2	-0.0	-0.0

3S1-3S2 TPZ Rb=7Ω cosφ = 1,0		4S1-4S2 20 VA cosφ = 0,8	
	1,0 In		1,0 In
ε I	-0.828	ε I	-0.017
Δφ I	179.5	Δφ I	0.3

5S1-6S2 TPY Rb=5Ω cosφ = 1,0		6S1-6S2 35 VA cosφ = 0,8	
ε I	-0.112	ε I	-0.924
Δφ I	22.3	Δφ I	31

Current part: Measurements uncertainty: **ε I = ±0,045 %, Δφ I = ±2,3 min**
Voltage part: Measurements uncertainty: **ε U = ±0,044 %, Δφ U = ±2,2 min**

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	5	233.59	422.28	$U < E_{FS}$	☑
2S1-2S2	0.5	226.56	527.8	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Condition	Assessment
4S1-4S2	424.19	0.045	0.02	$\varepsilon_c < 5\%$	☑
6S1-6S2	821.4	0.222	1.11	$\varepsilon_c < 5\%$	☑

Determination of parameters of class TPZ core 3S1-3S2:

Ipn (A)	3000
Rb [Ω]	7
Współczynnik Kssc	16.72 ≥ 15
Współczynnik Ktd	7.52 ≥ 7.4
Ts [s]	0.0587 ≤ (±10% x 0,5)
ε-peak [%]	≤ 10%
K_a [%]	≤ 10%

Determination of parameters of class TPY core 5S1-5S2:

Ipn (A)	3000
Rb [Ω]	5
Współczynnik Kssc	13.33 ≥ 10
Współczynnik Ktd	13.11 ≥ 13
Ts [s]	0.5502 ≤ (±30% x 0,5s)
ε-peak [%]	7.915 ≤ 10 %

Determination of parameters of class PR core 6S1-6S2:

Ipn (A)	3000
Sn [VA]	35
ALF	28.05 ≥ 20
Ts [s]	0.3468 ≤ (±30% x 0,5s)
ε-i [%]	1.07

Determination of parameters of class PXR core 6S1-6S2:

Ipn (A)	3000
Rb [Ω]	27
Ek [V]	936.51 >700
Ie [mA]	259.83
E1 [V]	350
Ie1 [mA]	92.83 < 400
Kx	28.36 ≥ 20
Ts [s]	0.3573 ≤ (±30% x 0,5s)
ε-t [%]	-0.277% ≤ ±1%
K_a [%]	2 ≤ 10%

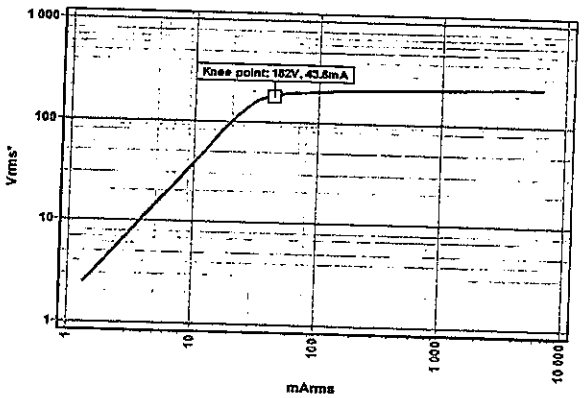
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.23	1417	4.462	0.25	1133	3.571	0.23	284	0.894
63 kV	0.24	1418	28.07	0.24	1134	22.44	0.23	284	5.61
71 kV	0.24	1418	31.48	0.24	1134	25.18	0.23	284	5.302

Core magnetization characteristics:

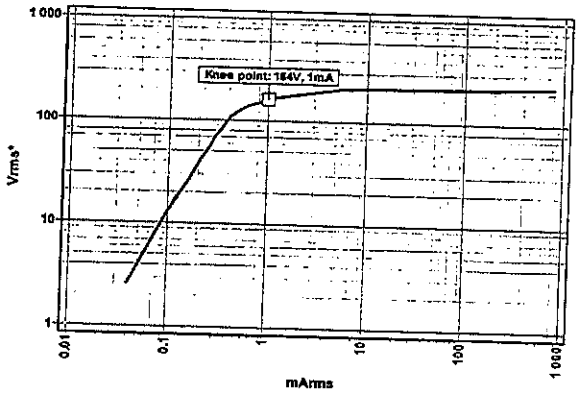
Winding 1S1-1S2

[V]	[mA]
234.6	6259
232.7	3895.7
229.8	2056.8
226.7	1250.8
213.7	226.2
208.8	133.9
200.4	77.08
192.6	55.55
179.6	40.64
166.9	33.82
152.9	29.57
111	21.61
68.8	15.18
26	7.56
2.4	1.36



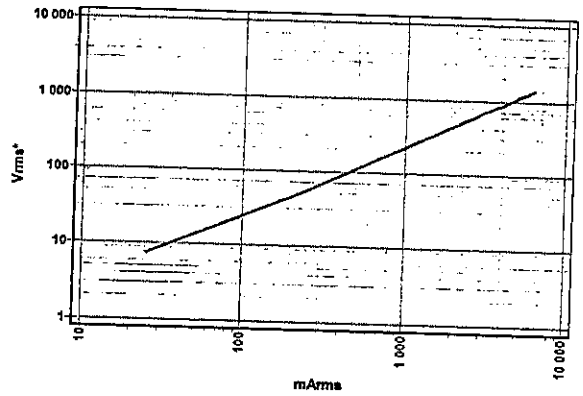
Winding 2S1-2S2

[V]	[mA]
230	799.6
223.6	235.6
219	16.07
203.5	4.14
196.9	3.48
180.8	1.77
167.3	1.09
153.6	0.84
140.2	0.6
124	0.49
97.5	0.38
68.6	0.29
41.1	0.21
13.2	0.1
2.6	0.04



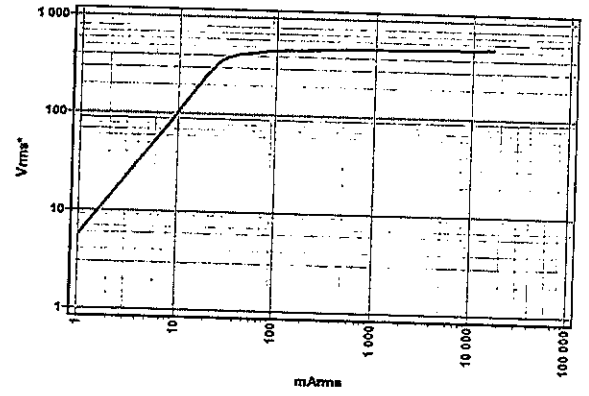
Winding 3S1-3S2

[V]	[mA]
1371.8	6278
1316	6018
1253.9	5710
1141.5	5207
1033	4692.7
983.9	4472.1
928	4210.9
838	3796.1
692.2	3135.4
552.1	2502.7
408.1	1847.7
258.3	1169.4
99.8	451.8
50.3	225.2
7.5	25.49



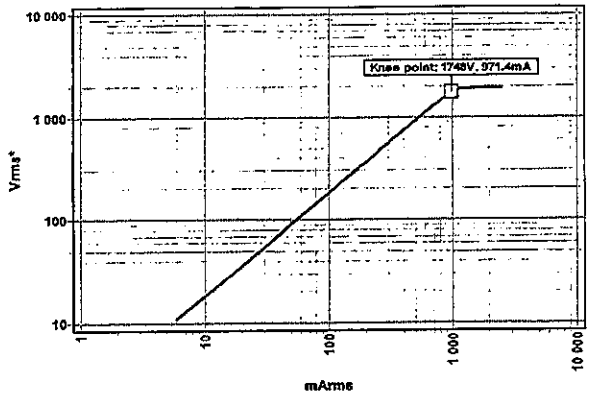
Winding 4S1-4S2

[V]	[mA]
532	16133
529.8	14038
526.3	10542
523.4	7280
522.4	6277
514.6	2065
493.4	431.9
456.8	76.94
384.8	31.31
304.5	22.77
221	17.32
136.8	12.05
52	5.84
26.3	3.45
5.7	1.02



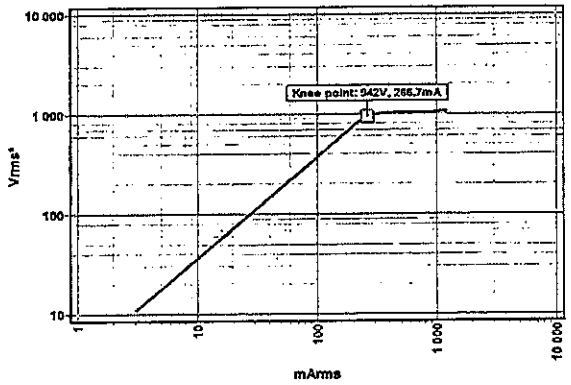
Winding 5S1-5S2

[V]	[mA]
1939.1	2480.9
1822.5	1037.7
1795.7	1009
1769.4	987.4
1732.8	959.4
1699.8	936.1
1666.3	917.3
1456.6	796.8
1255.8	685.7
1039.5	567.5
822	447.4
596.5	324.7
377.9	206.3
158.2	87.27
10.9	5.98



Winding 6S1-6S2

[V]	[mA]
1058	1202.9
1036.3	528.2
1015.9	364.3
995.3	314.1
966.1	280.7
936	263.2
915.7	254.2
885.3	242.9
833.2	225.8
777.5	209.3
610.1	162.8
443.2	118.8
274.2	74.15
105.4	29.08
10.8	3.08



Measurement of windings' resistance

Windings' resistance of current part:

	R (22°C)	R ct (75°C)
P1-P2 zakres 3000 A	28.0 µΩ	33.8 µΩ
1S1-1S2	0.454 Ω	0.549 Ω
2S1-2S2	5.670 Ω	6.851 Ω
3S1-3S2	4.397 Ω	5.313 Ω
4S1-4S2	0.571 Ω	0.690 Ω
5S1-5S2	5.830 Ω	7.044 Ω
5S1-5S2	6.040 Ω	7.298 Ω

Windings' resistance of voltage part:

	R (24,9°C)	R ct (75°C)
A-N	21.50 kΩ	25.978 kΩ
1a-1n	47.340 mΩ	57.200 mΩ
2a-2n	48.320 mΩ	58.385 mΩ
3a-3n	49.900 mΩ	60.294 mΩ
4a-4n	51.300 mΩ	61.985 mΩ
Da-dn	113.800 mΩ	137.503 mΩ

Checked by: ... OG-4 KJ-06

Przasnysz, 10.12.2013 r.

