ANNEX 1 for test report EWN/134/E/15

(3 pages)

Documents provided by ABB Sp. z o.o. used as base of identification of test object:

- Declaration of conformity – No. 102/2015 (EN),
- Rating plate – Document No. 1HSE 22040-PCB,
- Technical drawing – Document id. 1HSE8851773.

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

DECLARATION OF CONFORMITY No. 102/2015 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2015

Additional information:
Serial numbers: **1HSE8851773;**

Place and date of issue of declaration

Przasnysz 29.10.2015

Kierownik ... ABB Sp. z o.o. Oddział w Przasnyszu ... (Name)

Kierownik ds. Zapewnienia Jakości ABB Sp. z o.o. Oddział w Przasnyszu *Krzysztof Lubecki* (Signature)

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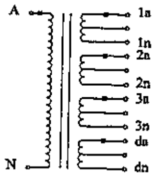
ABB CE

Voltage transformer		ABB AB	Made in Sweden
Serial number	1HSE nnnnnnn	Type EMF-E145 Production year	yyyy
Insulation level	275/650 kV	Standard	IEC 61869-3
Rated primary voltage	145000/√3 V	Frequency	50 Hz
Highest voltage for equipment	145 kV	Temperature range	-40 – +40 °C
		Total mass	295 kg

1HSE 68504-5

Serial number	1HSE nnnnnnn
Insulation oil	(IEC 61039: L-NTIO-296) 80 kg
Voltage factor	1,9 / 8h



Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA
A-N	145000/√3				
1a-1n	115/√3	0.1	25	75	1500+0
1a-1n	115/√3	1.0	25	550	1500+0
2a-2n	115/√3	0.1	25	75	1500+0
2a-2n	115/√3	1.0	25	550	1500+0
3a-3n	115/√3	0.1/3P	25	75	1500+0
3a-3n	115/√3	3.0/3P	500	550	1500+0
da-dn	115	1.0	100	650	450+0
da-dn	115	3P	300	850	450+0

1HSE 68504-6

Serial number 1HSE nnnnnnn = 1HSE 8851773

Production year yyyy = Actual year for production

Prepared		Responsible department	Title	
Gustaf Högberg	2015-06-18	PPHC/IM	Rating plate	
Approved		Take over department		Language
Björn Sjöström	2015-06-18			en
Revision			Order No.	Sheet
A Data changed.	2015-07-01		E90000012-20	1
ABB ABB AB			Document No. 1HSE 22040-PCB	Last 1

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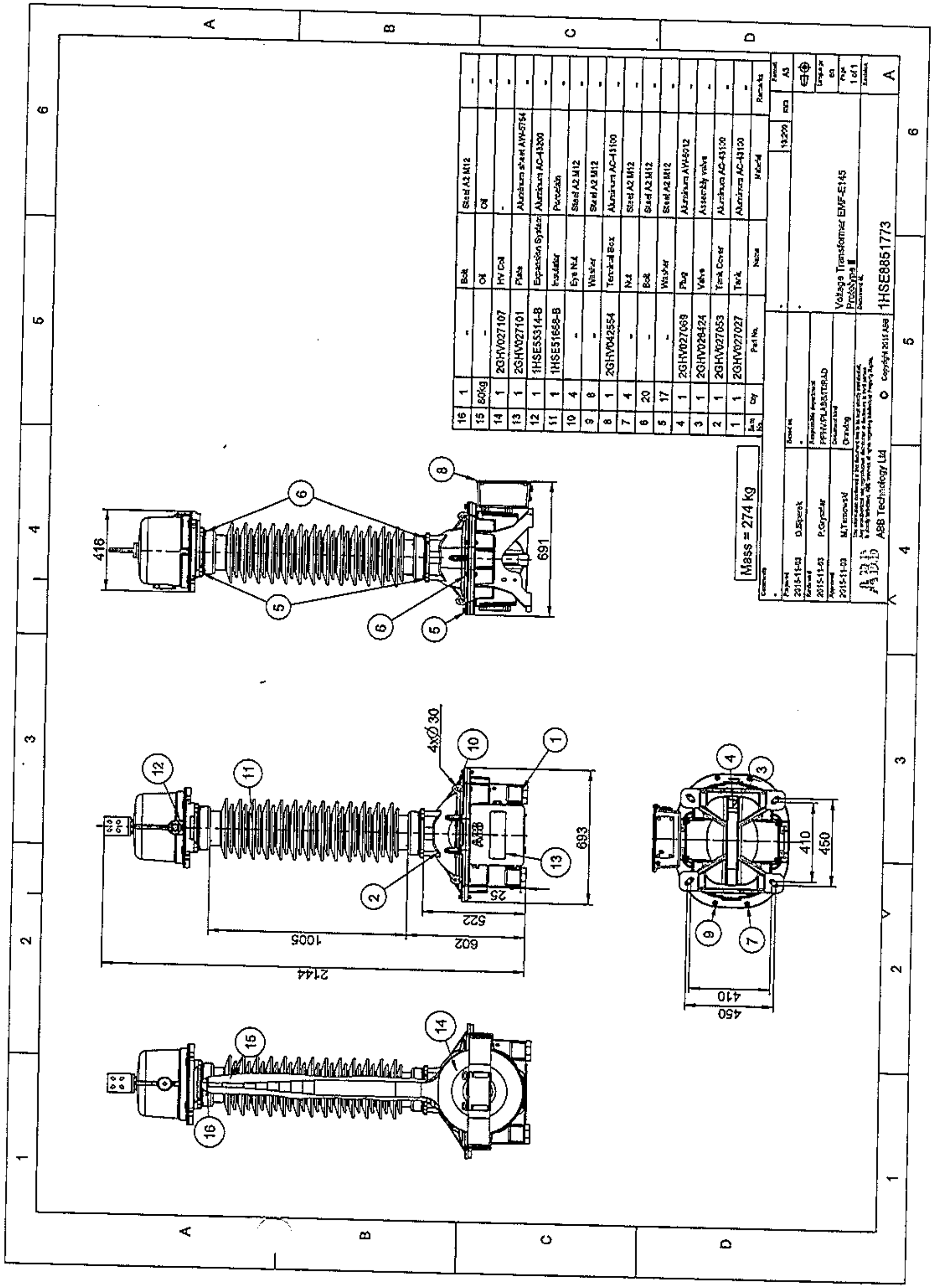

ANNEX 2 for test report EWN/134/E/15

(8 pages)

Reports of routine test and determination of errors:

- Routine test report of voltage instrument transformer EMF-145 (1HSE8851773),
- Routine test report of voltage instrument transformer EMF-145 (1HSE8851773) after lightning impulse,

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		**Routine test report of voltage instrument Transformer**	**TYPE:** EMF-E145 **Serial no:** 1HSE8851773	
A-N 145:√3 kV	145/275/650 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1500
1a - 1n	0,115:√3	25	1,0	1500
2a - 2n	0,115:√3	25	0,1	1500
2a - 2n	0,115:√3	25	1,0	1500
3a - 3n	0,115:√3	25	0,1/3P	1500
3a - 3n	0,115:√3	500	3,0/3P	1500
da - dn	0,115	100	0,1	450
da - dn	0,115	300	3P	450

1. Oil dielectric parameters 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 - A: Up = 275kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings. - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC 60247
  Tg δ = 0.0909 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 75.58 kV, Relative standard deviation = 4.66 %;
  f = 50Hz, oil temp. = 22.8 °C, measurement without the stirrer, type of electrodes used: partially spherical

Sample	Breakdown voltage [kV]
1	78.6
2	73.5
3	75.3
4	77.2
5	69.8
6	79.1

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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: 120 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100.5 kV
Level of partial discharge	0.6 pC	0.6 pC

Remarks: background noise level: 0.5 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating charge).

Verification of accuracy (ε U%), ($\Delta\varphi$ U min)

Date of measurement: 2015-10-20

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.042	-0.041	-0.040
Δφ U	1.3	1.3	1.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.009	-0.008	-0.007
Δφ U	1.1	1.1	1.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.054	-0.052	-0.052
Δφ U	0.8	0.8	0.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.021	-0.019	-0.019
Δφ U	1.0	1.0	1.1

3a-3n: 25 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA — 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	-0.135	-0.099	-0.053	-0.052	-0.051	-0.137
Δφ U	1.0	0.9	0.8	0.8	0.9	-1.3

3a-3n: 6.25 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA — 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	-0.112	-0.072	-0.026	-0.024	-0.023	-0.109
Δφ U	1.2	1.0	0.9	1.0	1.0	-1.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.037	0.039	0.040
Δφ U	0.6	0.6	0.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.007	-0.006	-0.005
Δφ U	2.2	2.2	2.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.026	0.027	0.028
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.015
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.016	0.017	0.018
Δφ U	2.0	2.0	2.1

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.103	-0.064	-0.017	-0.016	-0.015	-0.101
Δφ U	1.8	1.6	1.6	1.6	1.6	-0.6

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.073	-0.036	0.010	0.012	0.013	-0.073
Δφ U	2.4	2.1	1.9	1.9	2.0	-0.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.235	0.237	0.238
Δφ U	2.0	2.0	2.1

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

Measurements uncertainty: $\varepsilon_U = \pm 0,044\,\%$, $\Delta\varphi_U = \pm 2,2$ min

Verification of accuracy (ε U%), ($\Delta\varphi$ U min)

Date of measurement: 2015-10-20

1a-1n: 25 VA — p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.384	-0.383	-0.381
Δφ U	-7.5	-7.5	-7.5

1a-1n: 6.25 VA — p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.351	-0.349	-0348
Δφ U	-7.6	-7.6	-7.6

2a-2n: 25 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.442	-0.447	-0.452
Δφ U	-8.4	-8.4	-8.4

2a-2n: 6.25 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.381	-0.380	-0.379
Δφ U	-8.5	-8.5	-8.4

3a-3n: 500 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA — 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	-0.828	-0.793	-0.740	-0.738	-0.739	-0.985
Δφ U	-1.8	-2.0	-2.0	-2.0	-1.9	-8.5

3a-3n: 125 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA — 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	-0.283	-0.248	-0.201	-0.199	-0.199	-0.436
Δφ U	0.5	0.3	0.2	0.3	0.3	-6.2

da-dn: 300 VA — p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.809	-0.762	0.710	-0.715
Δφ U	-9.7	-9.7	-9.5	-9.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.007	-0.006	-0.005
Δφ U	2.2	2.2	2.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.026	0.027	0.028
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.020	-0.018	-0.018
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.013	0.014	0.015
Δφ U	2.0	2.0	2.1

3a-3n: 500 VA — p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.794	-0.754	-0705	-0.703	-0.704	-0.948
Δφ U	-0.7	-0.8	-1.0	-1.0	-0.9	-7.3

3a-3n: 125 VA — p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.248	-0.211	-0.165	-0.163	-0.162	-0.410
Δφ U	1.7	1.4	1.2	1.3	1.3	-5.2

da-dn: 75 VA — p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un	1,2 Un
ε U	0.050	0.092	0.143	0.140
Δφ U	2.2	2.1	2.1	2.2

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

Measurements uncertainty: $\varepsilon_U = \pm 0,044\,\%$, $\Delta\varphi_U = \pm 2,2$ min

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 23 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.21	238	0.773
84 kV	0.24	239	6.309
84 kV	0.24	239	6.309

Measurement of windings' resistance

	R (23 °C)	Rct (75 °C)
A-N	18.20 kΩ	21.919 kΩ
1a-1n	53.000 mΩ	63.831 mΩ
2a-2n	51.700 mΩ	62.265 mΩ
3a-3n	33.100 mΩ	39.864 mΩ
da-dn	143.900 mΩ	173.307 mΩ

Checked by: ....

Przasnysz, 2015-10-20

INSTITUTE OF POWER ENGINEERING
Certification Department
Witnessed ☒ Reviewed ☐
Date / Sign. M. Sc. Eng. Jerzy Mikołajczyk

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59	Routine test report of voltage instrument transformer after lighting impulse	TYPE: EMF-E145 Serial no: 1HSE8851773
A-N 145:√3 kV	145/275/650 kV	Voltage factor: 1.9/8h
IEC 61869-3	50 Hz	

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1500
1a - 1n	0,115:√3	25	1,0	1500
2a - 2n	0,115:√3	25	0,1	1500
2a - 2n	0,115:√3	25	1,0	1500
3a - 3n	0,115:√3	25	0,1/3P	1500
3a - 3n	0,115:√3	500	3,0/3P	1500
da - dn	0,115	100	1,0	450
da - dn	0,115	300	3P	450

1. Oil dielectric parameters 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 - A: Up = 220 kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC 60247
  Tg δ = 0.0909 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 75.58 kV, Relative standard deviation = 4.66 %;
  f = 50Hz, oil temp. = 22.8 °C, measurement without the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	78.6
2	73.5
3	75.3
4	77.2
5	69.8
6	79.1

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: 220 kV / 60 s

Frequency: 120 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100.5 kV
Level of partial discharge	0.5 pC	0.5 pC

Remarks: background noise level: 0.5 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Verification of accuracy ε U%), Δφ U min)

Date of measurement: 2015-11-10

Ambient temperature: 23 +/- 2°C

Relative air humidity: 28 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.047	-0.045	-0.045
Δφ U	1.3	1.3	1.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.012	-0.011	-0.010
Δφ U	1.2	1.2	1.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.052	-0.051	-0.050
Δφ U	1.1	1.2	1.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.020	-0.018	-0.018
Δφ U	1.1	1.1	1.1

3a-3n: 25 VA — 1a-1n: 25VA; 2a-2n: 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	-0.141	-0.102	-0.055	-0.054	-0.053	-0.164
Δφ U	1.0	0.9	0.8	0.9	0.9	-2.0

3a-3n: 6.25 VA — 1a-1n: 25VA; 2a-2n: 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	-0.112	-0.075	-0.028	-0.027	-0.026	-0.136
Δφ U	1.2	1.0	1.0	1.0	1.0	-1.8

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.065	-0.023	0.029	0.027
Δφ U	0.8	0.7	0.9	1.0

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.011	-0.009	-0.008
Δφ U	2.2	2.3	2.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.024	0.025	0.026
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.016	-0.014	-0.013
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.017	0.019	0.019
Δφ U	2.0	2.0	2.1

3a-3n: 25 VA — 1a-1n: 0 VA; 2a-2n: 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	-0.102	-0.064	-0.018	-0.016	-0.015	-0.126
Δφ U	2.1	1.9	1.8	1.8	1.8	-1.0

3a-3n: 6.25 VA — 1a-1n: 0 VA; 2a-2n: 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	-0.075	-0.036	0.010	0.011	0.012	-0.099
Δφ U	2.3	2.0	1.9	2.0	2.0	-0.9

da-dn: 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	1,0 Un	1,9 Un
ε U	0.137	0.184	0.235	0.233
Δφ U	2.2	2.1	2.1	2.2

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

Measurements uncertainty: $\varepsilon_U = \pm 0{,}044$ %, $\Delta\varphi_U = \pm 2{,}2$ min

Verification of accuracy ε U%), Δφ U min)

Date of measurement: 2015-11-10

Ambient temperature: 23 +/-

Relative air humidity: 24 +/-

1a-1n: 25 VA — 2a-2n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag. p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.385	-0.384	-0.382
Δφ U	-7.5	-7.5	-7.5

1a-1n: 6.25 VA — 2a-2n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag. p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.352	-0.350	-0.349
Δφ U	-7.6	-7.6	-7.6

2a-2n: 25 VA — 1a-1n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag. p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.416	-0.415	-0.413
Δφ U	-8.4	-8.4	-8.4

2a-2n: 6.25 VA — 1a-1n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag. p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.384	-0.383	-0.381
Δφ U	-8.5	-8.5	-8.5

3a-3n: 500 VA — 1a-1n: 25VA; 2a-2n: 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	-0.819	-0.782	-0.734	-0.733	-0.730	-0.976
Δφ U	-2.2	-2.3	-2.3	-2.3	-2.2	-8.7

3a-3n: 125 VA — 1a-1n: 25VA; 2a-2n: 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	-0.284	-0.247	-0.201	-0.199	-0.199	-0.444
Δφ U	0.4	0.2	0.2	0.2	0.2	-6.4

da-dn: 300 VA — 1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA — p.f. = 0,8 lag. p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.806	-0.758	-0.705	-0.710
Δφ U	-9.6	-9.8	-9.6	-9.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.010	-0.009	-0.008
Δφ U	2.2	2.2	2.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.023	0.025	0.025
Δφ U	2.0	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.018	-0.017	-0.016
Δφ U	2.1	2.1	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.015	0.016	0.017
Δφ U	2.0	2.0	2.0

3a-3n: 500 VA — 1a-1n: 0 VA; 2a-2n: 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	-0.784	-0.743	-0.696	-0.694	-0.692	-0.938
Δφ U	-1.0	-1.2	-1.2	-1.2	-1.2	-7.7

3a-3n: 125 VA — 1a-1n: 0 VA; 2a-2n: 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	-0.247	-0.211	-0.164	-0.163	-0.162	-0.407
Δφ U	1.5	1.3	1.2	1.2	1.2	-5.4

da-dn: 75 VA — 1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA — p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.045	0.090	0.141	0.138
Δφ U	2.3	2.1	2.1	2.2

* at 1,9 Un winding da-dn is loaded with 300 VA, p.f. = 0,8

Measurements uncertainty: $\varepsilon_U = \pm 0{,}044$ %, $\Delta\varphi_U = \pm 2{,}2$ min

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 23 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.19	241	0.785
84 kV	0.19	241	6.362
84 kV	0.19	241	6.362

Measurement of windings' resistance

	R (23 °C)	Rct (75 °C)
A-N	18.20 kΩ	21.991 kΩ
1a-1n	52.800 mΩ	63.798 mΩ
2a-2n	51.200 mΩ	61.864 mΩ
3a-3n	32.970 mΩ	39.837 mΩ
da-dn	145.400 mΩ	175.685 mΩ

Checked by: J. Krawczyk

OG-4 KJ-58

Przasnysz, 2015-11-10

INSTITUTE OF POWER ENGINEERING
Certification Department
Witnessed ☒ Reviewed ☐
Date / Sign. M. Sc. Eng. Jerzy Mikołajczyk

HIGH VOLTAGE LABORATORY
INSTYTUT ENERGETYKI
01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242
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ANNEX 3 for test report EWN/134/E/15

(7 pages)

Lightning impulse test protocol:

- ewn134e15

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fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

Próba udarem uciętym 1,2/50us

project : ewn134e15 test date 06-11-2015

Test - object - data

WNR EWN/134/E/15 TR-No. 1HSE8851773 O.-No. 4500678253

test object EMF-E145 vector group -
output - kVA BIL 650
voltage 145 kV frequency 50 Hz

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

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
1	-326.4	1.21	45.3		-71.42	LI: A - RW(50.0%)
2	-648.4	1.22	45.6		-142.1	LI: A - FW(100.0%)
3	-374.3	1.22		3.42	-137.1	LI: A - CRW(57.5%)
4	-746.6	1.22		3.43	-285.1	LI: A - CFW(115.0%)
5	-746.9	1.23		3.41	-287.1	LI: A - CFW(115.0%)
6	-649.9	1.22	45.6		-141.9	LI: A - FW(100.0%)
7	-649.7	1.22	45.6		-142	LI: A - FW(100.0%)
8	-649.7	1.22	45.6		-141.9	LI: A - FW(100.0%)
9	-650.1	1.22	45.6		-141.9	LI: A - FW(100.0%)
10	-650.2	1.22	45.6		-142	LI: A - FW(100.0%)
11	-649.7	1.22	45.6		-141.9	LI: A - FW(100.0%)
12	-650	1.22	45.7		-142	LI: A - FW(100.0%)
13	-649.8	1.22	45.7		-142	LI: A - FW(100.0%)
14	-650.2	1.22	45.7		-142	LI: A - FW(100.0%)
15	-649.9	1.22	45.6		-142.1	LI: A - FW(100.0%)
16	-649.6	1.22	45.7		-142.2	LI: A - FW(100.0%)
17	-649.7	1.22	45.7		-142	LI: A - FW(100.0%)
18	-650	1.22	45.7		-142	LI: A - FW(100.0%)
19	-650.2	1.22	45.7		-142.1	LI: A - FW(100.0%)
20	327.1	1.22	45.5		71.62	LI: A - RW(50.0%)
21	649	1.22	46		142	LI: A - FW(100.0%)
22	649.5	1.22	45.9		142	LI: A - FW(100.0%)
23	649.3	1.23	45.9		142	LI: A - FW(100.0%)
24	649.3	1.23	45.9		142.1	LI: A - FW(100.0%)
25	649	1.22	45.9		142	LI: A - FW(100.0%)
26	648.6	1.23	46		141.9	LI: A - FW(100.0%)
27	648.6	1.22	45.9		142.1	LI: A - FW(100.0%)
28	648.4	1.22	46		142	LI: A - FW(100.0%)
29	647.9	1.22	46		142	LI: A - FW(100.0%)

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Próba udarem uciętym 1,2/50us

project : ewn134e15

30	647.6	1.22	46		141.9	LI: A - FW(100.0%)
31	648.6	1.23	45.9		141.9	LI: A - FW(100.0%)
32	648.5	1.22	46		142.1	LI: A - FW(100.0%)
33	647	1.22	46.1		142.3	LI: A - FW(100.0%)
34	648.4	1.22	46		141.9	LI: A - FW(100.0%)
35	647.8	1.22	46		141.7	LI: A - FW(100.0%)

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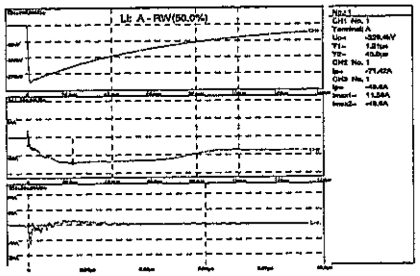
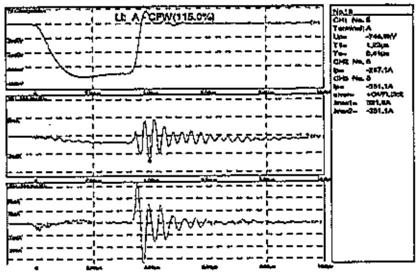
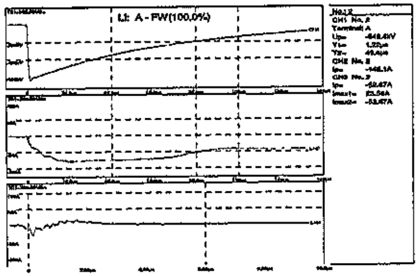
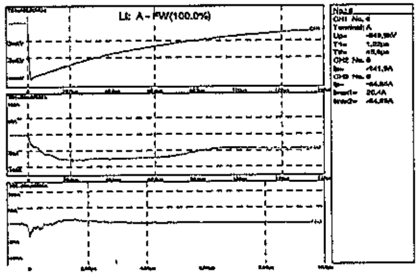
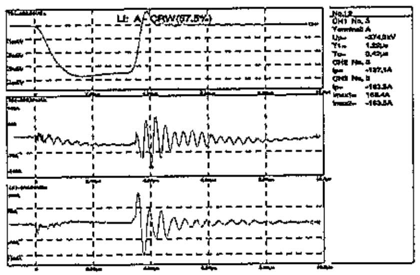
project : ewn134e15

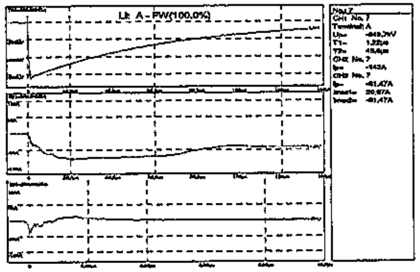


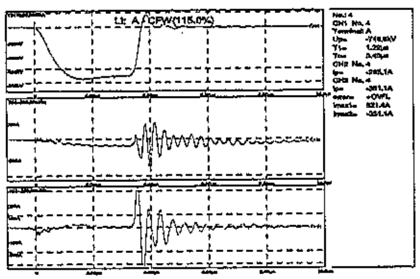


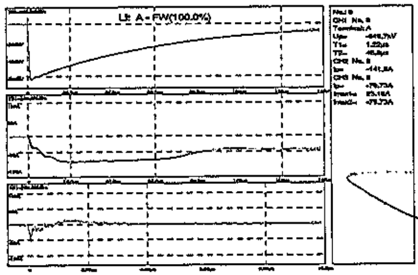












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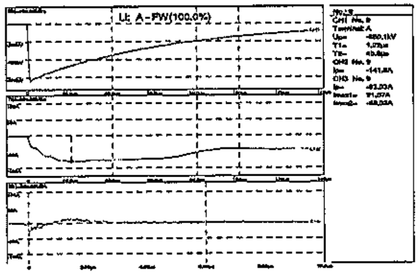
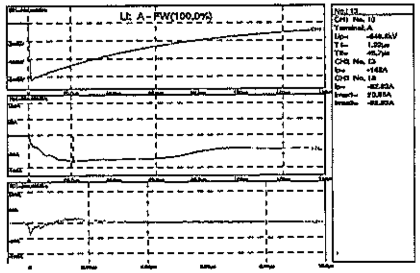
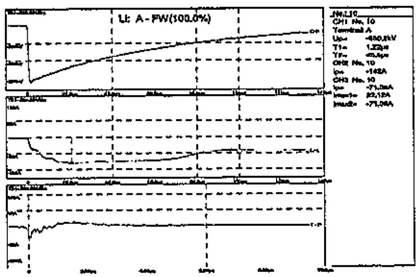
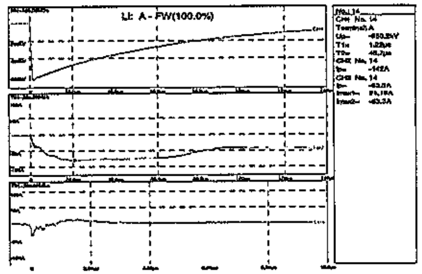
Próba udarem uciętym 1,2/50us

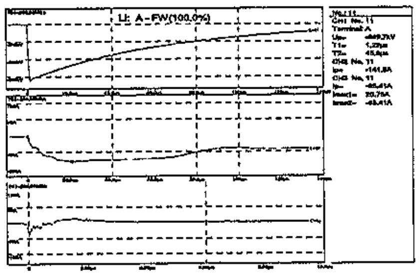
project : ewn134e15

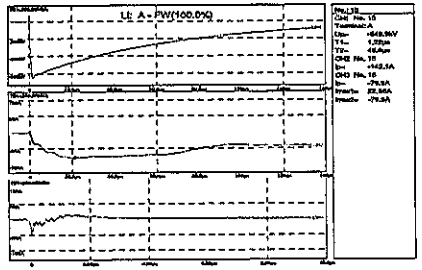


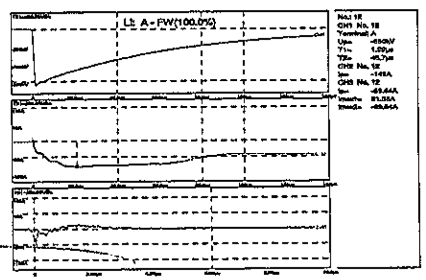


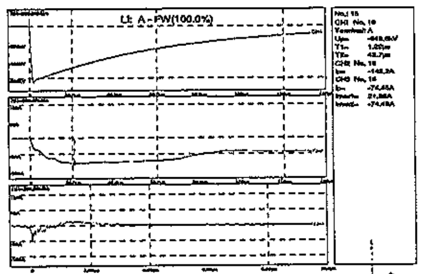












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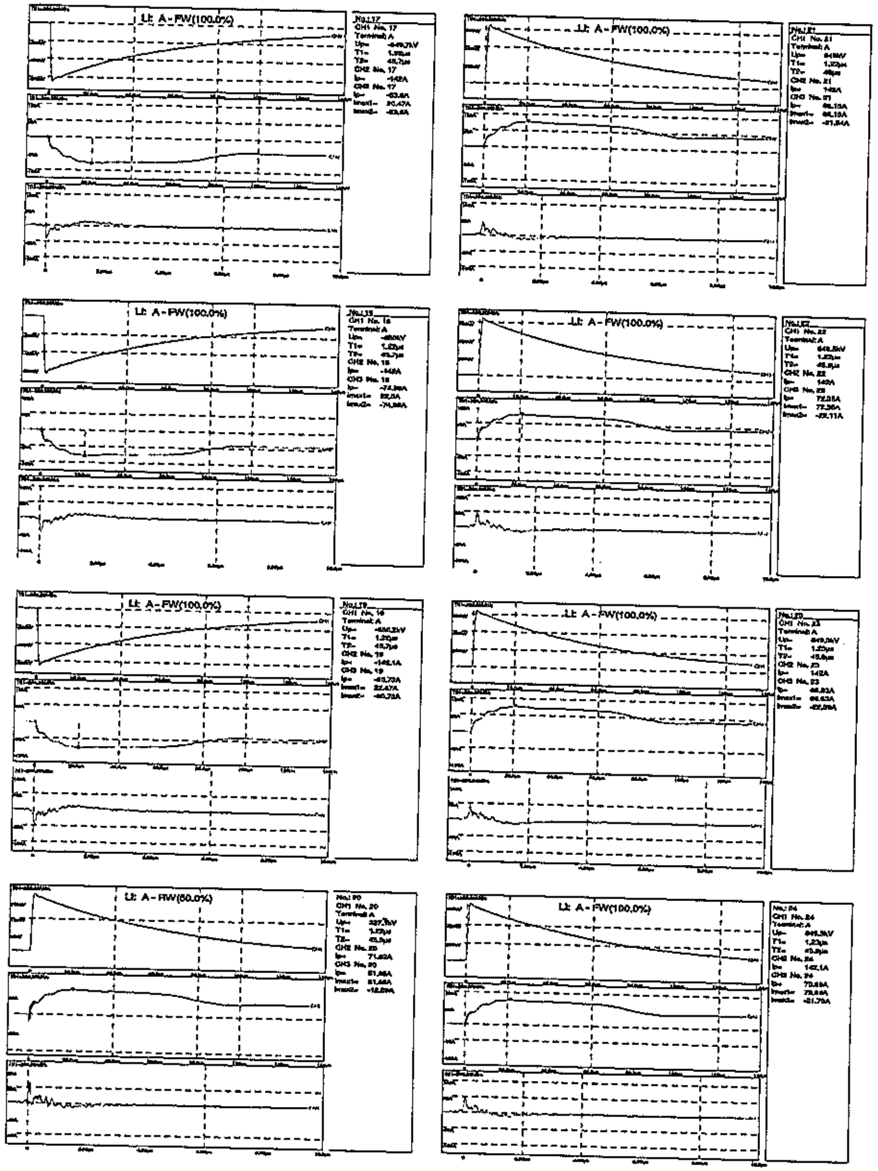
project : ewn134e15



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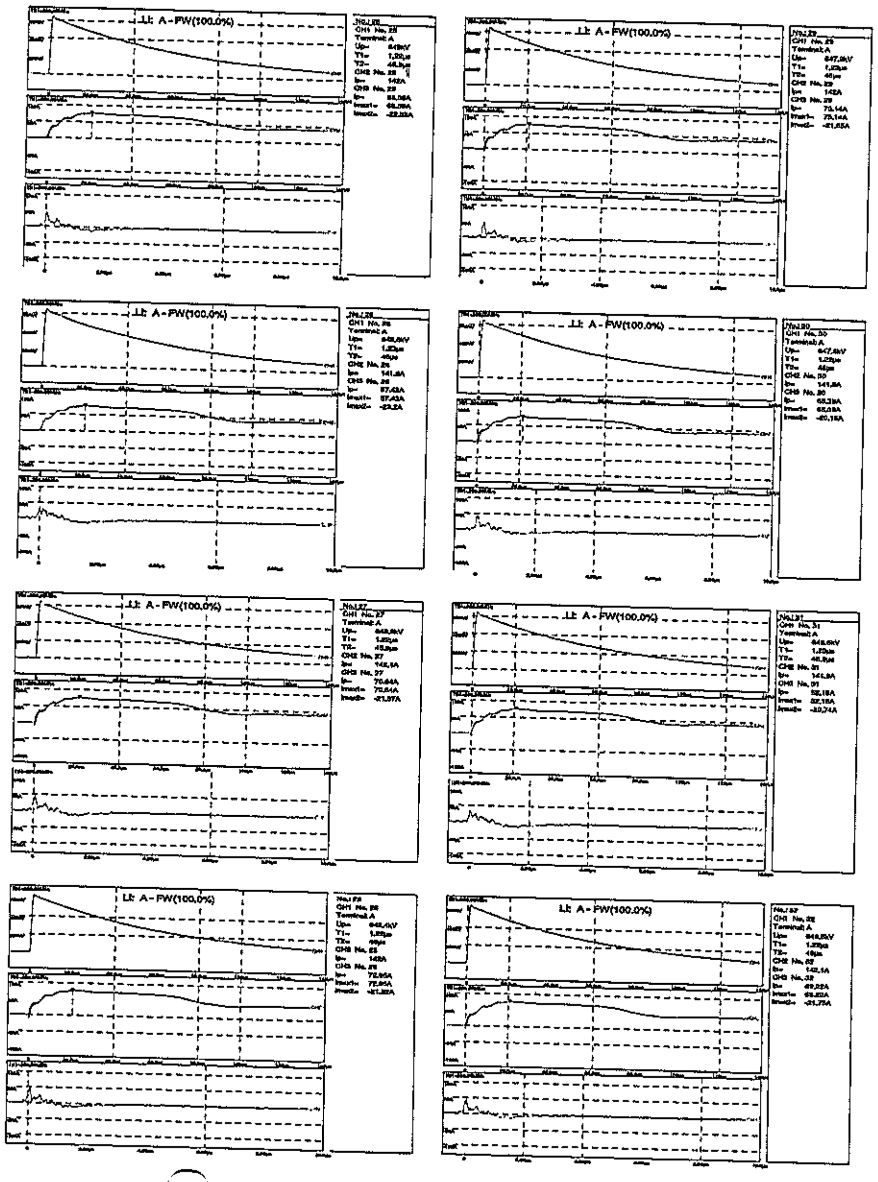

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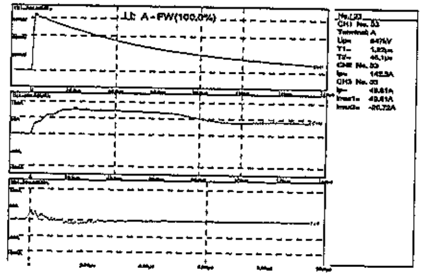

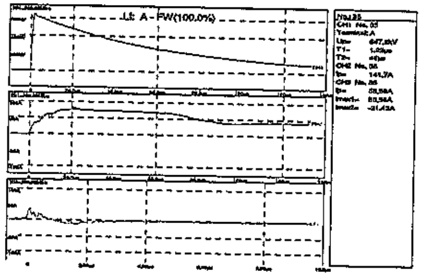

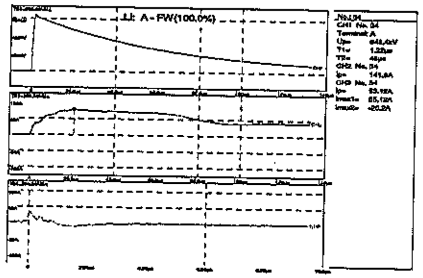

HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

PCA AB 272 ilac-MRA

TEST REPORT
No EWN/45/E/16

Impulse voltage withstand test on primary terminal, chopped impulse voltage withstand test on primary terminal, of voltage instrument transformer type PV145a

Warsaw, May 2016

	HIGH VOLTAGE LABORATORY **INSTYTUT ENERGETYKI** 01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242 tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl	EWN/45/E/16 Page 2/8

TEST REPORT EWN/45/E/16

TEST OBJECT:	**Voltage instrument transformer type PV145a**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
ORDER NO:	**4500743552 (17.05.2016)**
TEST TYPE:	**Impulse voltage withstand test on primary terminal, Chopped impulse voltage withstand test on primary terminal**
TEST PROCEDURE:	**According to:** **PN-EN 61869-1:2009 (IEC 61869-1:2007)** **PN/EN 61869-3:2011 (IEC 61869-3:2011)**
TEST DATE:	**19.05.2016**
TEST RESULT:	**Positive - details are presented in following parts of report**

TEST PERFOMERS:	**Michał Molas, M. Sc. EE**	Signature
	Adam Wielonek, Tech.	Signature
AUTHORISATION:	**Jerzy Mikołajczyk, M. Sc. EE**	Signature
HEAD OF LABORATORY:	**J. L. Mikulski, Prof., Ph. D. EE**	Signature

Warsaw, May 2016.

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CONTENTS

Test report includes:

8 numbered pages;
2 figures;
1 photograph;
3 tables.

Attached to the test report:

Annex 1: Dimensional drawing (1 page);
Annex 2: Reports of routine test and determination of errors (8 pages);
Annex 3: Lightning impulse test protocol (7 pages);

1 COMPETENCE OF THE LABORATORY

The High Voltage Laboratory is in possession of accreditation issued by the Polish Centre for Accreditation (Accreditation Certificate of Testing Laboratory No AB 272) concerning following tests:

Insulators and insulator strings	– lightning and switching impulse tests – power frequency voltage 50 Hz tests – radio interference measurements
Distribution substations	– lightning and switching impulse tests – power frequency voltage 50 Hz tests – radio interference measurements
Circuit breakers, switches	– lightning and switching impulse tests – power frequency voltage 50 Hz tests – radio interference measurements
Disconnectors	– lightning and switching impulse tests – power frequency voltage 50 Hz tests – radio interference measurements
Current and voltage transformers	– lightning and switching impulse tests – power frequency voltage 50 Hz tests – radio interference measurements
Power transformers	– lightning and switching impulse tests – power frequency voltage 50 Hz tests
Lightning arresters and limiters	– lightning and switching impulse tests – power frequency voltage 50 Hz tests
Cables and cable fittings	– lightning and switching impulse tests – power frequency voltage 50 Hz tests
Line and station fittings	– radio interference measurements
Occupational safety equipment	– power frequency voltage 50 Hz tests

Full scope of accreditation of High Voltage Laboratory available on www.pca.gov.pl

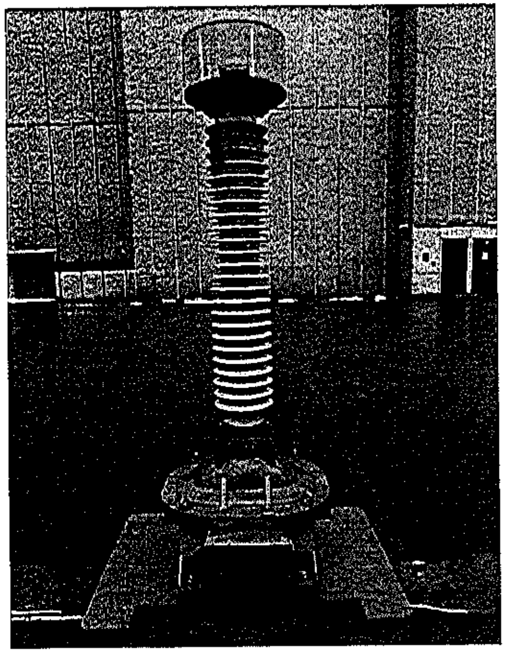
2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer PV145a manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Type – PV145a

Serial number: 2GKP015V1188086

- Highest voltage for equipment: 145 kV
- Rated primary voltage: 145000 / √3 V
- Rated secondary voltage: 115/√3 V (1a-1n, 2a-2n, 3a-3n) ; 115 V (da-dn)
- Insulation level: 275 / 650 kV
- Frequency: 50 Hz
- Temperature range: -40 – +40 °C
- Total mass: 265 kg



Phot. 1: Tested voltage transformer PV145a – general view

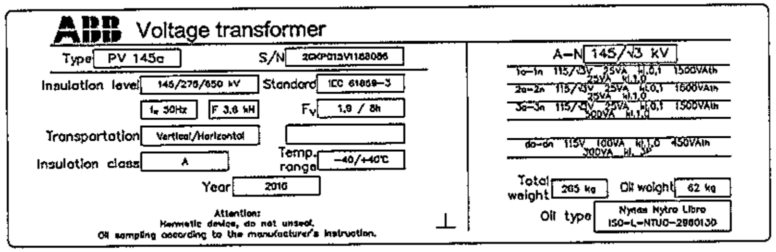


Fig. 1: Tested voltage transformer PV145a – rating plate

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type PV145a was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
1	Impulse voltage withstand test on primary terminal	PN-EN/IEC 61869-1, p.7.2.3
2	Chopped impulse voltage test on primary terminal	PN-EN/IEC 61869-1, p.7.4.1

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o.. Detailed results are presented in Annex 2.

Tests were carried out according to:

- IEC 61869-1:2007 „Instrument transformers - Part 1: General requirements" (equiv. with: PN-EN 61869-1:2009 "Przekładniki – Część 1: Wymagania ogólne")
- IEC 61869-3:2011 „Instrument transformers - Part 3: Additional requirements for inductive voltage transformers" (equiv. with: PN-EN 61869-3:2011 "Przekładniki – Część 3: Wymagania szczegółowe dotyczące przekładników napięciowych indukcyjnych")

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3.1 Impulse voltage withstand test on primary terminal

3.1.1 Method of testing and acceptance criteria

According to IEC 61869-1 clause 7.4.1 lightning impulse test (for negative polarity) can be combined with chopped impulse voltage test. For positive polarity lightning impulse test was performed according to IEC 61869-1 clause 7.2.3 (15 impulse method).

It is considered that the instrument transformer passed the test with a positive result if analysis of the waveforms recorded during the test does not indicate failure of internal insulation of instrument transformer.

3.1.2 Test arrangement

Arrangement for testing with full lightning impulse 1,2/50 µs and chopped lightning impulse was based on Marx impulse generator made by HAEFELY. Voltage measurement was performed with impulse voltage measuring system Dr Strauss TR-AS 200-14, in connection with a capacitive voltage divider (impulse peak value measuring uncertainty doesn't exceed 2% of the measured value for the coverage probability 95% and coverage factor k=2). Simplified diagram of the measurement system is shown in the Fig. 2.

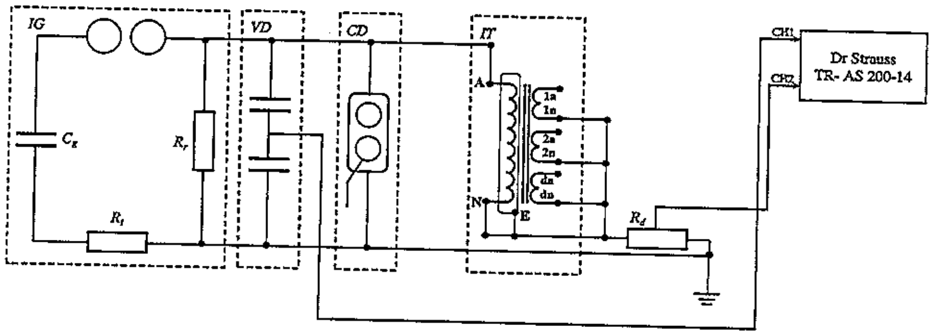

Fig. 2: Simplified diagram of the lightning impulse measurement system (for one step of the generator): *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; *CD* – chopping device; *IT* - instrument transformer (general schematic representation); R_d – detection resistance

3.1.3 Test conditions

Test conditions for full lightning impulse 1,2/50 µs test and chopped lightning impulse test (parameters of the measurement system, values of test voltages and sequence of impulses applications) are presented in Tab. 2 and Tab. 3. The influence of atmospheric condition on test voltage value was not taken into consideration.

Tab. 2: Parameters of the lightning impulse measurement system

IMPULSE GENERATOR			
Number of steps	n	-	6
General capacitance	C_g	µF	0,125
Discharge resistance	R_r	Ω	534
Damping resistance	R_t	Ω	157
VOLTAGE DIVIDER			
HV unit capacitance	C_u'	pF	~1200
LV unit capacitance	C_u''	µF	1,103
Scale factor	ϑ_V	-	927,0
DETECTION RESISTOR			
Detection resistance	R_d	Ω	0,707

Tab. 3: Values of test voltages and sequence of impulses applications

Full impulse test voltage	RW = 325 kV FW = 650 kV	
Chopped impulse test voltage	CRW = 373,7 kV CFW = 747,5 kV	
Sequence of impulses	Positive polarity 1 reduced full impulse (RW), 15 full impulses (FW).	Negative polarity 1 reduced full impulse (RW), 1 full impulse (FW), 1 reduced chopped impulse (CRW), 2 chopped impulses (CFW), 14 full impulses (FW).
Registration	Transients of test voltage (channel 1) Current flowing through whole voltage transformer (channel 2)	

3.1.4 Test results

Oscillograms registered during the tests do not indicate any failures of the transformers' insulation (Annex 3). Comparison of the accuracy verification before and after the lightning impulse test of the transformers don't indicate significant changes of the transformers' metrological characteristics (Annex 2).

TEST RESULT: POSITIVE

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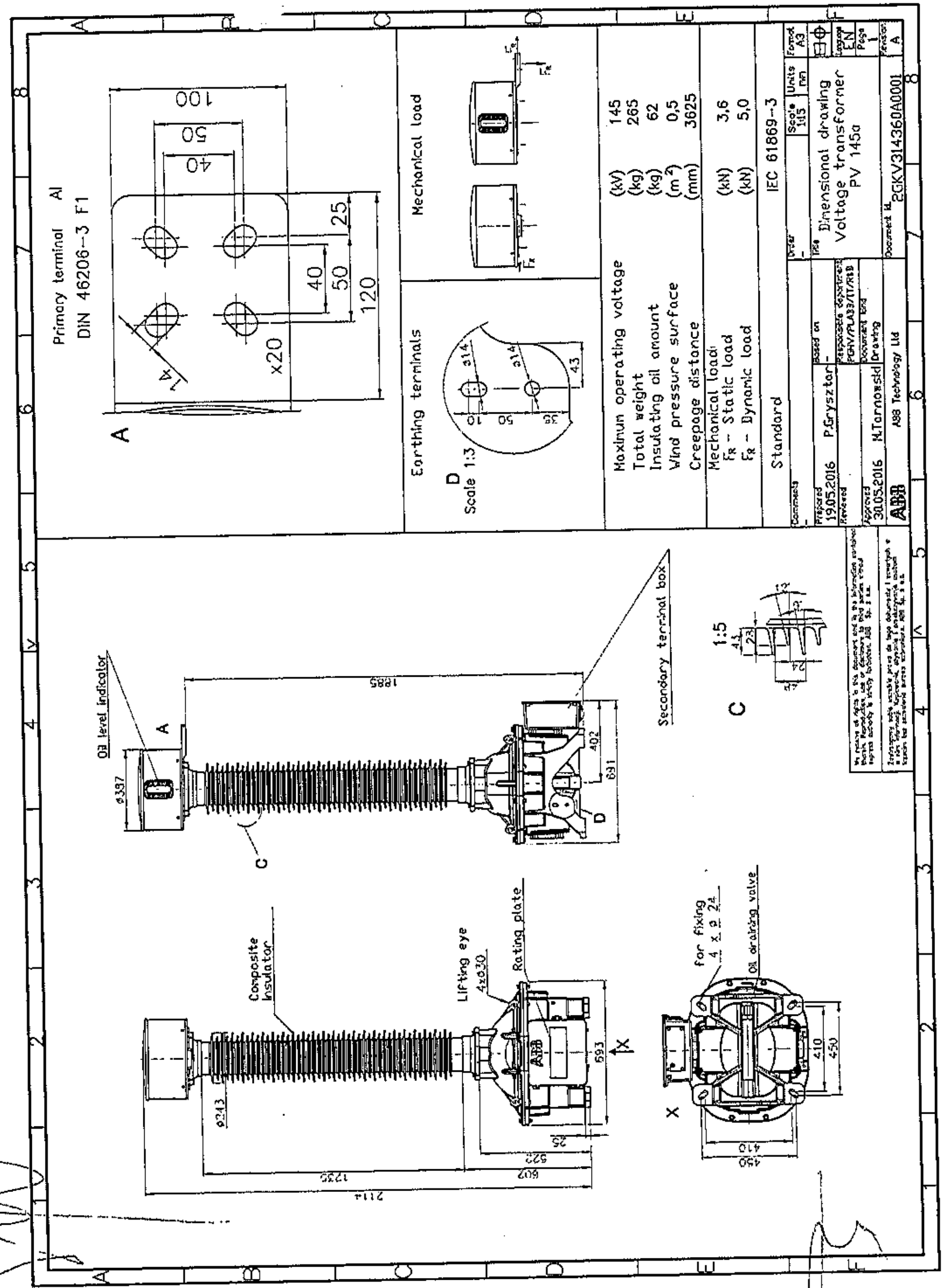
ANNEX 1 for test report EWN/45/E/16

(1 page)

Dimensional drawing:

- ID: 2GKV314360A0001



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HIGH VOLTAGE LABORATORY
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tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl

ANNEX 2 for test report EWN/45/E/16

(8 pages)

Reports of routine test and determination of errors:

- ▫ Routine test report of voltage instrument transformer – before lightning impulse test
- ▫ Routine test report of voltage instrument transformer – after lightning impulse test

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		**Routine test report of voltage instrument transformer-before lightning impulse test**	**TYPE:** **PV 145a** **Serial no:** **2GKP015V1188086**	
A-N 145:√3 kV	Insulation level: 145/275/650 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Rating 1				
Winding	**Usn [kV]**	**Sn [VA]**	**Class**	**Sth [VA]**
1a - 1n	0,115:√3	25	0,1	1500
2a - 2n	0,115:√3	25	0,1	1500
3a - 3n	0,115:√3	25	0,1	1500
da - dn	0,115	100	1,0	450

Rating 2				
Winding	**Usn [kV]**	**Sn [VA]**	**Class**	**Sth [VA]**
1a - 1n	0,115:√3	25	1,0	1500
2a - 2n	0,115:√3	25	1,0	1500
3a - 3n	0,115:√3	500	1,0	1500
da - dn	0,115	300	3P	450

List of performed tests

1. Power-frequency withstand test on primary windings — A: Up = 275kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
2. Partial discharge measurement ☑
3. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
4. Determination of errors ☑
5. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
6. Measurement of windings' resistance ☑
7. Rating plate ☑

☑

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: 120 Hz

Test voltage	**1,2 Um = 174 kV**	**1,2 Um /√3 = 100.5 kV**
Level of partial discharge	**0.6 pC**	**0.6 pC**

- PD inception voltage: 230 kV
- PD extinction voltage: 225 kV

Remarks: background noise level: 0.5 (measured after voltage switch off), measuring circuit was calibrated with 5.1 pC (calibrating charge).

Verification of accuracy (ε U%), (Δφ U min) – rating 1

Date of measurement:	2016-05-17
Ambient temperature:	31 +/- 2°C
Relative air humidity:	40 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.056	-0.054	-0.054
Δφ U	0.7	0.7	0.7

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.020	-0.018	-0.018
Δφ U	0.5	0.6	0.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.057	-0.056	-0.055
Δφ U	0.5	0.5	0.5

2a-2n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.023	-0.022	-0.021
Δφ U	0.5	0.5	0.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.060	-0.059	-0.058
Δφ U	0.2	0.2	0.2

3a-3n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.032	-0.030	-0.030
Δφ U	0.4	0.4	0.4

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.128	-0.064	0.010	0.003
Δφ U	-1.1	-0.7	0.0	0.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.015	-0.014	-0.013
Δφ U	1.7	1.8	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.021	0.022	0.023
Δφ U	1.6	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.016	-0.014	-0.014
Δφ U	1.6	1.6	1.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.018	0.020	0.020
Δφ U	1.6	1.6	1.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.019	-0.017	-0.017
Δφ U	1.3	1.3	1.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.010	0.011	0.012
Δφ U	1.5	1.5	1.5

da-dn: 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	1,0 Un	1,9 Un
ε U	0.092	0.158	0.233	0.228
Δφ U	0.7	1.0	1.6	1.7

Measurements uncertainty: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Verification of accuracy (ε U%), (Δφ U min) – rating 2

Date of measurement: 2016-05-17
Ambient temperature: 31 +/- 2°C
Relative air humidity: 40 +/- 10%

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.434	-0.432	-0.432
Δφ U	-9.7	-9.7	-9.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.015	-0.014	-0.013
Δφ U	1.7	1.8	1.8

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.398	-0.398	-0.396
Δφ U	-9.8	-9.8	-9.8

2a-2n: 25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.450	-0.450	-0.448
Δφ U	-10.6	-10.6	-10.5

2a-2n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.417	-0.415	-0.414
Δφ U	-10.6	-10.6	-10.6

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.932	-0.930	-0.931
Δφ U	0.5	0.6	0.6

3a-3n: 125 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.212	-0.210	-0.210
Δφ U	-0.7	-0.7	-0.7

da-dn: 300 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.911	-0.844	-0.770	-0.775
Δφ U	-14.2	-13.8	-13.1	-13.0

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.021	0.022	0.023
Δφ U	1.6	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.016	-0.014	-0.013
Δφ U	1.6	1.6	1.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.019	0.020	0.021
Δφ U	1.6	1.6	1.6

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.893	-0.892	-0.890
Δφ U	1.6	1.7	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.171	-0.170	-0.169
Δφ U	0.4	0.5	0.5

da-dn: 75 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.006	0.068	0.141	0.138
Δφ U	0.5	0.8	1.3	1.4

Measurements uncertainty: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Measurement of capacitance and dielectric dissipation factor – tg δ
Temperature: 26 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.2	241	0.839
63 kV	0.2	241	5.759
71 kV	0.2	241	6.422

Measurement of windings' resistance

	R (28 °C)	Rct (20 °C)	Rct (75 °C)
A-N	18.50 kΩ	17.918 kΩ	21.917 kΩ
1a-1n	53.7 mΩ	52.012 mΩ	63.619 mΩ
2a-2n	52 mΩ	50.365 mΩ	61.605 mΩ
3a-3n	33.8 mΩ	32.737 mΩ	40.043 mΩ
da-dn	147.6 mΩ	142.959 mΩ	174.863 mΩ

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Rating plate

ABB Voltage transformer

Type PV 145a S/N 2GKP015V1188086

Insulation level 145/275/650 kV Standard IEC 61869-3

f_N 50Hz F 3,6 kN F_V 1,9 / 8h

Transportation Vertical/Horizontal

Insulation class A Temp. range −40/+40°C

Year 2016

Attention:
Hermetic device, do not unseal.
Oil sampling according to the manufacturer's instruction.

A–N 145/√3 kV

1a–1n 115/√3V 25VA kl.0,1 1500VAth
25VA kl.1,0

2a–2n 115/√3V 25VA kl.0,1 1500VAth
25VA kl.1,0

3a–3n 115/√3V 25VA kl.0,1 1500VAth
500VA kl.1,0

da–dn 115V 100VA kl.1,0 450VAth
300VA kl. 3P

Total weight 265 kg Oil weight 62 kg

Oil type Nynas Nytro Libra ISO-L-NTUO-2980130

Checked by: .... (signature, stamp: OG-4 KJ-06)

Przasnysz, 2016-05-17

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine test report of voltage instrument transformer-after lightning impulse test	TYPE: PV 145a Serial no: 2GKP015V1188086	
A-N 145:√3 kV	Insulation level: 145/275/650 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

		Rating 1		
Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1500
2a - 2n	0,115:√3	25	0,1	1500
3a - 3n	0,115:√3	25	0,1	1500
da - dn	0,115	100	1,0	450
		Rating 2		
Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	1,0	1500
2a - 2n	0,115:√3	25	1,0	1500
3a - 3n	0,115:√3	500	1,0	1500
da - dn	0,115	300	3P	450

List of performed tests

1. Power-frequency withstand test on primary windings - A: Up = 220kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
2. Partial discharge measurement ☑
3. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
4. Determination of errors ☑
5. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
6. Measurement of windings' resistance ☑
7. Rating plate ☑

☑

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: 220 kV / 60 s
  Frequency: 120 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um /√3 = 100.5 kV
Level of partial discharge	1 pC	0.6 pC

- PD inception voltage: >220 kV
- PD extinction voltage: >220 kV

Remarks: background noise level: 0.6 (measured after voltage switch off), measuring circuit was calibrated with 5.1 pC (calibrating charge).

Verification of accuracy (ε U%), (Δφ U min) – rating 1

Date of measurement: 2016-05-30
Ambient temperature: 31 +/- 2°C
Relative air humidity: 40 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.058	-0.056	-0.055
Δφ U	0.7	0.7	0.7

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.022	-0.020	-0.019
Δφ U	0.6	0.6	0.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.064	-0.062	-0.062
Δφ U	0.5	0.5	0.6

2a-2n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.030	-0.028	-0.027
Δφ U	0.5	0.5	0.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.063	-0.061	-0.061
Δφ U	0.2	0.3	0.3

3a-3n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.033	-0.032	-0.031
Δφ U	0.4	0.4	0.4

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.116	-0.053	0.023	0.020
Δφ U	-1.4	-1.0	-0.4	-0.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.015
Δφ U	1.8	1.8	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.019	0.020	0.021
Δφ U	1.7	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.023	-0.021	-0.021
Δφ U	1.6	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.012	0.013	0.014
Δφ U	1.6	1.6	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.022	-0.020	-0.019
Δφ U	1.4	1.4	1.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.007	0.009	0.010
Δφ U	1.5	1.6	1.6

da-dn: 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	1,0 Un	1,9 Un
ε U	0.095	0.162	0.237	0.233
Δφ U	0.6	1.0	1.6	1.7

Measurements uncertainty: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Verification of accuracy (ε U%), (Δφ U min) – rating 2

Date of measurement: 2016-05-30
Ambient temperature: 31 +/- 2°C
Relative air humidity: 40 +/- 10%

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.433	-0.431	-0.431
Δφ U	-9.6	-9.6	-9.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.015	-0.014
Δφ U	1.8	1.8	1.8

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.399	-0.398	-0.396
Δφ U	-9.7	-9.6	-9.6

2a-2n: 25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.452	-0.451	-0.449
Δφ U	-10.4	-10.4	-10.4

2a-2n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.418	-0.415	-0.415
Δφ U	-10.5	-10.4	-10.4

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.944	-0.943	-0.945
Δφ U	0.7	0.7	0.8

3a-3n: 125 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.256	-0.254	-0.253
Δφ U	0.6	0.6	0.6

da-dn: 300 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.943	-0.877	-0.807	-0.809
Δφ U	-13.6	-13.2	-12.1	-12.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.018	0.020	0.021
Δφ U	1.7	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.024	-0.022	-0.021
Δφ U	1.7	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.011	0.013	0.013
Δφ U	1.6	1.6	1.7

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.910	-0.910	-0.910
Δφ U	1.8	1.8	1.8

3a-3n: 125 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.178	-0.176	-0.175
Δφ U	0.5	0.5	0.6

da-dn: 75 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.007	0.059	0.134	0.131
Δφ U	0.6	1.0	1.5	1.6

Measurements uncertainty: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Measurement of capacitance and dielectric dissipation factor – tg δ
Temperature: 26 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.2	239	0.835
63 kV	0.2	239	6.316
71 kV	0.2	239	6.868

Measurement of windings' resistance

	R (28 °C)	Rct (20 °C)	Rct (75 °C)
A-N	18.50 kΩ	17.918 kΩ	21.917 kΩ
1a-1n	53.7 mΩ	52.012 mΩ	63.619 mΩ
2a-2n	52 mΩ	50.365 mΩ	61.605 mΩ
3a-3n	33.8 mΩ	32.737 mΩ	40.043 mΩ
da-dn	147.6 mΩ	142.959 mΩ	174.863 mΩ

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Rating plate

ABB Voltage transformer

Type PV 145a S/N 2GKP015V1188086

Insulation level 145/275/650 kV Standard IEC 61869-3

f_R 50Hz F 3,5 kN F_V 1,9 / 8h

Transportation Vertical/Horizontal

Insulation class A Temp. range −40/+40°C

Year 2016

A–N 145/√3 kV

1a–1n 115/√3V 25VA kl.0,1 1500VAth 25VA kl.1,0

2a–2n 115/√3V 25VA kl.0,1 1500VAth 25VA kl.1,0

3a–3n 115/√3V 25VA kl.0,1 1500VAth 500VA kl.1,0

da–dn 115V 100VA kl.1,0 450VAth 300VA kl. 3P

Total weight 265 kg Oil weight 62 kg

Oil type Nynas Nytro Libra ISO-L-NTUO-2980130

Attention:
Hermetic device, do not unseal.
Oil sampling according to the manufacturer's instruction.

Checked by: OG-4 KJ-06

Przasnysz, 2016-05-30

HIGH VOLTAGE LABORATORY
INSTYTUT ENERGETYKI
01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242
tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl

ANNEX 3 for test report EWN/45/E/16

(8 pages)

Lightning impulse test protocol:

- ewn45e16

HIGH VOLTAGE LABORATORY

POLAND 01-330 WARSZAWA, ul. Mory 8
fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

project : ewn45e16 test date 19-05-2016

Test - object - data

WNR ewn45e16 TR-No. 2GKP0115V1188086 O.-No. 4500743552

test object	PV145a		vector group	-	
output	-	kVA	BIL	650	
voltage	145	kV	frequency	50	Hz

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

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
1	-325.3	1.22	45.4		-363.6	LI: A - RW(50.0%)
2	-648.1	1.23	45.8		-453	LI: A - FW(100.0%)
3	-375	1.22		3.48	-625.2	LI: A - CRW(57.5%)
4	-744.8	1.24		3.44	-1122	LI: A - CFW(115.0%)
5	-745.3	1.24		3.4	-1123	LI: A - CFW(115.0%)
6	-647.7	1.23	45.7		-537.8	LI: A - FW(100.0%)
7	-648	1.23	45.8		-361.4	LI: A - FW(100.0%)
8	-648.2	1.23	45.8		-393.7	LI: A - FW(100.0%)
9	-648.3	1.23	45.8		-412.2	LI: A - FW(100.0%)
10	-648	1.23	45.8		-493.4	LI: A - FW(100.0%)
11	-646.9	1.24	45.9		-465.1	LI: A - FW(100.0%)
12	-648	1.23	45.9		-531.1	LI: A - FW(100.0%)
13	-648.3	1.23	45.8		-498.6	LI: A - FW(100.0%)
14	-648.2	1.23	45.9		-305.8	LI: A - FW(100.0%)
15	-648.2	1.23	45.9		-346.5	LI: A - FW(100.0%)
16	-648.7	1.23	45.8		-394.9	LI: A - FW(100.0%)
17	-648.9	1.23	45.8		-353	LI: A - FW(100.0%)
18	-648.1	1.23	45.9		-481.3	LI: A - FW(100.0%)
19	-648	1.23	45.8		-460	LI: A - FW(100.0%)
20	323.8	1.23	45.5		326.4	LI: A - RW(50.0%)
21	649.9	1.23	45.9		425.5	LI: A - FW(100.0%)
22	650.2	1.23	45.8		364.9	LI: A - FW(100.0%)
23	650.2	1.23	45.6		424.7	LI: A - FW(100.0%)
24	649.5	1.23	45.9		476.2	LI: A - FW(100.0%)
25	649.9	1.23	45.9		323.1	LI: A - FW(100.0%)
26	649.9	1.22	45.8		433.1	LI: A - FW(100.0%)
27	649.6	1.23	45.9		538.4	LI: A - FW(100.0%)
28	649.4	1.23	45.9		349.9	LI: A - FW(100.0%)
29	649.3	1.23	45.7		396.1	LI: A - FW(100.0%)

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POLAND 01-330 WARSZAWA, ul. Mory 8
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project : ewn45e16

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
30	649.2	1.23	45.9		367.3	LI: A - FW(100.0%)
31	649.1	1.22	45.9		459.3	LI: A - FW(100.0%)
32	649.6	1.22	45.9		376.5	LI: A - FW(100.0%)
33	648.6	1.22	45.9		343.2	LI: A - FW(100.0%)
34	649.1	1.23	45.9		540.2	LI: A - FW(100.0%)
35	648.8	1.23	45.8		336.1	LI: A - FW(100.0%)

HIGH VOLTAGE LABORATORY

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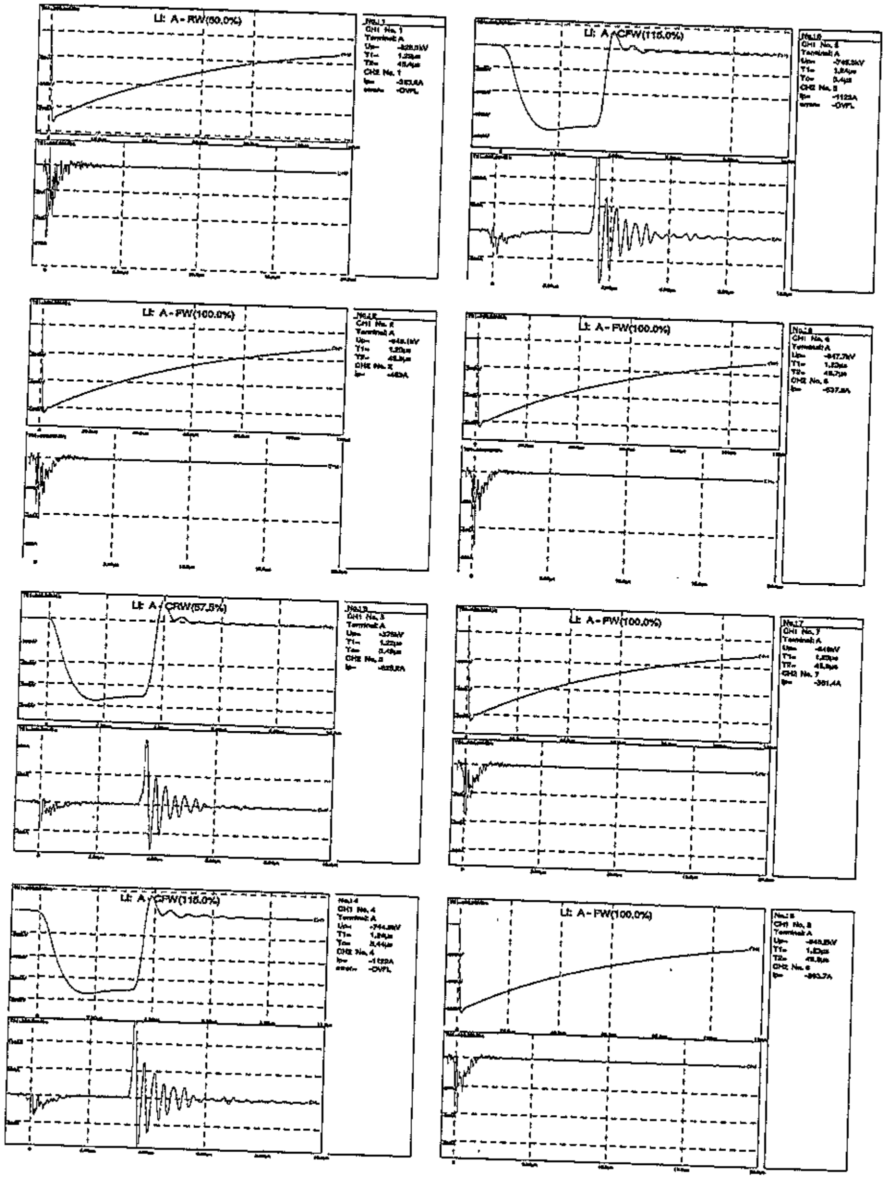
project : ewn45e16



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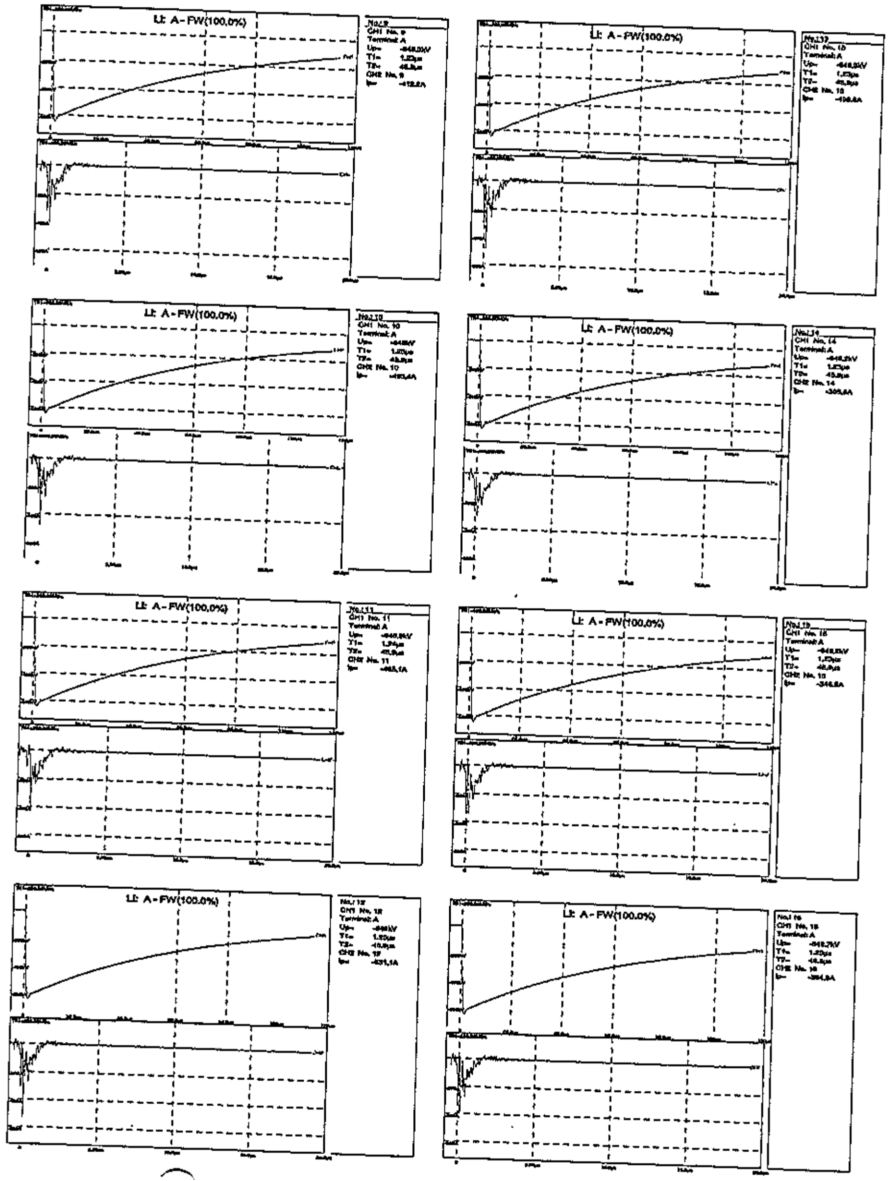

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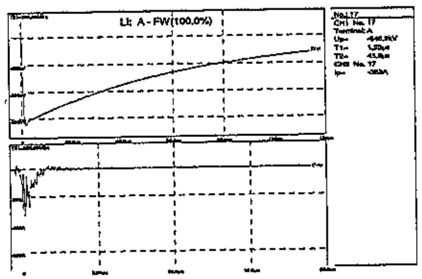

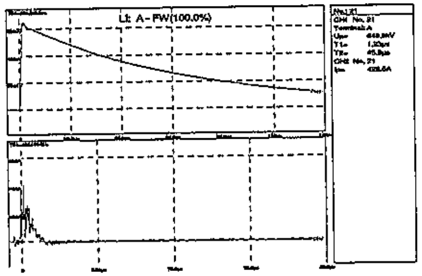

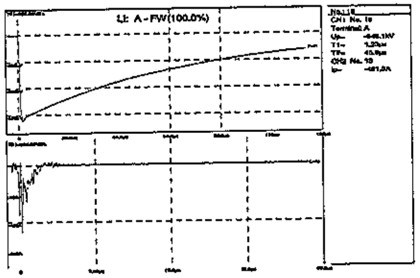

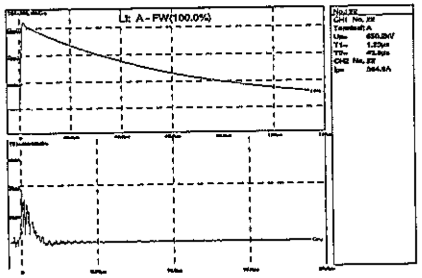

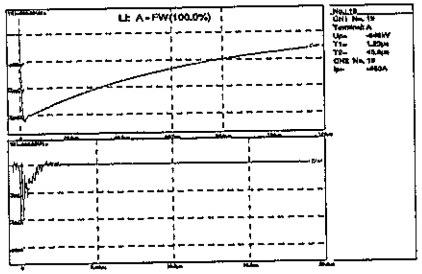

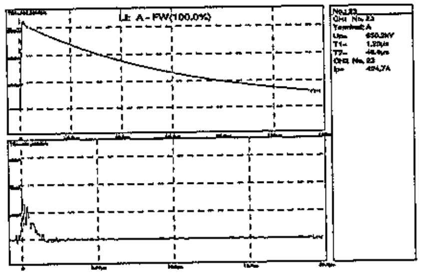

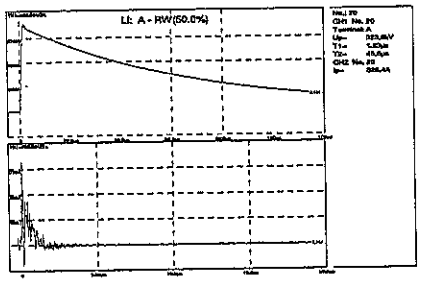

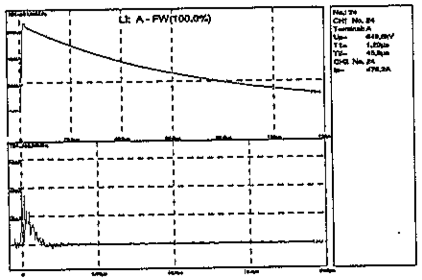

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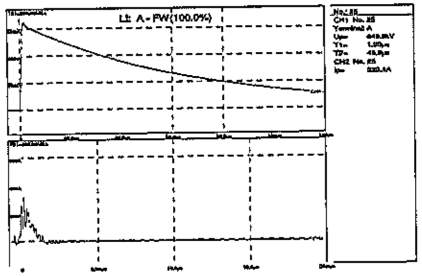

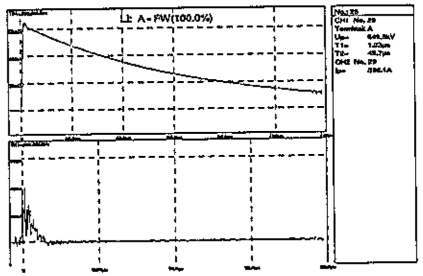

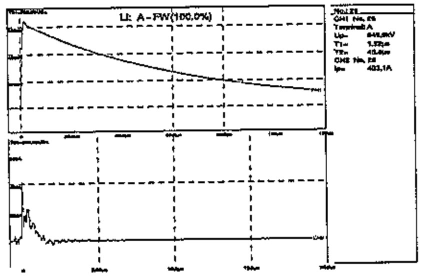

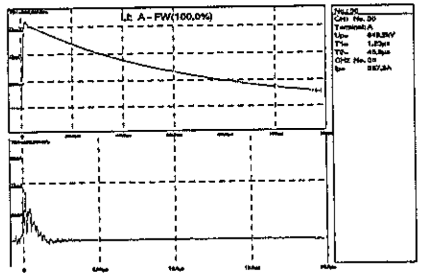

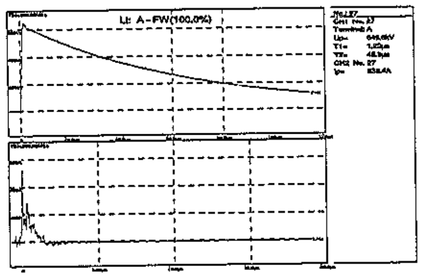

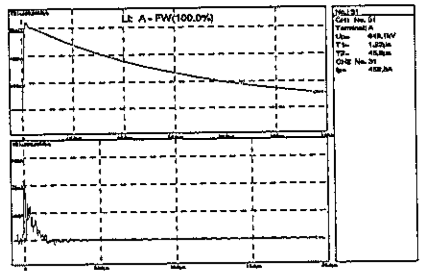

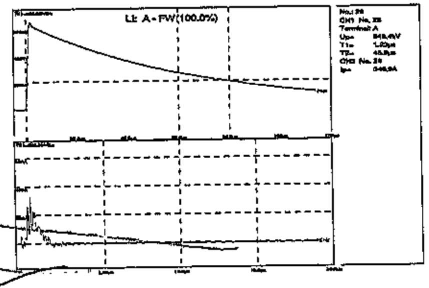

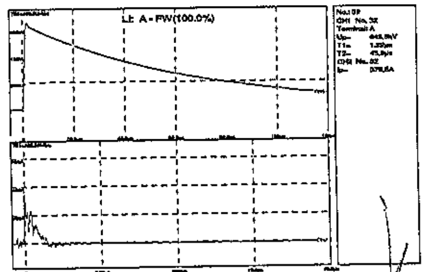

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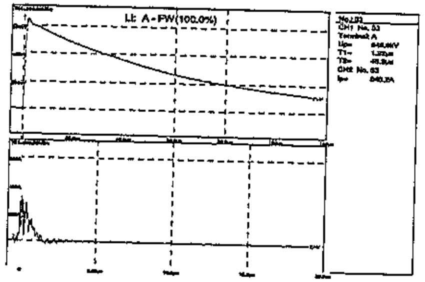
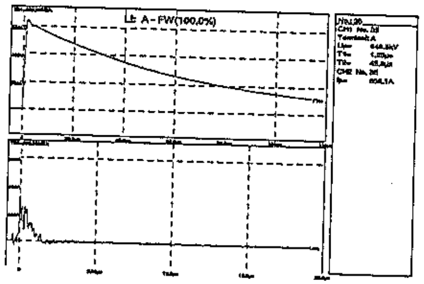
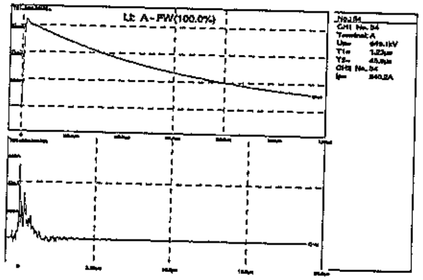
fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

project : ewn45e16







LABORATORIUM WYSOKICH NAPIĘĆ

INSTYTUT ENERGETYKI

LABORATORIUM AKREDYTOWANE
PRZY POLSKIM CENTRUM AKREDYTACJI

Certyfikat Akredytacji Laboratorium Badawczego
Nr AB 272

AB 272

SPRAWOZDANIE Z BADAŃ

Nr. EWN/45/E/16

Próba napięciem udarowym piorunowym pełnym,
próba napiciem udarowym piorunowym uciętym
przekładnika napięciowego typu PV145a

Warszawa, maj 2016 r.

01-330 WARSZAWA, ul. Mory 8, tel. (+48 22) 3451242
tel. fax. (+48 22) 836-80-48, e-mail: ewn@ien.com.pl

SPRAWOZDANIE Z BADAŃ EWN/45/E/16

OBIEKT BADAŃ:	**Przekładnik napięciowy typu PV145a**
ZLECENIODAWCA:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
PRODUCENT:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
NR ZAMÓWIENIA:	**4500743552 (17.05.2016)**
RODZAJ BADAŃ:	– **Próba napięciem udarowym piorunowym pełnym** – **Próba napięciem udarowym piorunowym uciętym**
PROCEDURA BADAŃ:	**Zgodna z:** **PN-EN 61869-1:2009 (IEC 61869-1:2007)** **PN/EN 61869-3:2011 (IEC 61869-3:2011)**
DATA WYKONANIA BADAŃ:	**19.05.2016**
WYNIK BADAŃ:	**<u>Pozytywny</u> – szczegóły w dalszej części raportu**

PROWADZĄCY BADANIA:	**mgr inż. Michał Molas**	Podpis
	tech Adam Wielonek	Podpis
AUTORYZUJĄCY BADANIA:	**mgr inż. Jerzy Mikołajczyk**	Podpis
KIEROWNIK LABORATORIUM:	**prof. nadzw. dr hab. inż. J. L. Mikulski**	Podpis

Warszawa, maj 2016 r.

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SPIS TREŚCI

Sprawozdanie zawiera:

8 stron kolejno numerowanych;

2 rysunki;

1 fotografię;

3 numerowane tablice.

Do sprawozdania załączono:

Załącznik 1: Rysunek wymiarowy (1 strona)

Załącznik 2: Protokoły z prób wyrobu i pomiaru uchybów (8 stron)

Załącznik 3: Protokół z próby napięciem udarowym (7 stron)

1 KOMPETENCJE LABORATORIUM

Laboratorium Wysokich Napięć posiada akredytację Polskiego Centrum Badań i Akredytacji (Certyfikat Akredytacji Laboratorium Badawczego Nr AB 272) w zakresie badań:

Izolatorów i łańcuchów izolatorów	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
	– pomiary zakłóceń radioelektrycznych
Stacje rozdzielcze	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
	– pomiary zakłóceń radioelektrycznych
Wyłączniki, rozłączniki	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
	– pomiary zakłóceń radioelektrycznych
Odłączniki	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
	– pomiary zakłóceń radioelektrycznych
Przekładniki prądowe i napięciowe	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
	– pomiary zakłóceń radioelektrycznych
Transformatory	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
Odgromniki i ograniczniki przepięć	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
Kable i osprzęt kablowy	– próby napięciem udarowym: piorunowym i łączeniowym
	– próby napięciem przemiennym 50 Hz
Osprzęt linii napowietrznych i stacji	– pomiary zakłóceń radioelektrycznych
Sprzęt BHP	– próby napięciem przemiennym 50 Hz

Pełny zakres akredytacji Laboratorium Wysokich Napięć dostępny na www.pca.gov.pl

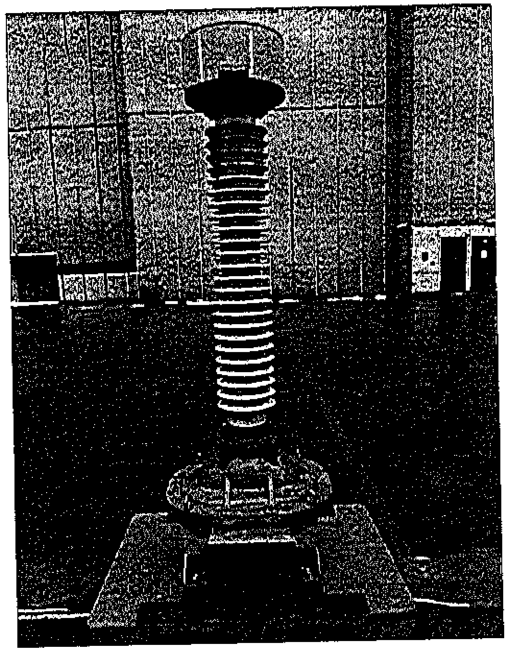
2 Opis obiektów badań

Obiektem badań był przekładnik napięciowy PV145a wyprodukowany przez ABB sp. z o.o. 04-713 Warszawa, Żegańska . (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59), o następujących parametrach technicznych:

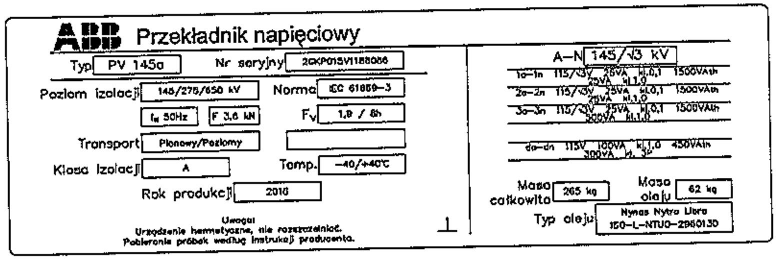
Typ – PV145a

Numer seryjny: 2GKP015V1188086

Najwyższe napięcie pracy urządzenia	145 kV
Znamionowe napięcie pierwotne	145000 / √3 V
Znamionowe napięcie wtórne	115/√3 V (1a-1n, 2a-2n, 3a-3n) ; 115 V (da-dn)
Poziom izolacji	275 / 650 kV
Częstotliwość	50 Hz
Zakres temperatury	-40 – +40 °C
Masa całkowita	265 kg



Fot. 1: Badany przekładnik napięciowy PV145a – widok ogólny



Rys. 1: Badany przekładnik napięciowy PV145a – tabliczka znamionowa

3 Uzgodniony zakres badań

Zakres badań dla przekładnika napięciowe PV145a został określony przez Zleceniodawcę. Tab. 1. Zawiera listę przeprowadzonych badań oraz wymagania, jakie badany przekładnik powinien spełniać.