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AEE Sp. z o.o. 06 – 300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer after short time current test		TYP: PVA145a Nr fabr. 2GKP013K1486141	
A – N 132: $\sqrt{3}$ kV	Insulation level: 145/275/650 kV	Voltage factor: 1,9 /8h	Ith 1 s [kA] 63	Idyn [kA] 158	Icth [A]: 3600 / IEC 61869-4 50 Hz

VOLTAGE PART	Winding	Uan [kV]	Sn [VA]	klasa	Sth [VA]
	1a-1n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	2a-2n	0,11:√3	25	0,2	1000
		0,11:√3	25	3,0	1000
	3a-3n	0,11:√3	25	0,2/3P	1000
		0,11:√3	500	3/3P	1000
	4a-4n	0,11:√3	25	3/3P	1000
		0,11:√3	25	3/3P	1000
	da-dn	0,11	150	1	450
		0,11	400	3P	450

CURRENT PART	Winding	Isn [A]	Sn [VA]	klasa	Ratio [A/A]
	1S1-1S2	5	200	0,2FS10	3000/5
	2S1-2S2	1	100	0,1FS5	3000/1
	3S1-3S2	1		TPZ Rb = 7 Ω Ksac = 15 Ktd = 7,4 Rct <= 6 Ω Tp = 50 ms Cykl 100 ms	3000/1
	4S1-4S2	5	20	5P80	3000/5
	5S1-5S2	1		TPY Rb = 5 Ω Ksac= 10 Ktd= 13 Rct <= 7 Ω Ts = 500 ms Tp = 50 ms cykl = 100 ms	3000/1
	6S1-6S2	1	35	5PR20	3000/1
				PXR Rb = 27 Ω 1/3000 Ek = 700 V Ie <= 0,4A / 350 V Rct <= 8 Ω Kx = 20	3000/1

List of performer tests

1. Oil dielectric parameters check before filling (oil after tgδ wg IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings – P1+P2/A; Up=247,5 kV / 60 s, f =97 Hz; N; Up = 3 kV/ 60s, f=50 Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary – Up = 3 kV/60 s ☑

7. Inter-turn overvoltage test for current transformers– lower value (U szczyt. = 4,5 kV lub U szczyt. Przy Icth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor (tgδ) ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tgδ according to IEC 60247
  Tgδ = 0,06%; electrical stress = 1 kV/mm, f=50 Hz, Oil temp. = 90°C±1°C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage =78,15 kV, Relative standard deviation = 5,89%; f=50 Hz, oil temp. = 25 °C, measurement with the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	73.7
2	84.3
3	82.8
4	78.4
5	76.9
6	72.8

Partial discharge measurement

- Measurement according to procedure B
  Stress voltage 247,5 kV / 60 s
  Frequency 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100.5 kV
Level of partial discharge	1.8 pC	1.2pC

Remarks: background noise level: 1 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	4.5	1400
2S1-2S2	4.5	320
3S1-3S2	0.448	3600
4S1-4S2	4.5	1000
5S1-5S2	3.2	3600
6S1-6S2	4.5	2100

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	0,2	1000
2a-2n	0,11:√3	25	0,2	1000
3a-3n	0,11:√3	25	0,2/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	150	1	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,078	-0,077	-0,079	
Δφ U	3,7	3,7	3,8	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,040	-0,040	-0,041	
Δφ U	3,7	3,7	3,8	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,072	-0,070	-0,074	
Δφ U	3,8	3,8	3,8	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,035	-0,035	-0,037	
Δφ U	3,7	3,7	3,8	

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,114	-0,132	-0,060	-0,060	-0,061	-0,194
Δφ U	2,5	3,6	3,9	3,8	3,9	1,7

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,071	-0,094	-0,022	-0,022	-0,023	-0,158
Δφ U	2,5	3,6	3,8	3,8	3,8	1,7

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,107	-0,133	-0,064	-0,065	-0,066	-0,200
Δφ U	2,9	4,0	4,1	4,1	4,2	2,2

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,071	-0,097	-0,024	-0,024	-0,025	-0,160
Δφ U	2,8	3,8	3,9	3,9	4,0	1,8

da – dn 100 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,937	-0,864	-0,867
Δφ U	4,5	4,7	5,6

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,006	-0,006	-0,007
Δφ U	5,3	5,3	5,4

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,032	0,032	0,031
Δφ U	5,3	5,3	5,4

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,001	0,001	0,000
Δφ U	5,4	5,4	5,5

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,038	0,038	0,035
Δφ U	5,4	5,4	5,4

3a – 3n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,040	-0,061	0,012	0,012	0,011	-0,126
Δφ U	4,3	5,4	5,5	5,5	5,5	3,4

3a – 3n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,002	-0,024	0,049	0,049	0,048	-0,087
Δφ U	4,2	5,3	5,4	5,4	5,5	3,4

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,039	-0,063	0,008	0,008	0,007	-0,131
Δφ U	4,8	5,6	5,7	5,7	5,7	3,6

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,001	-0,024	0,049	0,049	0,048	-0,090
Δφ U	4,5	5,4	5,5	5,5	5,6	3,5

da – dn 25 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,635	-0,563	-0,564
Δφ U	5,6	5,7	6,6

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

Determination of voltage part errors (ε U %), (Δφ U min), cosφ = 0,8

Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a-1n	0,11:√3	25	3,0	1000
2a-2n	0,11:√3	25	3,0	1000
3a-3n	0,11:√3	500	3/3P	1000
4a-4n	0,11:√3	25	3/3P	1000
da-dn	0,11	400	3P	450

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,520	-0,520	-0,521	
Δφ U	-6,7	-6,7	-6,6	

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,483	-0,482	-0,483	
Δφ U	-6,7	-6,8	-6,6	

2a – 2n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA. cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,517	-0,518	-0,518	
Δφ U	-6,7	-6,6	-6,6	

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 3a-3n 500 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,481	-0,480	-0,482	
Δφ U	-6,7	-6,7	-6,6	

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-1,035	-1,057	-0,978	-0,978	-0,980	-1,324
Δφ U	3,8	4,9	5,2	5,3	5,4	-1,5

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 4a-4n 25 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,308	-0,330	-0,256	-0,256	-0,257	-0,605
Δφ U	2,9	4,1	4,2	4,2	4,3	-2,7

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,544	-0,566	-0,490	-0,490	-0,491	-0,837
Δφ U	-7,2	-5,9	-5,5	-5,5	-5,1	-12,4

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 25 VA; 2a-2n 25 VA; 3a-3n 500 VA cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	k_t U_n
ε U	-0,497	-0,521	-0,448	-0,447	-0,449	-0,795
Δφ U	-7,2	-6,0	-5,7	-5,7	-5,6	-12,7

da – dn 300 VA; cos fi = 0,8 ind.
1a-1n 25VA; 2a-2n 25VA; 3a-3n 500VA; 4a-4n 25VA, cos fi = 0,8 ind

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-1,778	-1,803	-1,802	-1,738
Δφ U	-4,9	-3,5	-0,2	-1,8

1a – 1n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,006	-0,006	-0,007
Δφ U	5,3	5,3	5,4

1a – 1n 6,25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,031	0,032	0,031
Δφ U	5,3	5,3	5,3

2a – 2n 25 VA; cos fi = 0,8 ind.
2a-2n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA.

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	-0,004	-0,003	-0,005
Δφ U	5,4	5,4	5,5

2a – 2n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 3a-3n 0 VA; 4a-4n 0 VA

	0,8 U_n	1,0 U_n	1,2 U_n
ε U	0,084	0,086	0,086
Δφ U	5,4	5,4	5,4

3a – 3n 500 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,985	-0,987	-0,912	-0,911	-0,912	-1,254
Δφ U	5,6	6,6	6,8	6,8	6,9	0,2

3a – 3n 125 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 4a-4n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,238	-0,259	-0,185	-0,184	-0,186	-0,534
Δφ U	4,7	5,7	5,8	5,8	5,9	-1,0

4a – 4n 25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	-0,046	-0,065	0,009	0,009	0,008	-0,338
Δφ U	4,6	5,6	5,7	5,7	5,8	-1,1

4a – 4n 6,25 VA; cos fi = 0,8 ind.
1a-1n 0 VA; 2a-2n 0 VA; 3a-3n 0 VA

	0,02 U_n	0,05 U_n	0,8 U_n	1,0 U_n	1,2 U_n	1,9 U_n*
ε U	0,005	-0,022	0,050	0,051	0,050	-0,297
Δφ U	4,4	5,4	5,5	5,5	5,5	-1,4

da – dn 75 VA; cos fi = 0,8 ind.
1a-1n 0VA; 2a-2n 0VA; 3a-3n 0VA; 4a-4n 0VA,

	0,02 U_n	0,05 U_n	1,0 U_n	1,9 U_n
ε U	-0,729	-0,753	-0,684	-0,685
Δφ U	4,9	6,1	6,2	7,1

*) at 1,9 Un winding da-dn is loaded with Sn, cos fi = 0,8 ind.

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Determination of current part errors (ε I %), (Δφ I min),

Ipn (A): 3000

	1S1-1S2 200 VA; cosφ = 0,8				1S1-1S2 50 VA; cosφ = 0,8			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.263	-0.134	-0.039	-0.030	-0.019	0.056	0.092	0.095
Δφ I	6.5	3.9	1.0	0.8	3.9	1.9	1.0	0.9
	2S1-2S2 100 VA; cosφ = 1				2S1-2S2 25 VA; cosφ = 1			
	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n	0,05I_n	0,2 I_n	1,0 I_n	2,0 I_n
ε I	-0.039	-0.030	0.000	0.002	0.023	0.015	0.018	0.019
Δφ I	0.6	0.1	-0.6	-0.6	-0.1	0.2	-0.0	-0.0

3S1-3S2 TPZ Rb=7Ω cosφ = 1,0	
	1,0 In
ε I	-0.828
Δφ I	179.5

4S1-4S2 20 VA cosφ = 0,8	
	1,0 In
ε I	-0.017
Δφ I	0.3

5S1-5S2 TPY Rb=5Ω cosφ = 1,0	
ε I	-0.112
Δφ I	22.3

6S1-6S2 35 VA cosφ = 0,8	
ε I	-0.924
Δφ I	31

Current part: Measurements uncertainty: ε I = ±0,045 %, Δφ I = ±2,3 min
Voltage part: Measurements uncertainty: ε U = ±0,044 %, Δφ U = ±2,2 min

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	5	233.63	422.08	$U < E_{FS}$	☑
2S1-2S2	0.5	226.64	526.72	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Condition	Assessment
4S1-4S2	429.27	0.047	0.02	$\varepsilon_c < 5\%$	☑
6S1-6S2	920.12	0.255	1.28	$\varepsilon_c < 5\%$	☑

Determination of parameters of class TPZ core 3S1-3S2:

Ipn (A)	3000
Rb [Ω]	7
Współczynnik Kssc	16.67 ≥ 15
Współczynnik Ktd	7.5 ≥ 7.4
Ts [s]	0.0579 ≤ (±10% x 0,5)
ε-peak [%]	≤ 10%
K_x [%]	≤ 10%