Tab. 1: Plan badań dla przekładnika napięciowego

Punkt	Przeprowadzone badanie	Wymagania
1	Próba napięciem udarowym piorunowym pełnym	PN-EN/IEC 61869-1, p.7.2.3
2	Próba napięciem udarowym piorunowym uciętym	PN-EN/IEC 61869-1, p.7.4.1

Pomiar uchybów przekładnika wykonywany w celu potwierdzenia wyników kolejnych prób został przeprowadzony na terenie Laboratorium Fabrycznego ABB SP. z o.o.. Szczegółowe wyniki są przedstawione w Załączniku 2.

Badania zostały przeprowadzone zgodnie z:

- IEC 61869-1:2007 „Instrument transformers - Part 1: General requirements" (tożsame z: PN-EN 61869-1:2009 "Przekładniki – Część 1: Wymagania ogólne")
- IEC 61869-3:2011 „Instrument transformers - Part 3: Additional requirements for inductive voltage transformers" (tożsame z: PN-EN 61869-3:2011 "Przekładniki – Część 3: Wymagania szczegółowe dotyczące przekładników napięciowych indukcyjnych")

3.1 Próba napięciem udarowym piorunowym pełnym i uciętym

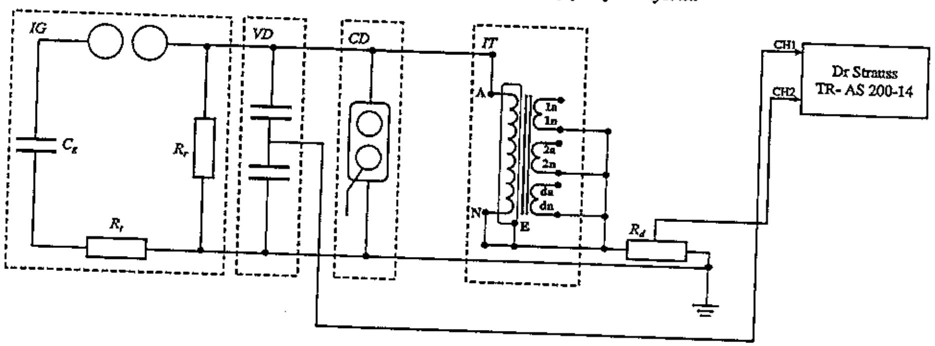
3.1.1 Metoda badania i kryteria oceny wyników

Zgodnie z IEC 61869-1 pkt. 7.4.1 próba napięciem udarowym piorunowym pełnym (dla biegunowości ujemnej) może być połączona z próbą napięciem udarowym uciętym. Dla biegunowości dodatniej próba udarowa została przeprowadzona zgodnie z IEC 61869-1 pkt. 7.2.3 (metoda 15 udarów).

Uznaje się, że wynik badań przekładnika napięciowego jest pozytywny, jeżeli analiza przebiegów zarejestrowanych w trakcie próby nie wskazuje na uszkodzenie izolacji wewnętrznej przekładnika.

3.1.2 Układ probierczo-pomiarowy

Układ probierczo-pomiarowy do prób napięciem udarowym piorunowym pełnym i uciętym składał się z generatora napięć udarowych pracującego w układzie Marxa, produkcji HAEFELY. Pomiar napięcia został przeprowadzony przy wykorzystaniu cyfrowego rejestratora napięć udarowych Dr Strauss TR-AS 200-14, współpracującego z pojemnościowym dzielnikiem napięć (niepewność pomiaru wartości szczytowej napięcia nie przekraczała 2% od wartości mierzonej, przy prawdopodobieństwie rozszerzenia 95% i współczynniku rozszerzenia k=2). Uproszczony schemat układu przedstawiony jest y na Rys. 2..



Rys. 2: Uproszczony schemat układu probierczo-pomiarowego (dla jednego stopnia generatora):
IG – generator udarowy; *VD* – dzielnik napięcia; C_g, R_t, R_r – elementy generator; *CD* – ucinacz napięcia;
IT – przekładnik napięciowy (uproszczony schemat); R_d – bocznik pomiarowy

3.1.3 Warunki próby

Warunki próby dla prób napięciem udarowym piorunowym pełnym i uciętym (parametry układu probierczo-pomiarowego, wartości napięć probierczych oraz sposób podawania napięcia) są przedstawione w Tab. 2 i Tab. 3. Wpływ warunków atmosferycznych na wartość napięcia probierczego nie był brany pod uwagę.

Tab. 2: Parametry układu probierczo-pomiarowego

GENERATOR NAPIĘCIA			
Ilość stopni	n	-	6
Pojemność główna	C_g	µF	0,125
Rezystancja rozładowcza	R_r	Ω	534
Rezystancja tłumiąca	R_t	Ω	157
DZIELNIK NAPIĘCIA			
Pojemność WN	C_v'	pF	~1200
Pojemność nn	C_v''	µF	1,103
Przekładania	ϑ_V	-	927,0
BOCZNIK POMIAROWY			
Bocznik pomiarowy	R_d	Ω	0,707

Tab. 3: Wartości napięć probierczych oraz sposób podawania napięcia

Próba napięciem udarowym pełnym	RW = 325 kV FW = 650 kV	
Próba napięciem udarowym uciętym	CRW = 373,7 kV CFW = 747,5 kV	
Sposób podawania napięcia	Biegunowość dodatnia: 1 udar pełny obniżony (RW), 15 udarów pełnych probierczych (FW).	Biegunowość ujemna: 1 udar pełny obniżony (RW), 1 udar pełny probierczy (FW), 1 udar ucięty obniżony (CRW), 2 udary ucięte probiercze (CFW), 14 udarów pełnych probierczych (FW).
Rejestracja	Przebieg napięcia probierczego (kanał 1) Przebieg prądu płynącego przez przekładnik (kanał 2)	

3.1.4 Wynik badań

Oscylogramy zarejestrowane w trakcie badań nie wskazują na wystąpienie uszkodzeń izolacji wewnętrznej przekładnika (Załącznik 3). Porównanie raportów z pomiarów uchybów wykonanych przed i po próbach udarowych nie wykazało żadnych znaczących zmian we własnościach metrologicznych przekładnika (Załącznik 2).

WYNIK BADAŃ: POZYTYWNY

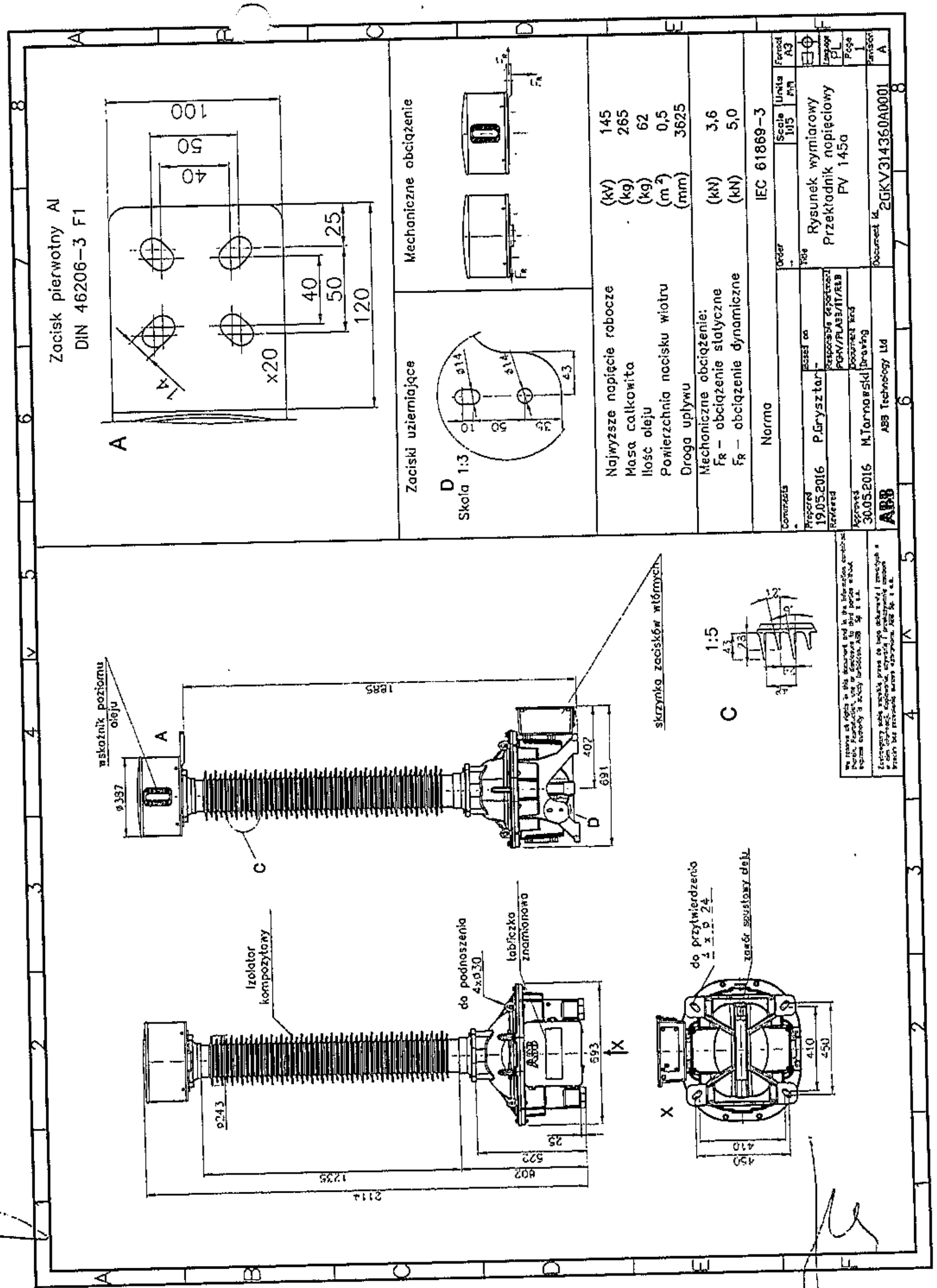
IEN	**HIGH VOLTAGE LABORATORY** **INSTYTUT ENERGETYKI** 01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242 tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl	EWN/45/E/16 Załącznik 1

Załącznik 1 do raportu EWN/45/E/16

(1 strona)

Rysunek wymiarowy:

- ID: 2GKV314360A0001



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HIGH VOLTAGE LABORATORY
INSTYTUT ENERGETYKI
01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242
tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl

Załącznik 2 do raportu EWN/45/E/16

(8 stron)

Protokoły z prób wyrobu i pomiaru uchybów:

- Protokół sprawdzenia Przekładnika Napięciowego – przed badaniem udarem piorunowym
- Protokół sprawdzenia Przekładnika Napięciowego – po badaniu udarem piorunowym

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59	**Protokół sprawdzania Przekładnika Napięciowego-przed badaniem udarem piorunowym**		**TYP:** PV 145a **Nr fabr.:** 2GKP015V1188086	
A-N 145:√3 kV	Poziom izolacji: 145/275/650 kV	Wsp.napięciowy: 1.9/8h	IEC 61869-3	50 Hz

Parametry 1				
Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1500
2a - 2n	0,115:√3	25	0,1	1500
3a - 3n	0,115:√3	25	0,1	1500
da - dn	0,115	100	1,0	450

Parametry 2				
Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a - 1n	0,115:√3	25	1,0	1500
2a - 2n	0,115:√3	25	1,0	1500
3a - 3n	0,115:√3	500	1,0	1500
da - dn	0,115	300	3P	450

Lista przeprowadzonych badań

1. Sprawdzenie oznaczeń wyprowadzeń ☑
2. Próba izolacji uzwojeń pierwotnych napięciem o częstotliwości sieciowej - A: Up = 275kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
3. Pomiar wyładowań niezupełnych ☑
4. Próba izolacji uzwojeń wtórnych napięciem o częstotliwości sieciowej - Up = 3 kV/60s ☑
5. Sprawdzenie dokładności ☑
6. Pomiar pojemności i współczynnika strat dielektrycznych (tg δ) przekładnika ☑
7. Pomiar rezystancji uzwojeń ☑
8. Tabliczka znamionowa ☑

Pomiar wyładowań niezupełnych

- Pomiar wykonano wg procedury A
  (napięcia probiercze osiągnięto podczas obniżania napięcia po próbie izolacji uzwojenia pierwotnego)
  Napięcie stresu: 275 kV / 60 s
  Częstotliwość: 120 Hz

Napięcie probiercze	1,2 Um = 174 kV	1,2 Um /√3 = 100.5 kV
Poziom wyładowań niezupełnych	0.6 pC	0.6 pC

- Napięcie zapłonu WNZ: 230 kV
- Napięcie wygaszenia WNZ: 225 kV

Uwagi: Poziom zakłóceń: 0.5 pC (odczyt po wyłączeniu napięcia), Ładunek kalibrujący: 5.1 pC

Sprawdzenie dokładności (ε U%), (Δφ U min) – parametry 1

Data pomiaru: 2016-05-17
Temperatura otoczenia: 31 +/- 2°C
Wilgotność względna powietrza: 40 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.056	-0.054	-0.054
Δφ U	0.7	0.7	0.7

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 25VA; 3a-3n: 25VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.020	-0.018	-0.018
Δφ U	0.5	0.6	0.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.057	-0.056	-0.055
Δφ U	0.5	0.5	0.5

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 25VA; 3a-3n: 25VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.023	-0.022	-0.021
Δφ U	0.5	0.5	0.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.060	-0.059	-0.058
Δφ U	0.2	0.2	0.2

3a-3n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 25VA; 2a-2n: 25VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.032	-0.030	-0.030
Δφ U	0.4	0.4	0.4

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.128	-0.064	0.010	0.003
Δφ U	-1.1	-0.7	0.0	0.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.015	-0.014	-0.013
Δφ U	1.7	1.8	1.8

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.021	0.022	0.023
Δφ U	1.6	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.016	-0.014	-0.014
Δφ U	1.6	1.6	1.6

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 0VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.018	0.020	0.020
Δφ U	1.6	1.6	1.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.019	-0.017	-0.017
Δφ U	1.3	1.3	1.4

3a-3n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.010	0.011	0.012
Δφ U	1.5	1.5	1.5

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.092	0.158	0.233	0.228
Δφ U	0.7	1.0	1.6	1.7

Niepewność pomiarów części napięciowej: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Sprawdzenie dokładności (ε U%), (Δφ U min) – parametry 2

Data pomiaru: 2016-05-17
Temperatura otoczenia: 31 +/- 2°C
Wilgotność względna powietrza: 40 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.434	-0.432	-0.432
Δφ U	-9.7	-9.7	-9.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.015	-0.014	-0.013
Δφ U	1.7	1.8	1.8

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 25VA; 3a-3n: 500VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.398	-0.398	-0.396
Δφ U	-9.8	-9.8	-9.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.450	-0.450	-0.448
Δφ U	-10.6	-10.6	-10.5

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 25VA; 3a-3n: 500VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.417	-0.415	-0.414
Δφ U	-10.6	-10.6	-10.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.932	-0.930	-0.931
Δφ U	0.5	0.6	0.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.212	-0.210	-0.210
Δφ U	-0.7	-0.7	-0.7

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.911	-0.844	-0.770	-0.775
Δφ U	-14.2	-13.8	-13.1	-13.0

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.021	0.022	0.023
Δφ U	1.6	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.016	-0.014	-0.013
Δφ U	1.6	1.6	1.6

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.019	0.020	0.021
Δφ U	1.6	1.6	1.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.893	-0.892	-0.890
Δφ U	1.6	1.7	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.171	-0.170	-0.169
Δφ U	0.4	0.5	0.5

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.006	0.068	0.141	0.138
Δφ U	0.5	0.8	1.3	1.4

Pomiar współczynnika stratności dielektrycznej (tg δ) oraz pojemności
Temperatura: 26 °C, Częstotliwość: 50 Hz

Napięcie pierwotne	Przekładnik		
	Tg δ [%]	Pojemność [pF]	Prąd upływu [mA]
10 kV	0.21	241	0.839
63 kV	0.21	241	5.759
71 kV	0.21	241	6.422

Pomiar rezystancji uzwojeń:

	R (28 °C)	Rct (20 °C)	Rct (75 °C)
A-N	18.50 kΩ	17.918 kΩ	21.917 kΩ
1a-1n	53.7 mΩ	52.012 mΩ	63.619 mΩ
2a-2n	52 mΩ	50.365 mΩ	61.605 mΩ
3a-3n	33.8 mΩ	32.737 mΩ	40.043 mΩ
da-dn	147.6 mΩ	142.959 mΩ	174.863 mΩ

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Tabliczka znamionowa

ABB Przekładnik napięciowy

Typ PV 145a | Nr seryjny 2GKP015V1188085

Poziom Izolacji 145/275/650 kV | Norma IEC 61869-3

f_R 50Hz | F 3,6 kN | F_V 1,9 / 8h

Transport Pionowy/Poziomy

Klasa izolacji A | Temp. -40/+40°C

Rok produkcji 2016

Uwaga: Urządzenie hermetyczne, nie rozszczelniać. Pobieranie próbek według instrukcji producenta.

A–N 145/√3 kV

1a–1n 115/√3V 25VA kl.0,1 25VA kl.1,0 1500VAth

2a–2n 115/√3V 25VA kl.0,1 25VA kl.1,0 1500VAth

3a–3n 115/√3V 25VA kl.0,1 500VA kl.1,0 1500VAth

da–dn 115V 100VA kl.1,0 300VA kl. 3P 450VAth

Masa całkowita 265 kg | Masa oleju 52 kg

Typ oleju Nynas Nytro Libra ISO-L-NTUO-2960130

Sprawdził: .... (OG-4 KJ-06)

Przasnysz, dn. 2016-05-17

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Protokół sprawdzania Przekładnika Napięciowego-po badaniu udarem piorunowym	TYP: PV 145a Nr fabr.: 2GKP015V1188086	
A-N 145:√3 kV	Poziom izolacji: 145/275/650 kV	Wsp.napięciowy: 1.9/8h	IEC 61869-3	50 Hz

Parametry 1				
Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1500
2a - 2n	0,115:√3	25	0,1	1500
3a - 3n	0,115:√3	25	0,1	1500
da - dn	0,115	100	1,0	450
Parametry 2				
Uzwojenie	Usn [kV]	Sn [VA]	klasa	Sth [VA]
1a - 1n	0,115:√3	25	1,0	1500
2a - 2n	0,115:√3	25	1,0	1500
3a - 3n	0,115:√3	500	1,0	1500
da - dn	0,115	300	3P	450

Lista przeprowadzonych badań

1. Próba izolacji uzwojeń pierwotnych napięciem o częstotliwości sieciowej - A: Up = 220kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
2. Pomiar wyładowań niezupełnych ☑
3. Próba izolacji uzwojeń wtórnych napięciem o częstotliwości sieciowej - Up = 3 kV/60s ☑
4. Sprawdzenie dokładności ☑
5. Pomiar pojemności i współczynnika strat dielektrycznych (tg δ) przekładnika ☑
6. Pomiar rezystancji uzwojeń ☑
7. Tabliczka znamionowa ☑

Pomiar wyładowań niezupełnych

- Pomiar wykonano wg procedury A
  (napięcia probiercze osiągnięto podczas obniżania napięcia po próbie izolacji uzwojenia pierwotnego)
  Napięcie stresu: 220 kV / 60 s
  Częstotliwość: 120 Hz

Napięcie probiercze	1,2 Um = 174 kV	1,2 Um /√3 = 100.5 kV
Poziom wyładowań niezupełnych	1 pC	0.6 pC

- Napięcie zapłonu WNZ: >220 kV
- Napięcie wygaszenia WNZ: >220 kV

Uwagi: Poziom zakłóceń: 0.6 pC (odczyt po wyłączeniu napięcia), Ładunek kalibrujący: 5.1 pC

Sprawdzenie dokładności (ε U%), (Δφ U min) – parametry 1

Data pomiaru: 2016-05-30
Temperatura otoczenia: 31 +/- 2°C
Wilgotność względna powietrza: 40 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.058	-0.056	-0.055
Δφ U	0.7	0.7	0.7

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 25VA; 3a-3n: 25VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.022	-0.020	-0.019
Δφ U	0.6	0.6	0.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.064	-0.062	-0.062
Δφ U	0.5	0.5	0.6

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 25VA; 3a-3n: 25VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.030	-0.028	-0.027
Δφ U	0.5	0.5	0.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.063	-0.061	-0.061
Δφ U	0.2	0.3	0.3

3a-3n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 25VA; 2a-2n: 25VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.033	-0.032	-0.031
Δφ U	0.4	0.4	0.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.015
Δφ U	1.8	1.8	1.8

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.019	0.020	0.021
Δφ U	1.7	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.023	-0.021	-0.021
Δφ U	1.6	1.7	1.7

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.012	0.013	0.014
Δφ U	1.6	1.6	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.022	-0.020	-0.019
Δφ U	1.4	1.4	1.4

3a-3n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.007	0.009	0.010
Δφ U	1.5	1.6	1.6

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.116	-0.053	0.023	0.020
Δφ U	-1.4	-1.0	-0.4	-0.2

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.095	0.162	0.237	0.233
Δφ U	0.6	1.0	1.6	1.7

Niepewność pomiarów części napięciowej: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Sprawdzenie dokładności (ε U%), (Δφ U min) – parametry 2

Data pomiaru:	2016-05-30
Temperatura otoczenia:	31 +/- 2°C
Wilgotność względna powietrza:	40 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.433	-0.431	-0.431
Δφ U	-9.6	-9.6	-9.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.015	-0.014
Δφ U	1.8	1.8	1.8

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 25VA; 3a-3n: 500VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.399	-0.398	-0.396
Δφ U	-9.7	-9.6	-9.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.452	-0.451	-0.449
Δφ U	-10.4	-10.4	-10.4

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 25VA; 3a-3n: 500VA cos fi = 0,8 ind.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.418	-0.415	-0.415
Δφ U	-10.5	-10.4	-10.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.944	-0.943	-0.945
Δφ U	0.7	0.7	0.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.256	-0.254	-0.253
Δφ U	0.6	0.6	0.6

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.943	-0.877	-0.807	-0.809
Δφ U	-13.6	-13.2	-12.1	-12.2

1a-1n: 6.25 VA cos fi = 0,8 ind.
2a-2n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.018	0.020	0.021
Δφ U	1.7	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.024	-0.022	-0.021
Δφ U	1.7	1.7	1.7

2a-2n: 6.25 VA cos fi = 0,8 ind.
1a-1n: 0 VA; 3a-3n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.011	0.013	0.013
Δφ U	1.6	1.6	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.910	-0.910	-0.910
Δφ U	1.8	1.8	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.178	-0.176	-0.175
Δφ U	0.5	0.5	0.6

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.007	0.059	0.134	0.131
Δφ U	0.6	1.0	1.5	1.6

Niepewność pomiarów części napięciowej: $U_{\varepsilon 95} = \pm 0{,}015$ %, $U_{\Delta\varphi 95} = \pm 1{,}5$ min

Pomiar współczynnika stratności dielektrycznej (tg δ) oraz pojemności
Temperatura: 26 °C, Częstotliwość: 50 Hz

Napięcie pierwotne	Przekładnik		
	Tg δ	Pojemność	Prąd upływu
	[%]	[pF]	[mA]
10 kV	0.2	239	0.835
63 kV	0.2	239	6.316
71 kV	0.2	239	6.868

Pomiar rezystancji uzwojeń:

	R (28 °C)	Rct (20 °C)	Rct (75 °C)
A-N	18.50 kΩ	17.918 kΩ	21.917 kΩ
1a-1n	53.7 mΩ	52.012 mΩ	63.619 mΩ
2a-2n	52 mΩ	50.365 mΩ	61.605 mΩ
3a-3n	33.8 mΩ	32.737 mΩ	40.043 mΩ
da-dn	147.6 mΩ	142.959 mΩ	174.863 mΩ

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Tabliczka znamionowa

ABB Przekładnik napięciowy

Typ	PV 145a
Nr seryjny	2GKP015V1188086
Poziom izolacji	145/275/650 kV
Norma	IEC 61869-3
	fN 50Hz; F 3,6 kN
FV	1,9 / 8h
Transport	Pionowy/Poziomy
Klasa izolacji	A
Temp.	-40/+40°C
Rok produkcji	2016

A–N 145/√3 kV

1a–1n 115/√3V 25VA kl.0,1 1500VAth; 25VA kl.3,0
2a–2n 115/√3V 25VA kl.0,1 1500VAth; 25VA kl.1,0
3a–3n 115/√3V 25VA kl.0,1 1500VAth; 200VA kl.1,0
da–dn 115V 100VA kl.1,0 450VAth; 200VA kl. 3P

Masa całkowita: 285 kg; Masa oleju: 62 kg

Typ oleju: Nynas Nytro Libra ISO-...-NTJO-2960130

Uwaga: Urządzenie hermetyczne, nie rozszczelniać. Pobieranie próbek według instrukcji producenta.

Sprawdził: .... [podpis] (OG-4 KJ-06)

Przasnysz, dn. 2016-05-30

HIGH VOLTAGE LABORATORY
INSTYTUT ENERGETYKI
01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242
tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl

Załącznik 3 do raportu EWN/45/E/16

(7 stron)

Protokół z próby napięciem udarowym:

- ewn45e16

HIGH VOLTAGE LABORATORY

POLAND 01-330 WARSZAWA, ul. Mory 8
fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

project : ewn45e16 test date 19-05-2016

Test - object - data

WNR ewn45e16 TR-No. 2GKP0115V1188086 O.-No. 4500743552

test object PV145a vector group -
output - kVA BIL 650
voltage 145 kV frequency 50 Hz

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

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
1	-325.3	1.22	45.4		-363.6	LI: A - RW(50.0%)
2	-648.1	1.23	45.8		-453	LI: A - FW(100.0%)
3	-375	1.22		3.48	-625.2	LI: A - CRW(57.5%)
4	-744.8	1.24		3.44	-1122	LI: A - CFW(115.0%)
5	-745.3	1.24		3.4	-1123	LI: A - CFW(115.0%)
6	-647.7	1.23	45.7		-537.8	LI: A - FW(100.0%)
7	-648	1.23	45.8		-361.4	LI: A - FW(100.0%)
8	-648.2	1.23	45.8		-393.7	LI: A - FW(100.0%)
9	-648.3	1.23	45.8		-412.2	LI: A - FW(100.0%)
10	-648	1.23	45.8		-493.4	LI: A - FW(100.0%)
11	-646.9	1.24	45.9		-465.1	LI: A - FW(100.0%)
12	-648	1.23	45.9		-531.1	LI: A - FW(100.0%)
13	-648.3	1.23	45.8		-498.6	LI: A - FW(100.0%)
14	-648.2	1.23	45.9		-305.8	LI: A - FW(100.0%)
15	-648.2	1.23	45.9		-346.5	LI: A - FW(100.0%)
16	-648.7	1.23	45.8		-394.9	LI: A - FW(100.0%)
17	-648.9	1.23	45.8		-353	LI: A - FW(100.0%)
18	-648.1	1.23	45.9		-481.3	LI: A - FW(100.0%)
19	-648	1.23	45.8		-460	LI: A - FW(100.0%)
20	323.8	1.23	45.5		326.4	LI: A - RW(50.0%)
21	649.9	1.23	45.9		425.5	LI: A - FW(100.0%)
22	650.2	1.23	45.8		364.9	LI: A - FW(100.0%)
23	650.2	1.23	45.6		424.7	LI: A - FW(100.0%)
24	649.5	1.23	45.9		476.2	LI: A - FW(100.0%)
25	649.9	1.23	45.9		323.1	LI: A - FW(100.0%)
26	649.9	1.22	45.8		433.1	LI: A - FW(100.0%)
27	649.6	1.23	45.9		538.4	LI: A - FW(100.0%)
28	649.4	1.23	45.9		349.9	LI: A - FW(100.0%)
29	649.3	1.23	45.7		396.1	LI: A - FW(100.0%)

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project : ewn45e16

30	649.2	1.23	45.9		367.3	LI: A - FW(100.0%)
31	649.1	1.22	45.9		459.3	LI: A - FW(100.0%)
32	649.6	1.22	45.9		376.5	LI: A - FW(100.0%)
33	648.6	1.22	45.9		343.2	LI: A - FW(100.0%)
34	649.1	1.23	45.9		540.2	LI: A - FW(100.0%)
35	648.8	1.23	45.8		336.1	LI: A - FW(100.0%)

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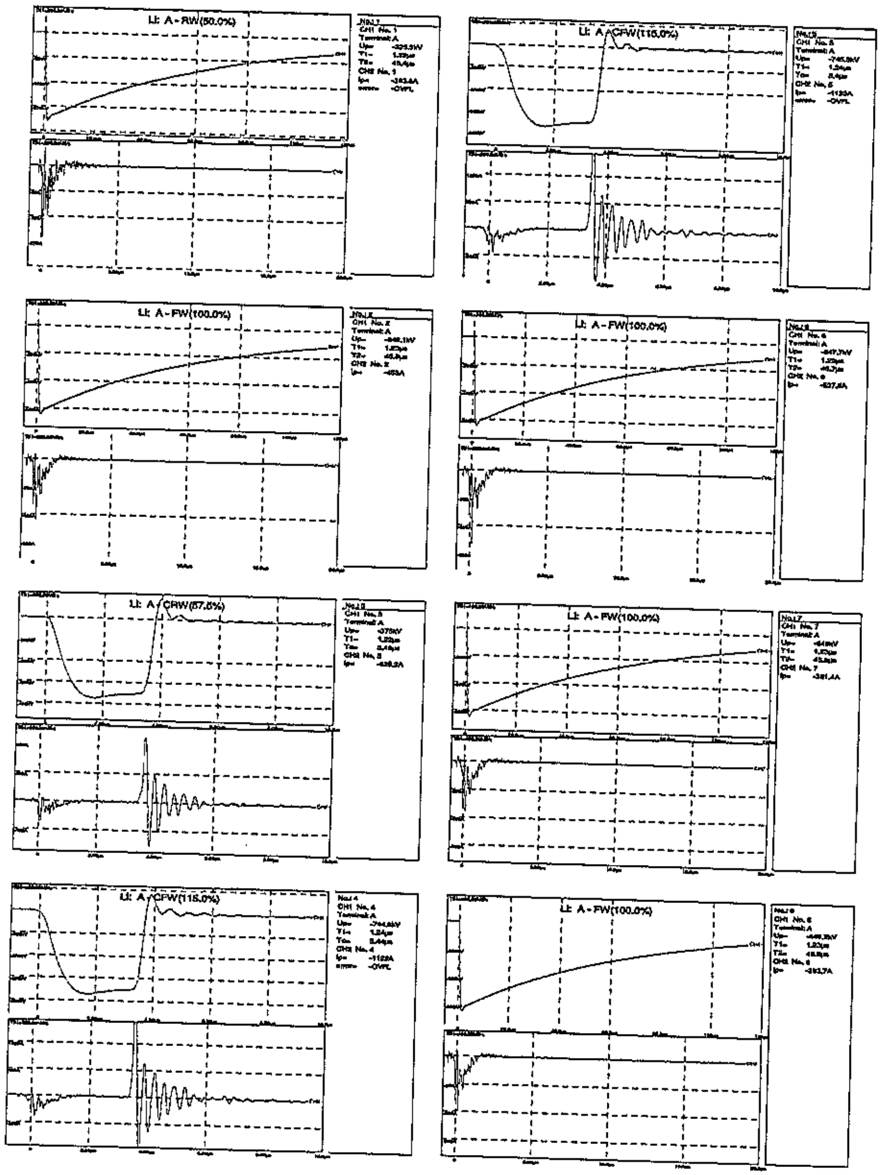

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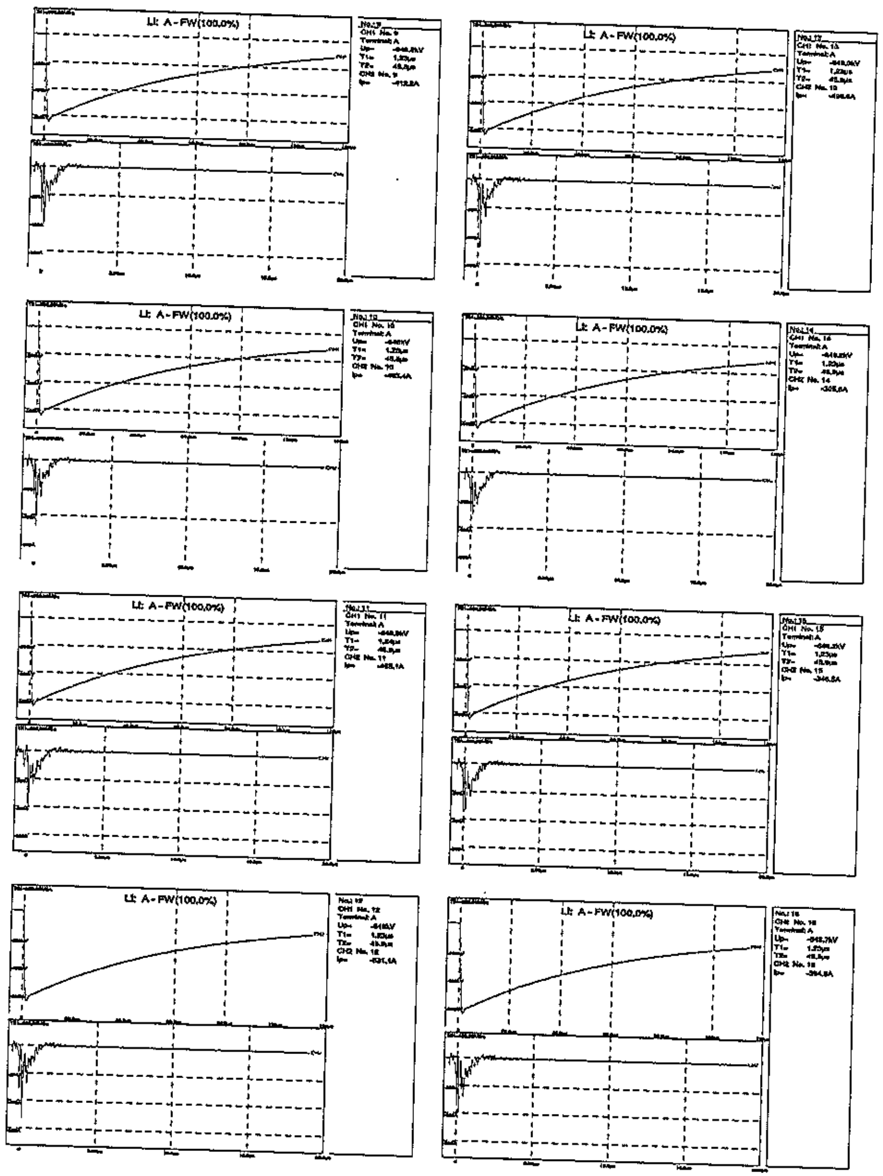

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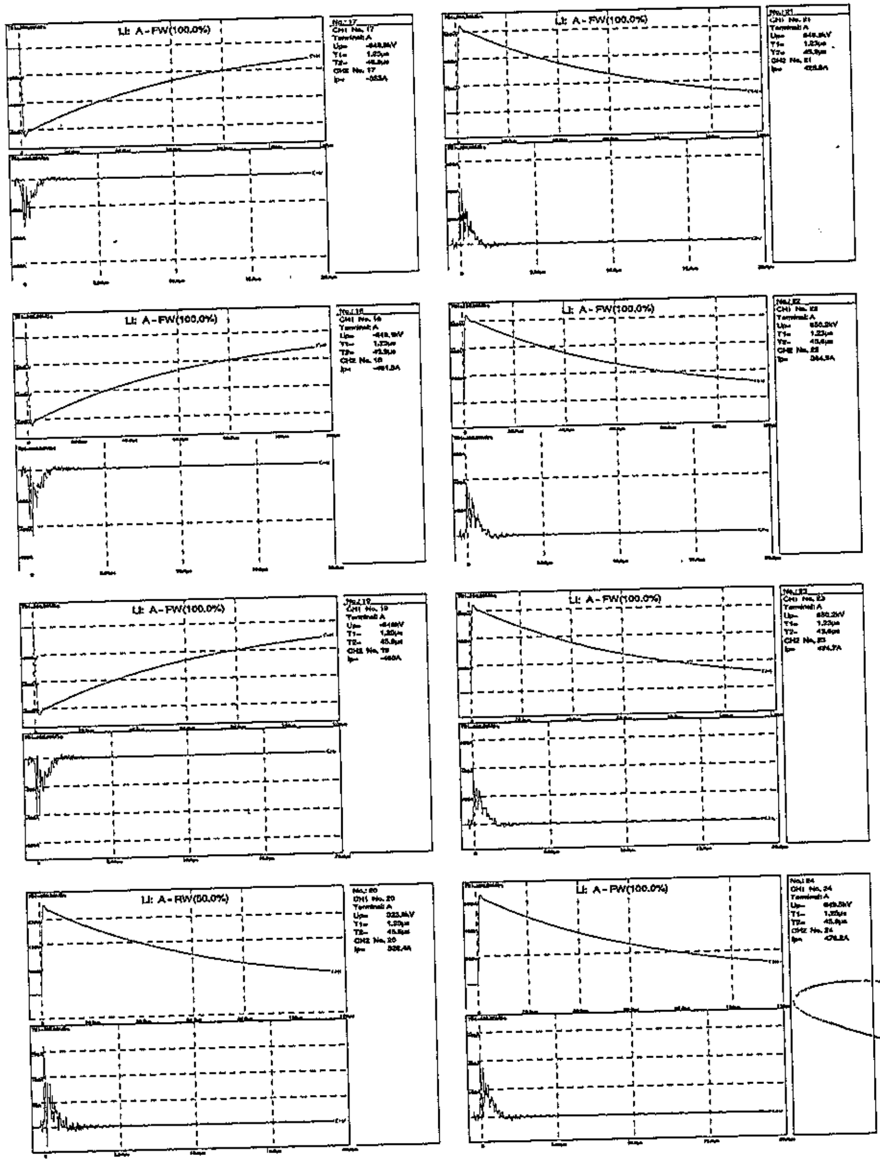

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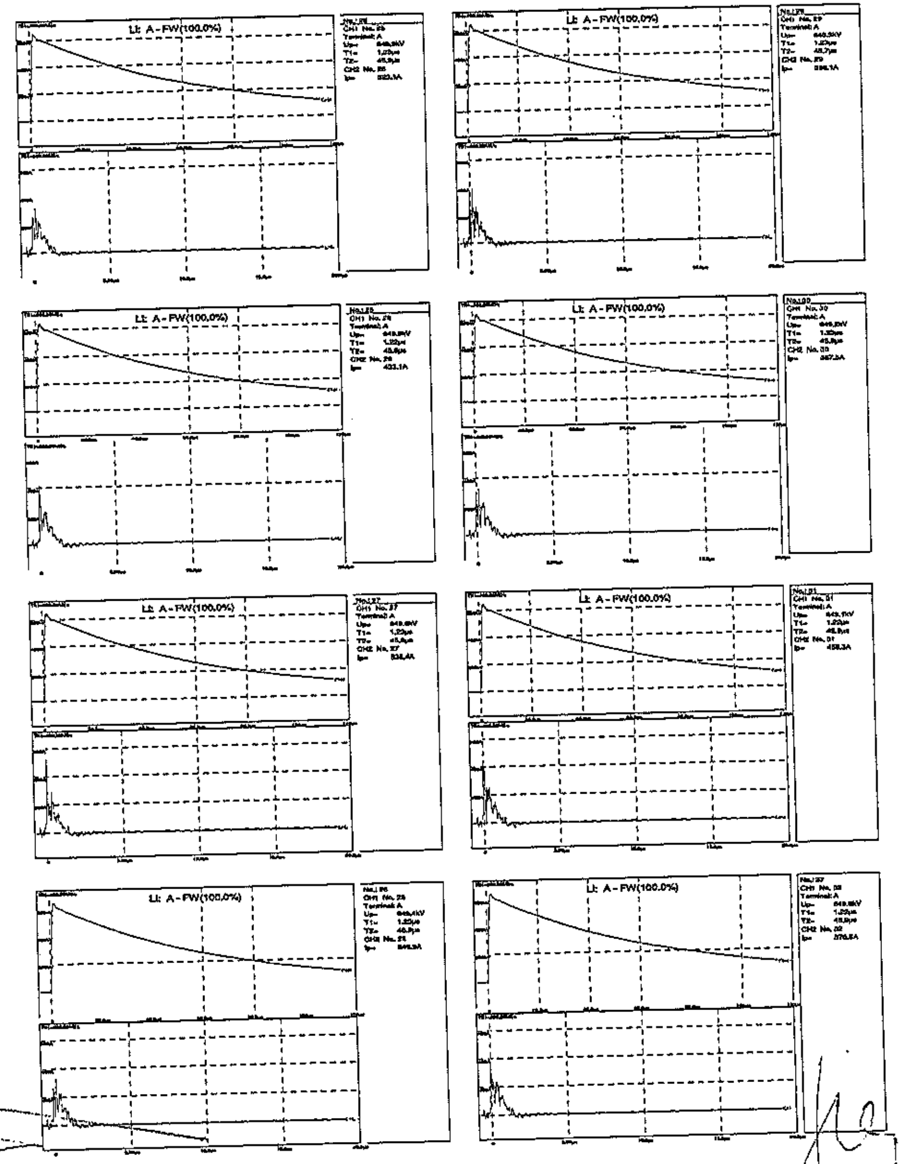

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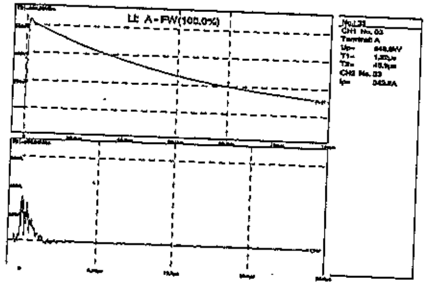

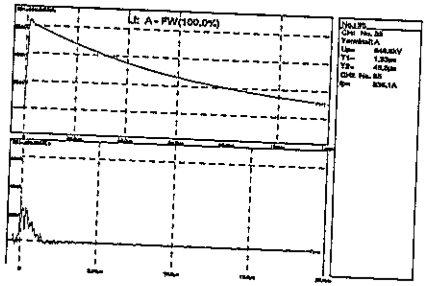

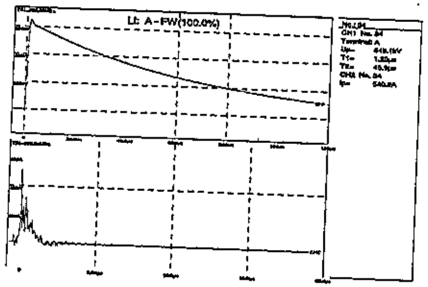

INSTYTUT ENERGETYKI
INSTITUTE OF POWER ENGINEERING
LABORATORIUM WIELKOPRĄDOWE
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TEST REPORT NO. EWP/40/E/2015

TEST OBJECT: Voltage transformers type EMF-E072 and EMF-E145

MANUFACTURER: ABB Sp. z o.o.
Ul. Leszno 59
06–300 Przasnysz, Poland

TESTS ORDERED BY: ABB Sp. z o.o.
Ul. Żegańska 1
04-713 Warszawa, Poland
Orders No. 4500660979 dated 08.07.2015 and No. 4500679239 dated 17.09.2015

TYPE OF TESTS: Mechanical impact test

TESTS PROCEDURE: IEC 61869-1:2007

OBJECT DELIVERED: 24.08.2015

DATE OF TESTS: 25.08.2015 – 02.10.2015

TESTS RESULTS: Positive

THE TESTS WERE WITNESSED BY:

Authorised by TEST ENGINEER:
Mariusz SUL M.Sc. Eng.
Mariusz Sul

Approved by HEAD OF LABORATORY:
Maciej OWSIŃSKI M.Sc. Eng.