Determination of parameters of class TPY core 6S1-6S2:

Ipn (A)	3000
Rb [Ω]	5
Współczynnik Kssc	13.35 ≥ 10
Współczynnik Ktd	13.11 ≥ 13
Ts [s]	0.5512 ≤ (±30% x 0,5s)
ε-peak [%]	7.894 ≤ 10 %

Determination of parameters of class PR core 6S1-6S2:

Ipn (A)	3000
Sn [VA]	35
ALF	28.06 ≥ 20
Ts [s]	0.3481 ≤ (±30% x 0,5s)
ε-I [%]	1.06

Determination of parameters of class PXR core 6S1-6S2:

Ipn (A)	3000
Rb [Ω]	27
Ek [V]	936.69 >700
Ie [mA]	258.89
E1 [V]	350
Ie1 [mA]	92.56 < 400
Kx	28.38 ≥ 20
Ts [s]	0.3588 ≤ (±30% x 0,5s)
ε-t [%]	-0.301% ≤ ±1%
K_x [%]	2 ≤ 10%

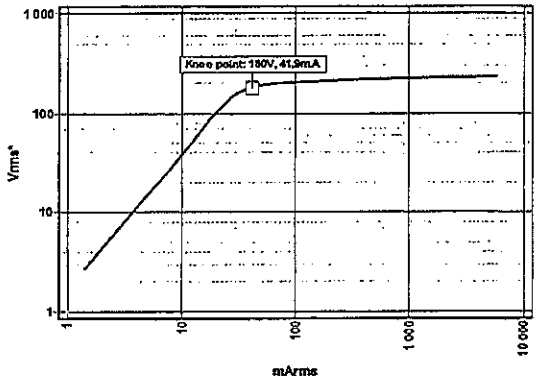
Measurement of capacitance and dielectric dissipation factor (tg δ)
Temperature: 22,3 °C, Frequency: 50 Hz

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current	Tg δ	Capacity	Leak current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.23	1415	4.409	0.24	1132	3.522	0.22	283	0.887
63 kV	0.24	1416	27.74	0.24	1132	22.21	0.22	284	5.58
71 kV	0.24	1416	31.36	0.24	1132	25.07	0.22	284	6.281

Core magnetization characteristics:

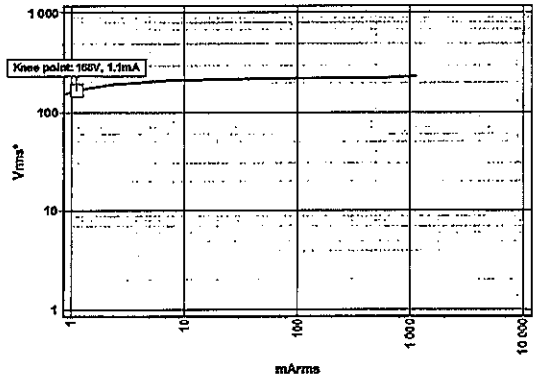
Winding 1S1-1S2

[V]	[mA]
234.3	5673
229.8	2004.8
218.5	429.6
205.9	105.39
198.0	68.51
184.4	44.93
171	35.7
156.9	30.69
141.4	26.94
127.6	24.31
97.8	19.56
70.6	15.45
40.6	10.46
13.5	4.66
2.7	1.44



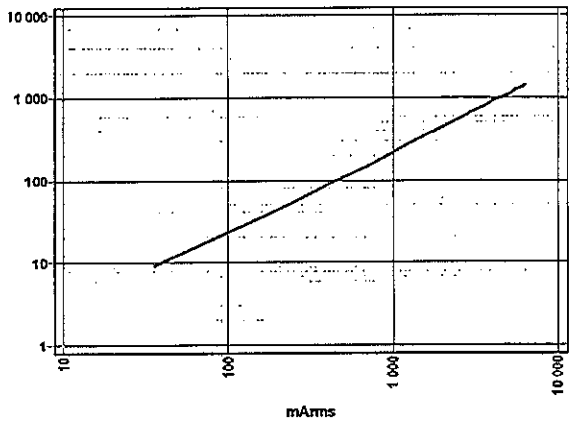
Winding 2S1-2S2

[V]	[mA]
233.2	1124.2
226.5	485.0
214.7	8.01
200.8	3.88
192.8	2.62
184.7	1.95
171.3	1.21
157.5	0.94
144.0	0.64
127.7	0.49
100.5	0.38
70.5	0.3
42.5	0.21
13.5	0.1
2.7	0.0



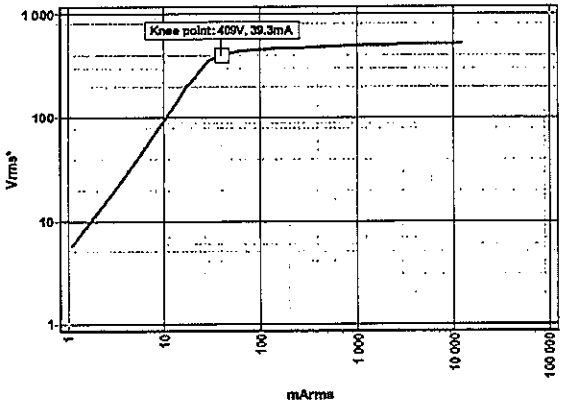
Winding 3S1-3S2

[V]	[mA]
1392.3	6364
1324.7	6056
1270.1	5799
1152.9	5257.1
1044.8	4742.8
985.5	4515.7
944	4280
841.8	3896.1
695.5	3814.8
553.3	3148.6
416.9	2504.3
264.4	1196
102.1	460.9
51.4	230.5
9.5	36.5



Winding 4S1-4S2

[V]	[mA]
528.1	12462
521.6	5696
514	2018.5
489.6	336.1
449.5	65.75
434.6	50.67
423.8	44.1
398.5	35.39
364.7	29.55
338.2	26.94
311.2	25.02
225.1	18.61
139	12.86
52.8	6.36
5.8	1.1



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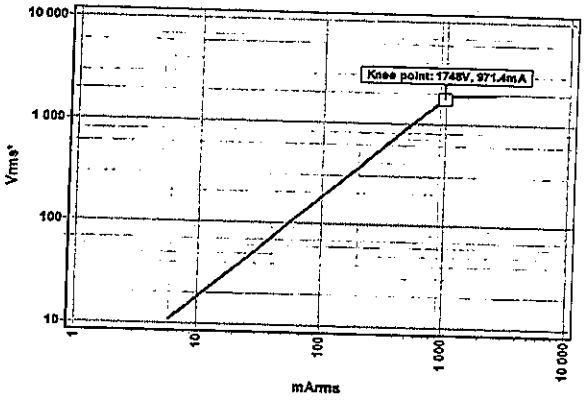
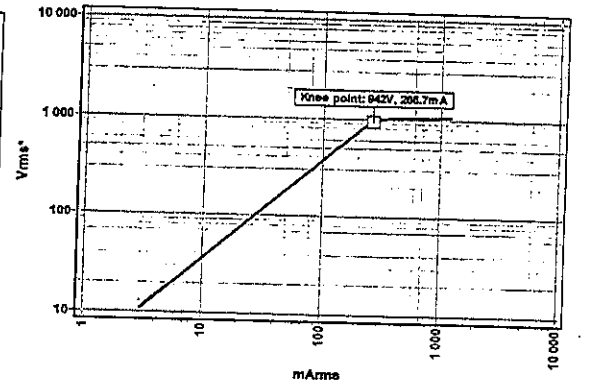
Winding 5S1-5S2

[V]	[mA]
1936.5	2390.7
1816.3	1029
1791.2	1004.3
1761.4	979.5
1729.4	957.3
1702.2	938.9
1673.2	922.2
1487.3	814.5
1285.1	702.7
1055.8	576.6
837.9	456.2
616.6	336.1
394.3	215.3
165.9	91.62
10.8	5.88



Winding 6S1-6S2

[V]	[mA]
1061.7	1486
1044.5	696.9
1005.4	332.3
986.3	298.6
957.2	272.8
926.3	257.8
903.8	248
873.7	237.7
842.0	227.6
788.2	211.5
618.1	164.2
448.2	119.6
277.6	74.72
106.8	29.35
10.9	3.15



Measurement of windings' resistance

Windings' resistance of current part:

	R (22°C)	R ct (75°C)
P1-P2 zakres 3000 A	44.0 µΩ	53.0 µΩ
1S1-1S2	0.452 Ω	0.544 Ω
2S1-2S2	5.470 Ω	6.588 Ω
3S1-3S2	4.383 Ω	5.279 Ω
4S1-4S2	0.588 Ω	0.708 Ω
5S1-5S2	5.730 Ω	6.901 Ω
5S1-5S2	6.020 Ω	7.250 Ω

Windings' resistance of voltage part:

	R (24,9°C)	R ct (75°C)
A-N	21.40 kΩ	25.773 kΩ
1a-1n	47.190 mΩ	56.834 mΩ
2a-2n	48.280 mΩ	58.147 mΩ
3a-3n	50.000 mΩ	60.218 mΩ
4a-4n	51.700 mΩ	62.265 mΩ
da-dn	113.800 mΩ	136.695 mΩ

Checked by: ... OG-4 KJ-06

Przasnysz. 03.01.2014 r.