Warsaw, 8.10.2015

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Contents	
1.	Description of the test object
2.	Technical data declared by the Manufacturer
3.	Technical documentation of the test object
4.	Scope of the tests
5.	Tests and their results
6.	Summary
7.	Opinions and interpretations
8.	Photographic documentation

Report contents 17 numbered pages with:
6 Photographs
6 Appendices

1. Description of the test object

Test object No.1	Voltage transformer
Type	EMF-E072
Serial number	2GKP015V1188091
Year of production	2015
Insulator	Porcelain insulator
Dimensions	According to drawing No. 2GKP015V1188091 (Appendix No. 1)

Test object No.2	Voltage transformer
Type	EMF-E072
Serial number	2GKP015V1188038
Year of production	2015
Insulator	Composite insulator
Dimensions	According to drawing No. 2GKP015V1188038 (Appendix No. 2)

Test object No.3	Voltage transformer
Type	EMF-E145
Serial number	1HSE8849700
Year of production	2015
Insulator	Composite insulator
Dimensions	According to drawing No. 1HSE8849700 (Appendix No. 3)

Test object No.4	Voltage transformer
Type	EMF-E145
Serial number	2GKP013K1486306
Year of production	2015
Insulator	Porcelain insulator
Dimensions	According to drawing No. 2GKP013K1486306 (Appendix No. 4)

Test object No.5	Voltage transformer
Type	EMF-E072
Serial number	2GKP015V1188093
Year of production	2015
Insulator	Porcelain insulator
Dimensions	According to drawing No. 2GKP015V1188093 (Appendix No. 5)

Test object No.6	Voltage transformer
Type	EMF-E072
Serial number	2GKP015V1188092
Year of production	2015
Insulator	Composite insulator
Dimensions	According to drawing No. 2GKP015V1188092 (Appendix No. 6)

The identification of the test objects was made by Laboratory basing on the documentation mentioned in sub-cl. 3 and appendices No. 1-6. The objects were prepared for tests by the Manufacturer.

2. Technical data declared by the Manufacturer

Protection against mechanical impact (IK code)	IK 07

3. Technical documentation of the test object

1. Voltage transformer EMF-E072. Prototype V - drawing No. 2GKP015V1188091.
2. Voltage transformer EMF-E072. Prototype IV - drawing No. 2GKP015V1188038.
3. Voltage transformer EMF-E145. Prototype VII - drawing No. 1HSE8849700.
4. Voltage transformer EMF-E145. Prototype VIII - drawing No. 2GKP013K1486306.
5. Voltage transformer EMF-E072. Prototype X - drawing No. 2GKP015V1188093.
6. Voltage transformer EMF-E072. Prototype IX - drawing No. 2GKP015V1188092.

4. Scope of the tests

Test program agreed with Orderer comprised of the following tests:

Kind of test	Standard
Mechanical impact test	IEC 61869-1:2007 sub-cl. 7.2.7.2

5. Tests and their results

		According to standard
5.1	**Mechanical impact test (IK code)**	IEC 61869-1:2007 sub-cl. 7.2.7.2

Mechanical impact tests were performed on six specimens of voltage transformers. Three shocks were applied to points of the enclosure that are likely to be the weakest points. The impact energy was equal 2J. Places such as connectors and displays were exempt from the test. After the tests enclosures did not have any breaks or deformation that may affect the normal operation of the voltage transformers. Specified degree of protection was fulfilled. The points of impact are shown on the photographs 1-6.

Test result: Positive for IK 07.

6. Summary

Tested voltage transformers meet the requirements of the following standards:

Kind of test	Standard	Test result
Mechanical impact test	IEC 61869-1:2007 sub-cl. 7.2.7.2	Positive

7. Opinions and interpretations

None

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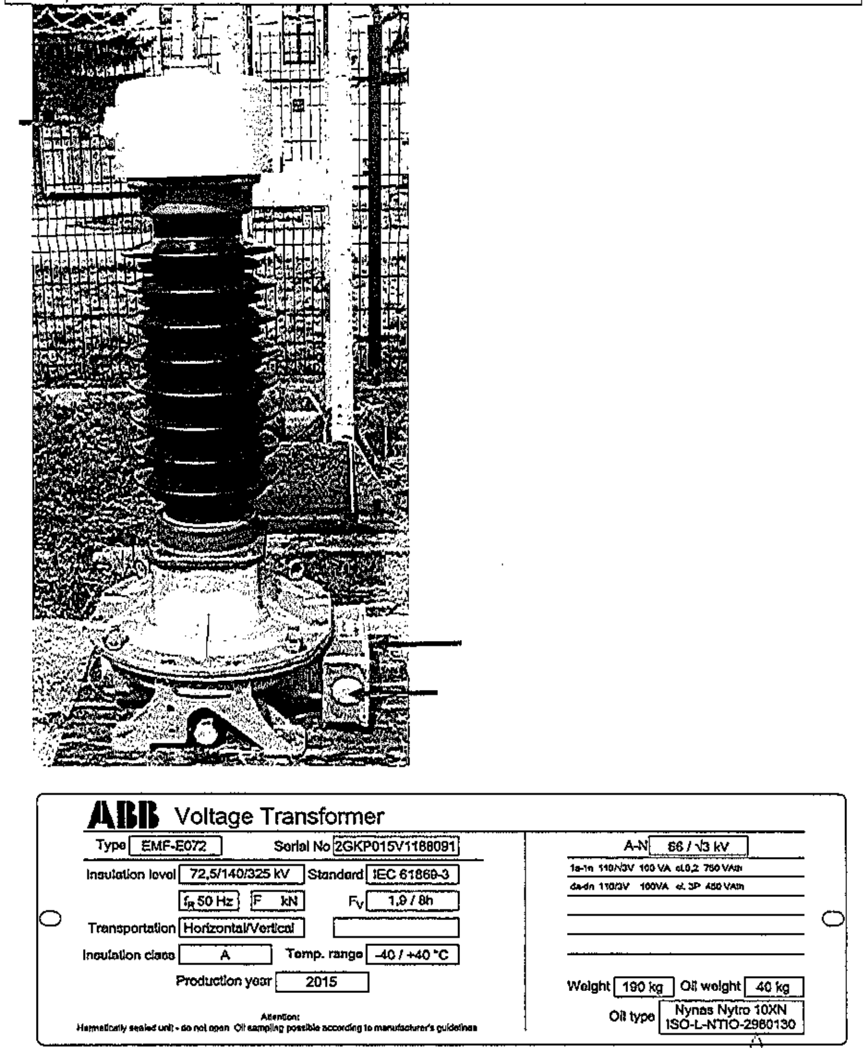
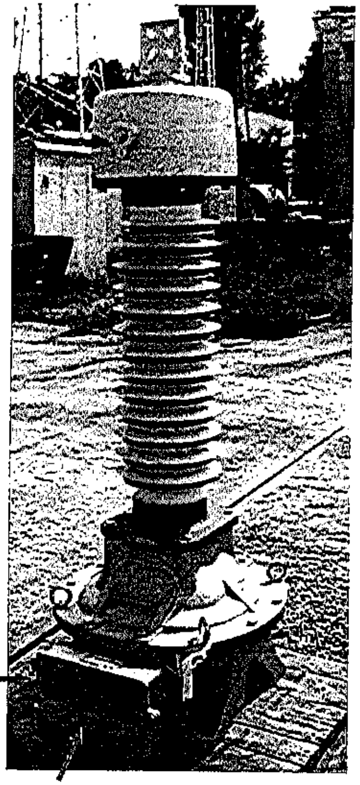
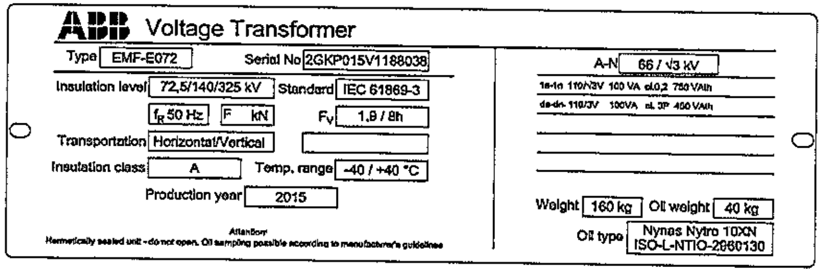
8. Photographic documentation

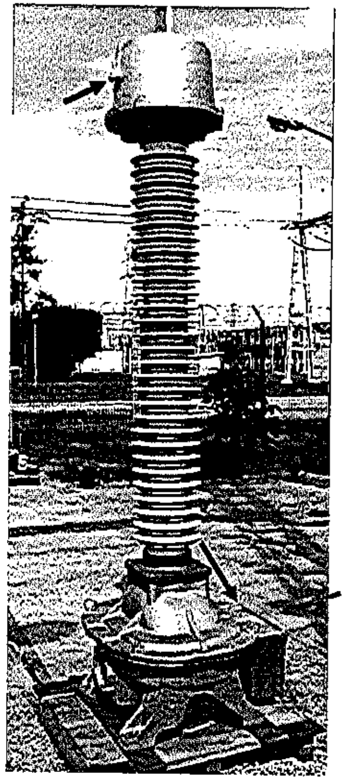


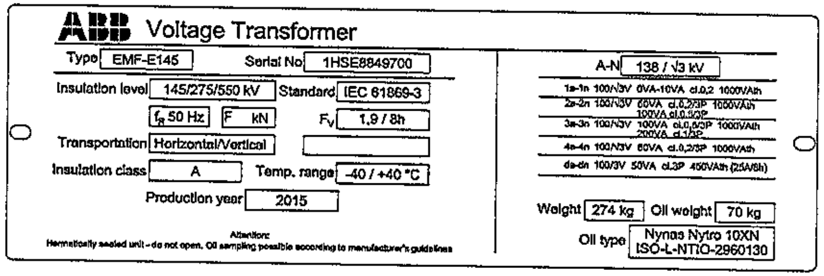
Photograph No. 1. Tested object No. 1



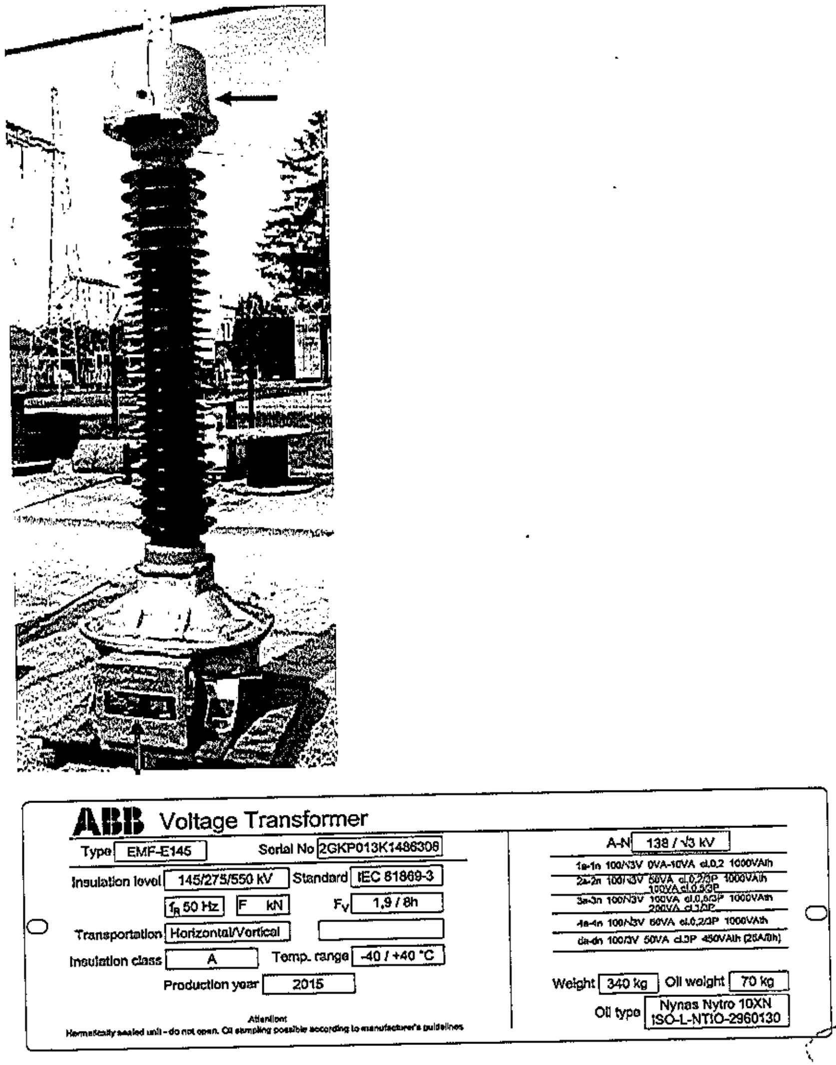


Photograph No 2. Tested object No. 2





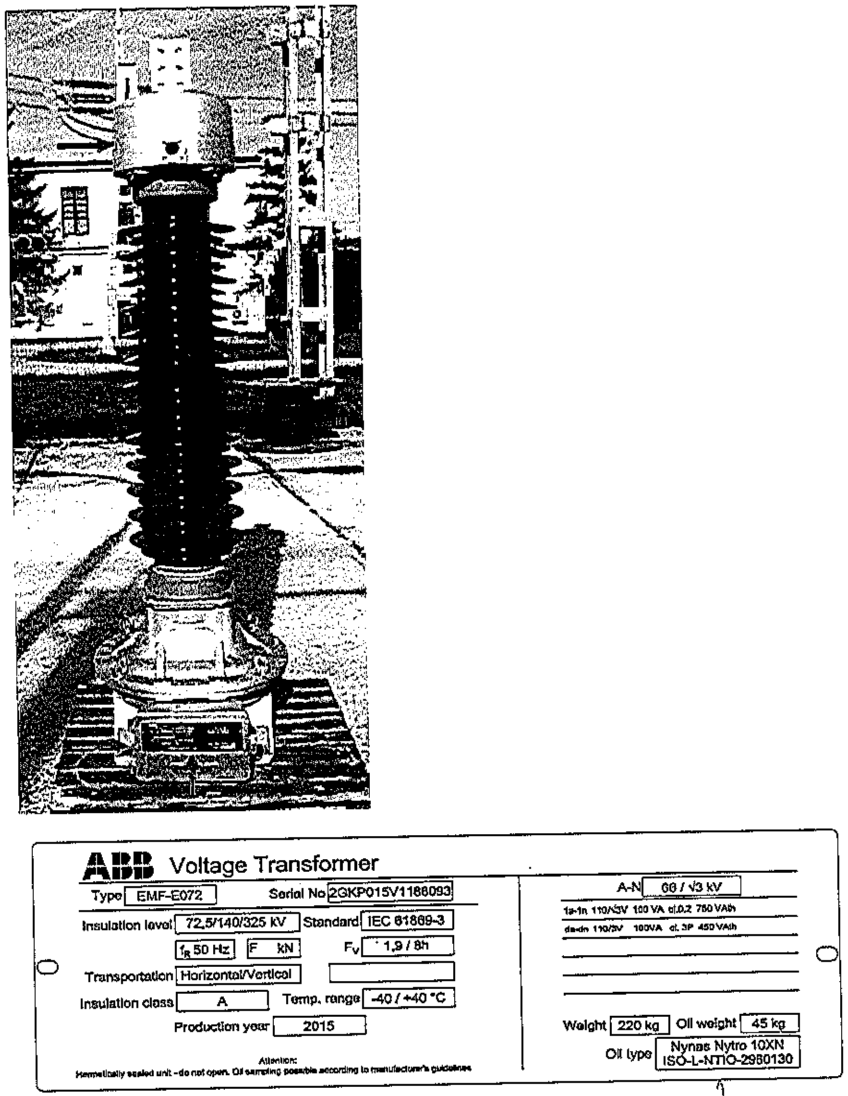
Photograph No. 3. Tested object No. 3.



Photograph No. 4. Tested object No. 4.

INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY

Test Report No.
EWP/40/E/2015



Photograph No. 5. Tested object No. 5.

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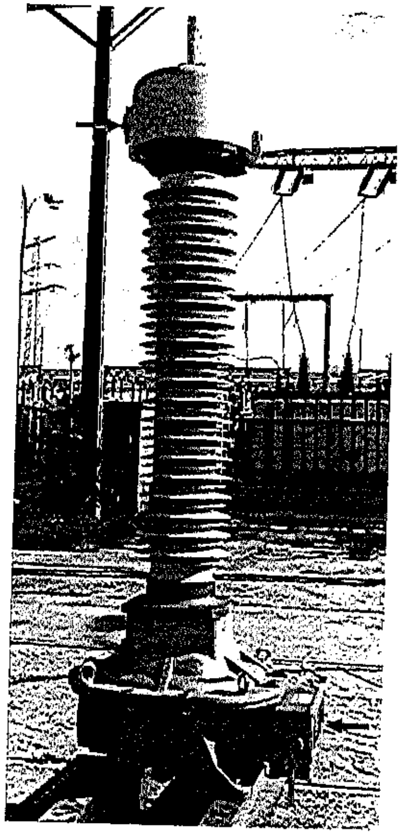
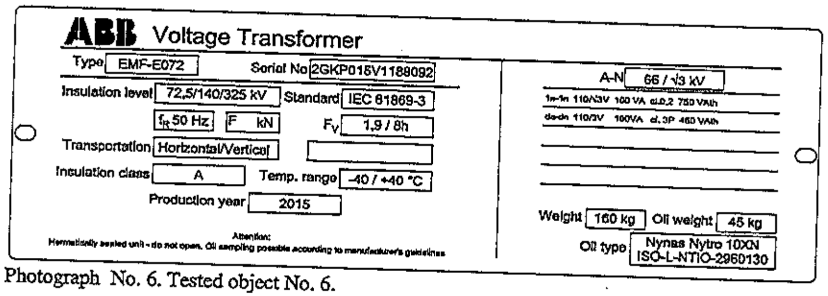
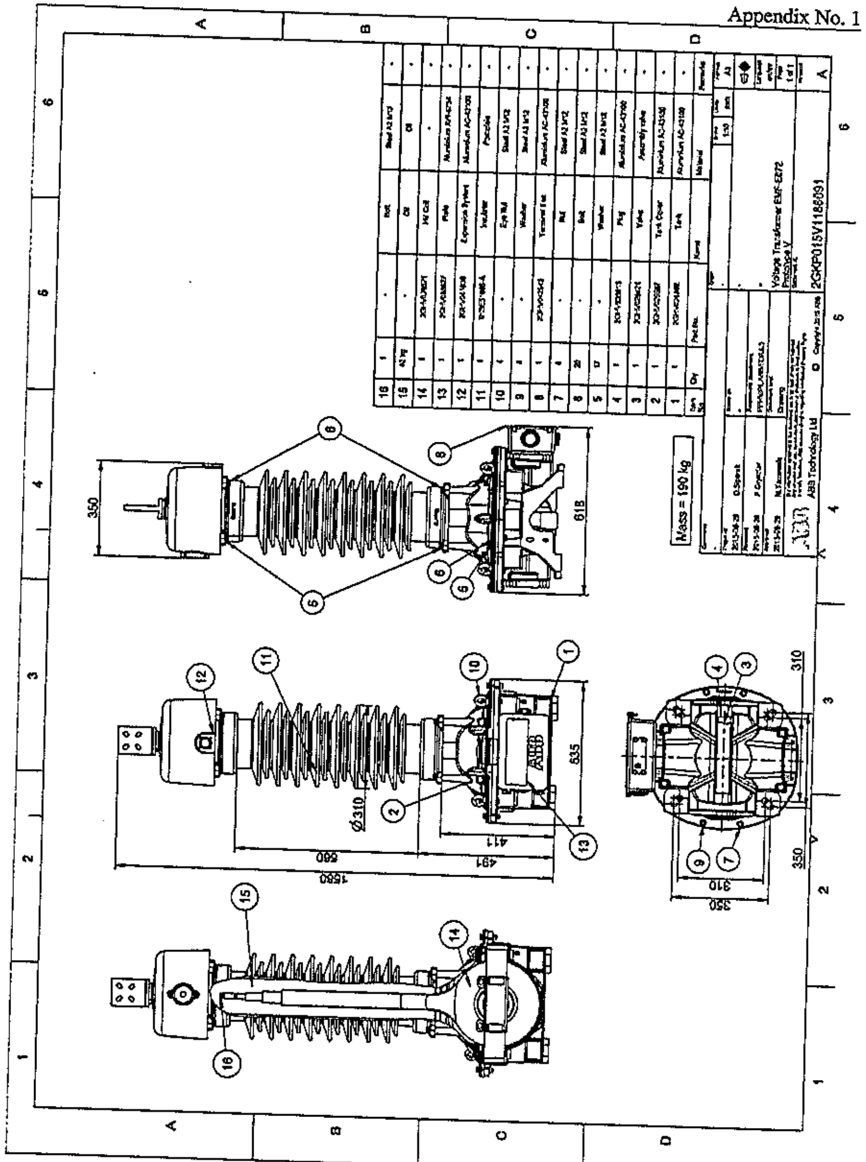




Photograph No. 6. Tested object No. 6.

Appendix No. 1



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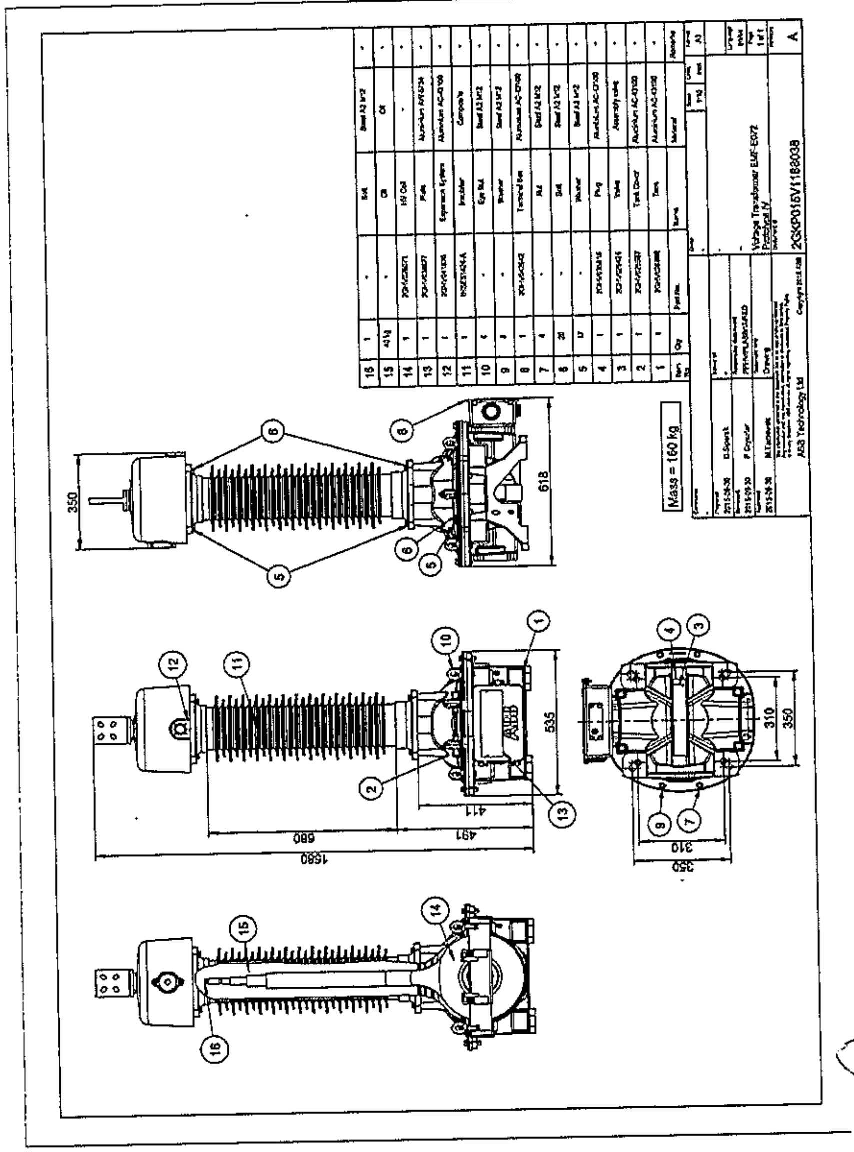

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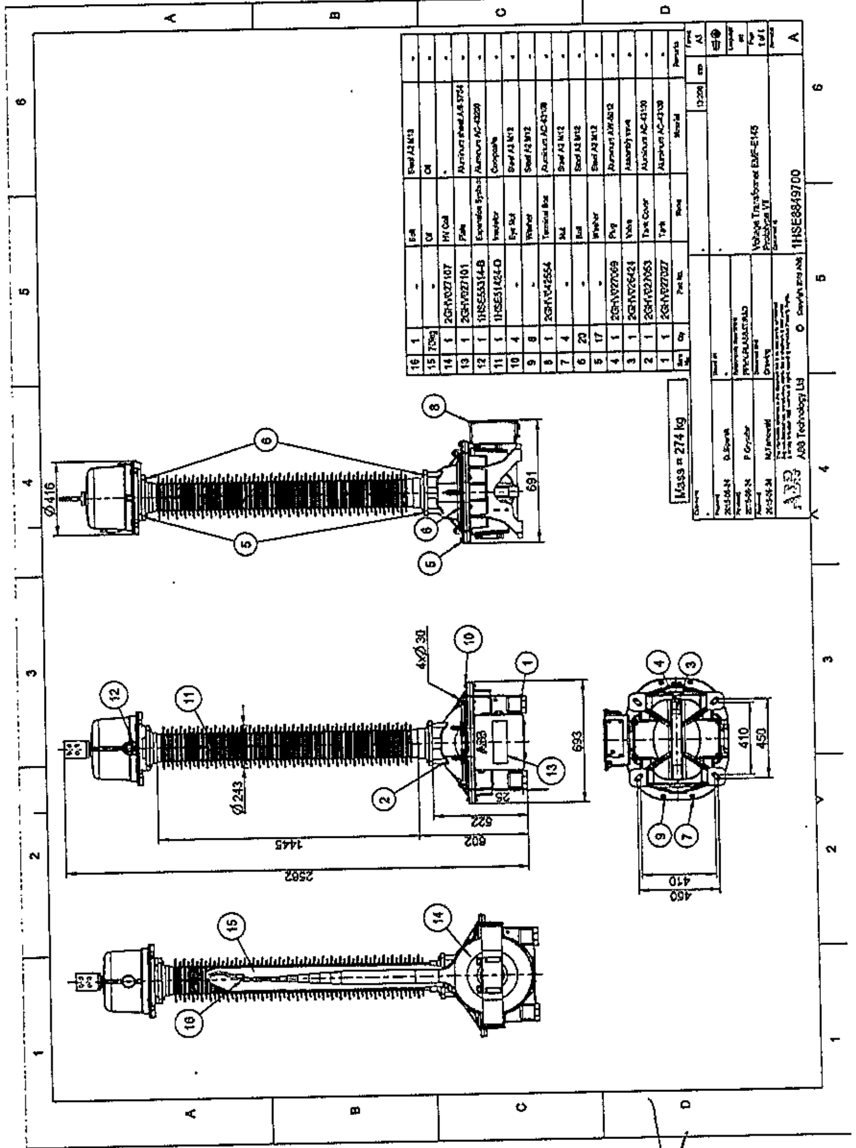

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HIGH CURRENT LABORATORY

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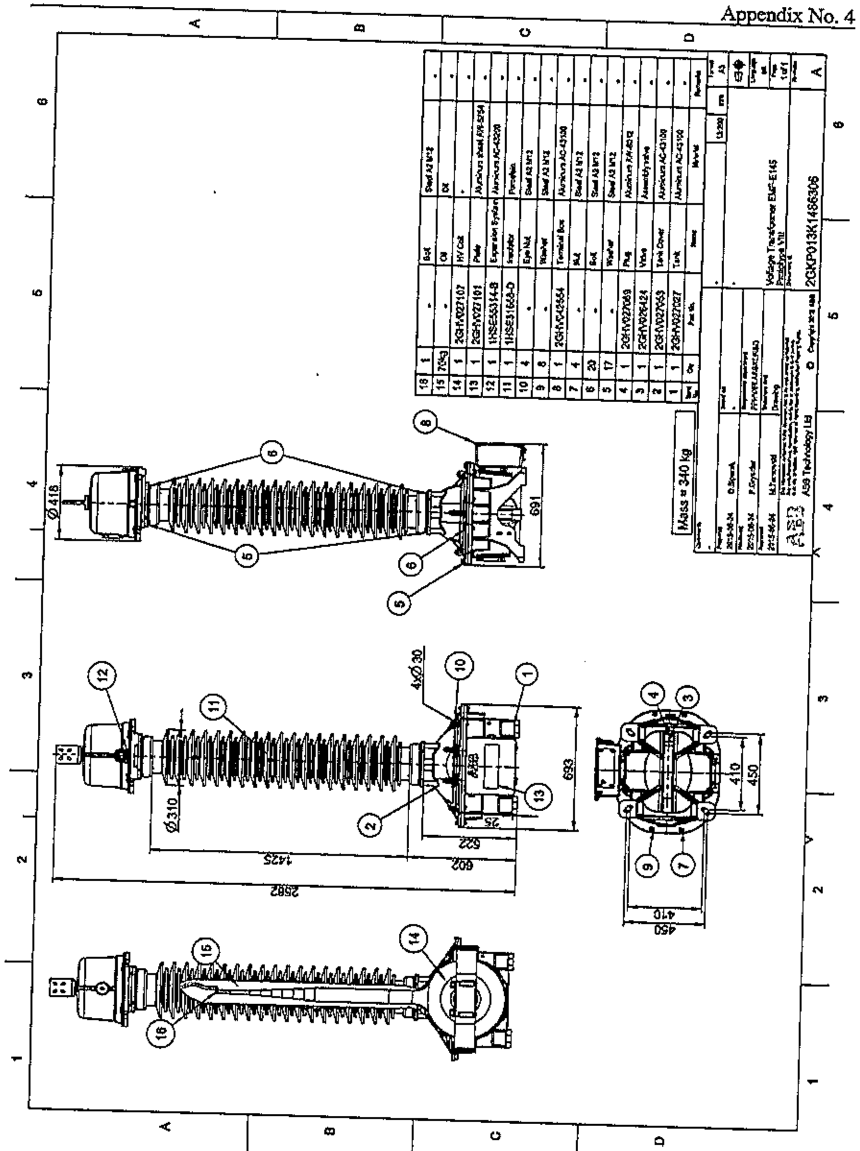
Appendix No. 4



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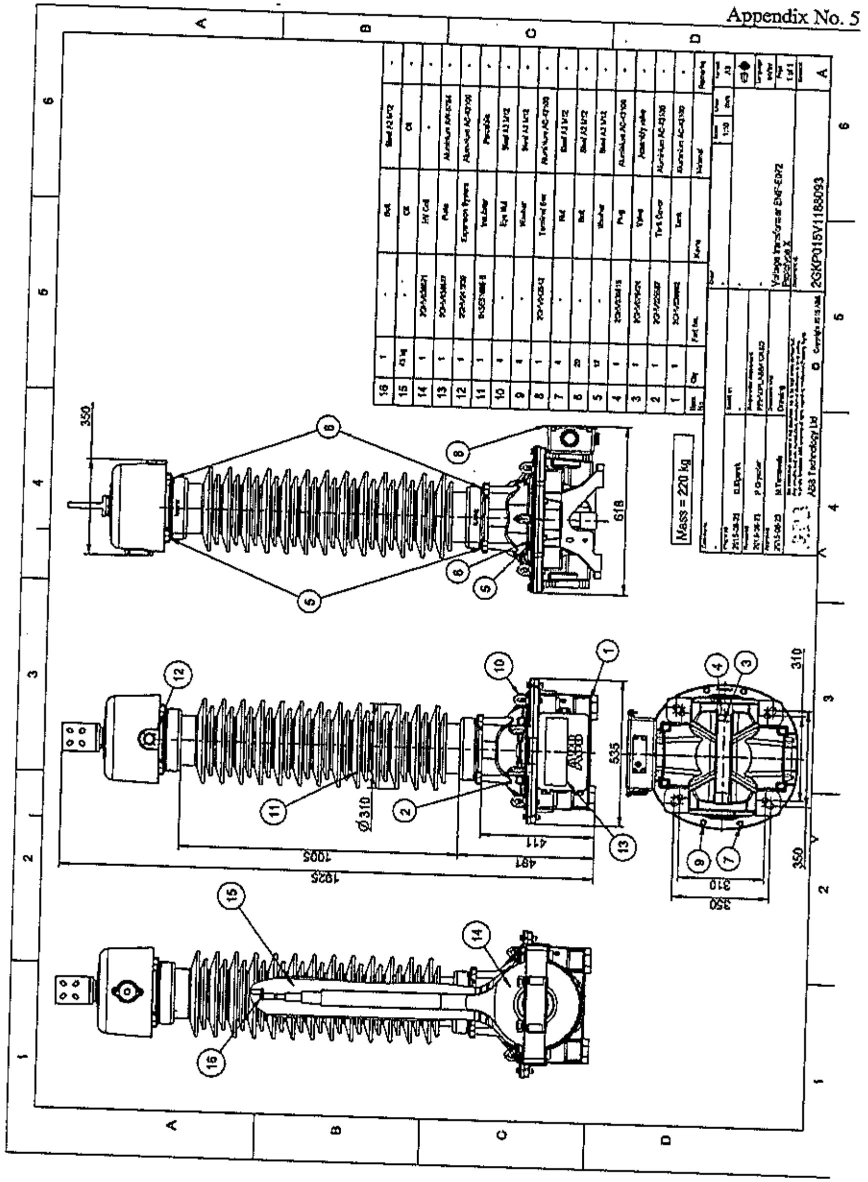
Appendix No. 5



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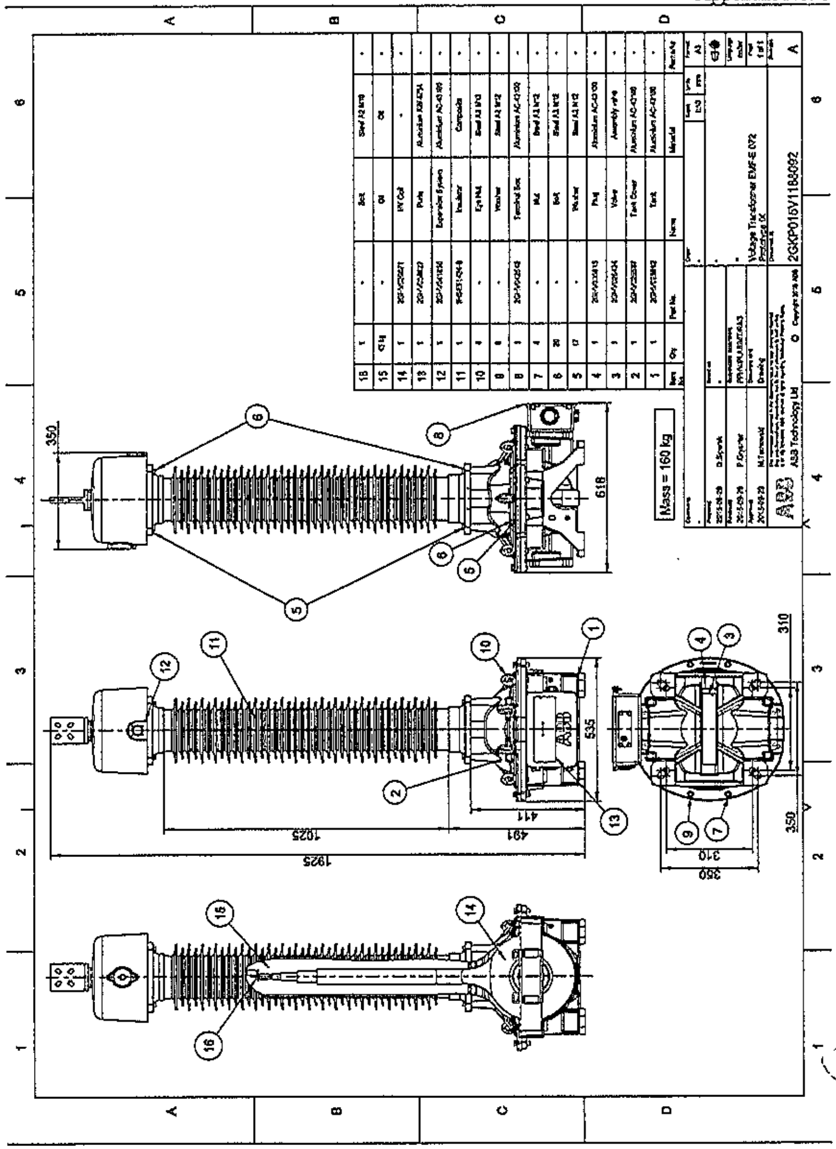
Appendix No. 6



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TEST REPORT NO. EWP/52/E/2015-1

TEST OBJECT: Voltage transformer type EMF-E084

MANUFACTURER: ABB Sp. z o.o.
Ul. Leszno 59
06–300 Przasnysz, Poland

TESTS ORDERED BY: ABB Sp. z o.o.
Ul. Żegańska 1
04-713 Warszawa, Poland
Order No. 4500678261 dated 15.09.2015

TYPE OF TESTS: Temperature-rise test

TESTS PROCEDURE: IEC 61869-1:2007, IEC 61869-3:2011

OBJECT DELIVERED: 02.10.2015

DATE OF TESTS: 06.10.2015

TESTS RESULTS: Positive

THE TESTS WERE WITNESSED BY:

Authorised by
TEST ENGINEER:
Mariusz SUL M.Sc. Eng.
Mariusz Sul

Approved by
HEAD OF LABORATORY:
Maciej OWSIŃSKI M.Sc. Eng.

Warsaw, 12.10.2015

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Contents

Report contains 13 numbered pages with:	
2	Drawings
1	Photographs
2	Appendices

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1.	Description of the test object
Test object	Voltage transformer
Type	EMF-E084
Serial number	1HSE8851777
Manufacturer	ABB Sp. z o.o.
Year of production	2015
Insulator	Porcelain insulator
Number of windings	3
Oil type	L-NTIO-296
Temperature range	-40°C - +40°C
Insulating oil weight	41 kg
Total weight	190 kg
Dimensions	According to appendix No.1 1HSE8851777

The laboratory made the identification of test objects basing documentation given in sub-cl. 3, appendix No. 1. The test object is shown in the photographs No. 1. The object was prepared for tests by the Manufacturer.