ANNEX 4 **Documentations delivered by orderer**

ABB Sp. z o.o.	Declaration of conformity	ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 090/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486141;**

Place and date of issue of declaration

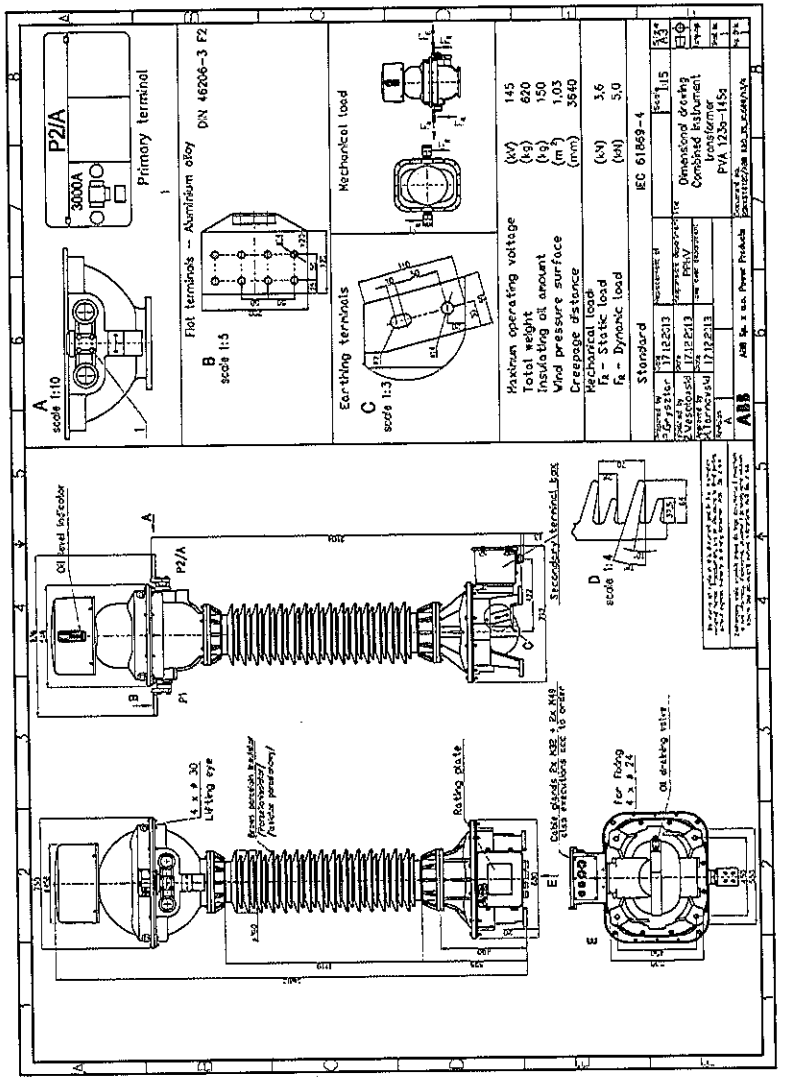
Przasnysz 13.01.2014

ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
NIP: 526-030-44-64; PL 5260304464
Regon 010017166
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 6921, fax (22) 223 6956
(9)

Dokument os. Realizacji Zamówień
ABB Sp. z o.o.
Oddział w Przasnyszu
Małgorzata Gaździcka

Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Lubecki

(Name) (Signature)



ABB

Combined Instrument Transformer

Type: PVA 145a

Insulation level	145/275/650 kV	Standard	IEC61869-4	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	620 / 150 kg	Temp. range	-50°C ÷ +40°C
S/N	2GKP013K1486141	Voltage factor	1,9Un/8h	Ue	0,2 mV/kA

CURRENT PART

K_n: 3000 / 5-1-1-5-1-1 A/A

I_{th}/1s: 63 kA I_{dyn}: 158 kA

I_{cth}: 3000 A

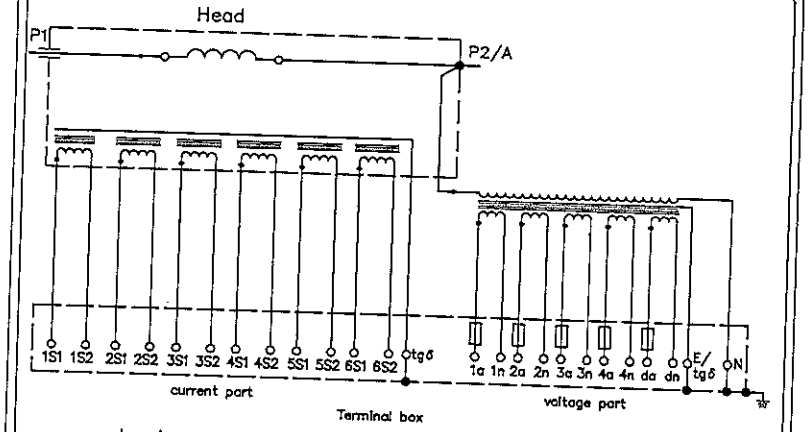
	A	VA	class	FS/ALF	Ext.%
1S1-1S2	5	200	0,2	10	-
2S1-2S2	1	100	0,1	5	-
3S1-3S2	1	Rb=7Ω, class TPZ 15x7,4, Rct<=6 Ω, cykl 100 ms, Tp=50ms			
4S1-4S2	5	20	5P	60	-
5S1-5S2	1	Rb=5Ω, classTPY 10x13, Rct<=7Ω,Ta=500 ms, cykl 100 ms, Tp=50 ms			
6S1-6S2	1	35	5PR	20	Rct<= 8 Ω
		Rb=27Ω, class PXR, 1/3000, Ek=700 V, Ie<=0,4 A/350 V, Rct<=8Ω, Kx=20			

VOLTAGE PART

A-N: 132:√3 kV

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3	110:√3	110:√3	110
VA	25	25	25	25	150
Klasa	0,2	0,2	0,2/3P	3/3P	1,0
VA	(25)	(25)	(500)	(25)	(400)
Klasa	(3)	(3)	(3/3P)	(3/3P)	(3P)
VAzn	1000	1000	1000	1000	450

Transportation: Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!

1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ, tgδ MUST BE EARTHED
3. AFTER THREE WINDINGS da - dn ARE CONNECTED IN BROKEN DELTA THE CIRCUIT SHOULD BE EARTHED IN ONE POINT ONLY

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86

TEST REPORT No. EUR/71/E/13-4 E

TEST OBJECT: Combined instrument transformer type PVA 145a with composite insulator
Serial No. 2GKP013K1486145/13

MANUFACTURER: ABB Sp. z o.o. Division in Przasnysz, ul. Leszno 59, 06-300 Przasnysz

TESTS ORDERED BY: Internal order No. EWN/145/E/13 dated 12.12.2013

TYPE OF TESTS: Short-time current tests
Test for composite error

TESTS PROCEDURE: According to IEC 61869-2:2012

DATE OF TESTS: 18/19.12.2013

TESTS RESULT: Positive for
$I_{dyn} = 50$ kA, $I_{th} = 20$ kA, $t = 1$ s for 150 A terminal

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: Z. Wesołowski – ABB Sp. z o.o.

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 15.01.2014

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figures	2
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1. TEST OBJECT

1.1 Description

Combined instrument transformer type PVA 145a is used for supplying of measuring and protection circuits in the network of maximum operating voltage 145 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common housing with composite insulator immersed with transformer oil.

1.2 Technical data

The Manufacturer attributed the following construction data to the test object.

Maximum operating voltage	145 kV
Rated frequency	50 Hz
Rated continuous thermal current	180 A, 360 A
Rated short-time current for 1 s	20 kA
Rated dynamic current	50 kA

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing combined transformer PVA 123a-145a, No. 2GKK614123 (17.12.2013),
- routine tests report of combined instrument transformer (04.12.2013),
- routine tests report of combined instrument transformer after short-time current test (03.01.2014),
- rating plate,
- instrument transformer electrical diagram

prepared by ABB Sp. z o.o (Annex 3 and 4).
The laboratory proceeded the identification of test object on the base of above documentation and the rating plate. Conformity of manufacturing with constructional documentation is stated in manufacturer's declaration, copy of which presents Annex 4.

1.4 Preparation for tests

The test object was prepared for tests in the factory by the manufacturer.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-2:2012:

- short-time current tests of current transformer acc. to item 7.2.201 of above standard at parameters:

  $I_{dyn} \geq 50$ kA, $I_{th} = 20$ kA, $t_{th} = 1$ s, $I_{th}^2 \times t_{th} \geq 400$ kA^2×s for 150 A terminal.

- test for composite error acc. to item 7.2.6.203 of above standard with current's transformer burden of about 2,4 Ω connected to 3S1-3S2 windings at parameters:

  $3 > I_{th} \geq 3{,}3$ kA, $t_{th} = 1$ s for 150 A terminal,

- routine test before and after short-time current test made in factory.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests and test for composite error were made in one-phase circuit presented on fig. 1 at dimensions presented on fig.2.
The following quantities were recorded during the tests using digital recorder type HIOKI 8842:

- primary current (with short-circuited all secondary terminals) during short-time current tests using laboratory current transformer type CdC class 0,5 with a ratio 50.000/2 A/A (uncertainty of measurement ±0,018% for k = 2),
- secondary currents in 1S1-1S2, 3S1-3S2, 4S1-4S2 windings by means of laboratory toroidal current transformers type IL20a class 0,5 with a ratio 1.000/5 A/A and 2.000/5 A/A (uncertainty of measurement ±0,012% for k = 2),
- voltage drop (U_0) on test object during short-time current tests by means of a resistance-capacitance voltage divider with a bandwidth from 0 to 100 kHz.

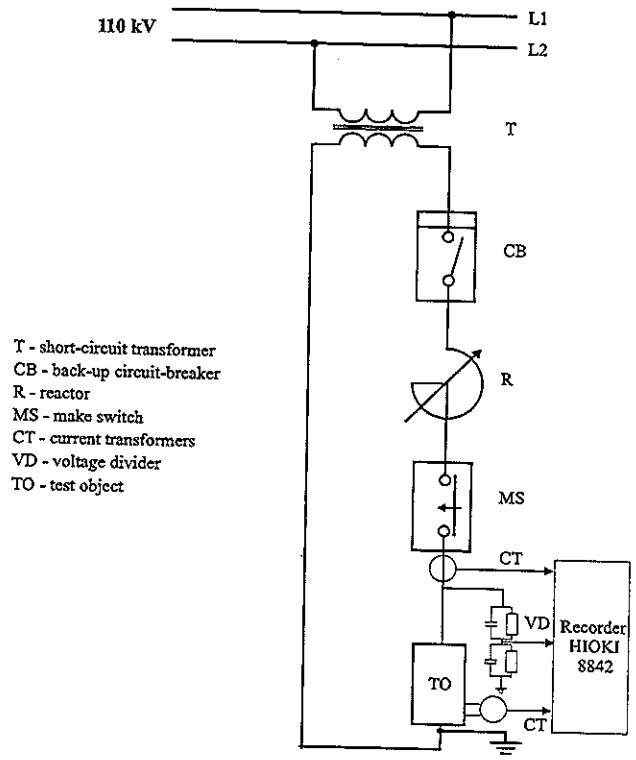

Fig.1. Test and measuring circuits during tests

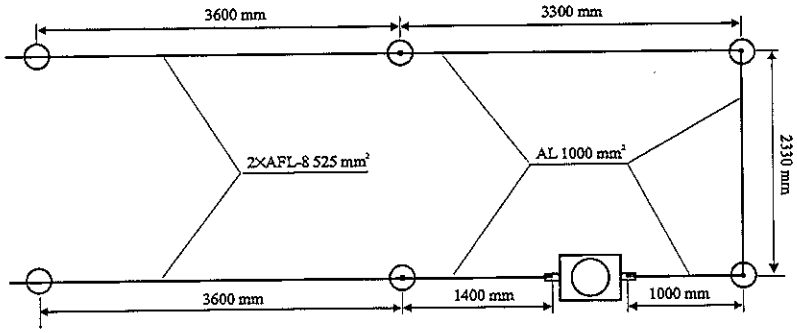

Fig. 2. Configuration of test circuit during tests

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents tables 1 and 2.
During the tests the following records were made:
- Nos. 33101, 33104 – calibration of measuring and test circuit,
- Nos. 33102, 33103 – short-time current tests,
- No. 33105 – composite error test,
  (Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory's archives),
- phot. 1 – current transformer on short-circuit tests stand
  (Annex 2 presents the photograph).