2.	Technical data declared by the Manufacturer
Rated voltage	77:√3 kV
Maximum operating voltage	84 kV
Rated frequency	50 Hz
Voltage factor and time	1,9U_n/8h

Winding	1a-1n	2a-2n	da-dn
Rated secondary voltage	110:√3 V	110:√3 V	110/3 V
Rated output	25 VA	25 VA	50 VA
Accuracy class	0,2	0,2	3P
Thermal limiting output	1000 VA	1000 VA	150 VA

3.	Technical documentation of the test object
1.	Drawing No. 1HSE8851777 – Voltage Transformer EMF-E084 PROTOTYPE V ; ABB Sp. z o.o. , approved 29.09.2015 – Appendix No. 1
2.	Declaration of Comformity No. 098/2015 (EN) ; ABB Sp. z o.o., Przasnysz, 05.10.2015 – Appendix No. 2

4. Scope of the tests

Test programm agreed with Orderer comprised of following tests:

No.	Kind of test	Tests according the Standard	Location of the test
1.	Temperature-rise tests	IEC 61869-1:2007 sub-cl. 6.4.1 and 7.2.2 IEC 61869-3:2011 sub-cl. 6.4.1 and 7.2.2 IEC 62271-1:2007, table No. 3	EWP

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

5. Tests and their results

Voltage transformer was installed at the test stand, as it was during normal operation. Electric diagram of terminal box of tested voltage 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 program given below, which was agreed with the Orderer.

The arrangement of the thermocouples is given in Fig. 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. The abstract of the protocol of temperature-rise test is given in Table No. 1. The summary of test results is given in Table No. 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. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value 1,2 U_n = 53,4 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cosφ = 1, at the voltage 110/√3 V; 2a-2n ⇒ 25 VA, cosφ = 1, at the voltage 110/√3 V.
The winding of residual voltage remained open.
The test was performed till reached steady state of the measured temperatures.

Stage No. 2: Test of 8 h

Test was done immediately after the Stage No. 1 according to the IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value 1,9 U_n = 84,5 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cosφ = 1, at the voltage 110/√3 V; 2a-2n ⇒ 25 VA, cosφ = 1, at the voltage 110/√3 V.
The residual winding da-dn was loaded by ⇒ 150 VA, cosφ = 1, at the voltage 110/3 V.
The duration of the test was 8 h.

Stage No. 3: Test with thermal limiting output

Test was done immediately after Stage No. 2 according to the IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value U_n = 44,5 kV was applied to the A terminal.
According to Manufacturers request secondary voltage windings (i.e. 1a-1n, 2a-2n) were loaded by limit power 1000 VA at cosφ = 1. The residual winding remained open.
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 thermocouples type K immersed into tank filled with oil. These thermocouples were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor - the accuracy of measurement ±0,6°C[1]. The resistance was measured by means of meter type 2291 manufactured by TETTEX Instruments with accuracy ± 0,01 mΩ[1]

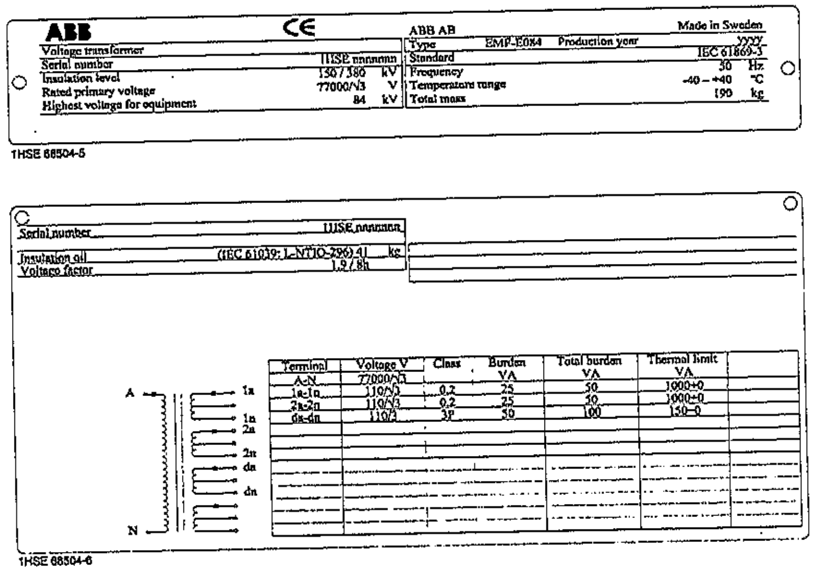

Fig. 1. Nameplates of tested voltage transformer

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

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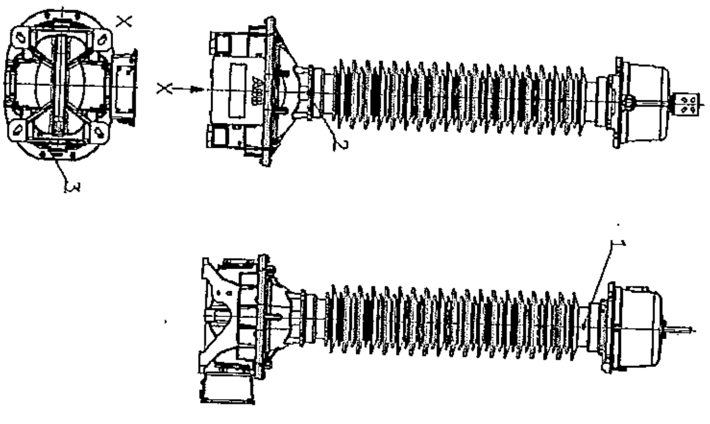

Fig. 2. Arrangement of thermocouples during temperature-rise test:
1- oil; 2- under the flange of tank lid; 3- lower tank (placed inside over earthing terminal).

Table No. 1. Temperature-rise test results of voltage transformer EMF-E084, serial No. 1HSE8851777

Parameter	Heating time [h]																				
	Stage No. 1					Stage No. 2								Stage No. 3							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
U_t, kV	53,4					84,5								44,5							
I_{A-N}, mA	-	2,6	-	-	-	4,3	-	-	-	-	-	-	-	42,5	-	-	-	-	-	-	-
ΔT thermocouple No.1, K	0	0,62	0,52	0,93	1,07	1,75	1,79	1,76	1,79	1,74	2,10	2,54	2,90	3,36	3,72	4,18	4,83	5,51	5,89	6,35	6,76
ΔT thermocouple No. 2, K	0	0,67	0,72	1,28	1,68	2,19	2,40	2,52	2,68	2,90	3,08	3,28	3,32	3,48	3,70	4,23	4,76	5,07	5,45	5,59	5,60
ΔT thermocouple No. 3, K	0	0,59	0,64	1,77	1,86	2,59	2,65	3,10	3,43	3,61	3,76	3,94	4,03	3,99	3,97	4,51	5,03	5,51	5,82	6,13	6,14
t_m, °C	19,25	19,48	19,56	19,55	19,56	19,59	19,65	19,73	19,72	19,85	19,85	19,89	19,90	20,06	20,11	19,97	19,87	19,73	19,72	19,68	19,64
R_{1a-1n}, mΩ	108,8	109,48	109,84	110,12	110,33	110,88	111,30	111,55	111,82	112,01	112,21	112,32	112,45	120,23	121,81	122,88	123,62	124,18	124,68	124,87	124,91
R_{2a-2n}, mΩ	100,20	100,85	101,19	101,44	101,63	102,15	102,53	102,75	103	103,18	103,36	103,46	103,57	110,39	111,79	112,72	113,37	113,86	114,30	114,48	114,55
R_{da-dn}, mΩ	39,77	40,04	40,16	40,25	40,32	40,53	40,67	40,75	40,84	40,91	40,96	41,01	41,04	42,97	43,37	43,65	43,83	43,99	44,11	44,17	44,20
R_{A-N}, kΩ	14,20	14,25	14,28	14,32	14,34	14,40	14,45	14,48	14,53	14,56	154,58	14,60	14,65	15,37	15,79	16,09	16,25	16,37	16,46	16,53	16,58
$ΔT_{1a-1n}$	0	1,56	2,39	3,03	3,52	4,78	5,74	6,32	6,94	7,38	7,84	8,09	8,39	26,26	29,89	32,35	34,05	35,34	36,49	36,93	37,02
$ΔT_{2a-2n}$	0	1,62	2,47	3,09	3,57	4,87	5,81	6,36	6,99	7,44	7,88	8,13	8,41	25,42	28,92	31,24	32,86	34,08	35,18	35,63	35,80
$ΔT_{da-dn}$	0	1,70	2,48	3,06	3,48	4,79	5,66	6,18	6,73	7,15	7,52	7,78	8,02	20,15	22,63	24,40	25,54	26,53	27,29	27,70	27,87
$ΔT_{A-N}$	0	0,88	1,41	2,11	2,47	3,52	4,40	4,93	5,81	6,34	6,69	7,04	7,92	20,60	27,99	33,28	36,09	38,20	39,79	41,02	41,90

Table No. 2. Temperature-rises [K] given during the tests voltage transformer EMF-E084 serial No. 1HSE8851777

			Temperature rise ΔT [K]	Limit [K]
Stage No. 1	Windings	1a- 1n	3,52	65[1]
		2a-2n	3,57	
		da-dn	3,48	
		A-N	2,47	
	Thermocouple No. 1	Oil	1,07	55[1]
	Thermocouple No. 2	Under the flange of tank lid	1,68	40[2]
	Thermocouple No. 2	Enclosure of lower tank	1,86	
Stage No. 2	Windings	1a- 1n	8,39	65+10[1]
		2a-2n	8,41	
		da-dn	8,02	
		A-N	7,92	
	Thermocouple No. 1	Oil	2,90	55+10[1]
	Thermocouple No. 2	Under the flange of tank lid	3,32	40[2]
	Thermocouple No. 2	Enclosure of lower tank	4,03	
Stage No. 3	Windings	1a- 1n	37,02	65[1]
		2a-2n	35,80	
		da-dn	27,87	
		A-N	41,90	
	Thermocouple No. 1	Oil	6,76	55[1]
	Thermocouple No. 2	Under the flange of tank lid	5,60	40[2]
	Thermocouple No. 2	Enclosure of lower tank	6,14	

[1] acc. to IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2
[2] acc. to IEC 62271-1

6. Summary

In tested voltage transformer type EMF-E084 with porcelain insulator, as results of temperature-rise test:

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

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

- results of test with thermal limiting output for all voltage windings (without residual windings) and supply voltage U_n (Stage No. 3), shows that permitted temperature-rise limits were not exceeded.

The tested voltage transformer met requirements of IEC 61869-1:2007 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3:2011 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 62271-1:2007 standards.

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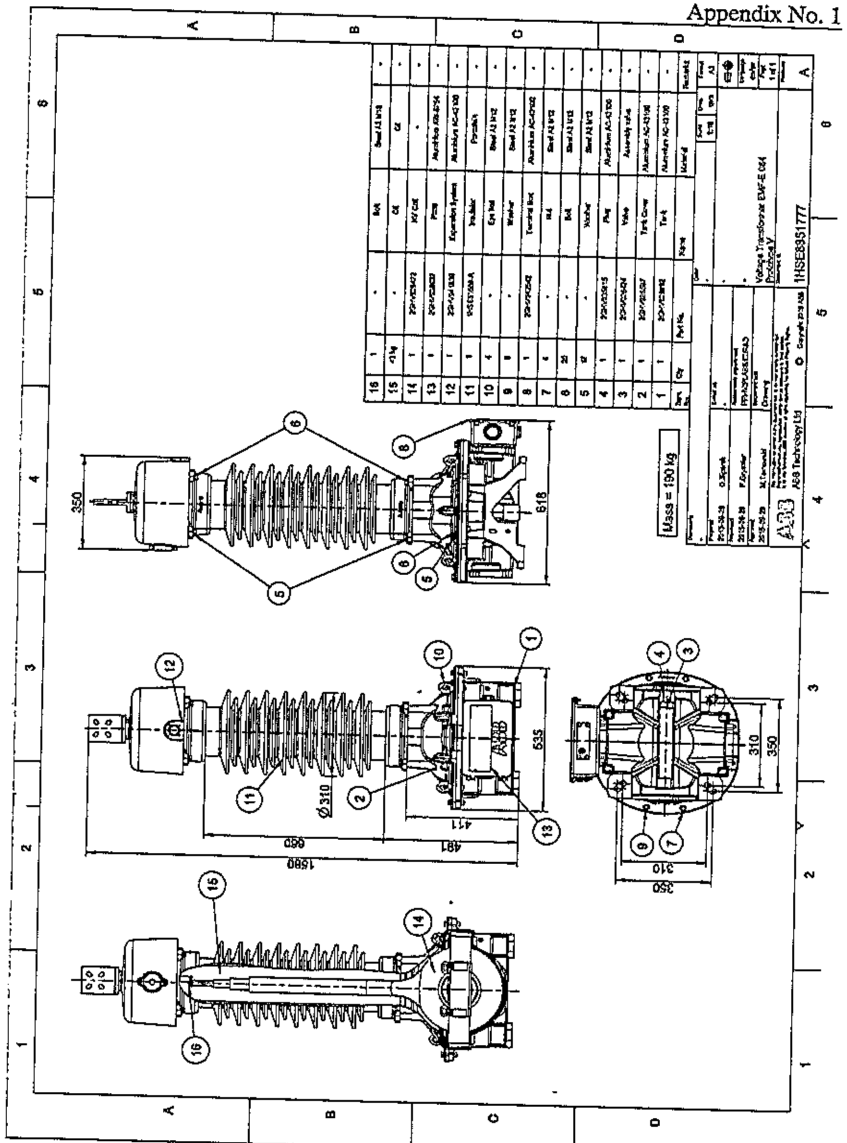
7. Photographic documentation

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

Appendix No. 1



Appendix No. 2

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

DECLARATION OF CONFORMITY No. 098/2015 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E084

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2015

Additional information:
Serial numbers: **1HSE 8851777;**

Place and date of issue of declaration

Przasnysz 05.10.2015

Kierownik Operacyjny PPNV ABB Sp. z o.o. Oddział w Przasnyszu

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

(Name) (Signature)

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e-mail: ewp@ien.com.pl
www.ien.com.pl/ewp

TEST REPORT NO. EWP/52/E/2015-3

TEST OBJECT:	Voltage transformer type EMF-E145
MANUFACTURER:	ABB Sp. z o.o. ul. Leszno 59 06–300 Przasnysz, Poland
TESTS ORDERED BY:	ABB Sp. z o.o. ul. Żegańska 1 04-713 Warszawa, Poland Order No. 4500678261 dated 15.09.2015
TYPE OF TESTS:	Temperature-rise test
TESTS PROCEDURE:	IEC 61869-1:2007, IEC 61869-3:2011
OBJECT DELIVERED:	22.10.2015
DATE OF TESTS:	25.10.2015
TESTS RESULTS:	Positive
THE TESTS WERE WITNESSED BY:	

Authorised by
TEST ENGINEER:
Mariusz SUL M.Sc. Eng.

Mariusz Sul

Approved by
HEAD OF LABORATORY:
Maciej OWSIŃSKI M.Sc. Eng.

Warsaw, 16.11.2015

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Report contains 12 numbered pages with:	
2	Drawings
1	Photographs
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1. Description of the test object

Test object	Voltage transformer
Type	EMF-E145
Serial number	1HSE8851772
Manufacturer	ABB Sp. z o.o.
Year of production	2015
Insulator	Composite insulator
Number of windings	4
Oil type	L-NTIO-296
Temperature range	-40°C - +40°C
Insulating oil weight	80 kg
Total weight	248 kg
Dimensions	According to appendix No.1 1HSE8851772

The laboratory made the identification of test objects basing documentation given in sub-cl. 3. The test object is shown in the photographs No. 1. The object was prepared for tests by the Manufacturer.

2. Technical data declared by the Manufacturer

Rated voltage [kV]	145:√3
Maximum operating voltage [kV]	145
Rated frequency [Hz]	50
Voltage factor and time	$1{,}9U_n$/8h

Winding	1a-1n		2a-2n		3a-3n		da-dn	
Rated secondary voltage [V]	115:√3	115:√3	115:√3	115:√3	115:√3	115:√3	115	115
Rated output [VA]	25	25	25	25	25	500	100	300
Accuracy class	0,1	1,0	0,1	1	0,1/3P	3,0/3P	1,0	3P
Thermal limiting output [VA]	1500	1500	1500	1500	1500	1500	450	450

3. Technical documentation of the test object

1.	Drawing No. 1HSE8851772 – Voltage Transformer EMF-E145 PROTOTYPE I; ABB Sp. z o.o. , approved 23.06.2015 – Appendix No. 1
2.	Declaration of Comformity No. 101/2015 (EN) ; ABB Sp. z o.o., Przasnysz, 29.10.2015 – Appendix No. 2

4. Scope of the tests

Test program agreed with Orderer comprised of following tests:

No.	Kind of test	Tests according the Standard	Location of the test
1.	Temperature-rise tests	IEC 61869-1:2007 sub-cl. 6.4.1 and 7.2.2 IEC 61869-3:2011 sub-cl. 6.4.1 and 7.2.2 IEC 62271-1:2007, table No. 3	EWP

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

5. Tests and their results

Voltage transformer was installed at the test stand, as it was during normal operation. Electric diagram of terminal box of tested voltage 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 program given below, which was agreed with the Orderer.

The arrangement of the thermocouples is given in Fig. 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. The abstract of the protocol of temperature-rise test is given in Table No. 1. The summary of test results is given in Table No. 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. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value 1,2 U_n = 100,5 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cosφ = 1, at the voltage 115/√3 V; 2a-2n ⇒ 25 VA, cosφ = 1, at the voltage 115/√3 V; 3a-3n ⇒ 500 VA, cosφ = 1, at the voltage 115/√3 V.
The winding of residual voltage remained open.
The test was performed till reached steady state of the measured temperatures.

Stage No. 2: Test of 8 h

Test was done immediately after the Stage No. 1 according to the IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value 1,9 U_n = 159 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 25 VA, cosφ = 1, at the voltage 115/√3 V; 2a-2n ⇒ 25 VA, cosφ = 1, at the voltage 115/√3 V; 3a-3n ⇒ 500 VA, cosφ = 1, at the voltage 115/√3 V.
The residual winding da-dn was loaded by ⇒ 450 VA, cosφ = 1, at the voltage 115 V.
The duration of the test was 8 h.

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 thermocouples type K immersed into tank filled with oil. These thermocouples were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor - the accuracy of measurement ±0,6°C[1]. The resistance was measured by means of meter type 2291 manufactured by TETTEX Instruments with accuracy ± 0,01 mΩ[1]

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

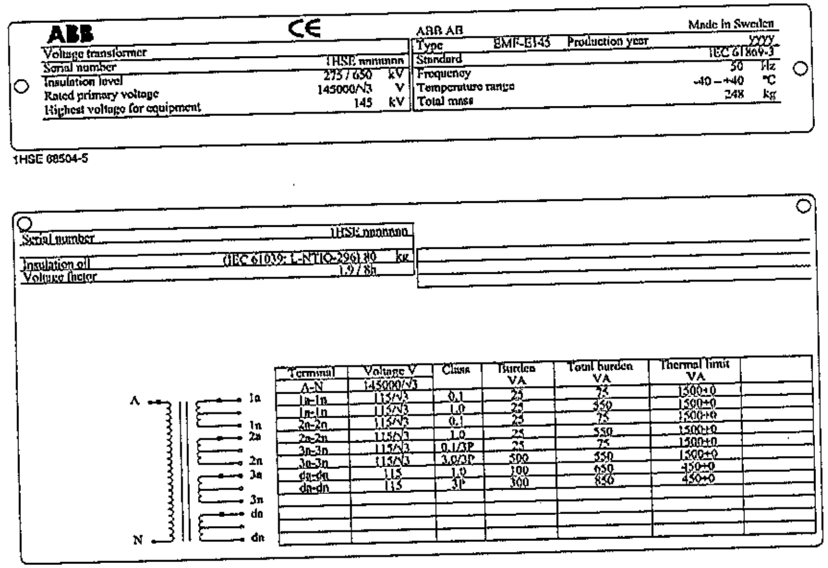

Fig. 1. Nameplates of tested voltage transformer

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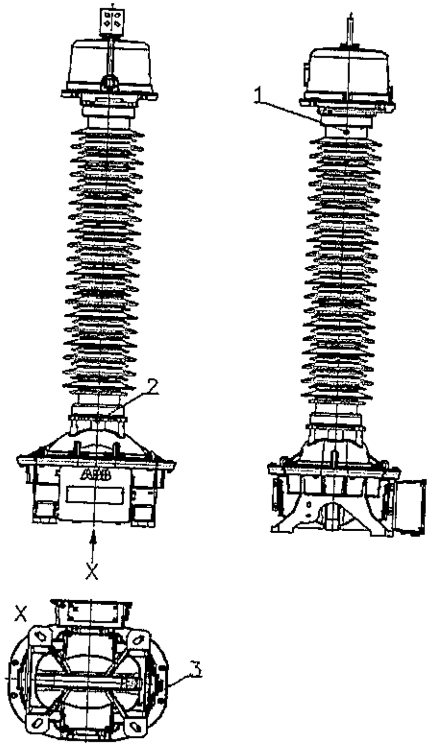


Fig. 2. Arrangement of thermocouples during temperature-rise test:
1- oil; 2- under the flange of tank lid; 3- lower tank (placed inside over earthing terminal).

Table No. 1. Test results of voltage transformer EMF-E145, serial No. 1HSE8851772

Parameter	Heating time [h]												
	Stage No. 1					Stage No. 2							
	0	1	2	3	4	5	6	7	8	9	10	11	12
U_t, kV	100,5					159							
I_{A-N}, mA		8,9	8,9	8,9	8,9-	24	24	24	24	24	24	24	24
ΔT thermo-couple No.1, K	0	-0,07	0,10	0,52	0,81	2,01	3,02	3,38	4,15	4,48	4,90	5,26	5,54
ΔT thermo-couple No. 2, K	0	-0,02	0,60	1,05	1,36	2,77	3,81	4,61	5,22	5,74	6,08	6,39	6,67
ΔT thermo-couple No. 3, K	0	0,30	0,15	0,45	0,74	1,59	2,32	3,03	3,64	3,89	4,27	4,54	4,75
t_{av}, °C	18,94	18,95	19,13	19,43	19,49	19,48	19,51	19,52	19,73	19,72	19,58	19,54	19,58
R_{1a-1n}, mΩ	53,19	53,51	53,75	53,93	54,07	55,07	55,50	55,83	56,09	56,29	56,47	56,62	56,72
R_{2a-2n}, mΩ	51,88	52,21	52,45	52,63	52,77	53,76	54,16	54,49	54,75	54,94	55,10	55,23	55,33
R_{3a-3n}, mΩ	33,35	33,55	33,70	33,80	33,89	34,50	34,74	34,93	35,07	35,20	35,31	35,39	35,44
R_{da-dn}, mΩ	142,58	143,58	144,24	144,73	145,09	147,90	149,04	149,89	150,72	151,07	151,53	151,86	152,11
R_{A-N}, kΩ	18,03	18,08	18,13	18,21	18,23	18,58	18,75	18,91	19,00	19,06	19,13	19,21	19,28
ΔT_{1a-1n}	0	1,49	2,63	3,47	4,14	8,80	10,84	12,41	13,61	14,56	15,40	16,09	16,55
ΔT_{2a-2n}	0	1,59	2,76	3,62	4,27	9,04	10,97	12,55	13,82	14,73	15,51	16,13	16,64
ΔT_{3a-3n}	0	1,51	2,64	3,34	4,07	8,64	10,44	11,87	12,89	13,89	14,67	15,31	15,68
ΔT_{da-dn}	0	1,75	2,91	3,77	4,40	9,33	11,33	12,82	13,92	14,89	15,69	16,27	16,71
ΔT_{A-N}	0	0,69	1,39	2,50	2,77	7,63	9,98	12,20	13,45	14,28	15,25	16,36	17,33

Table No. 2. Temperature-rises given during the tests voltage transformer EMF-E145 serial No. 1HSE8851772

			Temperature rise ΔT [K]	Limit [K]
Stage No. 1	Windings	1a- 1n	4,14	65[1)]
		2a-2n	4,27	
		3a-3n	4,07	
		da-dn	4,40	
		A-N	2,77	
	Thermocouple No. 1	Oil	0,81	55[1)]
	Thermocouple No. 2	Under the flange of tank lid	1,36	40[2)]
	Thermocouple No. 2	Enclosure of lower tank	0,74	

Table No. 2. cont.

			Temperature rise ΔT [K]	Limit [K]
Stage No. 2	Windings	1a- 1n	16,55	65+10[1]
		2a-2n	16,64	
		3a-3n	15,68	
		da-dn	16,71	
		A-N	17,33	
	Thermocouple No. 1	Oil	5,54	55+10[1]
	Thermocouple No. 2	Under the flange of tank lid	6,67	40[2]
	Thermocouple No. 2	Enclosure of lower tank	4,75	

[1] acc. to IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2
[2] acc. to IEC 62271-1

6. Summary

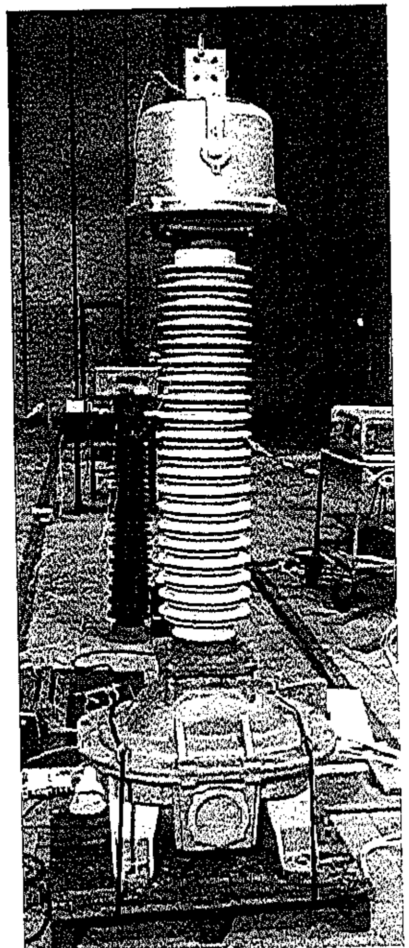
Results of temperature-rise test of tested voltage transformer type EMF-E145 are as follow:

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

- results of test 8 h at supply voltage $1{,}9U_n$ and rated load of voltage windings and load of residual winding with thermal limiting output (Stage No. 2), shows that permitted temperature-rise limits were not exceeded.

The tested voltage transformer met requirements of IEC 61869-1:2007 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3:2011 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 62271-1:2007 standards.

7. Photographic documentation



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

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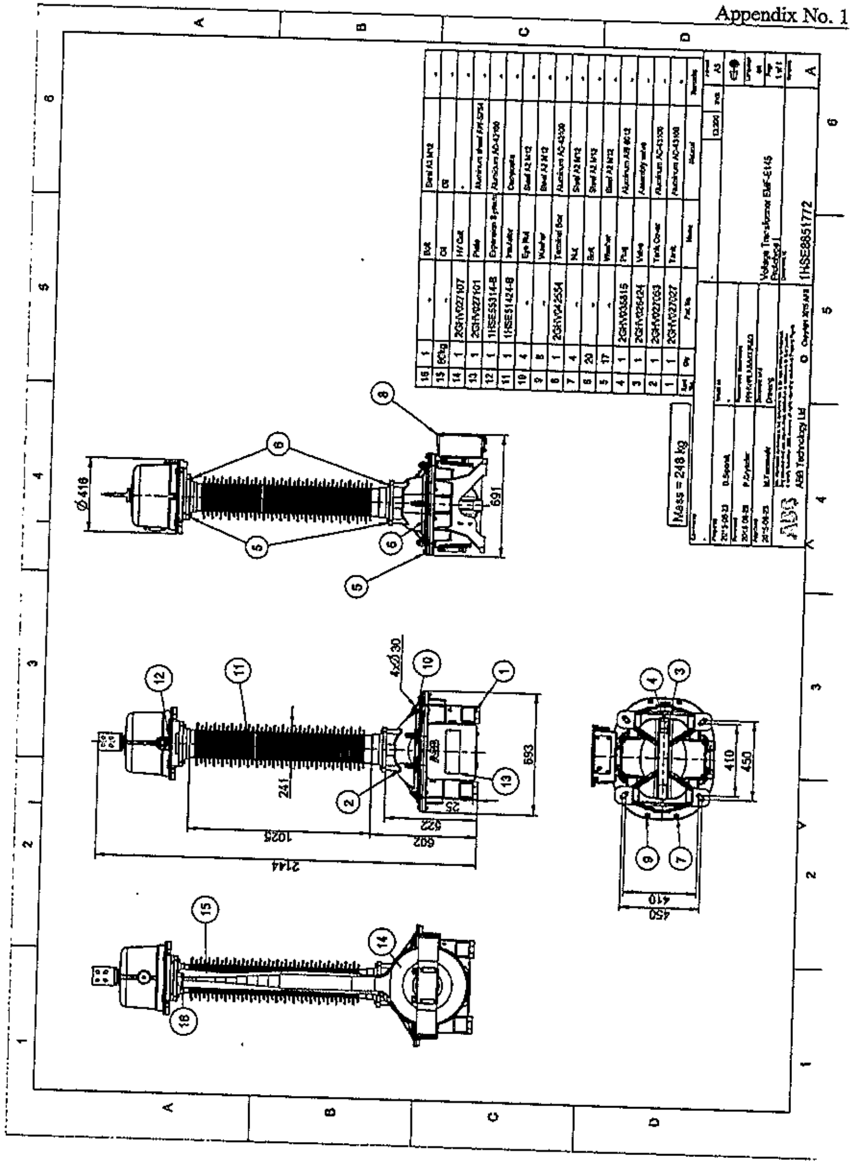
Appendix No. 1



Appendix No. 2

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

DECLARATION OF CONFORMITY No. 101/2015 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2015

Additional information:
Serial numbers: **1HSE8851772;**

Place and date of issue of declaration

Przasnysz 29.10.2015

Kierownik Operacyjny PPHV
ABB Sp. z o.o.
Oddział w Przasnyszu
(Name)

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

INSTYTUT ENERGETYKI
INSTITUTE OF POWER ENGINEERING
LABORATORIUM WIELKOPRĄDOWE
HIGH CURRENT LABORATORY

address: ul. Mory 8
01-330 Warszawa; Poland
phone/fax +48 22 836 80 16
e-mail: ewp@ien.com.pl
www.ien.com.pl/ewp

TEST REPORT NO. EWP/52/E/2015-4

TEST OBJECT: Voltage transformer type EMF-E145

MANUFACTURER: ABB Sp. z o.o.
ul. Leszno 59
06–300 Przasnysz, Poland

TESTS ORDERED BY: ABB Sp. z o.o.
ul. Żegańska 1
04-713 Warszawa, Poland
Order No. 4500678261 dated 15.09.2015

TYPE OF TESTS: Temperature-rise test

TESTS PROCEDURE: IEC 61869-1:2007, IEC 61869-3:2011

OBJECT DELIVERED: 12.11.2015

DATE OF TESTS: 17.11.2015

TESTS RESULTS: Positive

THE TESTS WERE WITNESSED BY:

Authorised by
TEST ENGINEER:
Grzegorz Zaboklicki M.Sc. Eng.

Approved by
HEAD OF LABORATORY:
Maciej OWSIŃSKI M.Sc. Eng.

Warsaw, 18.11.2015

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Contents

Report contains 13 numbered pages with:	
2	Drawings
1	Photographs
2	Appendices

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1. Description of the test object

Test object	Voltage transformer
Type	EMF-E145
Serial number	1HSE8851773
Manufacturer	ABB Sp. z o.o.
Year of production	2015
Insulator	Porcelain insulator
Number of windings	4
Oil type	L-NTIO-296
Temperature range	-40°C - +40°C
Insulating oil weight	80 kg
Total weight	296 kg
Dimensions	According to appendix No.1 1HSE8851773

The laboratory made the identification of test objects basing on documentation given in sub-cl. 3. The test object is shown in the photographs No. 1. The object was prepared for tests by the Manufacturer.

2. Technical data declared by the Manufacturer

Rated voltage [kV]	145:√3
Maximum operating voltage [kV]	145
Rated frequency [Hz]	50
Voltage factor and time	$1{,}9U_n/8h$

Winding	1a-1n		2a-2n		3a-3n		da-dn	
Rated secondary voltage [V]	115:√3	115:√3	115:√3	115:√3	115:√3	115:√3	115	115
Rated output [VA]	25	25	25	25	25	500	100	300
Accuracy class	0,1	1,0	0,1	1	0,1/3P	3,0/3P	1,0	3P
Thermal limiting output [VA]	1500	1500	1500	1500	1500	1500	450	450

3. Technical documentation of the test object

1.	Drawing No. 1HSE8851773 – Voltage Transformer EMF-E145 PROTOTYPE II; ABB Sp. z o.o. , approved 03.11.2015 – Appendix No. 1
2.	Declaration of Comformity No. 102/2015 (EN) ; ABB Sp. z o.o., Przasnysz, 29.10.2015 – Appendix No. 2

4. Scope of the tests

Test program agreed with Orderer comprised of following tests:

No.	Kind of test	Tests according the Standard	Location of the test
1.	Temperature-rise tests	IEC 61869-1:2007 sub-cl. 6.4.1 and 7.2.2 IEC 61869-3:2011 sub-cl. 6.4.1 and 7.2.2 IEC 62271-1:2007, table No. 3	EWP

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

5. Tests and their results

Voltage transformer was installed at the test stand, as it would be during normal operation. Electric diagram of terminal box of tested voltage 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 program given below This program was agreed with the Orderer.

The arrangement of the thermocouples is given in Fig. 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. The abstract of the protocol of temperature-rise test is given in Table No. 1. The summary of test results is given in Table No. 2.

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

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

Stage No. 1: Test with thermal limiting output

Test was performed according to the IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value U_n = 83,7 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 1500 VA, cosφ = 1, at the voltage 115/√3 V; 2a-2n ⇒ 1500 VA, cosφ = 1, at the voltage 115/√3 V; 3a-3n ⇒ 1000 VA, cosφ = 1, at the voltage 115/√3 V.
The winding of residual voltage was opened.
The test was performed till reached steady state of the measured temperatures.

Stage No. 2: Test with thermal limiting output

Test was done immediately after the Stage No. 1 according to the IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value U_n = 83,7 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 1500 VA, cosφ = 1, at the voltage 115/√3 V; 2a-2n ⇒ 1500 VA, cosφ = 1, at the voltage 115/√3 V; 3a-3n ⇒ 1500 VA, cosφ = 1, at the voltage 115/√3 V.
The winding of residual voltage was opened.
The test was performed till reached steady state of the measured temperatures.

Stage No. 3: Test with thermal limiting output

Stage no. 3 was started after three hours break from Stage No. 2. Test was done according to the IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2. The voltage value U_n = 83,7 kV was applied to the A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 2400 VA, cosφ = 1, at the voltage 115/√3 V;
The other windings were opened.
The test was performed till reaching the steady state of the measured temperatures.

Measuring equipment

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 thermocouples type K immersed into tank filled with oil. These thermocouples were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor - the accuracy of measurement ±0,6°C[1]. The resistance was measured by means of meter type 2291 manufactured by TETTEX Instruments with accuracy ± 0,01 mΩ[1]

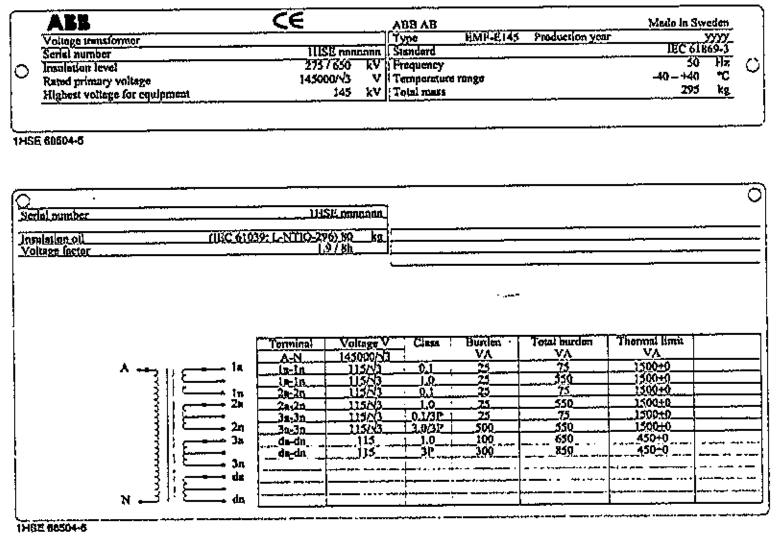

Fig. 1. Nameplates of tested voltage transformer

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

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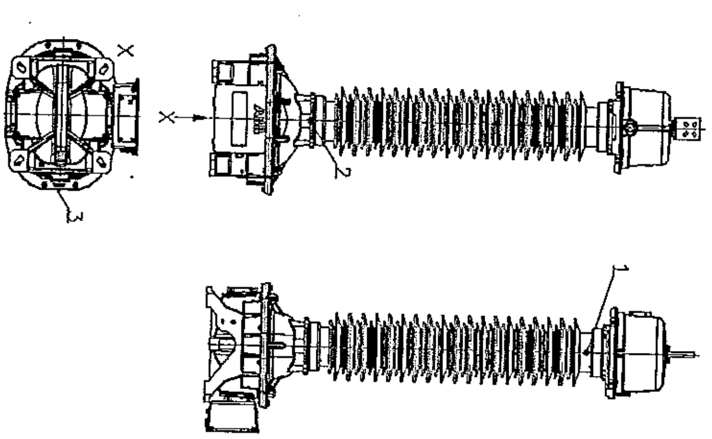


Fig. 2. Arrangement of thermocouples during temperature-rise test:
1- oil; 2- under the flange of tank lid; 3- lower tank (placed inside over earthing terminal).

INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY

Test Report No.
EWP/52/E/2015-4

Table No. 1. Temperature-rise test results of voltage transformer EMF-E145, serial No. 1HSE8851773

Parameter	Heating time [h]																						
	Stage No. 1											Stage No. 2							Stage No. 3				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17-19	20	21	22	23	24
U_s, kV	83,7kV											83,7kV											
I_{A-N}, mA	44,8	44,8	44,9	44,9	44,8	44,7	44,8	44,9	44,9	44,9	44,9	50,4	50,2	50,2	50,2	50,2	50,2		27,2	27,2	27,2	27,2	27,2
ΔT thermo-couple No.1, K	0	0,41	0,47	2,60	3,48	4,39	5,38	5,56	5,76	6,59	6,80	7,59	7,65	8,55	8,54	8,69	8,80		5,37	5,70	6,65	6,88	7,17
ΔT thermo-couple No. 2, K	0	0,54	1,62	2,45	3,21	3,95	4,66	5,12	5,69	6,05	6,35	6,77	7,14	7,49	7,60	7,87	8,08		4,62	5,13	5,61	5,98	6,20
ΔT thermo-couple No. 3, K	0	-0,06	0,70	1,47	2,14	2,76	3,26	3,66	4,05	4,39	4,62	4,87	5,14	5,37	5,48	5,70	5,81		4,03	3,89	4,10	4,38	4,50
t_{ot}, °C	19,08	19,01	19,18	19,33	19,42	19,49	19,72	19,56	19,63	19,66	19,73	19,78	19,84	19,85	19,86	19,84	19,80		19,43	19,62	19,68	19,70	19,78
R_{1a-1n}, mΩ	52,90	56,56	57,35	58,31	58,84	59,29	59,67	59,89	60,17	60,32	60,47	61,07	61,37	61,61	61,73	61,83	61,97		56,36	59,69	60,19	60,46	60,59
R_{2a-2n}, mΩ	51,58	55,07	55,80	56,69	57,18	57,61	57,96	58,16	58,42	58,56	58,70	59,28	59,55	59,78	59,89	59,97	60,11	BREAK	54,82	57,87	58,34	58,59	58,70
R_{3a-3n}, mΩ	33,10	35,08	35,51	36,01	36,29	36,51	36,72	36,85	37,00	37,09	37,17	37,52	37,68	37,80	37,87	37,92	38,00		35,00	36,66	36,94	37,06	37,13
R_{da-dn}, mΩ	144,72	153,43	155,41	157,74	158,70	159,87	160,77	161,33	161,96	162,38	162,72	164,23	165,11	165,62	166,16	166,42	166,76		153,29	160,71	162,19	162,54	162,78
R_{A-N}, kΩ	17,94	18,72	19,18	19,71	20,12	20,38	20,52	20,61	20,76	20,86	20,92	21,19	21,40	21,58	21,72	21,82	21,89		20,01	20,28	20,35	20,40	20,43
$ΔT_{1a-1n}$	0	17,27	21,04	25,54	28,07	30,21	31,99	33,04	34,34	35,06	35,78	38,60	40,02	41,18	41,73	42,19	42,87		16,33	32,07	34,42	35,72	36,31
$ΔT_{2a-2n}$	0	16,90	20,43	24,76	27,13	29,19	30,90	31,89	33,14	33,82	34,51	37,30	38,64	39,74	40,26	40,67	41,34		15,70	30,49	32,77	33,96	34,51
$ΔT_{3a-3n}$	0	14,93	18,18	21,98	24,06	25,75	27,33	28,31	29,39	30,09	30,71	33,33	34,57	35,49	35,97	36,36	36,97		14,33	26,89	28,98	29,89	30,42
$ΔT_{da-dn}$	0	15,05	18,47	22,15	24,15	26,17	27,73	28,69	29,78	30,51	31,10	33,70	35,22	36,10	37,04	37,49	38,07		14,80	27,62	30,18	30,78	31,20
$ΔT_{A-N}$	0	10,87	17,28	24,67	30,38	34,00	35,95	37,21	39,30	40,69	41,53	45,29	48,22	50,73	52,68	54,07	55,05		28,85	32,61	33,58	34,28	34,70
I_{1a-1n}, A	21,49	21,48	21,44	21,43	21,46	21,48	21,50	21,48	21,44	21,50	21,47	21,41	21,41	21,40	21,43	21,40	21,40		34,60	34,44	34,41	34,38	34,30
I_{2a-2n}, A	21,29	21,29	21,09	21,09	21,06	21,08	21,10	21,08	21,04	21,10	21,08	21,02	21,02	21,09	21,02	21,01	21,01		-	-	-	-	-
I_{3a-3n}, A	14,47	14,46	14,43	14,43	14,44	14,45	14,48	14,47	14,42	14,45	14,43	21,54	21,51	21,49	21,50	21,51	21,51		-	-	-	-	-
I_{A-N}, mA	44,8	44,8	44,9	44,9	44,8	44,7	44,8	44,9	44,9	44,9	44,9	50,4	50,2	50,2	50,2	50,2	50,2		27,2	27,2	27,2	27,2	27,2

Table No. 2. Temperature-rises [K] given during the tests voltage transformer EMF-E145 serial No. 1HSE8851773

Winding	ΔT after Stage No. 1	ΔT after Stage No. 2	ΔT after Stage No. 3	ΔT_{per}
1a- 1n	35,78	42,87	36,31	65[1]
2a-2n	34,51	41,34	34,51	
3a-3n	30,71	36,97	30,42	
da-dn	31,10	38,07	31,20	
A-N	41,53	55,05	34,70	

Thermocouple No.	Thermocouple Location	ΔT after Stage No. 1	ΔT after Stage No. 2	ΔT after Stage No. 3	ΔT_{per}
1	Oil	6,80	8,80	7,17	55[1]
2	Under the flange of tank lid	6,35	8,08	6,20	40[2]
3	Enclosure of lower tank	4,62	5,81	4,50	

[1] acc. to IEC 61869-1 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3 sub-cl. 6.4.1, sub-cl. 7.2.2
[2] acc. to IEC 62271-1

ΔT - temperature-rise [K]; ΔT_{per} – permitted value in steady state [K]

Table No. 3. Power losses in windings

Winding	Stage No. 1			Stage No. 2			Stage No. 3		
	R [mΩ]	I [A]	P_{20} [W]	R [mΩ]	I [A]	P_{20} [W]	R [mΩ]	I [A]	P_{20} [W]
1a- 1n	60,47	21,5	24,5	61,97	21,4	24,4	60,59	34,4	62,9
2a-2n	58,70	21,1	23,0	60,11	21,1	22,9	-	-	-
3a-3n	37,17	14,4	6,9	38,00	21,5	15,4	-	-	-
	R [kΩ]	I [mA]	P_{20} [W]	R [kΩ]	I [mA]	P_{20} [W]	R [kΩ]	I [mA]	P_{20} [W]
A-N	20,92	44,9	36,4	21,89	50,2	45,5	20,43	27,2	13,3

P_{20} – power losses calculated for temperature 20°C

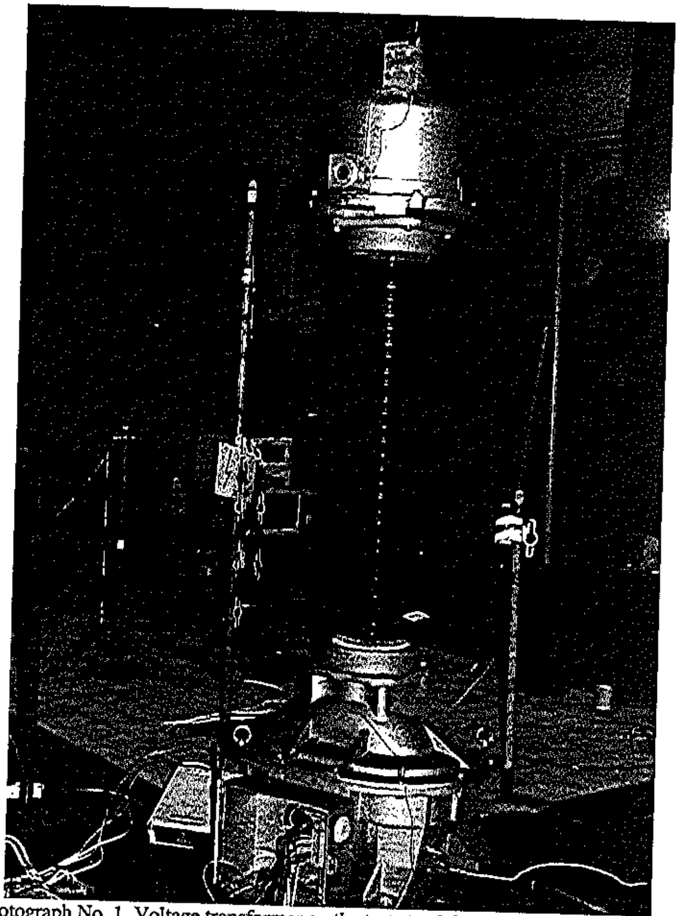
6. Summary

Results of temperature-rise test of tested voltage transformer type EMF-E145 are as follow:

1. Results of test with thermal limiting output for Stage No. 1 described in sub-cl. 5 of this Test Report: permitted temperature-rise limits were not exceeded;
2. Results of test with thermal limiting output for Stage No. 2 described in sub-cl. 5 of this Test Report: permitted temperature-rise limits were not exceeded;
3. Results of test with thermal limiting output for Stage No. 3 described in sub-cl. 5 of this Test Report: permitted temperature-rise limits were not exceeded;

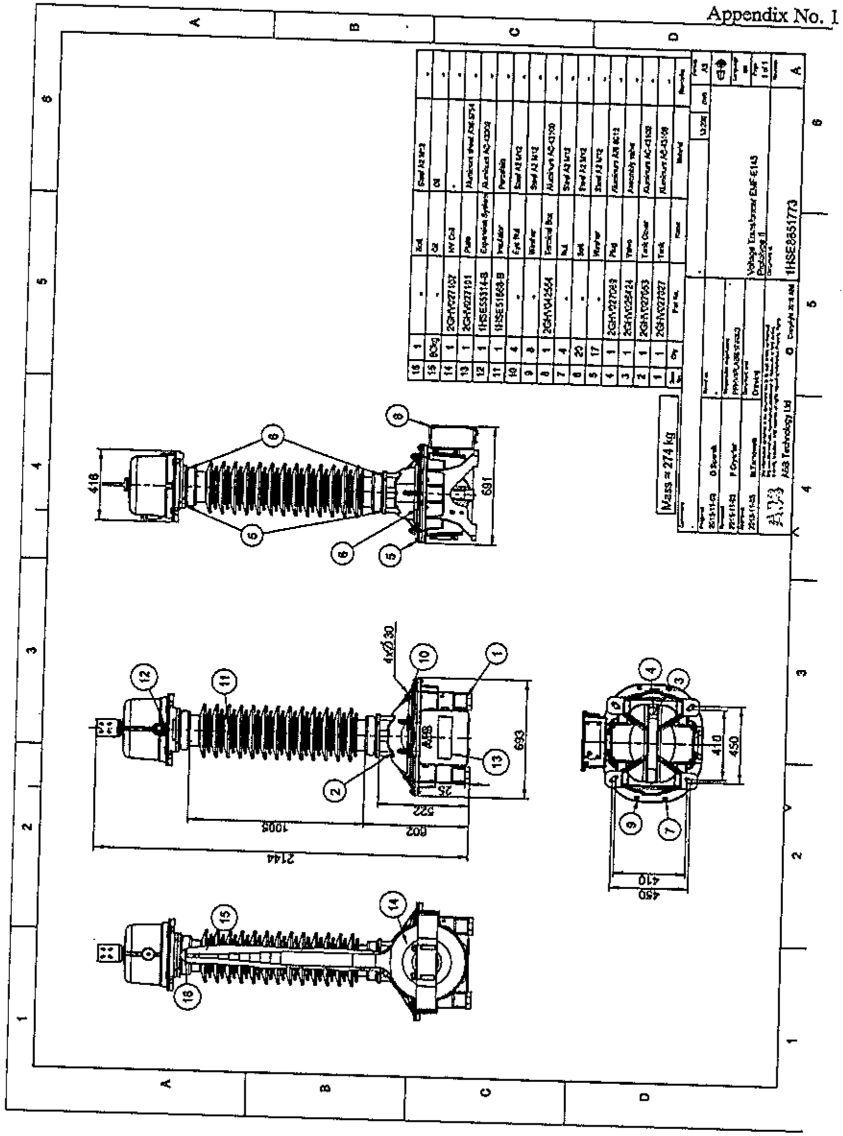
The tested voltage transformer met requirements of IEC 61869-1:2007 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 61869-3:2011 sub-cl. 6.4.1, sub-cl. 7.2.2 and IEC 62271-1:2007 standards.

6.	Photographic documentation



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

Appendix No. 1



Appendix No. 2

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

DECLARATION OF CONFORMITY No. 102/2015 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product comforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2015

Additional Information:
Serial numbers: **1HSE8851773;**

Place and date of issue of declaration

Przasnysz 29.10.2015

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

Kierownik Operacyjny PPHV
ABB Sp. z o.o.
Oddział w Przasnyszu

(Name) (Signature)

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ABB	ZCCO Corporate Research	9ADB008898		
Issued by department: ZCCO/Poland/SST	Last edit date: 2015-05-25	Lang.: English	Revision: 1.0	Page: 1/37
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Approved by: Marek Florkowski/PLCRC		Final Approval Date: 2015-05-21		

Technical_Note.dot Rev 1.00

Electronic document

Technical report

Simulation Support Team

Case submitted by	Marcin Tarnowski
Business Unit	PPHV
Type of analysis (used tool)	ABAQUS (seismic analysis)
Description of analysis	Seismic analysis different variants of current, voltage and combined transformers (PA123a / PA145a, PV123, PVA123a / PVA145a) according to guidelines described in IEC standard. Consideration of seismic, wind, and dead loads.

Executive summary

This report covers investigation related to seismic analysis of HV Instrument transformers (PV123, PA123a /PA145a, PVA123a /PVA145a) subjected to various load scenarios. Simulation covered the following load conditions: dead load, wind load, terminal force load, seismic load (AF5 - 0.5 g). Analysis showed that all designs are satisfying required safety criteria.

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1 INTRODUCTION

The goal of the analysis was to evaluate seismic performance of PA123a /PA145a (see 8.1), PV123 (see 8.2), PVA145a/PVA123a (8.3) type transformers. Simulation was done using guidelines of IEC TR 62271-300 standard. For more information please see [1].

Computations concerned evaluation of stress field distribution and maximum bending moment between flange and insulator. Present report describes used simulation technique, analysis steps, loads and boundary conditions variations and summarizes obtained results.

2 SIMULATION SOFTWARE

All simulations were performed using Abaqus/CAE package. Abaqus includes FEM (finite element method) solver, pre- and post processor and enables performing many types of multiphysics simulations: mechanical, thermal, acoustic, piezoelectric, seismic, and others.

Parts and assemblies can be created in Abaqus, or they can be imported from CAD systems using native file formats. Abaqus functionality enables to define materials, interactions, loads, boundary conditions, mesh. User is also available to set up simulation parameters such as pre-processing memory. It is always possible to change all simulation settings and properties, because they're all parameterized.

Simulation results can be visualized in Abaqus postprocessor or in external software, which is able to import simulation results in Abaqus format. In postprocessor user can view all predefined field outputs, show or hide part instances, create cross-sections, make animations, automatically generate reports, diagnose model (warnings, errors). For more information about ABAQUS please see [2].

3 SIMULATION SETUP

Analysis has been made using Finite Element Method.

3.1 Simulation procedure

According to [1] analysis included three main simulation steps:

- Static load:
  - Wind load.
  - Terminal load.
  - Gravitational load.
- Natural frequency extraction.
- Dynamic analysis.

3.2 Simulation steps

Simulation consisted of three main simulation steps.

3.2.1 Natural frequency extraction

In the first simulation step natural frequency extraction was performed. The frequency extraction procedure performs eigenvalue extraction to calculate the natural frequencies and the corresponding mode shapes of a system.

The eigenvalue problem for the natural frequencies of an undamped finite element model can be described by equation (3-1):

$$(-\omega^2 M^{MN} + K^{MN})\phi^N = 0 \qquad (3\text{-}1)$$

where: M^{MN} – mass matrix (kg); K^{MN} – stiffness matrix (Pa), which includes initial stiffness effects if the base state (gravitational load); ϕ – eigenvector (the mode of vibration); M, N – degrees of freedom (-). Based on specification [1] one can assume that most critical frequency modes are in range of 0-35 Hz.

3.2.2 Response spectrum analysis

The response spectrum method is a convenient way of describing shock motion in terms of the maximum response of a single degree of freedom (1-DOF) oscillator of arbitrary natural period and damping ratio. Each data point of the response spectrum curve represents the peak response from a time history analysis of the earthquake applied to 1-DOF oscillator system. The ordinate defines the natural period at which the oscillator is tuned. Repeating the procedure for a great many frequencies defines a continuous curve for an assumed level of damping.

A spectral response analysis estimates the maximum displacement of the structure during a 'design' shock load without recourse of direct integration. Finite element implementation of the response spectrum calculate the response of each mode independent, and then combine the scaled response one of a number of established combination rules, to give an estimate of peak response. Spectrum plot used in simulation is presented in Figure 1.

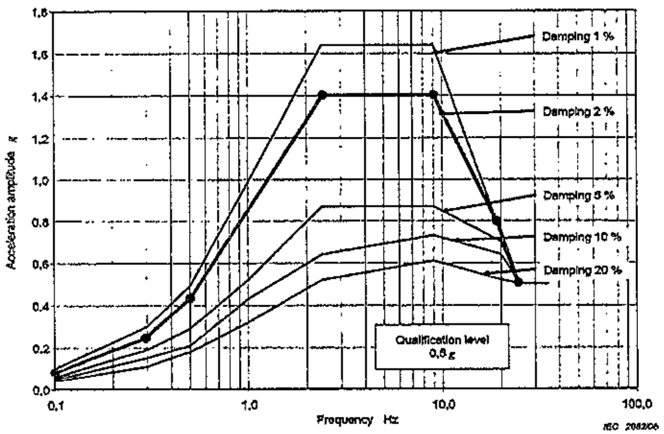

Figure 1. *Design response spectrum – 2% damping (red curve)*

3.3 Loads and boundary conditions

3.3.1 Loads

The following static load scenarios have been considered

1. Gravitational load, g=9.81 m/s^2.
2. Terminal operating load, acc. to [3]. According to Table 14, page 90 terminal force are adequate to rated voltage and current level. Applied force values were the following:
   a. **PA123a /PA145a:** Longitudinal force-1250 N, Transversal force – 1000 N, Vertical force – 1250 N.
   b. **PV123:** Longitudinal force-1750 N, Transversal force – 1250 N, Vertical force – 1500 N.
   c. **PVA123a/PVA145a:** Longitudinal force-1750 N, Transversal force – 1250 N, Vertical force – 1500 N.
3. Wind load, 10m/s load. Wind load has been represented as directional pressure evaluated according to drag force equation:

$$F_D = \frac{1}{2}\rho u^2 C_D A \qquad (3\text{-}1)$$

where: F_D – drag force [N], ρ – mass density of the fluid [kg/m^3], u – flow velocity [m/s], A – reference area [m^3], C_D – drag coefficient [-].

Evaluated pressure level for all designs was ca. p=71 Pa.

Seismic load have been predefined according design response spectrum described in the standard [1] – ground acceleration reference AF5. Main input parameters were the following:

- XZ base motion with vertical load equal to 50% of horizontal direction.
- YZ base motion with vertical load equal to 50% of horizontal direction.
- Damping ratio – 2% ([1], page 23, chapter 7.3.2 point b).

As the final outcome from the analysis static loads were combined with the most conservative seismic load.

3.3.2 Boundary conditions

Simulation assumes that the apparatus will be mounted on ground. An example of boundary conditions is presented in

During analysis model has been fixed at the bottom face of used test frame. General view of static loads and boundary conditions is presented in Figure 2. Area highlighted by red has been constrained (Y-rotation released). Base of the bottom tank has been supported in Y direction (as it is placed on the ground). Described boundary conditions have been used for all analyzed models.

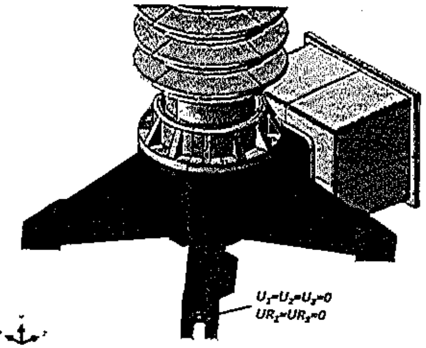

Figure 2. *Boundary conditions – general view*

3.4 Acceptance criteria

According to [1] the following acceptance criteria shall be met:

- Stresses observed at metallic parts should not exceed yield point of material.
- The maximum bending moment of the insulator should not exceed ultimate value. For more information please refer to [4] (Table 1, page 23).

3.5 Current transformer - PA 123a/PA 145a

This chapter gathers details related to FE model of current transformer **PA 123a/PA 145a**.

3.5.1 Model simplifications

For simulation requirements some areas of the model were simplified. Small geometrical features like casting rounding, chamfers were removed in order to improve mesh generation process. Details of the geometry and center of mass can be found in Figure 3. Red point indicates center of mass of the transformer.

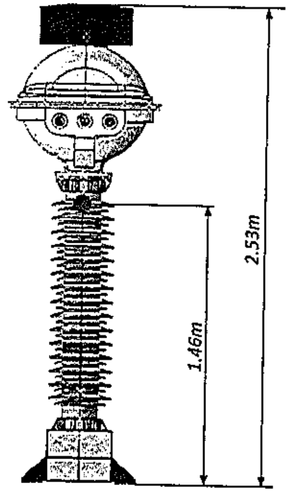

Figure 3. *Simplified representation of the PA 123a/PA 145a transformer*

Concrete between flange and ceramic insulator has been introduced using connector element with predefined rotational stiffness.

Because of the simulation method (dynamics based on modal analysis) components were connected together using bonded connection or conformal mesh.

3.6 Material and mass information

Component naming is presented in Figure 4.

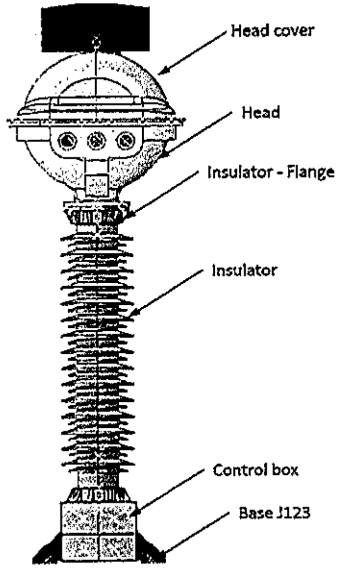

Figure 4. *Assembly – component naming*

Material and mass information is listed in Table 1

Table 1. *Mass and material data*

Drawing number	Component name	Material name	Mass [kg]	Young's modulus [MPa]	Yield strength [MPa]	Ultimate strength [MPa]
2GKA310015	Base J123	EN-AC 43200 (grade F)	16.5	69000	80	160
2GKA310404	Insulator	Porcelain	71	100000	140	
	Insulator - Flange	EN-AC 43200 (grade T6)	3.5	69000	180	220
2GKA414718	Head	EN-AC 43200 (grade F)	22.5	69000	80	160
2GKK314089	Head cover	EN-AC 43200 (grade F)	20	69000	80	160
	Coil	-	150			
2GKK311093R	Control box	EN-AC 43200 (grade F)	5.5	69000	80	160
	Oil		120			

The maximum allowable bending moment for ceramic insulator is equal to **M_B=13.3 kNm.**

3.7 Finite element (FE) model

General view of FE model is presented in Figure 5.

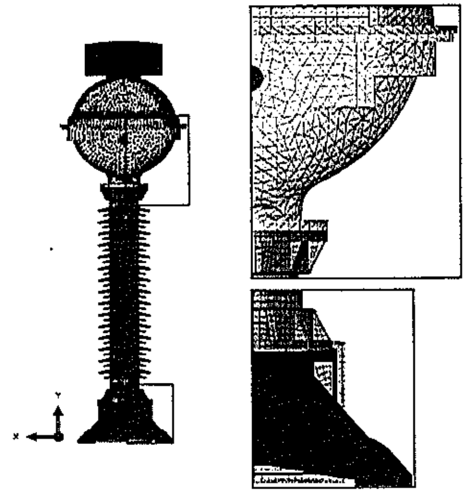

Figure 5. *FE model – general view*

Mesh statistics were the following:

- Total number of nodes: 533430
- Total number of elements: 242866
  - 210555 quadratic tetrahedral elements of type C3D10
  - 31050 quadratic hexahedral elements of type C3D20R
  - 1243 quadratic quadrilateral elements of type S8R
  - 18 quadratic triangular elements of type STRI65

Description of the coordinate system.

- X – 1st horizontal axis.
- Z – 2nd horizontal axis.
- Y – vertical axis.

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3.8 Voltage transformer - PV 123

This chapter gathers details related to FE model of voltage transformer PV 123.

3.8.1 Model simplifications

For simulation requirements some areas of the model were simplified. Small geometrical features like casting rounding, chamfers were removed in order to improve mesh generation process. Details of the geometry and center of mass can be found in Figure 6. Red point indicates center of mass of the transformer.

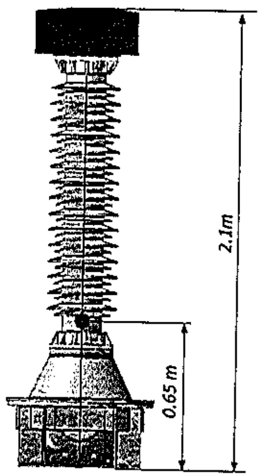

Figure 6. *Simplified representation of the PV 123 transformer*

Concrete between flange and ceramic insulator has been introduced using connector element with predefined rotational stiffness.

Because of the simulation method (dynamics based on modal analysis) components were connected together using bonded connection or conformal mesh.

3.9 Material and mass information

Component naming is presented in Figure 7.

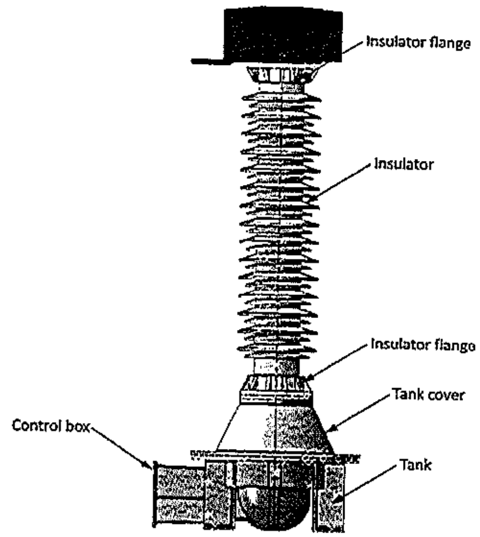

Figure 7. *Assembly – component naming*

Material and mass information is listed in Table 2.

Table 2. *Mass and material data*

Drawing number	Component name	Material name	Mass [Kg]	Young's modulus [MPa]	Yield strenght [MPa]	Ultimate strenght [MPa]
2GKK310150P	Bottom tank	EN-AC 43200 (grade F)	25	69000	80	160
2GKK310147P	Core	Steel	22.5	206000	300	370
2GKV314005	Tank cover	EN-AC 43200 (grade F)	15.5	69000	80	160
2GKA310404	Insulator	Porcelain	71	100000	140	
	Insulator flange	EN-AC 43200 (grade T6)	3.5	69000	180	220
	Coil	-	30			
2GKK311093R	Control box	EN-AC 43200 (grade F)	5.5	69000	80	160
	Oil		60			

The maximum allowable bending moment for ceramic insulator is equal to **M_B=13.3 kNm.**

3.10 Finite element (FE) model

General view of FE model is presented in Figure 8.

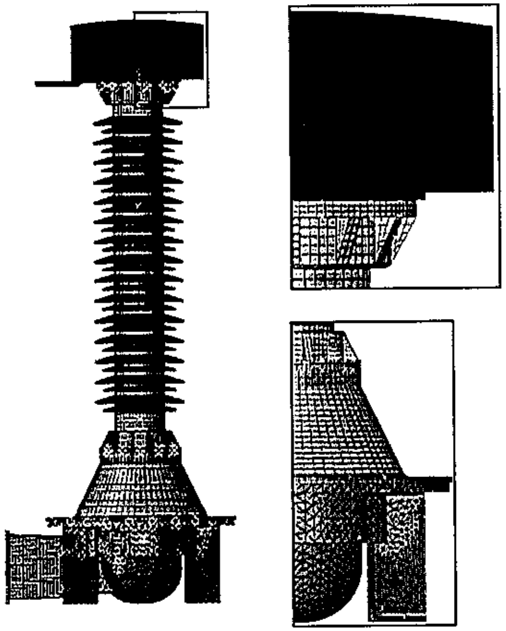

Figure 8. *FE model – general view*

Mesh statistics were the following:

- Total number of nodes: 608507
- Total number of elements: 236033
    - 4606 quadratic quadrilateral elements of type S8R
    - 58 quadratic triangular elements of type STRI65
    - 58965 quadratic hexahedral elements of type C3D20R
    - 8577 linear hexahedral elements of type C3D8R
    - 163827 quadratic tetrahedral elements of type C3D10

Description of the coordinate system.

- X – 1st horizontal axis.
- Z – 2nd horizontal axis.
- Y – vertical axis.

3.11 Combined transformer – PVA123a /PVA145a

This chapter gathers details related to FE model of combined transformer PVA123a /PVA145a.

3.11.1 Model simplifications

For simulation requirements some areas of the model were simplified. Small geometrical features like casting rounding, chamfers were removed in order to improve mesh generation process. Details of the geometry and center of mass can be found in Figure 9. Red point indicates center of mass of the transformer.

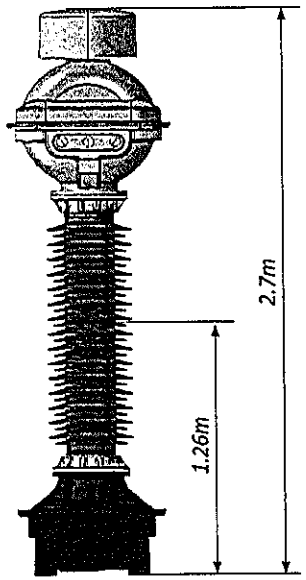

Figure 9. *Simplified representation of the PVA123a /PVA145a transformer*

Concrete between flange and ceramic insulator has been introduced using connector element with predefined rotational stiffness.

Because of the simulation method (dynamics based on modal analysis) components were connected together using bonded connection or conformal mesh.

3.12 Material and mass information

Component naming is presented in Figure 7.

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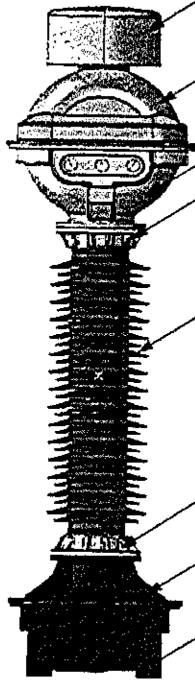

Figure 10. *Assembly – component naming*

Material and mass information is listed in Table 3.

Table 3. *Mass and material data*

Drawing number	Component name	Material name	Mass [kg]	Young's modulus [MPa]	Yield strength [MPa]	Ultimate strength [MPa]
2GKK314076	Tank	EN-AC 43200 (grade F)	25	69000	80	160
2GKK314084	Core	Steel	33.8	206000	300	370
2GKK314075	Tank cover	EN-AC 43200 (grade F)	18	69000	80	160
2GKK314070	Insulator	Porcelain	131	100000	140	
	Insulator flange	EN-AC 43200 (grade T6)	5	69000	180	220
2GKK314080	Head	EN-AC 43200 (grade F)	23.5	69000	80	160
2GKK314089	Head cover PVA-PA123a /PA145a-145	EN-AC 43200 (grade F)	23	69000	80	160
2GKK310902	Bellow	Stainless steel	5	190000	200	500
2GKK310014P	Below enclosure	EN-AC 43200 (grade F)	7	69000	80	160
-	Voltage coil	-	30	-	-	-
-	Current coil	-	150	-	-	-
2GKK310802	Epoxy Insulator	-	2.5	-	-	-
2GKK311093R	Control box	EN-AC 43200 (grade F)	5.5	69000	80	160
-	Oil		150	-	-	-

The maximum allowable bending moment for ceramic insulator is equal to **M_B=13.3 kNm.**

3.13 Finite element (FE) model

General view of FE model is presented in Figure 11.

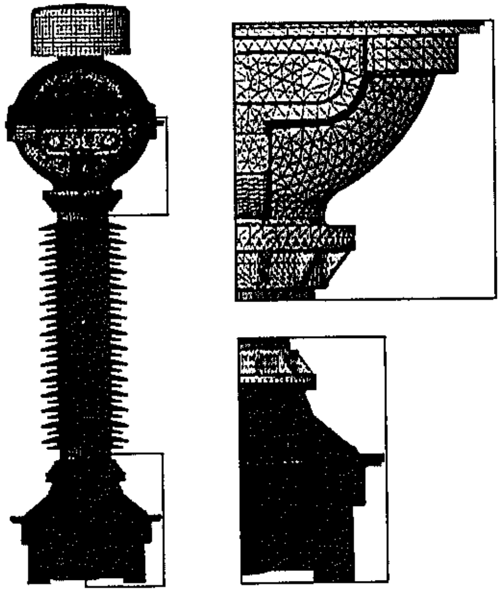

Figure 11. *FE model – general view*

Mesh statistics were the following:

- Total number of nodes: 1009580
- Total number of elements: 463007
  - 58507 quadratic hexahedral elements of type C3D20R
  - 300489 quadratic tetrahedral elements of type C3D10
  - 2519 linear quadrilateral elements of type S4R
  - 97 linear triangular elements of type S3
  - 9900 linear hexahedral elements of type C3D8R
  - 528 quadratic wedge elements of type C3D15
  - 90967 quadratic tetrahedral elements of type C3D10M

Description of the coordinate system.

- X – 1st horizontal axis.
- Z – 2nd horizontal axis.
- Y – vertical axis.

4 SIMULATION RESULTS

This chapter gathers simulation results evaluated in the analysis. Obtained outcome incudes static and the most conservative (design) seismic load.

4.1 PA123a /PA145a

4.1.1 Natural frequency extraction

Effective modal mass plot is presented Figure 12. Bubble size indicated amount of mass which participates in motion at specific frequency range. Based no presented plot one can see that the most critical modes were located between 6.9 – 8.2 Hz.

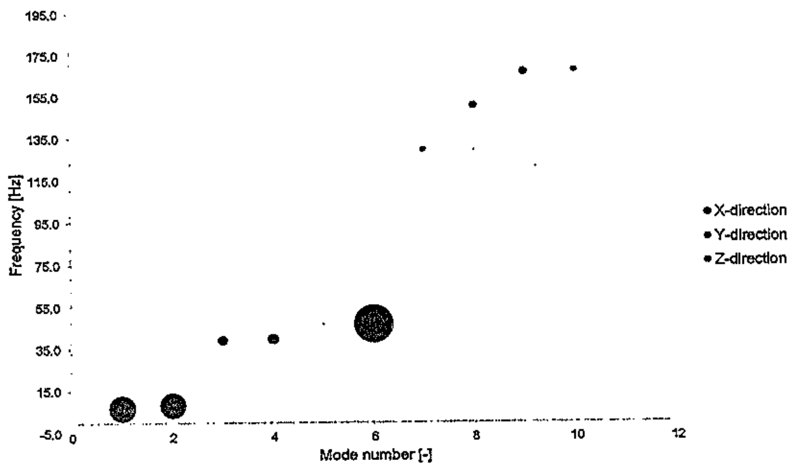

Figure 12. *Natural frequency extraction – effective modal mass*

Effective modes and associated with the shapes are presented in Figure 13.

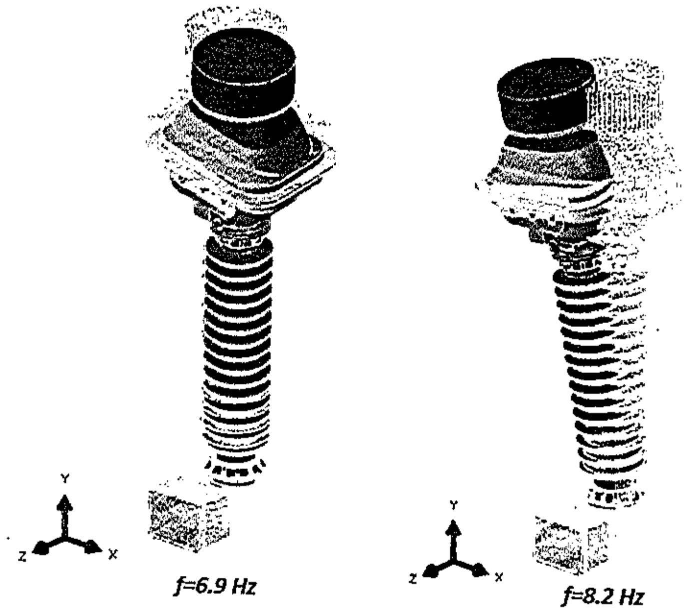

Figure 13. *Natural frequency extraction – mode shapes*

Summary of modal mass participation is listed in Table 4.

Table 4. *Modal mass participation – summary*

Mode no	Frequency [Hz]	X-direction	Y-direction	Z-direction
1	6.9	40%	0%	35%
2	8.2	34%	0%	40%
3	38.9	2%	0%	6%
4	39.7	6%	0%	2%
5	46.9	0%	0%	0%
6	98.7	0%	89%	0%
7	129.2	0%	0%	2%
8	150.3	4%	0%	0%
9	166.6	0%	0%	4%
10	167.4	2%	0%	0%

4.1.2 Dynamic analysis

Stress distribution for tank component is presented in Figure 14 and Figure 15. Stress scale has been limited to 80 MPa as the maximum allowable stress level.

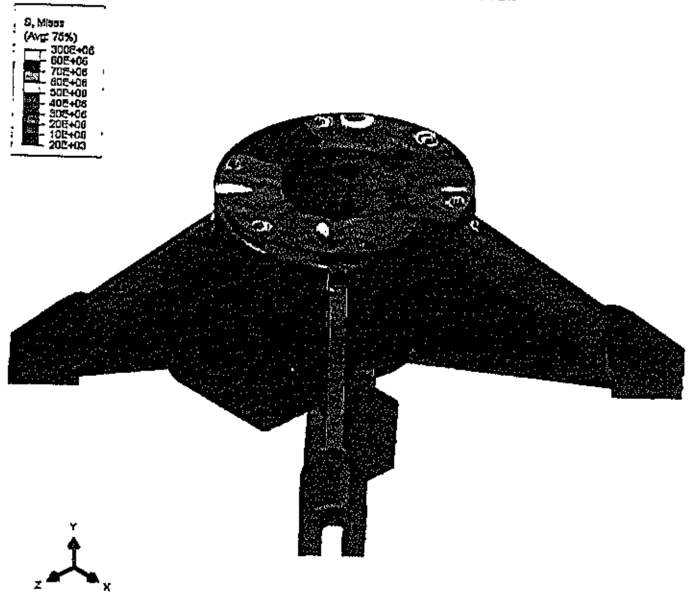

Figure 14. *Von-Mises stress [Pa] distribution – tank (view 01)*

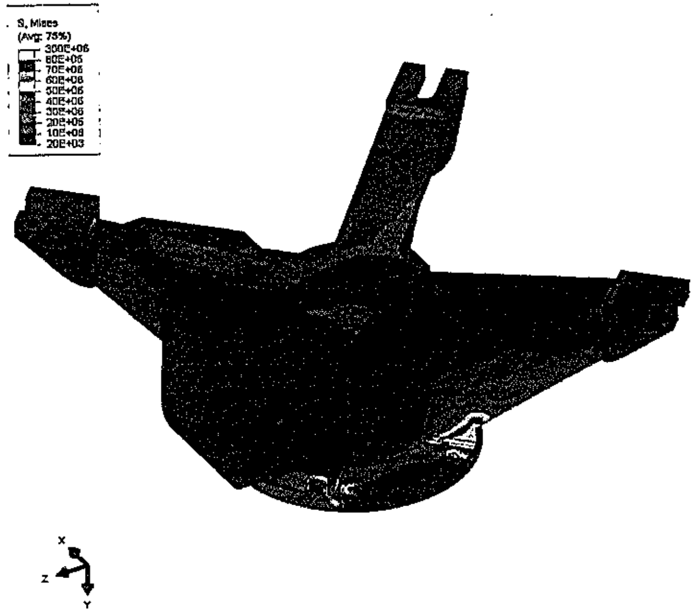

Figure 15. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 16.

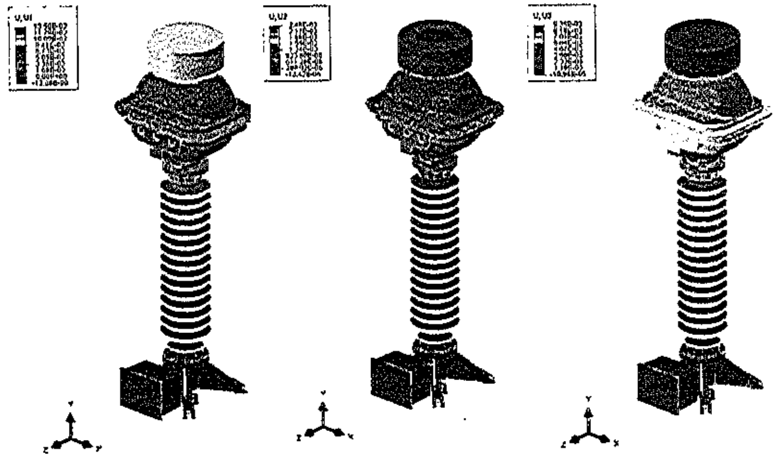

Figure 16.*Displacement [m] field - distribution*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=4848 Nm.
- M_z=7476 Nm.

Insulator has satisfied the maximum bending moment condition. One can observer that stresses evaluated at the base are slightly above yield point of material. Therefore small yielding may occur. One must have in mind that analysis did not cover possible casting imperfections. Design has been also verified according to AF3 seismic level (0.3 g Zero Period Acceleration). Stress distribution for such load scenario is presented from Figure 17 to Figure 18. Obtained stress level was significantly below yield point of material.

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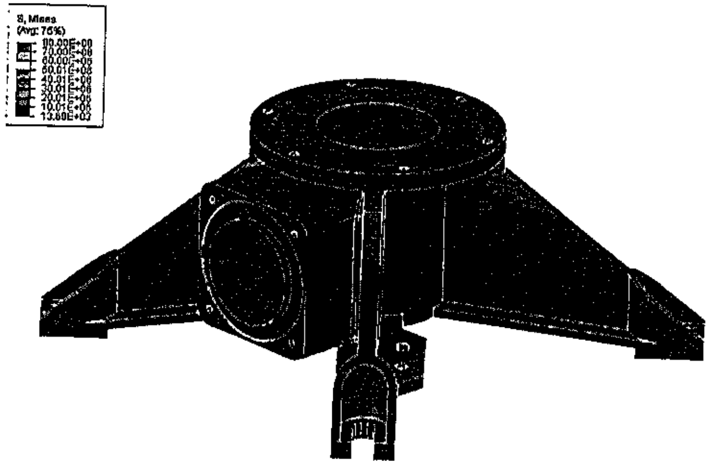


Figure 17. *Von-Mises stress [Pa] distribution (AF3) – tank (view 01)*

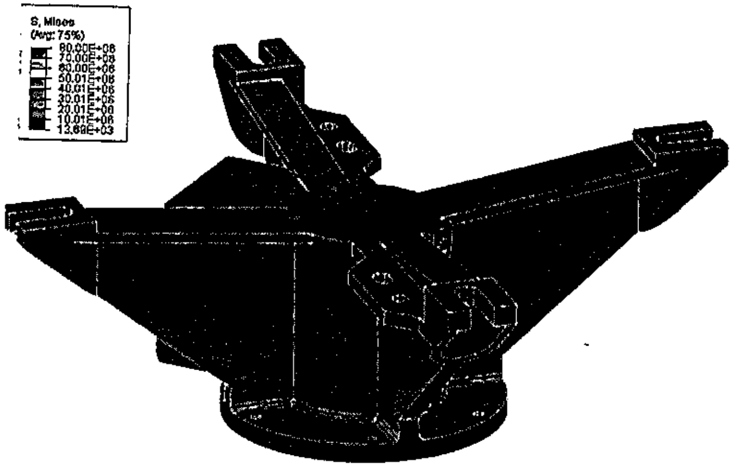


Figure 18. *Von-Mises stress [Pa] distribution (AF3) – tank (view 02)*

4.2 PV 123

4.2.1 Natural frequency extraction

Effective modal mass plot is presented Figure 19. Bubble size Indicated amount of mass which participates in motion at specific frequency range. Based no presented plot one can see that the most critical modes were located between 24.7– 25.3 Hz.