Table 1. Results of short-time current tests

Test No.	i_{peak}	I_z	t_z	$I_z^2 \times t_z$	$I_{1S1-1S2}$	$I_{3S1-3S2}$	$I_{4S1-4S2}$	U_0	Observations
-	kA	kA	s	$(kA)^2 \times s$	A	A	A	V	-
33102	52,12[1)]	20,31	0,06	–	–	–	–	–	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.
33103	34,56	20,31	1,02	420,7[2)]	232*	618	127	201	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
i_{peak} – peak value of test current,
I_z – r.m.s. value of test current (determined from test period without asymmetrical component),
t_z – test duration,
$I_{1S1-1S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{3S1-3S2}$ – r.m.s. value (determined from test period without asymmetrical component),
$I_{4S1-4S2}$ – r.m.s. value (determined from test period without asymmetrical component),
U_0 – r.m.s. value (determined from test period without asymmetrical component).
Required : [1)] $i_{peak} \geq 50$ kA,
[2)] $I_z^2 \times t_z \geq 400$ $(kA)^2 \times s$,
* – deformed waveform.

During the composite error test current's transformer burden connected to 3S1-3S2 was 2,4 Ω.

Table 2. Results of composite error test for 3S1-3S2 winding

Test No.	I_p	ε_c	t_z	Observations
-	kA	%	s	-
33105	3,02	0,71	1,00	Behaviour of transformer during the test was correct. After test no damage nor oil leak was stated.

Legend:
I_p – r.m.s. value of the test current (determined from test period without asymmetrical component),
t_z – test duration,

$$\varepsilon_c = \frac{\sqrt{\frac{1}{T}\int_0^T (k_r \cdot i_s - i_p)^2 \, dt}}{I_p} \cdot 100\%$$

k_r – rated transformation ratio (150/5 A/A),
i_p – instantaneous value of the primary current,
i_s – instantaneous value of the secondary current,
T – duration of one cycle.

5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-2:2012 the results of tests is positive for:

$I_{dyn} = 50$ kA, $I_{th} = 20$ kA, $t = 1$ s for 150 A terminal of tested combined instrument transformer.

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ANNEX 1 **Test records**

As not numbered pages the following copies of records are given:

33102, 33103 – short-time current tests,
33105 – composite error test.

Denotations:

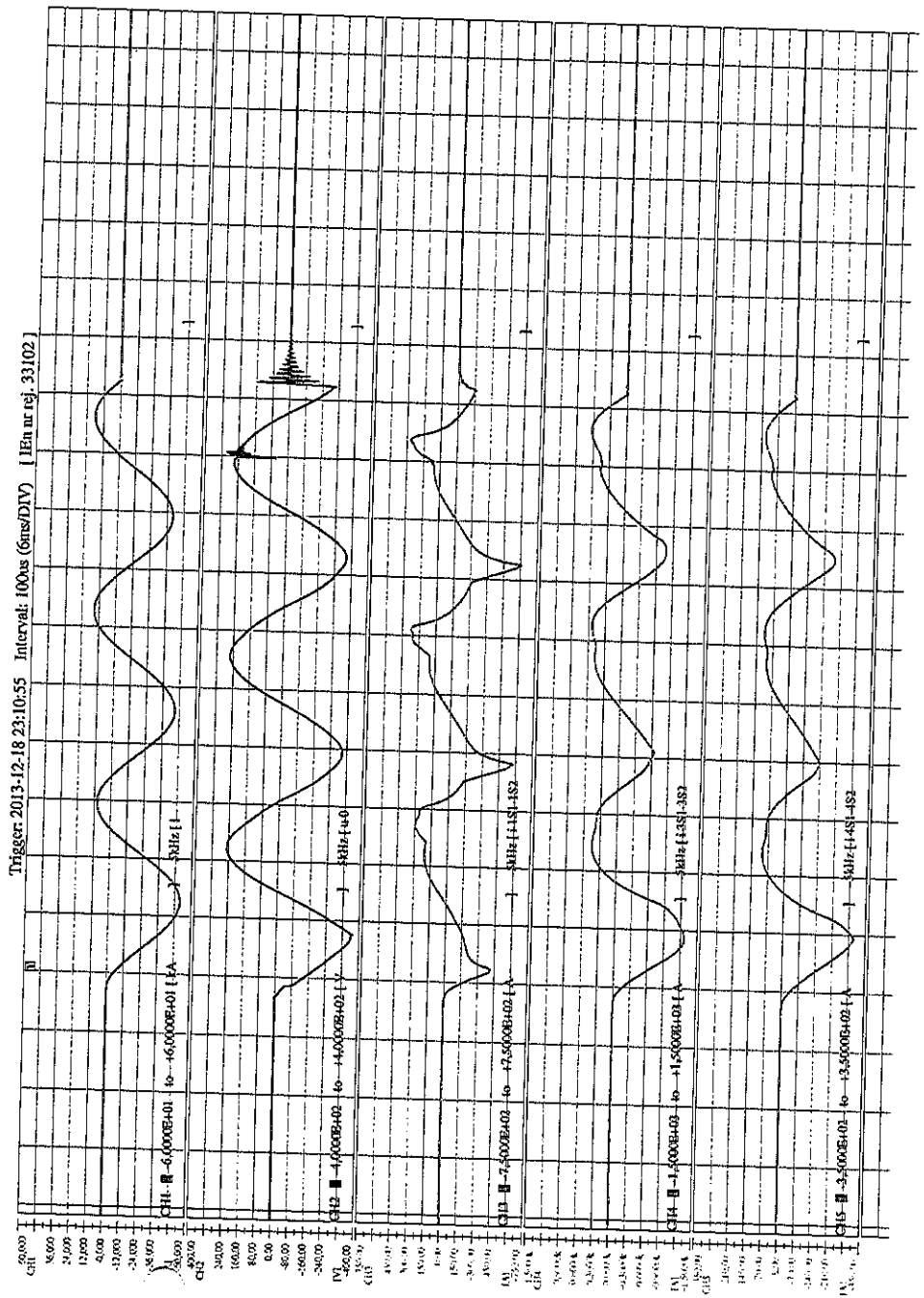
i – test current,

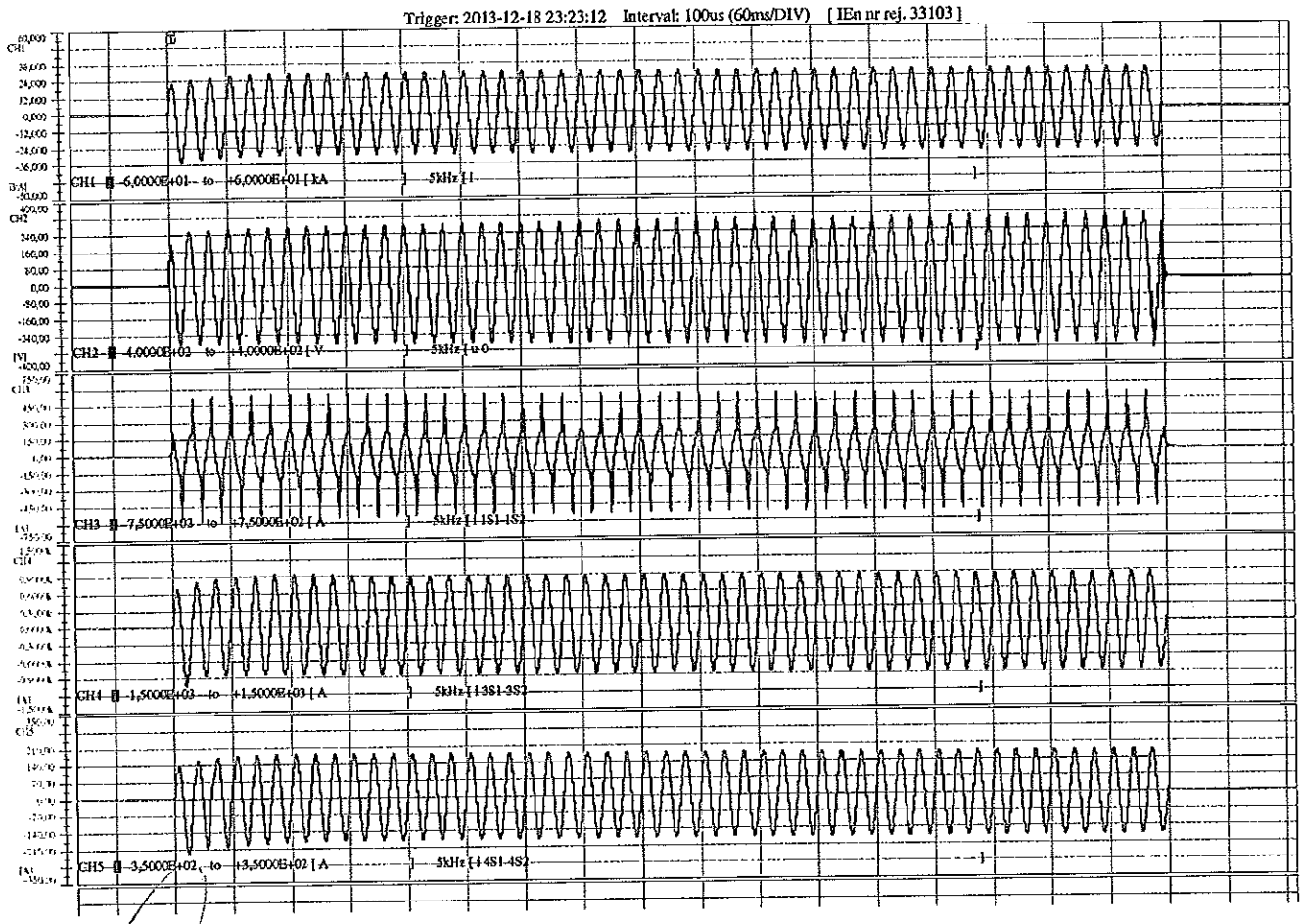
u_0 – voltage drop on test object,

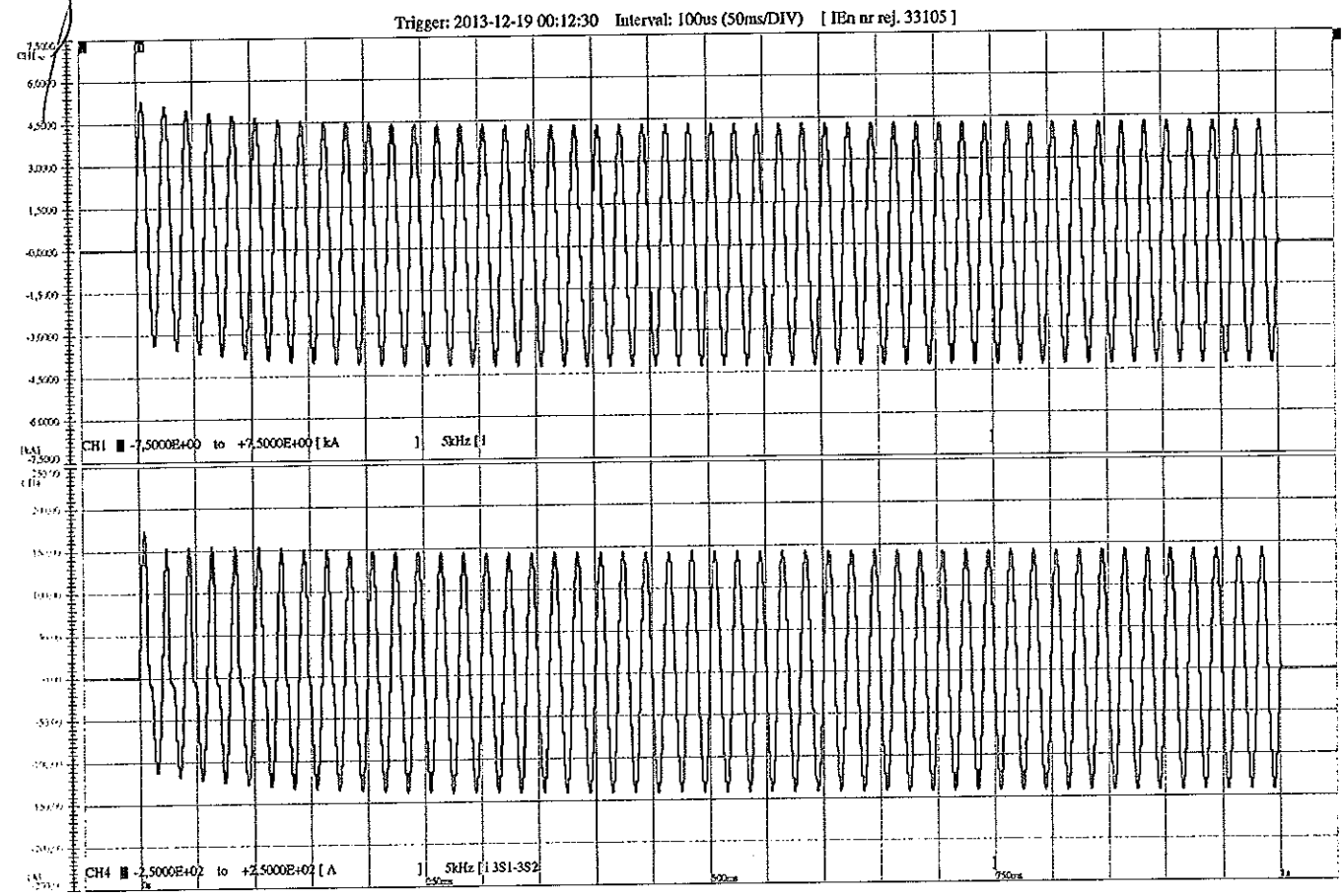
$i_{1S1\text{-}1S2}$ – 1S1-1S2 winding current,

$i_{3S1\text{-}3S2}$ – 3S1-3S2 winding current,

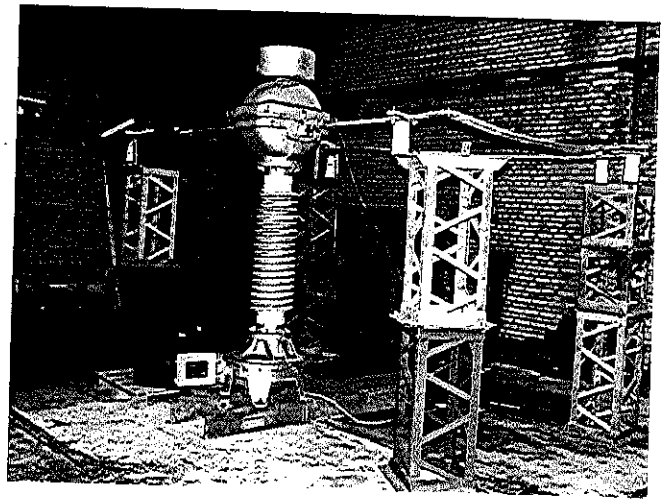
$i_{4S1\text{-}4S2}$ – 4S1-4S2 winding current.




Trigger: 2013-12-18 23:23:12 Interval: 100us (60ms/DIV) [IEn nr rej. 33103]
CH1 -6,0000E+01 to +6,0000E+01 [kA] 5kHz [1
CH2 -4,0000E+02 to +4,0000E+02 [V] 5kHz [u 0
CH3 -7,5000E+03 to +7,5000E+03 [A] 5kHz [1 3S1-1S2
CH4 -1,5000E+03 to +1,5000E+03 [A] 5kHz [1 3S1-2S2
CH5 -3,5000E+02 to +3,5000E+02 [A] 5kHz [1 4S1-4S2


Trigger: 2013-12-19 00:12:30 Interval: 100us (50ms/DIV) [IEn nr rej. 33105]
CH1 -7,5000E+00 to +7,5000E+00 [kA] 5kHz [1
CH4 -2,5000E+02 to +2,5000E+02 [A] 5kHz [1 3S1-3S2

ANNEX 2 Photographs taken during the tests



Phot. 1. PVA 145a after short-time current tests

ANNEX 3 Routine test report before and after short-time current tests

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine tests report of combined instrument transformer			TYPE: PVA145a Serial no: 2GKP013K1486145	
A-N	Insulation level:	Voltage factor:	Ith 1s [kA]:	Idyn [kA]:	Ith [A]:	IEC 61869-4
132:√3 kV	145/275/650 kV	1.9/8h	20-20	50-50	225-450	50 Hz

VOLTAGE PART	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
	1a - 1n	0,11:√3	100	1,0	1000
	2a - 2n	0,11:√3	100	1,0	1000
	3a - 3n	0,11:√3	100	1/3P	1000
	4a - 4n	0,11:√3	100	3/3P	1000
	da - dn	0,11:3	200	3,0	460

CURRENT PART	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
	1S1-1S2	5	30	0,2FS 5	150-300/5
	2S1-2S2	1	40	5P 20	150-300/1
	3S1-3S2	5	60	5P 20	150-300/5
	4S1-4S2	1	60	5P 20	150-300/1

List of performed tests:

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand on primary windings - P1+P2/A: Up = 275kV / 60s, f = 97Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary - Up = 3 kV/60s ☑
7. Inter-turn overvoltage test for current transformers - lower value (U peak=4,5kV or U peak for Icth) / 60s ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ☑
10. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.06 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 78.15 kV, Relative standard deviation = 5.99
  f = 50Hz, oil temp. = 25 °C, measurement with the stirrer, type of electrodes used: partially

Sample	Breakdown voltage [kV]
1	73.7
2	84.3
3	82.8
4	78.4
5	78.9
6	72.8

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the after the power-frequency withstand test on primary
  Stress voltage: 275 kV / 60 s
  Frequency: 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5
Level of partial discharge	2 pC	1,2 pC

Remarks: background noise level: 1 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	0.368	450
2S1-2S2	4.29	450
3S1-3S2	1.09	450
4S1-4S2	4.5	310

Determination of voltage part errors (ε U%), Δφ U min)

1a-1n: 100 VA p.f. = 0,8 lag.
2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.164	-0.162	-0.162
Δφ U	-1.3	-1.3	-1.3

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.016
Δφ U	-1.3	-1.3	-1.3

2a-2n: 100 VA p.f. = 0,8 lag.
1a-1n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.163	-0.162	-0.162
Δφ U	-1.1	-1.1	-1.1

2a-2n: 25 VA p.f. = 0,8 lag.
1a-1n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.015	-0.015
Δφ U	-1.3	-1.3	-1.3

3a-3n: 100 VA p.f. = 0,8 lag.
1a-1n: 100VA; 2a-2n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.254	-0.251	-0.150	-0.148	-0.149	-0.314
Δφ U	-2.1	-1.2	-0.8	-0.8	-0.8	-4.2

3a-3n: 25 VA p.f. = 0,8 lag.
1a-1n: 100VA; 2a-2n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.103	-0.102	-0.004	-0.003	-0.003	-0.170
Δφ U	-2.5	-1.5	-1.1	-1.1	-1.1	-4.6

4a-4n: 100 VA p.f. = 0,8 lag.
1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.261	-0.261	-0.163	-0.162	-0.162	-0.329
Δφ U	-1.0	-0.0	0.4	0.4	0.4	-3.1

1a-1n: 100 VA p.f. = 0,8 lag.
2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.116	0.117	0.118
Δφ U	5.1	5.2	5.2

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.263	0.265	0.265
Δφ U	5.1	5.1	5.2

2a-2n: 100 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.118	0.119	0.119
Δφ U	5.3	5.3	5.4

2a-2n: 25 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.266	0.267	0.267
Δφ U	5.2	5.2	5.2

3a-3n: 100 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.022	0.027	0.127	0.129	0.129	-0.038
Δφ U	4.8	5.5	5.6	5.6	5.6	2.5

3a-3n: 25 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.172	0.172	0.275	0.276	0.277	0.111
Δφ U	4.4	5.2	5.3	5.3	5.3	2.1

4a-4n: 100 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.007	0.008	0.107	0.108	0.109	-0.080
Δφ U	5.6	6.4	6.4	6.4	6.5	3.3

4a-4n: 25 VA p.f. = 0,8 lag.
1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.066	-0.096	0.001	0.002	0.002	-0.165
Δφ U	-1.9	-1.0	-0.6	-0.6	-0.6	-4.1

4a-4n: 25 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.179	0.176	0.273	0.274	0.275	0.107
Δφ U	4.6	5.4	5.5	5.5	5.5	2.3

da-dn: 200 VA p.f. = 0,8 lag.
1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.177	-0.159	-0.125
Δφ U	16.6	16.1	15.3

da-dn: 50 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	1.053	1.053	1.053
Δφ U	9.7	9.7	9.8

* at 1,9 Un winding da-dn is loaded with 200 VA, p.f. = 0,8

Determination of current part errors (ε I%), Δφ I min)

Ipn (A): 150

1S1-1S2: 30 VA p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.165	-0.113	-0.044	-0.060
Δφ I	4.3	1.7	-0.4	0.9

1S1-1S2: 7.50 VA p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.020	-0.017	0.003	0.007
Δφ I	2.4	1.6	0.4	0.2

2S1-2S2: 40 VA p.f. = 0,8 lag.

	1,0 In
ε I	-0.141
Δφ I	0.9

3S1-3S2: 60 VA p.f. = 0,8 lag.