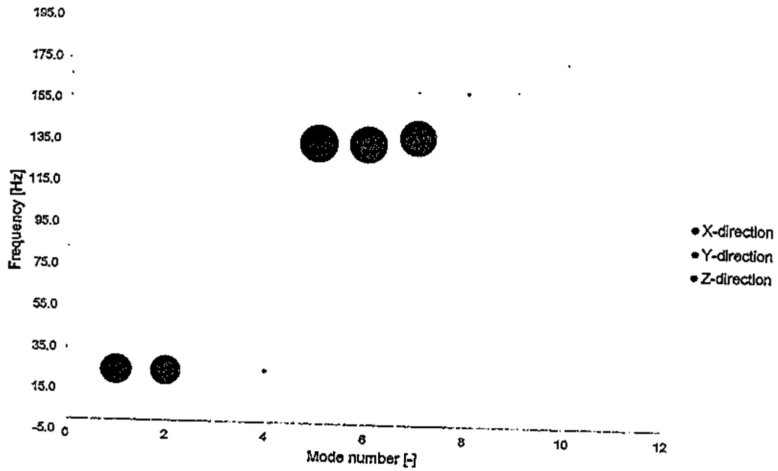
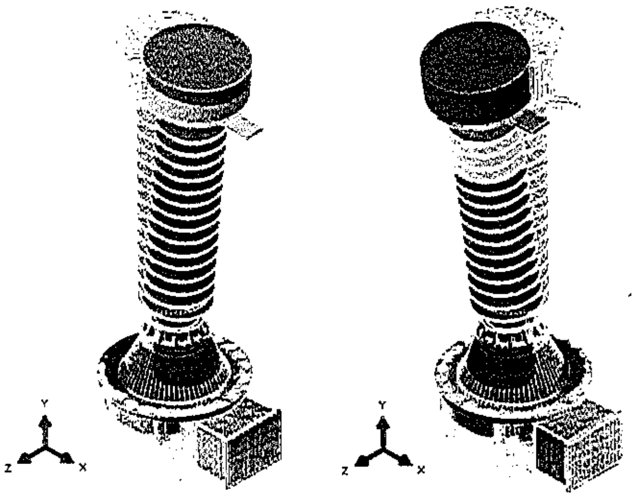


Figure 19. *Natural frequency extraction – effective modal mass*

Effective modes and associated with the shapes are presented in Figure 20.



f=24.7 Hz *f=25.3 Hz*

Figure 20. *Natural frequency extraction – mode shapes*

Summary of modal mass participation is listed in Table 5.

Table 5. *Modal mass participation – summary*

Mode no.	Frequency [Hz]	X-direction	Y-direction	Z-direction
1	24.7	24%	0%	0%
2	25.2	0%	0%	24%
3	25.4	0%	0%	0%
4	26.5	0%	0%	0%
5	135.5	37%	0%	0%
6	139.3	0%	0%	36%
7	161.3	0%	34%	0%
8	162.4	0%	0%	0%
9	175.8	0%	0%	0%
10	176.2	0%	0%	0%

4.2.2 Dynamic analysis

Stress distribution for tank component is presented in Figure 21 and Figure 22. As described in chapter 3.8.1 location of center of mass is close to the ground level, therefore expected bending moment and so the stress was low. One can see that the maximum stress level reached ca. 30 MPa and it was located at vicinity of coupling constraint. Stress level satisfies required safety condition.

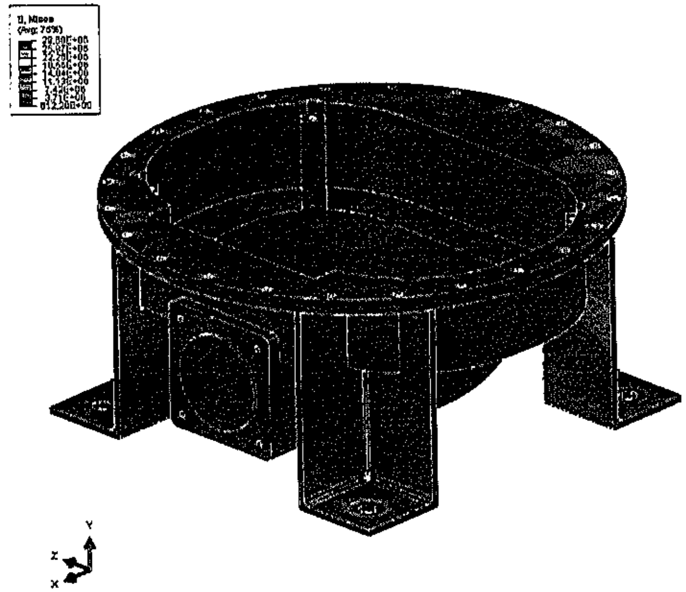


Figure 21. *Von-Mises stress [Pa] distribution – tank (view 01)*

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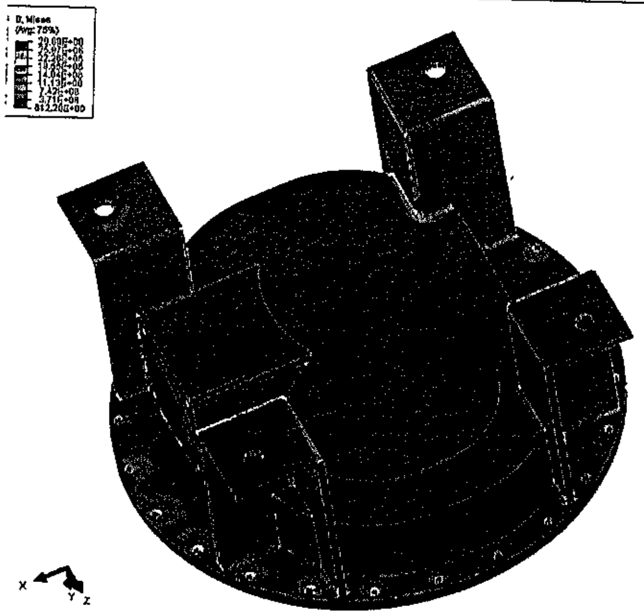

Figure 22. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 23.

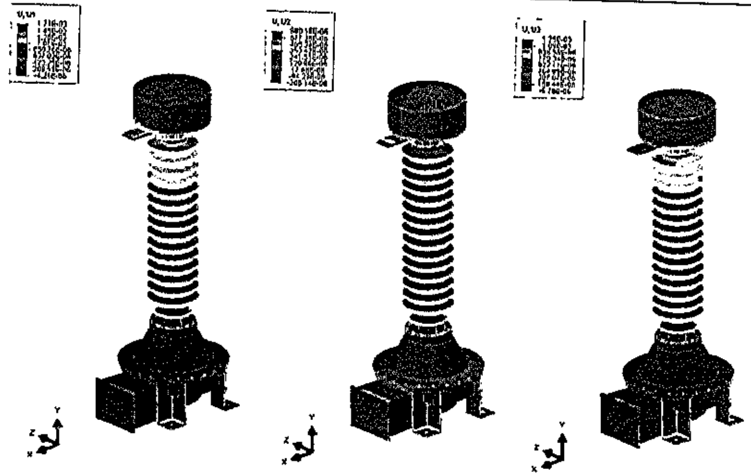

Figure 23.*Displacement [m] field - distribution*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=2079 Nm.
- M_z=2263 Nm.

Insulator has satisfied the maximum bending moment condition.

4.3 PVA123a /PVA145a

4.3.1 Natural frequency extraction

Effective modal mass plot is presented Figure 24. Bubble size indicated amount of mass which participates in motion at specific frequency range. Based no presented plot one can see that the most critical modes were located between 3.8– 4.1 Hz.

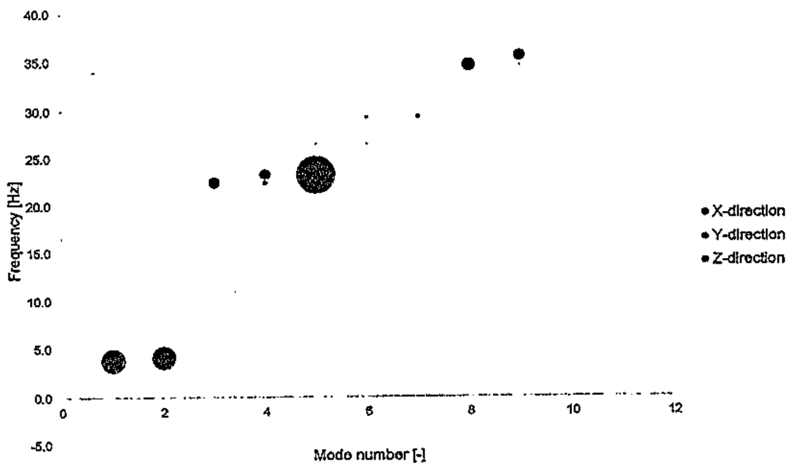

Figure 24. *Natural frequency extraction – effective modal mass*

Effective modes and associated with the shapes are presented in Figure 25.

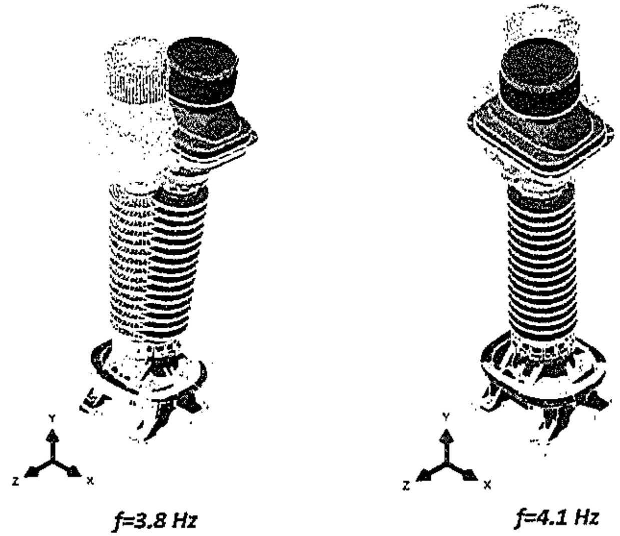

Figure 25. *Natural frequency extraction – mode shapes*

Summary of modal mass participation is listed in Table 6.

Table 6. *Modal mass participation – summary*

Mode no.	Frequency [Hz]	X-direction	Y-direction	Z-direction
1	3.8	35%	0%	32%
2	4.1	32%	0%	35%
3	22.4	7%	0%	0%
4	23.2	0%	2%	8%
5	26.5	0%	95%	0%
6	29.2	0%	0%	1%
7	29.3	1%	0%	0%
8	34.6	10%	0%	0%
9	35.5	0%	0%	8%
10	36.2	0%	0%	3%

4.3.2 Dynamic analysis

Stress distribution for tank component is presented in Figure 26 and Figure 27. One can see that the maximum stress level reached ca. 70 MPa. Stress level satisfies required safety condition.

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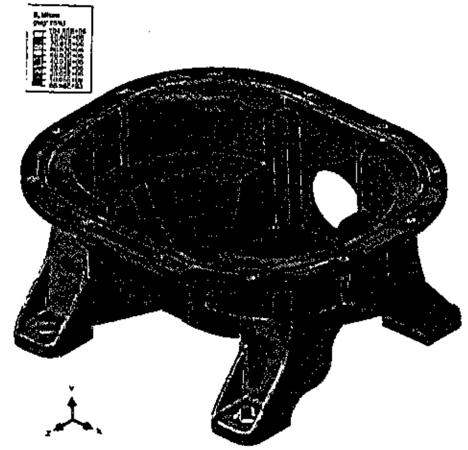

Figure 26. *Von-Mises stress [Pa] distribution – tank (view 01)*

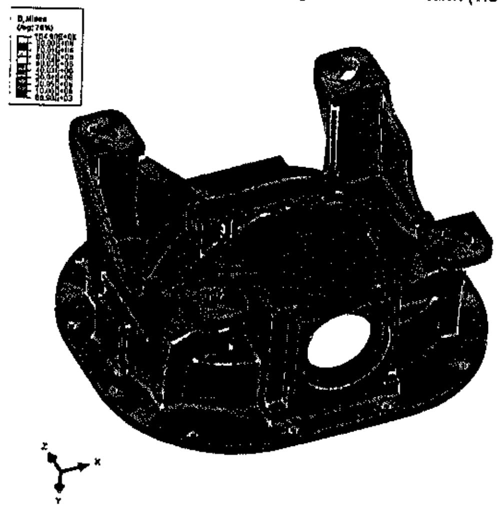

Figure 27. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 23.

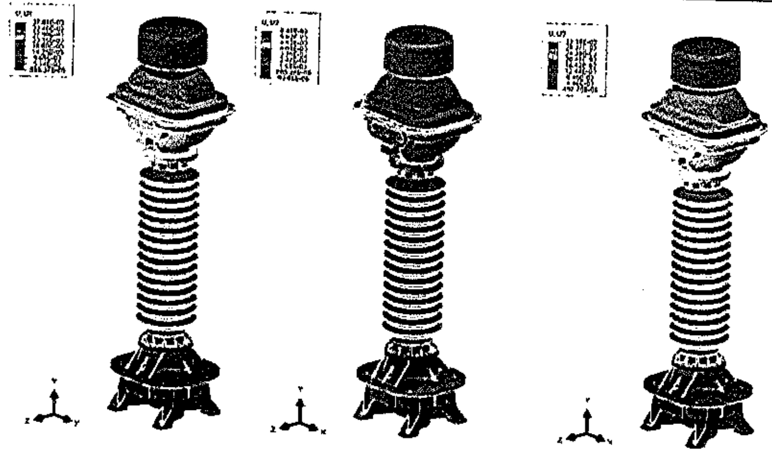

Figure 28. *Displacement [m] field - distribution*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=6864 Nm.
- M_z=7752 Nm.

Insulator has satisfied the maximum bending moment condition.

5 CONCLUSIONS

The goal of the analysis was to investigate family of HV Instrument Transformers using guidelines described in IEC 62271-300. Based on performed analysis main conclusions are the following:

- Current transformer PA 123a/PA 145a. This design has been investigated for two seismic levels: AF5 (0.5 g) and AF3 (0.3 g). For AF5 level stresses were above yield strength of material. These concentrations can be caused by sharp edges which are usually eliminated in real casting process. On the other hand one must have in mind that possible material imperfection were not considered in the simulation. For AF3 load scenario stresses were below yield strength of material. Bushing has satisfied required safety factor for both load scenarios.
- Voltage transformer - PV 123. Seismic level – AF5. Center of mass for this particular design is very close to the ground level. Therefore obtained level of stress and so bending moment was relatively low. Design satisfies required safety factors for AF5 seismic level.
- Combined transformer PVA 123a/PVA 145a. Seismic level – AF5. Obtained stress level was below yield strength of material. Bending moment was also below ultimate value. Whole design should be considered as safe.
- Damping factor used in the analysis was equal to 2%.
- Transformer oil has been modeled as uniformly distributed additional mass.

Disclaimer

The analysis documented herein has been prepared in accordance with reasonable standards of scientific endeavor and the best knowledge of the author(s).

The simulation results may depend on a variety of factors, including quality of input data, applied model simplifications and chosen numerical methods.

6 BIBLIOGRAPHY

[1] TR 62271-300 – *High voltage switchgear and controlgear – Part 300: Seismic qualification and alternating current circuit breakers*, Technical report. First edition:2006-11

[2] ABAQUS, *ABAQUS 6.13 Documentation*, DS Simulia, USA, www.simulia.com

[3] *IEC* **62271-100** – *High voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*, Technical report. Edition 2.0: 2008-04

[4] *IEC* **62155-100** – *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*, International standard. First edition: 2003-05

7 CHANGE HISTORY

Date	Revision	Author(s)	Change
2015-05-22	Rev. 1	Juszkiewicz Grzegorz	original document

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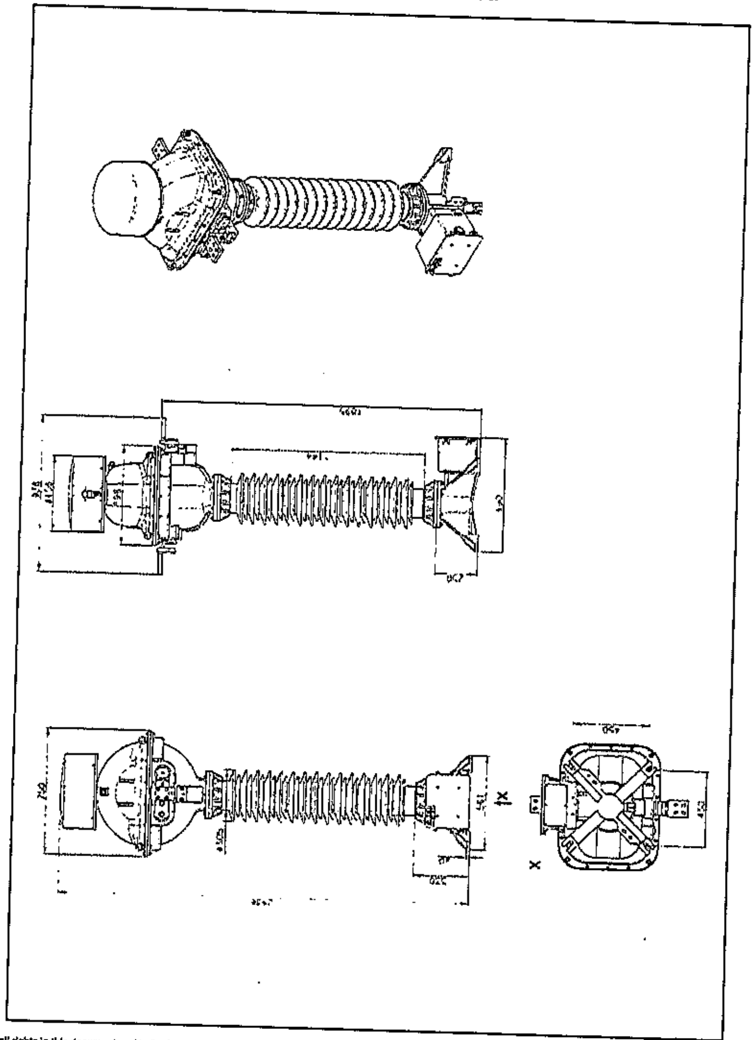
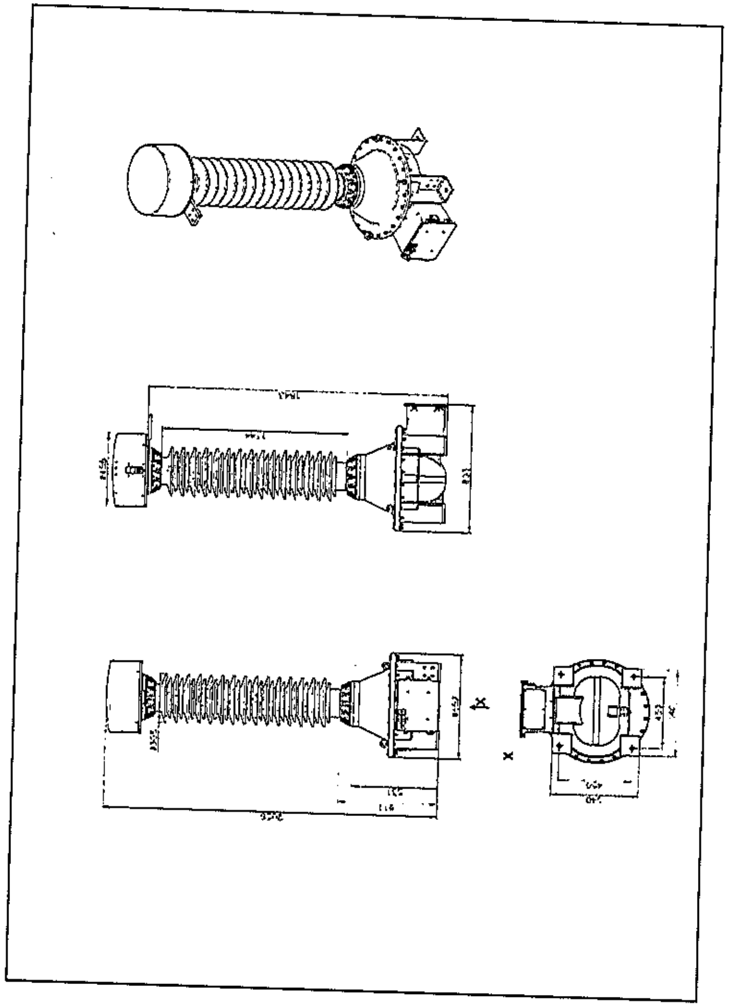
8 APPENDICES

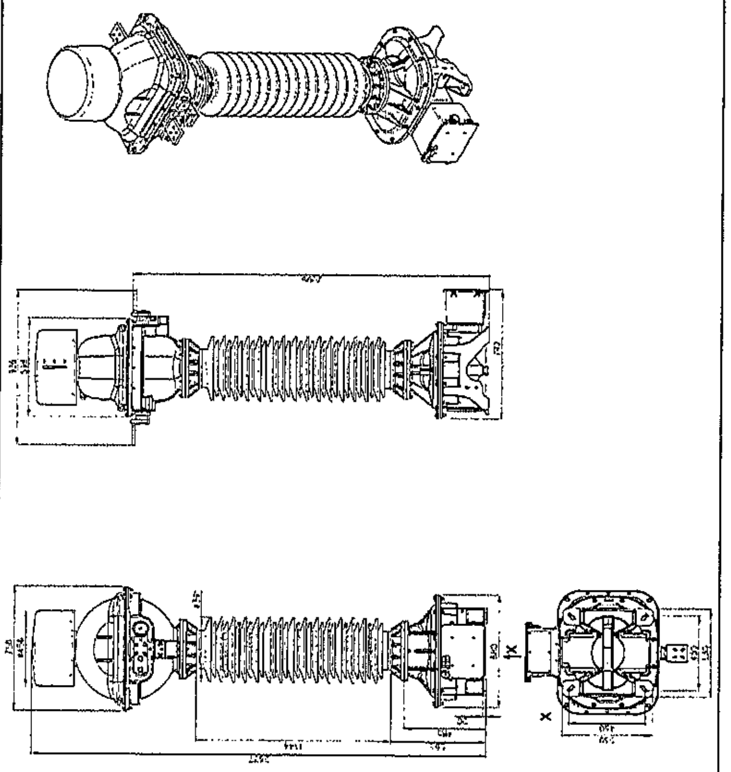
8.1 Current Instrument transformer PA123a/PA145a



8.2 Voltage Instrument transformer PV123



8.3 Combined Instrument transformer PVA123a /PVA145a



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Additional Author(s):				
Distribution: Marcin Tarnowski/PPHV, Pawel Grysztar/PPHV, Jaroslaw Duzdowski/PPHV, Dariusz Siperek/PPHV, Piotr Mikulski/PPHV, Przemyslaw Nasierowski/PPHV Piotr Saj/PLCRC, Marek Florkowski/PLCRC				
Keywords: simulation, FE method, seismic analysis, frequency modes, response spectrum				
Approved by:		Final Approval Date: 2015-08-17		

Technical_Note.dot Rev 1.00

Electronic document

Technical report

Simulation Support Team

Case submitted by	Marcin Tarnowski
Business Unit	PPHV
Type of analysis (used tool)	ABAQUS (seismic analysis)
Description of analysis	Seismic analysis different variants of current, voltage and combined transformers (PA123a/PA145a, PV123, PVA123a/PVA 145a) according to guidelines described in IEEE 693 standard. Consideration of seismic and dead loads.

Executive summary

This report covers investigation related to seismic analysis of HV Instrument transformers (PV123, PA123a /PA145a, PVA123a /PVA145a) subjected to various load scenarios. Simulation covered the following load conditions: dead load, terminal force load, seismic load (Moderate - 0.25g; High – 0.5g). Analysis showed that designs: **PA123a/PA145a** and **PVA123a /PVA145a** can withstand moderate seismic level, while **PV123** can withstand high seismic load scenario.

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1 INTRODUCTION

The goal of the analysis was to evaluate seismic performance of PA123a/PA145a (see 8.1), PV123 (see 8.2), PVA145a/PVA123a (see 8.3) type transformers. Simulation was done using guidelines of IEEE 693 standard. For more information please see [1].

Computations concerned evaluation of stress field distribution and maximum bending moment between flange and insulator. Present report describes used simulation technique, analysis steps, loads and boundary conditions variations and summarizes obtained results.

2 SIMULATION SOFTWARE

All simulations were performed using Abaqus/CAE package. Abaqus includes FEM (finite element method) solver, pre- and post processor and enables performing many types of multiphysics simulations: mechanical, thermal, acoustic, piezoelectric, seismic, and others.

Parts and assemblies can be created in Abaqus, or they can be imported from CAD systems using native file formats. Abaqus functionality enables to define materials, interactions, loads, boundary conditions, mesh. User is also available to set up simulation parameters such as pre-processing memory. It is always possible to change all simulation settings and properties, because they're all parameterized.

Simulation results can be visualized in Abaqus postprocessor or in external software, which is able to import simulation results in Abaqus format. In postprocessor user can view all predefined field outputs, show or hide part instances, create cross-sections, make animations, automatically generate reports, diagnose model (warnings, errors). For more information about ABAQUS please see [2].

3 SIMULATION SETUP

Analysis has been made using Finite Element Method.

3.1 Simulation procedure

According to [1] analysis included three main simulation steps:

- Static load:
    - Terminal load.
    - Gravitational load.
- Natural frequency extraction.
- Dynamic analysis.

3.2 Simulation steps

Simulation consisted of three main simulation steps.

3.2.1 Natural frequency extraction

In the first simulation step natural frequency extraction was performed. The frequency extraction procedure performs eigenvalue extraction to calculate the natural frequencies and the corresponding mode shapes of a system.

The eigenvalue problem for the natural frequencies of an undamped finite element model can be described by equation (3-1):

$$(-\omega^2 M^{MN} + K^{MN})\phi^N = 0 \qquad (3\text{-}1)$$

where: M^{MN} – mass matrix (kg); K^{MN} – stiffness matrix (Pa), which includes initial stiffness effects if the base state (gravitational load); ϕ – eigenvector (the mode of vibration); M, N – degrees of freedom (-). Based on specification [1] one can assume that most critical frequency modes are in range of 0-35 Hz.

3.2.2 Response spectrum analysis

The response spectrum method is a convenient way of describing shock motion in terms of the maximum response of a single degree of freedom (1-DOF) oscillator of arbitrary natural period and damping ratio. Each data point of the response spectrum curve represents the peak response from a time history analysis of the earthquake applied to 1-DOF oscillator system. The ordinate defines the natural period at which the oscillator is tuned. Repeating the procedure for a great many frequencies defines a continuous curve for an assumed level of damping.

A spectral response analysis estimates the maximum displacement of the structure during a 'design' shock load without recourse of direct integration. Finite element implementation of the response spectrum calculate the response of each mode independent, and then combine the scaled response one of a number of established combination rules, to give an estimate of peak response. Spectrum plot used in simulation is presented in Figure 1.

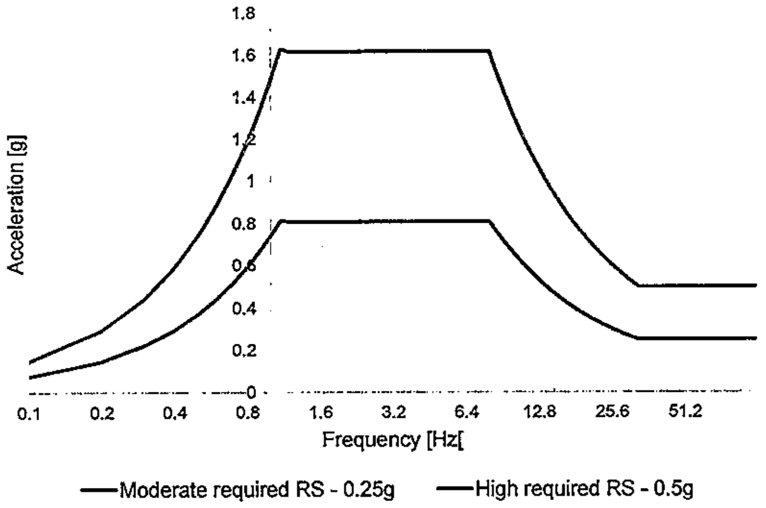

Figure 1. *Design response spectrum (RS) – 2% damping*

3.3 Loads and boundary conditions

3.3.1 Loads

The following static load scenarios have been considered

1. Gravitational load, g=9.81 m/s^2.
2. Terminal operating load. These load conditions were specified according to [3] (*Table 7 – Static withstand test loads*). For considered voltage-current range static withstand force (Load class II) should be equal to 3000 N. With respect to '*NOTE 1 The sum of the loads acting in routinely operating conditions should not exceed 50% of the specified withstand test load*', maximum operating force is equal to **1500 N**.

Seismic load have been predefined according design response spectrum described in the standard [1] – ground acceleration reference – Moderate/High Required Response Spectrum. Main input parameters were the following:

- XYZ base motion with vertical load (Y) equal to 80% of horizontal direction.
- Damping ratio – 2%.

As the final outcome from the analysis static loads were combined with the seismic load.

3.3.2 Boundary conditions

Simulation assumes that the apparatus will be mounted on ground. During analysis model has been fixed at the bottom face of used test frame. General view of static loads and boundary conditions is presented in Figure 2. Area highlighted by red has been constrained (Y-rotation released). Base of the bottom tank has been supported in Y direction (as it is placed on the ground). Described boundary conditions have been used for all analyzed models.

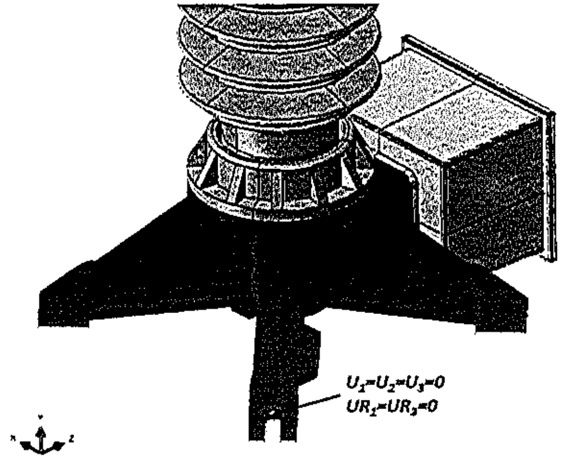

Figure 2. *Boundary conditions – general view*

3.4 Acceptance criteria

With respect to the standard [1] the following acceptance criteria were used

- Seismic load should be combined with dead load and possible normal operating loads.
- The maximum allowable bending moment shall not exceed **6.65 kNm** (50% of ultimate load/stress)
- Aluminum components shall not exceed **73 MPa** (minimum ultimate tensile strength divided by 2.2 safety factor).

3.5 Current transformer - PA 123a/PA 145a

This chapter gathers details related to FE model of current transformer **PA 123a/PA 145a.**

3.5.1 Model simplifications

For simulation requirements some areas of the model were simplified. Small geometrical features like casting rounding, chamfers were removed in order to improve mesh generation process. Details of the geometry and center of mass can be found in Figure 3. Red point indicates center of mass of the transformer.

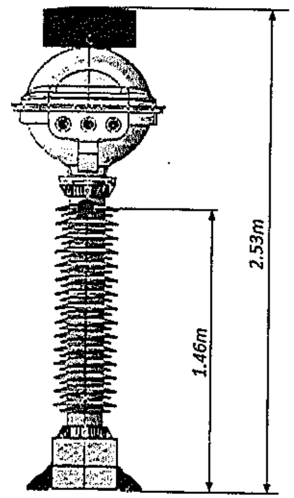

Figure 3. *Simplified representation of the PA 123a/PA 145a transformer*

Concrete between flange and ceramic insulator has been introduced using connector element with predefined rotational stiffness.

Because of the simulation method (dynamics based on modal analysis) components were connected together using bonded connection or conformal mesh.

3.6 Material and mass information

Component naming is presented in Figure 4.

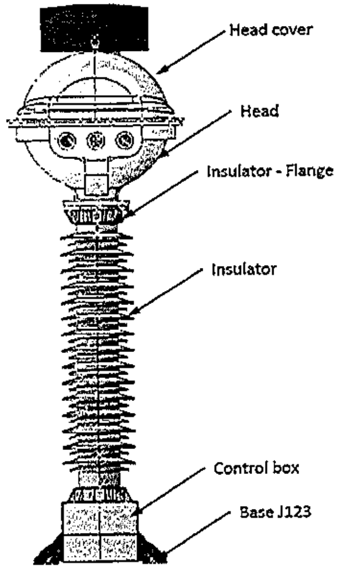

Figure 4. *Assembly – component naming*

Material and mass information is listed in Table 1

Table 1. *Mass and material data*

Drawing number	Component name	Material name	Mass [kg]	Young's modulus [MPa]	Yield strength [MPa]	Ultimate strength [MPa]
2GKA310015	Base J123	EN-AC 43200 (grade F)	16.5	69000	80	160
2GKA310404	Insulator	Porcelain	71	100000	140	
	Insulator - Flange	EN-AC 43200 (grade T6)	3.5	69000	180	220
2GKA414718	Head	EN-AC 43200 (grade F)	22.5	69000	80	160
2GKK314089	Head cover	EN-AC 43200 (grade F)	20	69000	80	160
	Coil	-	150			
2GKK311093R	Control box	EN-AC 43200 (grade F)	5.5	69000	80	160
	Oil		120			

The ultimate bending moment for ceramic insulator is equal to **M_B=13.3 kNm.**

3.7 Finite element (FE) model

General view of FE model is presented in Figure 5.

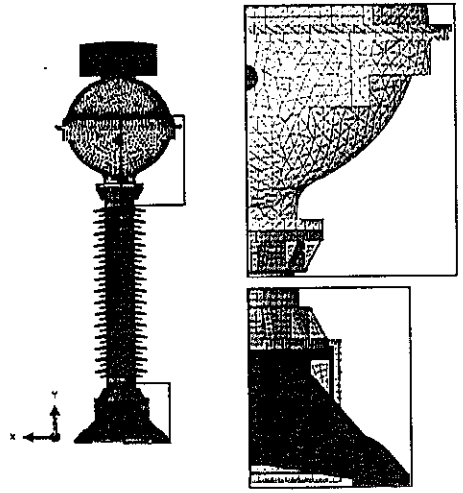

Figure 5. *FE model – general view*

Mesh statistics were the following:

- Total number of nodes: 533430
- Total number of elements: 242866
  - 210555 quadratic tetrahedral elements of type C3D10
  - 31050 quadratic hexahedral elements of type C3D20R
  - 1243 quadratic quadrilateral elements of type S8R
  - 18 quadratic triangular elements of type STRI65

Description of the coordinate system.

- X – 1st horizontal axis.
- Z – 2nd horizontal axis.
- Y – vertical axis.

3.8 Voltage transformer - PV 123

This chapter gathers details related to FE model of voltage transformer **PV 123**.

3.8.1 Model simplifications

For simulation requirements some areas of the model were simplified. Small geometrical features like casting rounding, chamfers were removed in order to improve mesh generation process. Details of the geometry and center of mass can be found in Figure 6. Red point indicates center of mass of the transformer.

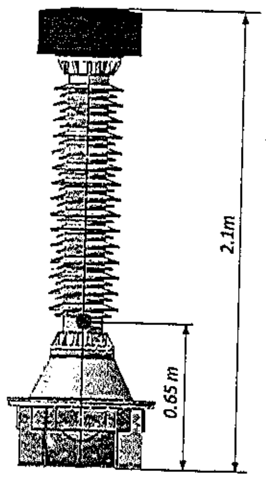

Figure 6. *Simplified representation of the PV 123 transformer*

Concrete between flange and ceramic insulator has been introduced using connector element with predefined rotational stiffness.

Because of the simulation method (dynamics based on modal analysis) components were connected together using bonded connection or conformal mesh.

3.9 Material and mass information

Component naming is presented in Figure 7.

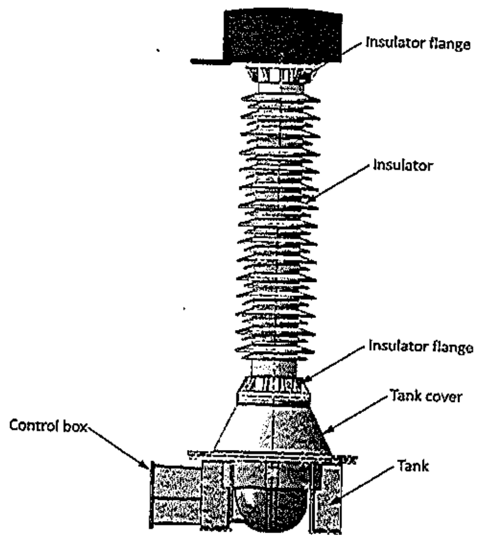

Figure 7. *Assembly – component naming*

Material and mass information is listed in Table 2.

Table 2. *Mass and material data*

Drawing number	Component name	Material name	Mass [kg]	Young's modulus [MPa]	Yield strenght [MPa]	Ultimate strenght [MPa]
2GKK310150P	Bottom tank	EN-AC 43200 (grade F)	25	69000	80	160
2GKK310147P	Core	Steel	22.5	206000	300	370
2GKV314005	Tank cover	EN-AC 43200 (grade F)	15.5	69000	80	160
2GKA310404	Insulator	Porcelain	71	100000	140	
	Insulator flange	EN-AC 43200 (grade T6)	3.5	69000	180	220
	Coil	-	30			
2GKK311093R	Control box	EN-AC 43200 (grade F)	5.5	69000	80	160
	Oil		60			

The ultimate bending moment for ceramic insulator is equal to M_B=13.3 kNm.

3.10 Finite element (FE) model

General view of FE model is presented in Figure 8.

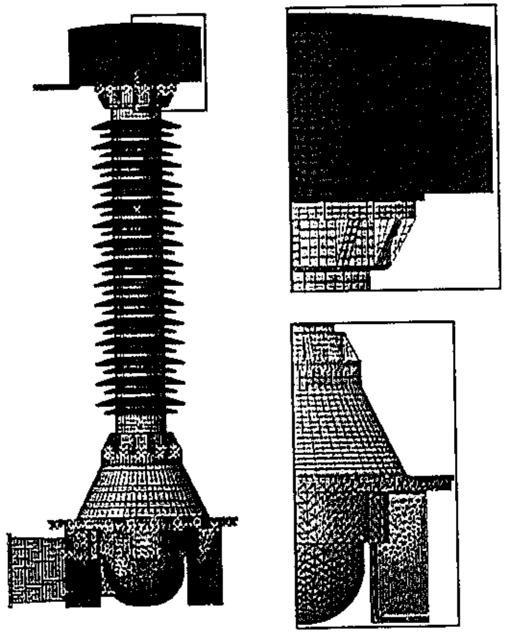

Figure 8. *FE model – general view*

Mesh statistics were the following:

- Total number of nodes: 608507
- Total number of elements: 236033
  - 4606 quadratic quadrilateral elements of type S8R
  - 58 quadratic triangular elements of type STRI65
  - 58965 quadratic hexahedral elements of type C3D20R
  - 8577 linear hexahedral elements of type C3D8R
  - 163827 quadratic tetrahedral elements of type C3D10

Description of the coordinate system.

- X – 1st horizontal axis.
- Z – 2nd horizontal axis.
- Y – vertical axis.

3.11 Combined transformer – PVA123a /PVA145a

This chapter gathers details related to FE model of combined transformer PVA123a /PVA145a.

3.11.1 Model simplifications

For simulation requirements some areas of the model were simplified. Small geometrical features like casting rounding, chamfers were removed in order to improve mesh generation process. Details of the geometry and center of mass can be found in Figure 9. Red point indicates center of mass of the transformer.

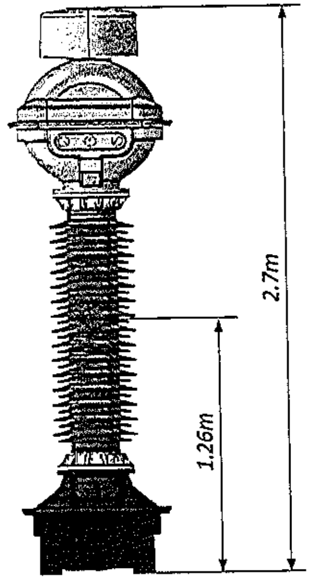

Figure 9. *Simplified representation of the PVA123a /PVA145a transformer*

Concrete between flange and ceramic insulator has been introduced using connector element with predefined rotational stiffness.

Because of the simulation method (dynamics based on modal analysis) components were connected together using bonded connection or conformal mesh.

3.12 Material and mass information

Component naming is presented in Figure 10

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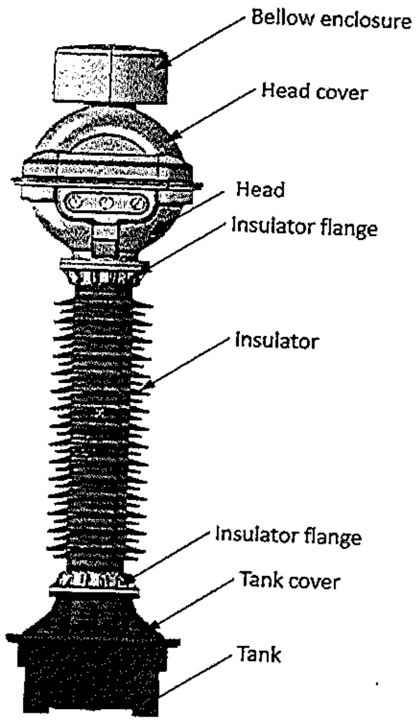

Figure 10. *Assembly – component naming*

Material and mass information is listed in Table 3.

Table 3. *Mass and material data*

Drawing number	Component name	Material name	Mass [kg]	Young's modulus [MPa]	Yield strength [MPa]	Ultimate strength [MPa]
2GKK314076	Tank	EN-AC 43200 (grade F)	25	69000	80	160
2GKK314084	Core	Steel	33.8	206000	300	370
2GKK314075	Tank cover	EN-AC 43200 (grade F)	18	69000	80	160
2GKK314070	Insulator	Porcelain	131	100000	140	
	Insulator flange	EN-AC 43200 (grade T6)	5	69000	180	220
2GKK314080	Head	EN-AC 43200 (grade F)	23.5	69000	80	160
2GKK314089	Head cover PVA-PA123A /PA145A-145	EN-AC 43200 (grade F)	23	69000	80	160
2GKK310902	Bellow	Stainless steel	5	190000	200	500
2GKK310014P	Below enclosure	EN-AC 43200 (grade F)	7	69000	80	160
-	Voltage coil	-	30	-	-	-
-	Current coil	-	150	-	-	-
2GKK310802	Epoxy Insulator	-	2.5	-	-	-
2GKK311093R	Control box	EN-AC 43200 (grade F)	5.5	69000	80	160
-	Oil		150	-	-	-

The ultimate bending moment for ceramic insulator is equal to **M_B=13.3 kNm.**

3.13 Finite element (FE) model

General view of FE model is presented in Figure 11.