	1,0 In
ε I	-0.153
Δφ I	1.7

4S1-4S2: 60 VA p.f. = 0,8 lag.

	1,0 In
ε I	-0.146
Δφ I	1.3

Ipn (A): 300

1S1-1S2: 30 VA p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.441	-0.110	-0.042	-0.057
Δφ I	17.7	1.6	-0.4	0.7

1S1-1S2: 7.50 VA p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.043	-0.018	0.003	0.004
Δφ I	3.1	2.1	0.5	0.6

2S1-2S2: 40 VA p.f. = 0,8 lag.

	1,0 In
ε I	-0.140
Δφ I	0.8

3S1-3S2: 60 VA p.f. = 0,8 lag.

	1,0 In
ε I	-0.148
Δφ I	1.7

4S1-4S2: 60 VA p.f. = 0,8 lag.

	1,0 In
ε I	-0.145
Δφ I	1.2

Current part: Measurements $\varepsilon_I = \pm 0{,}045\ \%$, $\Delta\varphi_I = \pm 2{,}3$ min
Voltage part: Measurements uncertainty: $\varepsilon_U = \pm 0{,}044\ \%$, $\Delta\varphi_U = \pm 2{,}2$ min

Determination of the over current factors:

- Instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	E_{FS} [V]	Condition	Assessment
1S1-1S2	2.5	17.84	36.02	$U < E_{FS}$	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	E_{ALF} [V]	Ie [A]	ε_c [%]	Condition	Assessment
2S1-2S2	960.93	0.015	0.08	$\varepsilon_c \leq 5\%$	☑

295

3S1-3S2	278.86	0.097	0.1	$\varepsilon_e \leq 5\%$	☑
4S1-4S2	1388.83	0.015	0.08	$\varepsilon_e \leq 5\%$	☑

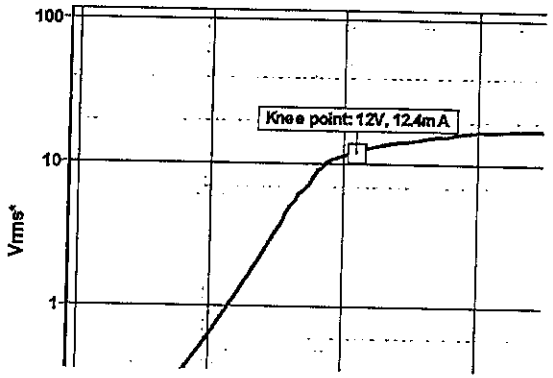
Measurement of capacitance and dielectric dissipation factor - δ
Temperature: 24.2 °C, Frequency: 50

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.23	1404	4.389	0.24	1128	3.572	0.23	276	0.862
63 kV	0.23	1404	27.83	0.24	1129	22.34	0.22	276	5.46
71 kV	0.23	1404	31.36	0.24	1129	25.21	0.22	276	6.156

Core magnetization characteristics:

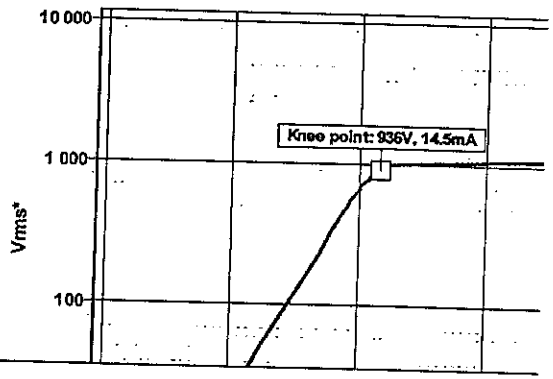
Winding 1S1-1S2

[V]	[mA]
18	3859
16.7	103.41
15.5	48.71
14.4	27.86
13.5	19.59
13	15.84
12.4	12.69
11.8	10.63
11.3	9.23
10.8	7.96
8.4	5.89
6.1	4.59
4	3.37
1.7	1.96
0.1	0.25



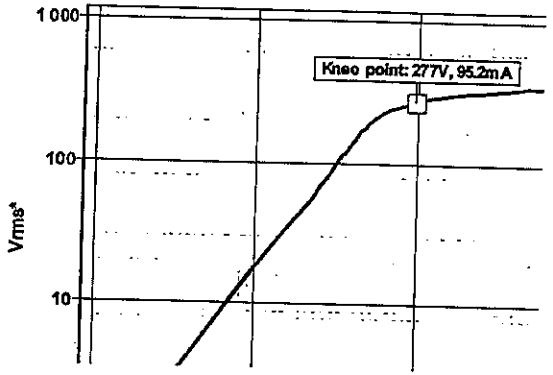
Winding 2S1-2S2

[V]	[mA]
1132.4	1427.9
1127.1	877.7
1104.4	263.7
1029.5	26.54
1000.1	17.54
978.	16.07
948.	14.66
894.	13.85
832.	12.48
782.	11.95
612	9.3
442.	7.32
274.	5.42
103.	2.88
10.2	0.66



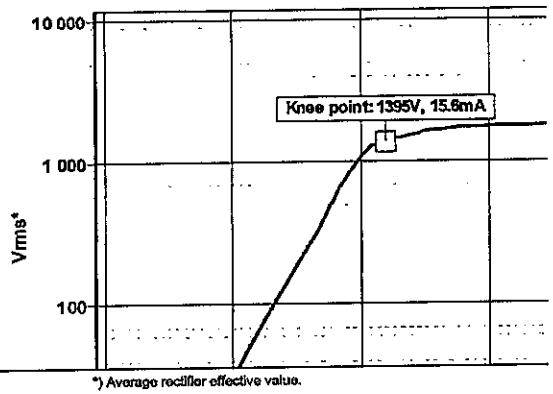
Winding 3S1-3S2

[V]	[mA]
375.	7431
331.	241.6
310.	162
304.	148.6
297.	128
282.	101.48
268.	83.09
253.	72.52
239.	65.23
197.	51.48
153.	41.82
111	33.85
68.8	25.06
26.5	13.39
2.4	2.72



Winding 4S1-4S2

[V]	[mA]
1872.8	2020.9
1734.7	80.36
1627.8	35.01
1534.8	23.91
1509.5	21.62
1451	17.85
1393.2	15.51
1339.3	13.82
1280.7	12.48
1052.2	9.76
832.	8.05
608.	6.47
389.	4.93
168.	2.92
10.3	0.52



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part:

	R (23 °C)	Rct (75 °C)
P1-P2 range 150A	1883.0 μΩ	2267.8 μΩ
P1-P2 range 300A	970.0 μΩ	1168.2 μΩ
1S1-1S2	0.239 Ω	0.287 Ω
2S1-2S2	7.990 Ω	9.623 Ω
3S1-3S2	0.389 Ω	0.468 Ω
4S1-4S2	9.450 Ω	11.381 Ω

Windings' resistance of voltage part:

	R (23 °C)	Rct (75 °C)
A-N	21.30 kΩ	25.653 kΩ
1a-1n	47.010 mΩ	56.617 mΩ
2a-2n	48.480 mΩ	58.387 mΩ
3a-3n	50.000 mΩ	60.218 mΩ
4a-4n	51.700 mΩ	62.265 mΩ
da-dn	34.080 mΩ	41.045 mΩ

Checked by: ..... OG-I Ki-DE

Przasnysz, 2013-12-04

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59	Routine tests report of combined instrument transformer After short time current test			TYPE: PVA145a Serial no: 2GKP013K1486145	
A-N / Insulation level:	Voltage factor:	Ith 1s [kA]:	Idyn [kA]:	Ioth [A]:	IEC 61869-4
132:√3 kV / 145/275/650 kV	1.9/8h	20-20	50-50	225-450	50 Hz

	Winding	Usn [kV]	Sn [VA]	class	Sth [VA]
VOLTAGE PART	1a - 1n	0,11:√3	100	1,0	1000
	2a - 2n	0,11:√3	100	1,0	1000
	3a - 3n	0,11:√3	100	1/3P	1000
	4a - 4n	0,11:√3	100	3/3P	1000
	da - dn	0,11:3	200	3,0	450

	Winding	Isn [A]	Sn [VA]	class	Ratio [A/A]
CURRENT PART	1S1-1S2	5	30	0,2FS 5	150-300/5
	2S1-2S2	1	40	5P 20	150-300/1
	3S1-3S2	5	60	5P 20	150-300/5
	4S1-4S2	1	60	5P 20	150-300/1

List of performed tests:

1. Oil dielectric parameters check before filling (oil after treatment): ☑
   tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil ☑
4. Power-frequency withstand ☑
   on primary windings - P1+P2/A: Up = 247,5 kV / 60s, f = 97Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge ☑
6. Power-frequency withstand test on secondary - Up = 3 kV/60s ☑
7. Inter-turn overvoltage test for current - lower value (U peak=4,5kV or U peak for Ioth) / ☑
8. Determination of errors ☑
9. Determination of the over current factors: FS, ALF ☑
10. Measurement of capacitance and dielectric dissipation factor - tg δ transformer ☑
11. Determination of core magnetization characteristics ☑
12. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after

- Measurement of oil tg δ according to IEC
  Tg δ = 0.06 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 78.15 kV, Relative standard deviation = 5.99
  f = 50Hz, oil temp. = 25 °C, measurement with the stirrer, type of electrodes used: partially

Sample	Breakdown voltage [kV]
1	73.7
2	84.3
3	82.8
4	78.4
5	76.9
6	72.8

Partial discharge measurement

- Measurement according to procedure B

Stress voltage: 247,5 kV / 60
Frequency: 97 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	2.5 pC	1.2 pC

Remarks: background noise level: 1 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating

Inter-turn overvoltage test for current transformers

Winding	Peak voltage on secondary winding [kVpeak]	Current in primary winding [A]
1S1-1S2	0.384	450
2S1-2S2	4.5	430
3S1-3S2	1.07	450
4S1-4S2	4.5	280

Determination of voltage part errors (ε U%), Δφ U min)

1a-1n: 100 VA — 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.163	-0.163	-0.162
Δφ U	-1.3	-1.3	-1.3

1a-1n: 25 VA — 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.016
Δφ U	-1.3	-1.3	-1.3

2a-2n: 100 VA — 1a-1n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.162	-0.161	-0.161
Δφ U	-1.1	-1.1	-1.1

2a-2n: 25 VA — 1a-1n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.016	-0.015	-0.015
Δφ U	-1.3	-1.3	-1.3

3a-3n: 100 VA — 1a-1n: 100VA; 2a-2n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.253	-0.254	-0.151	-0.149	-0.149	-0.314
Δφ U	-2.2	-1.2	-0.8	-0.8	-0.8	-4.2

3a-3n: 25 VA — 1a-1n: 100VA; 2a-2n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.103	-0.103	-0.004	-0.003	-0.003	-0.170
Δφ U	-2.5	-1.5	-1.1	-1.1	-1.1	-4.6

4a-4n: 100 VA — 1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.264	-0.265	-0.165	-0.164	-0.164	-0.329
Δφ U	-0.9	0.0	0.4	0.4	0.4	-3.1

1a-1n: 100 VA — 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.115	0.117	0.118
Δφ U	5.1	5.1	5.2

1a-1n: 25 VA — 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.263	0.265	0.265
Δφ U	5.1	5.1	5.2

2a-2n: 100 VA — 1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.117	0.119	0.119
Δφ U	5.3	5.4	5.4

2a-2n: 25 VA — 1a-1n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	0.265	0.267	0.267
Δφ U	5.2	5.2	5.2

3a-3n: 100 VA — 1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.023	0.024	0.127	0.129	0.129	-0.038
Δφ U	4.7	5.5	5.5	5.6	5.6	2.5

3a-3n: 25 VA — 1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.174	0.175	0.274	0.276	0.277	0.111
Δφ U	4.4	5.2	5.3	5.2	5.3	2.1

4a-4n: 100 VA — 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.007	0.006	0.106	0.107	0.107	-0.060
Δφ U	5.7	6.5	6.5	6.5	6.5	3.3

4a-4n: 25 VA — 1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.096	-0.096	0.001	0.003	0.002	-0.165
Δφ U	-1.9	-0.9	-0.6	-0.6	-0.6	-4.1

4a-4n: 25 VA — 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	0.174	0.174	0.273	0.274	0.275	0.107
Δφ U	4.7	5.5	5.5	5.5	5.5	2.3

da-dn: 200 VA — 1a-1n: 100VA; 2a-2n: 100VA; 3a-3n: 100VA; 4a-4n: 100VA — p.f. = 0,8 lag. / p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.177	-0.159	-0.125
Δφ U	16.6	16.1	15.3

da-dn: 50 VA — 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	1.000	1.001	0.995
Δφ U	11.1	11.1	11.2

*** at 1,9 Un winding da-dn is loaded with 200 VA, p.f. = 0,8**

Determination of current part errors (ε I%), Δφ I min)

Ipn (A): 150

1S1-1S2: 30 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.175	-0.105	-0.042	-0.050
Δφ I	4.8	1.5	-0.4	0.5

1S1-1S2: 7.50 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.023	-0.014	0.002	0.007
Δφ I	2.8	1.5	0.5	0.4

2S1-2S2: 40 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.139
Δφ I	0.8

3S1-3S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.160
Δφ I	1.2

4S1-4S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.148
Δφ I	1.0

Ipn (A): 300

1S1-1S2: 30 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.168	-0.101	-0.041	-0.056
Δφ I	4.7	1.4	-0.4	0.7

1S1-1S2: 7.50 VA — p.f. = 0,8 lag.

	0,05 In	0,2 In	1,0 In	1,5 In
ε I	-0.014	-0.008	0.004	0.007
Δφ I	2.5	1.4	0.5	0.5

2S1-2S2: 40 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.139
Δφ I	0.8

3S1-3S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.157
Δφ I	1.3

4S1-4S2: 60 VA — p.f. = 0,8 lag.

	1,0 In
ε I	-0.144
Δφ I	1.0

Current part: Measurements uncertainty: $\varepsilon_I = \pm 0{,}045\ \%$, $\Delta\varphi_I = \pm 2{,}3$ min
Voltage part: Measurements uncertainty: $\varepsilon_U = \pm 0{,}044\ \%$, $\Delta\varphi_U = \pm 2{,}2$ min

Determination of the over current factors:

- instrument security factor (FS) of measuring cores

Winding	Ie [A]	U [V]	EFS [V]	Condition	Assessment
1S1-1S2	2.5	17.84	35.93	U < EFS	☑

- accuracy limit factor (ALF) – test for composite error ε_c of protective cores

Winding	EALF [V]	Ie [A]	εc [%]	Condition	Assessment
2S1-2S2	960.1	0.015	0.08	εc ≤ 5%	☑

3S1-3S2	278.51	0.1	0.1	$\varepsilon_c \leq 5\%$	☑
4S1-4S2	1385.12	0.015	0.08	$\varepsilon_c \leq 5\%$	☑

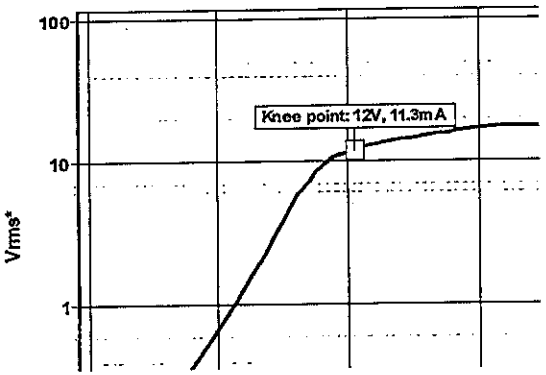
Measurement of capacitance and dielectric dissipation factor - δ
Temperature: 23.2 °C, Frequency: 50

Primary voltage	Instrument transformer			Current part			Voltage part		
	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current	Tg δ	Capacity	Leak.current
	[%]	[pF]	[mA]	[%]	[pF]	[mA]	[%]	[pF]	[mA]
10 kV	0.23	1391	4.392	0.24	1115	3.53	0.23	275	0.871
63 kV	0.23	1391	27.54	0.23	1115	22.08	0.23	275	5.453
71 kV	0.23	1391	30.91	0.23	1115	24.79	0.23	275	6.122

Core magnetization characteristics:

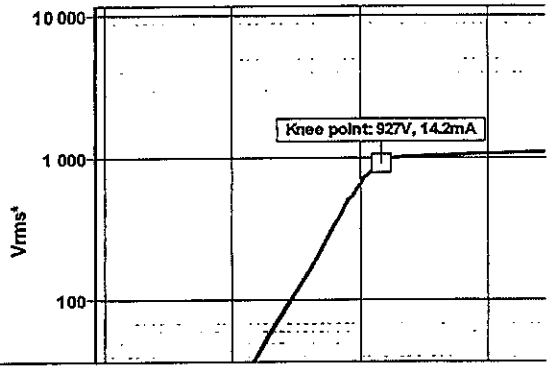
Winding 1S1-1S2

[V]	[mA]
18	3519.8
17	136.6
15.8	57.25
14.7	31.73
13.2	17.13
12.6	13.6
12.1	11.35
11.5	9.58
10.8	8.2
10.3	7.37
8.6	5.62
6.3	4.34
4	3.25
1.7	1.89
0.1	0.24



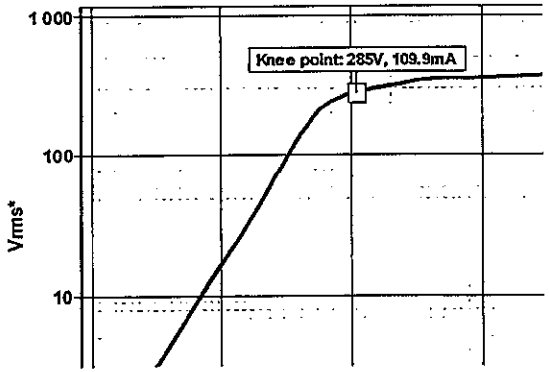
Winding 2S1-2S2

[V]	[mA]
1134.6	1823
1130.8	1194.6
1113.7	432.2
1047	40.79
1019.9	21.84
990.	16.73
967.	15.44
901.	13.44
847.	12.71
794.	12.29
621.	9.61
449.	7.46
277.	5.5
105.	2.95
10.7	0.7



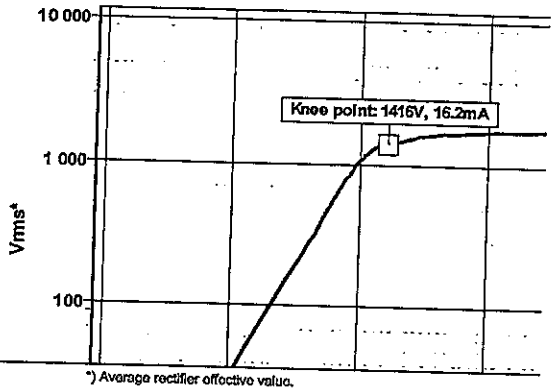
Winding 3S1-3S2

[V]	[mA]
377.	10440
335.	258.5
314	170.6
305.	148.6
300.	136.7
283.	106.74
270.	89.86
257	77.84
242.	68.66
200.	53.43
156.	43.17
113.	34.76
70.1	25.63
26.4	13.48
2.6	2.82



Winding 4S1-4S2

[V]	[mA]
1869	1774.6
1728.5	78.4
1610.1	31.58
1524.3	22.36
1499.9	20.86
1470.4	18.86
1413.8	16.1
1350.3	14.04
1286.1	12.73
1071.7	9.9
848.	8.23
611.	6.51
385.	4.9
159.	2.81
10.8	0.53



*) Average rectifier effective value.

Measurement of windings' resistance

Windings' resistance of current part:

	R (23 °C)	Rct (75 °C)
P1-P2 range 150A	1706.0 μΩ	2054.6 μΩ
P1-P2 range 300A	881.0 μΩ	1061.0 μΩ
1S1-1S2	0.236 Ω	0.284 Ω
2S1-2S2	7.950 Ω	9.575 Ω
3S1-3S2	0.385 Ω	0.464 Ω
4S1-4S2	9.270 Ω	11.164 Ω

Windings' resistance of voltage part:

	R (23 °C)	Rct (75 °C)
A-N	20.90 kΩ	25.171 kΩ
1a-1n	46.820 mΩ	56.388 mΩ
2a-2n	48.340 mΩ	58.219 mΩ
3a-3n	49.840 mΩ	60.025 mΩ
4a-4n	51.400 mΩ	61.904 mΩ
da-dn	34.010 mΩ	40.960 mΩ

Checked by: .....

Przasnysz, 2014-01-03

ANNEX 4 Documentations delivered by orderer

ABB Sp. z o.o. | Declaration of conformity | ABB Sp. z o.o. Dept. in Przasnysz POLAND

DECLARATION OF CONFORMITY No. 092/2013 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o. Dept. in Przasnysz

Address: Str. Leszno 59
06-300 Przasnysz / POLAND

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 4	Combined Instrument Transformers	2013

Additional information:
Serial numbers: **2GKP013K1486145;**

Place and date of Issue of declaration

Przasnysz 13.01.2014

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(9)

Kierownik ds. Realizacji Zam...
ABB Sp. z o.o.
Oddział w Przasnyszu
Małgorzata Jedziewska

Kierownik ds. Zapewnienia ...
ABB Sp/z o.o.
Oddział w Przasnyszu
Krzysztof Lebecki

(Name) (Signature)