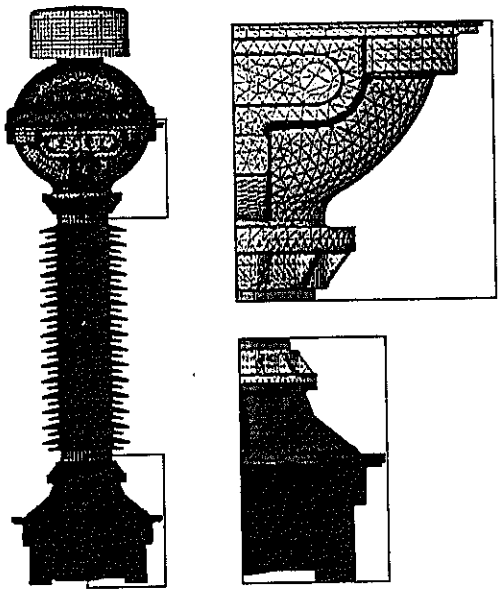

Figure 11. *FE model – general view*

Mesh statistics were the following:

- Total number of nodes: 1009580
- Total number of elements: 463007
  - 58507 quadratic hexahedral elements of type C3D20R
  - 300489 quadratic tetrahedral elements of type C3D10
  - 2519 linear quadrilateral elements of type S4R
  - 97 linear triangular elements of type S3
  - 9900 linear hexahedral elements of type C3D8R
  - 528 quadratic wedge elements of type C3D15
  - 90967 quadratic tetrahedral elements of type C3D10M

Description of the coordinate system.

- X – 1st horizontal axis.
- Z – 2nd horizontal axis.
- Y – vertical axis.

4 SIMULATION RESULTS

This chapter gathers simulation results evaluated in the analysis. Obtained outcome incudes static and the seismic load.

4.1 PA123a /PA145a

4.1.1 Natural frequency extraction

Effective modal mass plot is presented Figure 12. Bubble size indicated amount of mass which participates in motion at specific frequency range. Based no presented plot one can see that the most critical modes were located between 6.9 – 8.2 Hz.

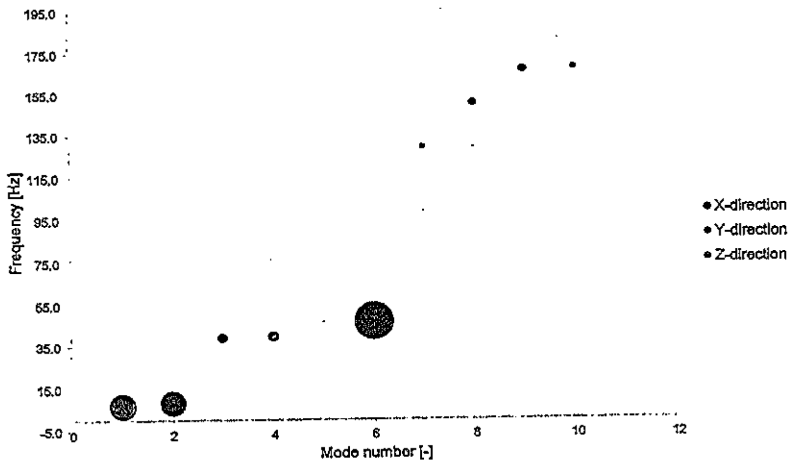

Figure 12. *Natural frequency extraction – effective modal mass*

Effective modes and associated with the shapes are presented in Figure 13.

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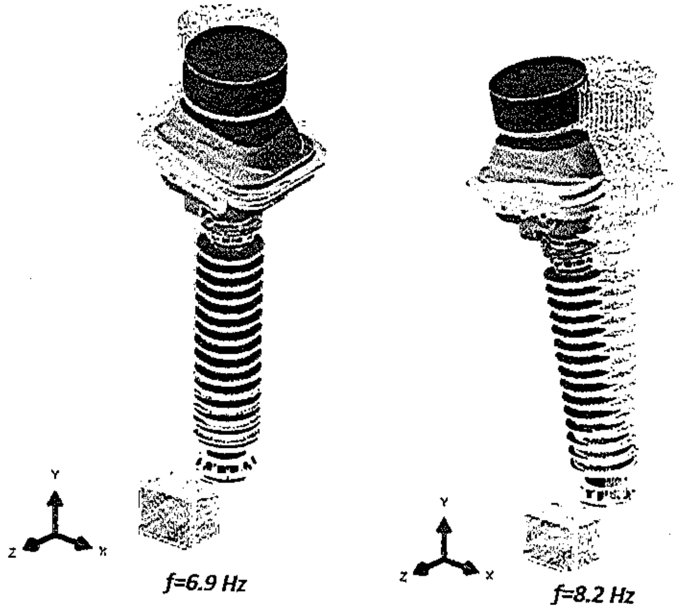

Figure 13. *Natural frequency extraction – mode shapes*

Summary of modal mass participation is listed in Table 4.

Table 4. *Modal mass participation – summary*

Mode no	Frequency [Hz]	X-direction	Y-direction	Z-direction
1	6.9	40%	0%	35%
2	8.2	34%	0%	40%
3	38.9	2%	0%	6%
4	39.7	6%	0%	2%
5	46.9	0%	0%	0%
6	98.7	0%	89%	0%
7	129.2	0%	0%	2%
8	150.3	4%	0%	0%
9	166.6	0%	0%	4%
10	167.4	2%	0%	0%

4.1.2 Dynamic analysis

Stress distribution for tank component is presented in Figure 14 and Figure 15. Stress scale has been limited to 73 MPa as the maximum allowable stress level.

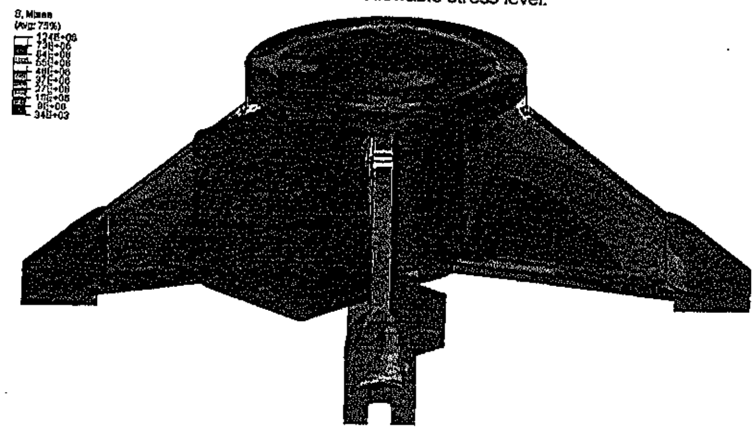

Figure 14. *Von-Mises stress [Pa] distribution – tank (view 01)*

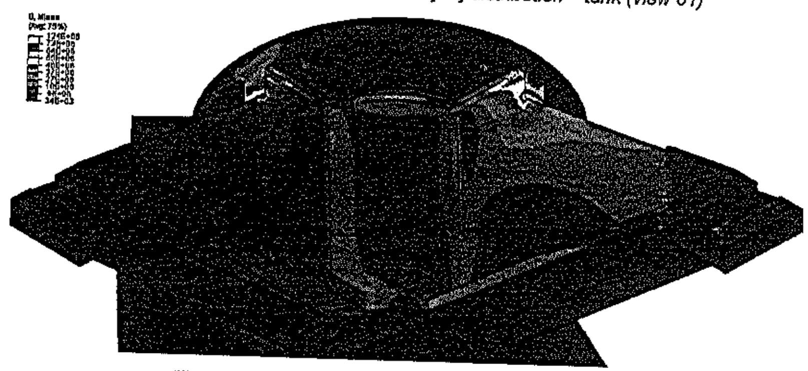

Figure 15. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 16.

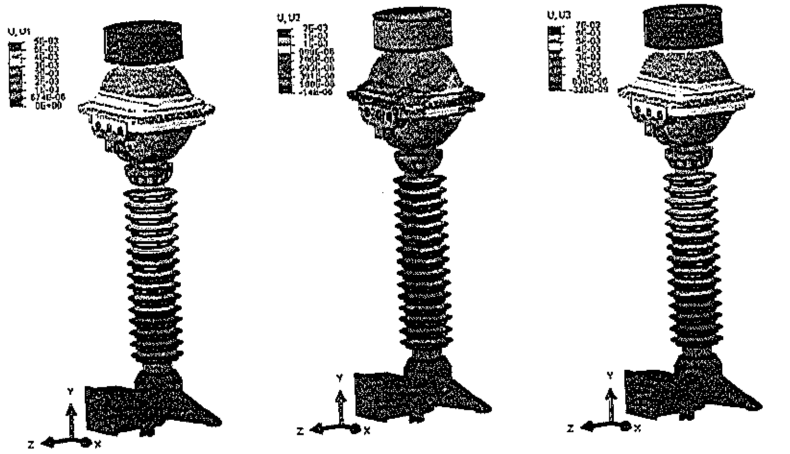

Figure 16. *Displacement [m] field - distribution*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=7961 Nm.
- M_z=7992 Nm.

Insulator **has not** satisfied the maximum bending moment condition. One can observe that stresses evaluated at the base are slightly above allowable value. Therefore small yielding may occur. One must have in mind that analysis did not cover possible casting imperfections.

Design has been verified according to Moderate seismic level (0.25 g Zero Period Acceleration). Stress distribution for such load scenario is presented from Figure 17 to Figure 18. Obtained stress level was below allowable level.

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=4816 Nm.
- M_z=4821 Nm.

Insulator **has satisfied** allowable bending moment condition.

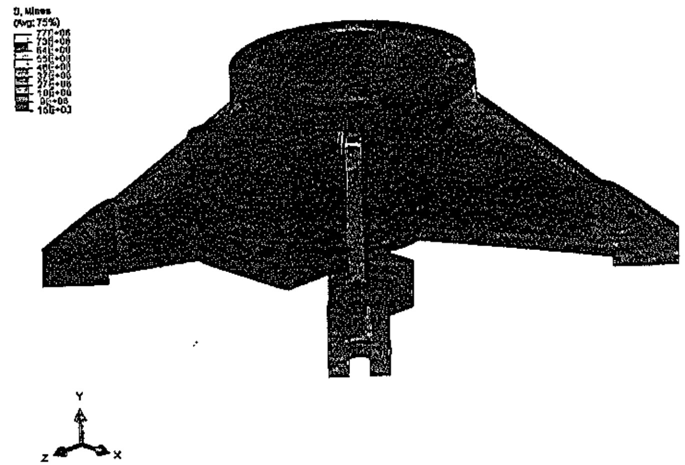

Figure 17. *Von-Mises stress [Pa] distribution (AF3) – tank (view 01)*

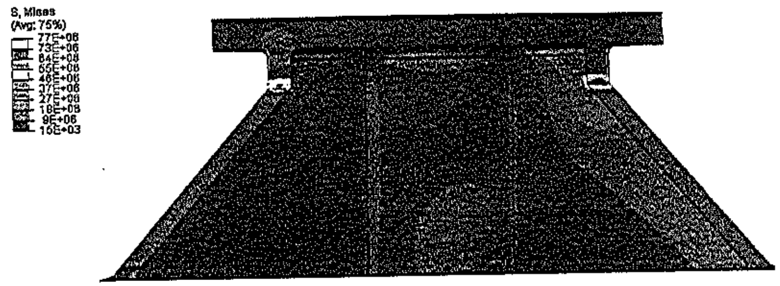

Figure 18. *Von-Mises stress [Pa] distribution (AF3) – tank (view 02)*

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4.2 PV 123

4.2.1 Natural frequency extraction

Effective modal mass plot is presented Figure 19. Bubble size indicated amount of mass which participates in motion at specific frequency range. Based no presented plot one can see that the most critical modes were located between 24.7–25.3 Hz.

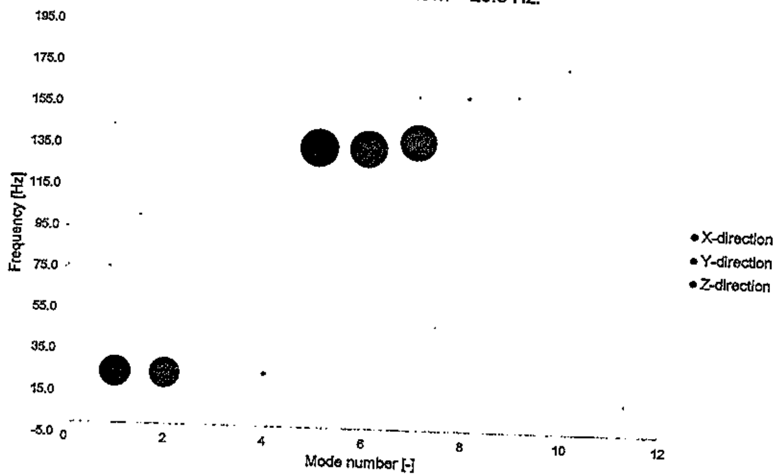


Figure 19. *Natural frequency extraction – effective modal mass*

Effective modes and associated with the shapes are presented in Figure 20.

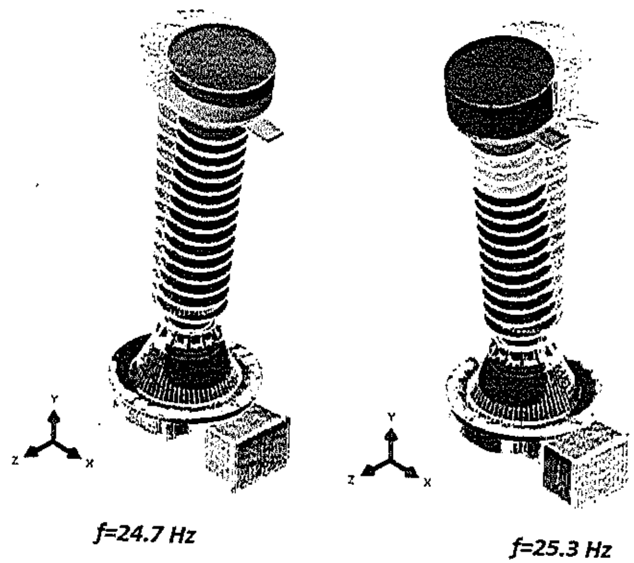


Figure 20. *Natural frequency extraction – mode shapes*

Summary of modal mass participation is listed in Table 5.

Table 5. *Modal mass participation – summary*

Mode no.	Frequency [Hz]	X-direction	Y-direction	Z-direction
1	24.7	24%	0%	0%
2	25.2	0%	0%	24%
3	25.4	0%	0%	0%
4	26.5	0%	0%	0%
5	135.5	37%	0%	0%
6	139.3	0%	0%	36%
7	161.3	0%	34%	0%
8	162.4	0%	0%	0%
9	175.8	0%	0%	0%
10	176.2	0%	0%	0%

4.2.2 Dynamic analysis

Stress distribution for tank component is presented in Figure 21 and Figure 22. As described in chapter 3.8.1 location of center of mass is close to the ground level, therefore expected bending moment and so the stress was low. One can see that the maximum stress level reached ca. 24 MPa and it was located at vicinity of coupling constraint. Stress level satisfies required safety condition.

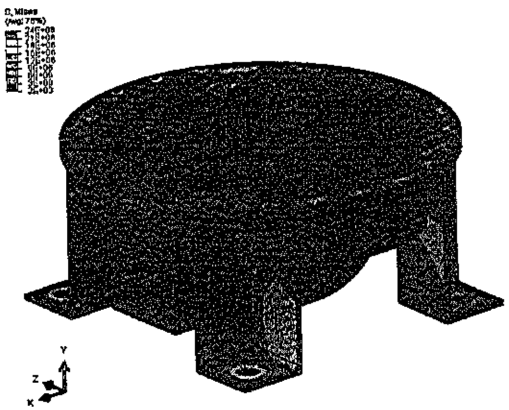


Figure 21. *Von-Mises stress [Pa] distribution – tank (view 01)*

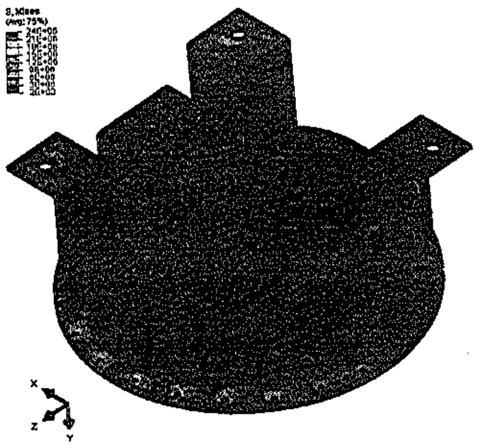


Figure 22. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 23.

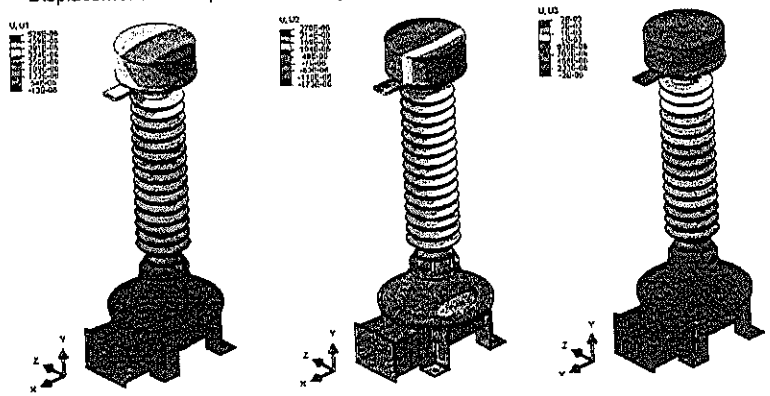


Figure 23.*Displacement [m] field - distribution*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=2224 Nm.
- M_z=2228 Nm.

Insulator **has satisfied** the maximum bending moment condition.

4.3 PVA123a /PVA145a

4.3.1 Natural frequency extraction

Effective modal mass plot is presented Figure 24. Bubble size indicated amount of mass which participates in motion at specific frequency range. Based no presented plot one can see that the most critical modes were located between 3.8–4.1 Hz.

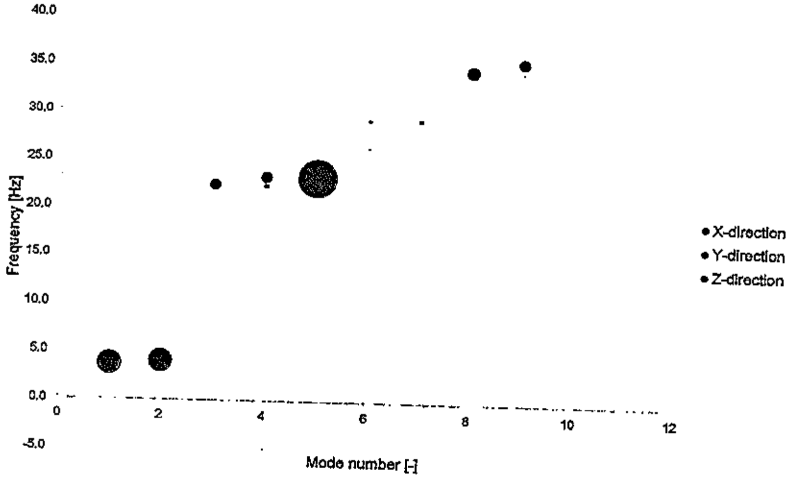
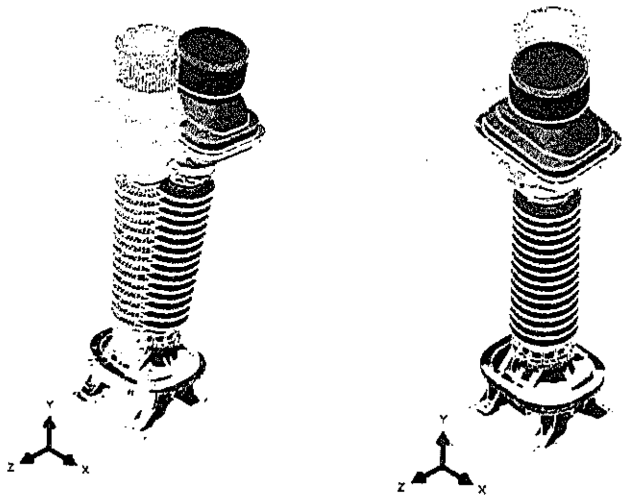


Figure 24. *Natural frequency extraction – effective modal mass*

Effective modes and associated with the shapes are presented in Figure 25.



f=3.8 Hz *f=4.1 Hz*

Figure 25. *Natural frequency extraction – mode shapes*

Summary of modal mass participation is listed in Table 6.

Table 6. *Modal mass participation – summary*

Mode no.	Frequency [Hz]	X-direction	Y-direction	Z-direction
1	3.8	35%	0%	32%
2	4.1	32%	0%	35%
3	22.4	7%	0%	0%
4	23.2	0%	2%	8%
5	26.5	0%	95%	0%
6	29.2	0%	0%	1%
7	29.3	1%	0%	0%
8	34.6	10%	0%	0%
9	35.5	0%	0%	8%
10	36.2	0%	0%	3%

4.3.2 Dynamic analysis

Stress distribution for tank component is presented in Figure 26 and Figure 27. One can see that the maximum stress was above 73 MPa allowable limit.

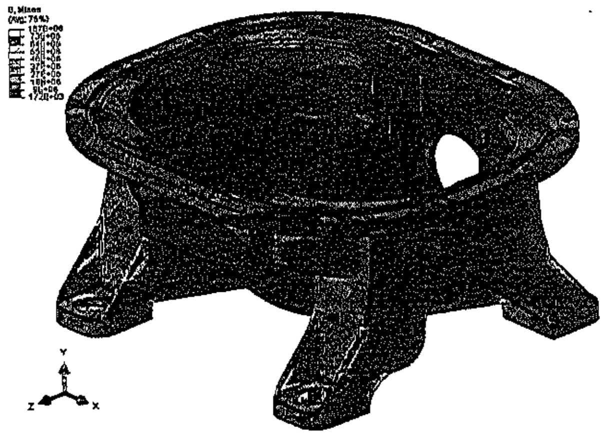


Figure 26. *Von-Mises stress [Pa] distribution – tank (view 01)*

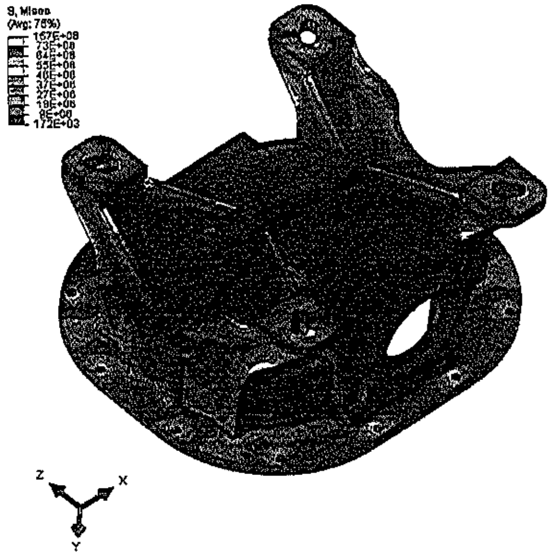


Figure 27. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 28.

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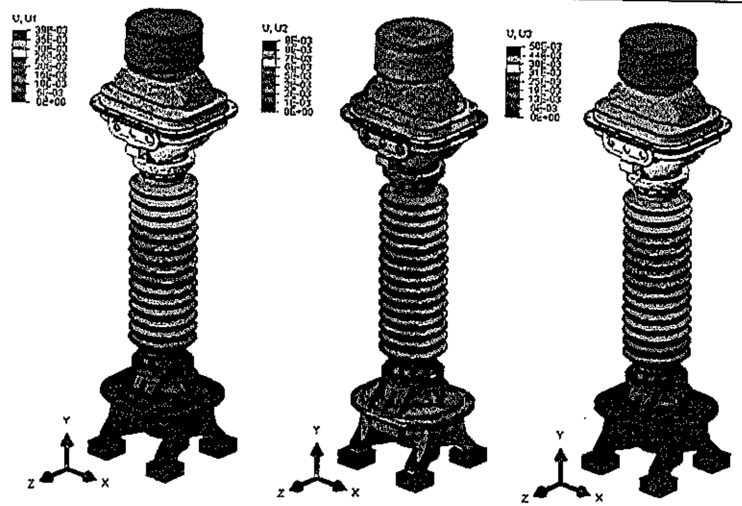

Figure 28.*Displacement [m] field - distribution*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=10451 Nm.
- M_z=8515 Nm.

Insulator **has not** satisfied the maximum bending moment condition. Stress distribution for moderate seismic level is presented in Figure 29 and Figure 30.

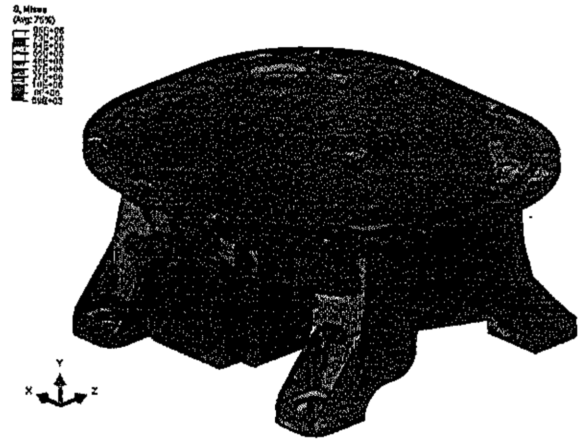

Figure 29. *Von-Mises stress [Pa] distribution – tank (view 01)*

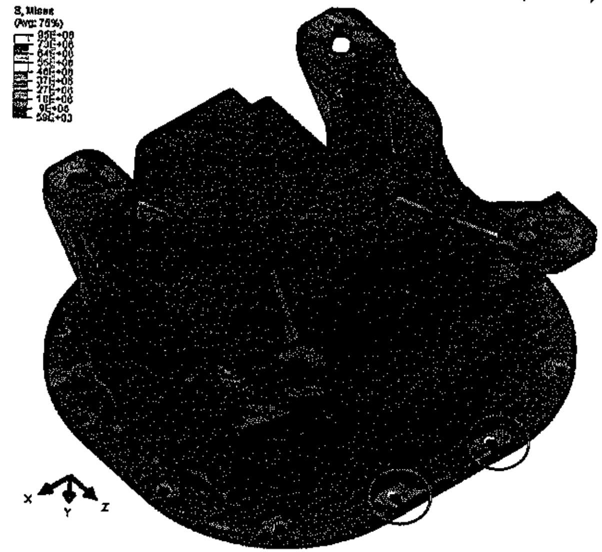

Figure 30. *Von-Mises stress [Pa] distribution – tank (view 02)*

The maximum bending moment evaluated at the interface between flange and insulator was equal to:

- M_x=6335 Nm.
- M_z=4080 Nm.

The maximum bending moment satisfies allowable value.

5 CONCLUSIONS

The goal of the analysis was to investigate family of HV Instrument Transformers using guidelines described in IEEE 693 standard. Summary of satisfied criteria is presented in Table 7. Column 'IEEE 693' lists allowable seismic level for selected design. Columns (2, 3) list seismic level where obtained stresses/bending moment were below yield strength/ultimate bending moment.

Table 7. *Summary of acceptance criteria*

Design name	(1) IEEE 693	(2) Yield strength	(3) Ultimate bending load
PA123a /PA145a	MODERATE	HIGH	HIGH
PV 123	HIGH	HIGH	HIGH
PVA123a /PVA145a	MODERATE	HIGH	HIGH

With respect to **IEEE 693 criteria** main conclusions are the following:

- PA123a/PA145a withstands Moderate seismic qualification level.
- PV 123 withstands High seismic qualification level.
- PVA123a/PVA145a withstand Moderate seismic qualification level.

Disclaimer

The analysis documented herein has been prepared in accordance with reasonable standards of scientific endeavor and the best knowledge of the author(s).

The simulation results may depend on a variety of factors, including quality of input data, applied model simplifications and chosen numerical methods.

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6 BIBLIOGRAPHY

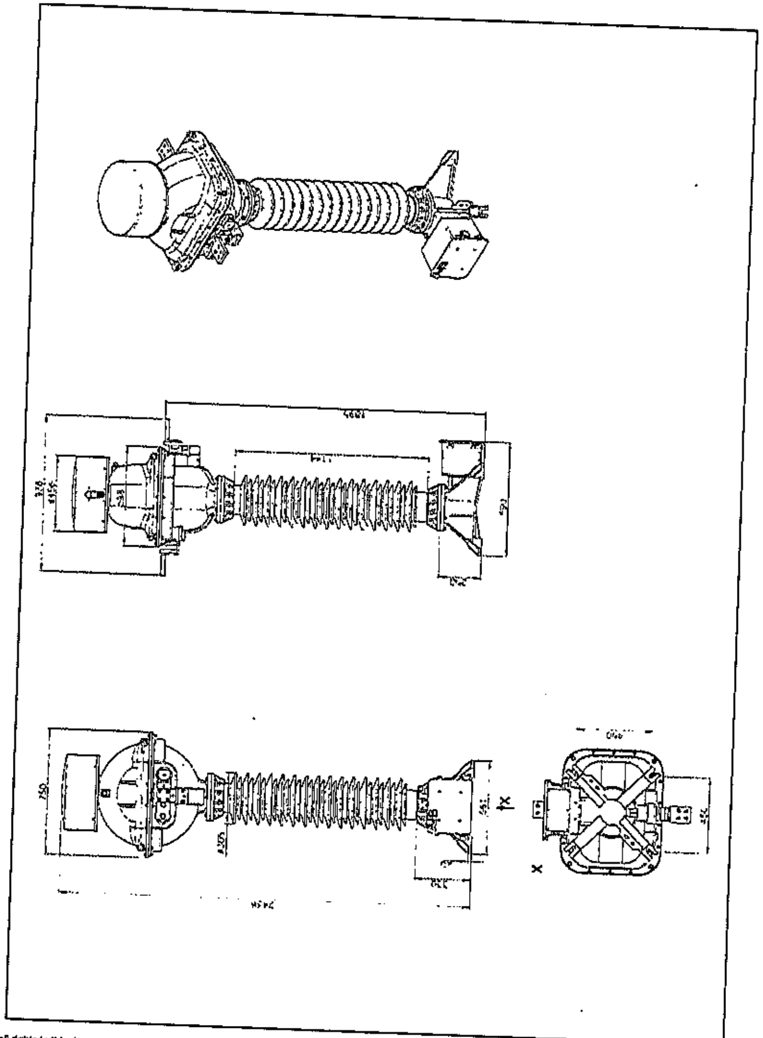
[1] IEEE 693 – *IEEE Recommended Practice for Seismic Design and Substations*, The Institute of Electrical and Electronics Engineers, Inc, NY 10016-5997, USA
[2] ABAQUS, *ABAQUS 6.13 Documentation*, DS Simulia, USA, www.simulia.com
[3] *IEC 61869-1 – Instrument transformers – Part 1: General requirements*, International standard, Edition 1.0 2007-10

7 CHANGE HISTORY

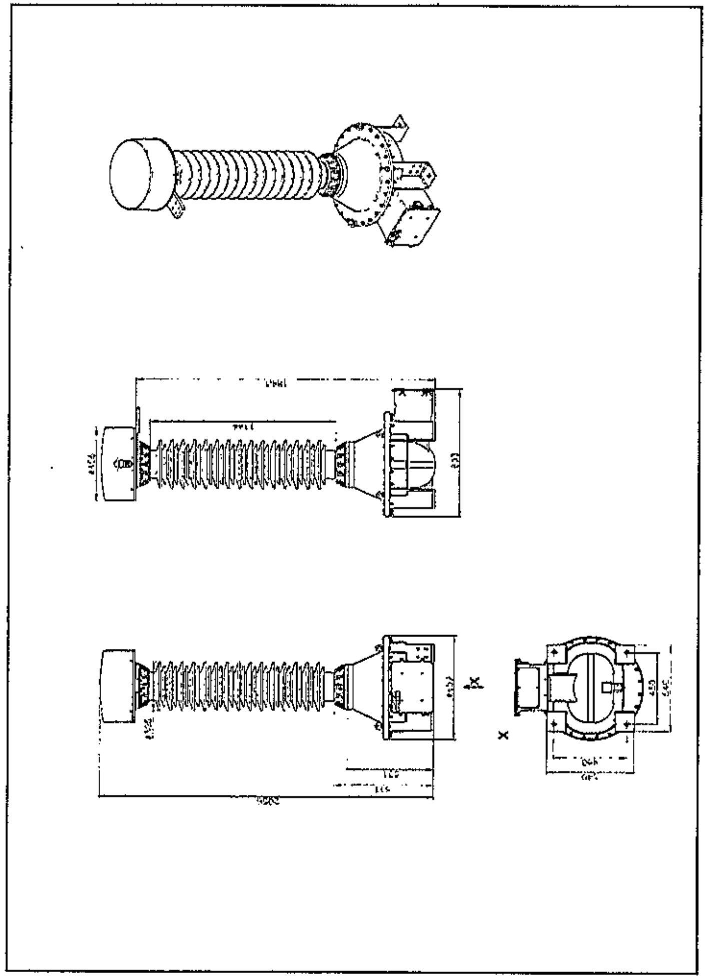
Date	Revision	Author(s)	Change
2015-08-31	Rev. 1	Juszkiewicz Grzegorz	original document

8 APPENDICES

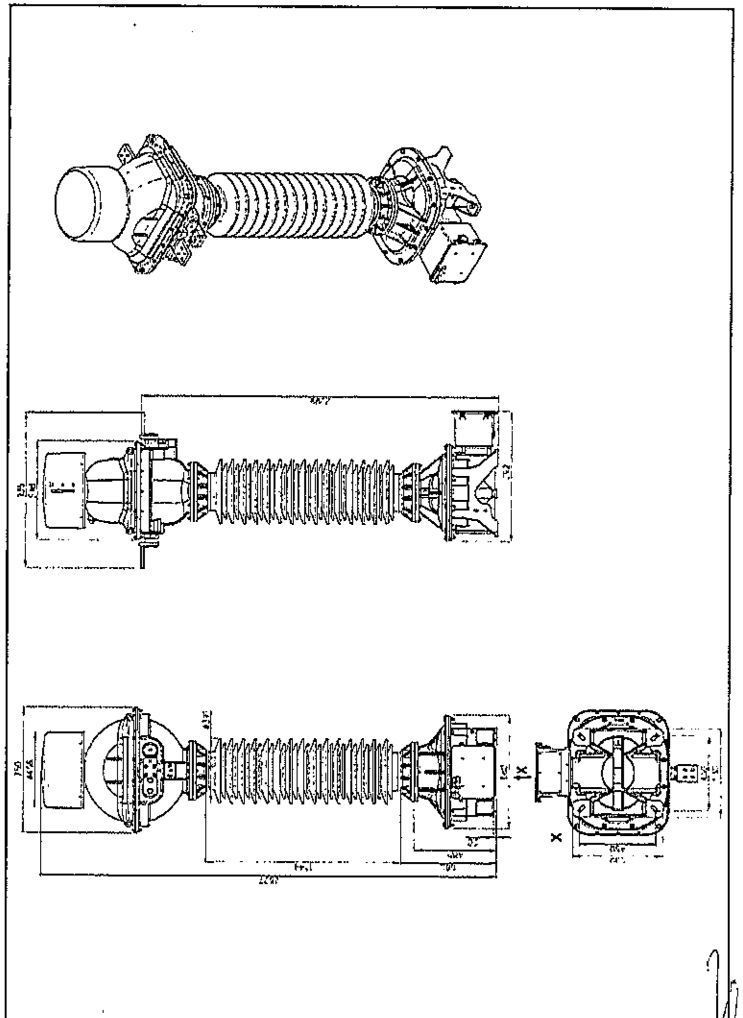
8.1 Current transformer PA123a /PA145a



8.2 Voltage transformer PV123



8.3 Combined transformer PVA123a /PVA145a



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Issued by department: ZCRD/Poland/SST	Last edit date: 2015-10-13	Lang.: English	Revision: 1.0 · Page: 1/14
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Doc. title: Calculation of damping factors and natural frequencies based on dynamic test.		Status of document:	Released
Project name/ID:		Research Area:	Mechanical Engineering
Main Author: Bartłomiej Kasprzyk/PLABB			
Additional Author(s):			
Distribution: Marek Florkowski/PLCRC, Piotr Saj/PLCRC			
Keywords: calculation, damping factor, natural frequencies, dynamic test, FFT transformation, voltage transformer			
Approved by: Marek Florkowski/PLCRC		Final Approval Date:	2015-10-13

Technical_Note.dot Rev 1.00

Technical note

Simulation Support Team

Calculation of damping factors and natural frequencies based on dynamic test performed in institute of power engineering.

Executive summary

The technical note covers investigation related to evaluation of damping factors and natural frequencies based on real dynamic test. Calculations were based on literature resources.

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TABLE OF CONTENTS

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1 TEST OBJECT

The voltage transformers type EMF-E072 and EMF-E145 are used for supplying of measuring and protection circuits. The transformer consists of coil, winding, porcelain enclosure, tank, cover and other parts. All parts inside the voltage transformer are immersed in the oil. For more details see [5].

2 SCOPE OF TEST

The test program of voltage transformers is sudden loading the A terminal in two horizontal directions. Two values of force were applied: 2040N and 3650N. For more details see [5].

3 RESULTS

In this chapter the result of tests are presented. The results were supplied by the institute of power engineering in Warsaw. Results contain distribution of the force [kN] vs. time [s] during dynamic test for two types of voltage transformers: EMF-E072 and EMF-E123/145. Both types of voltage transformers have two versions:

- Porcelain insulator.
- Composite insulator.

The force was recorded using electronic dynamometer. For more details see [5].

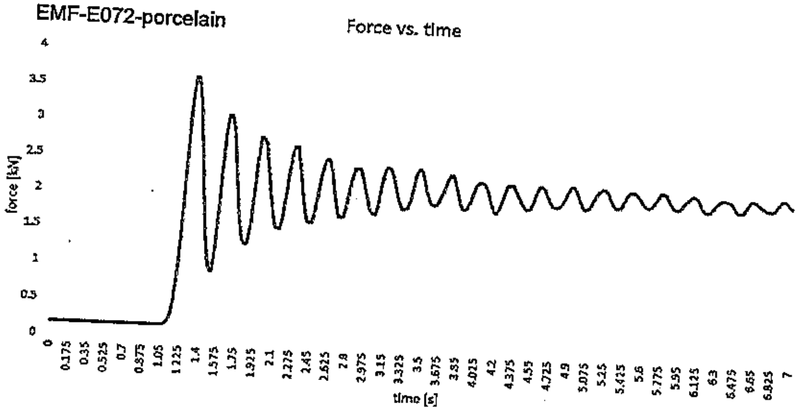

Figure 1. *Force vs. time recorded for longitudinal direction – 2000N.*

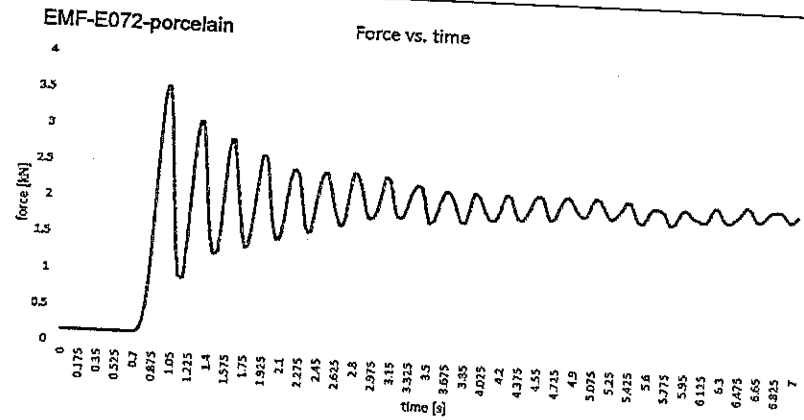

Figure 2. *Force vs. time recorded for transverse direction - 2000N.*

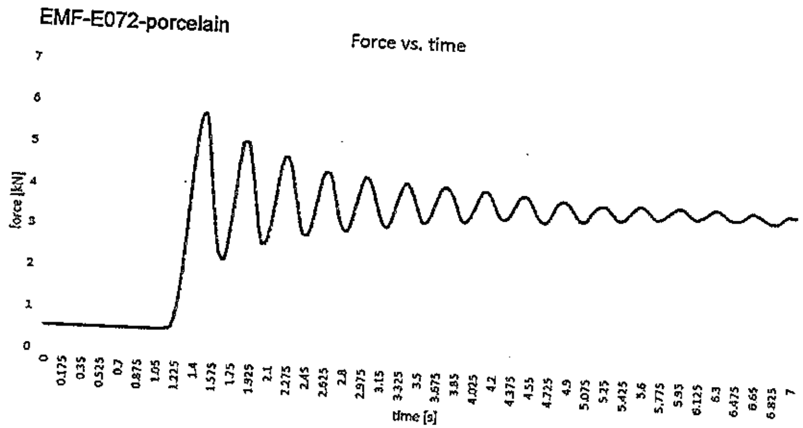

Figure 3. *Force vs. time recorded for longitudinal direction – 3600N.*

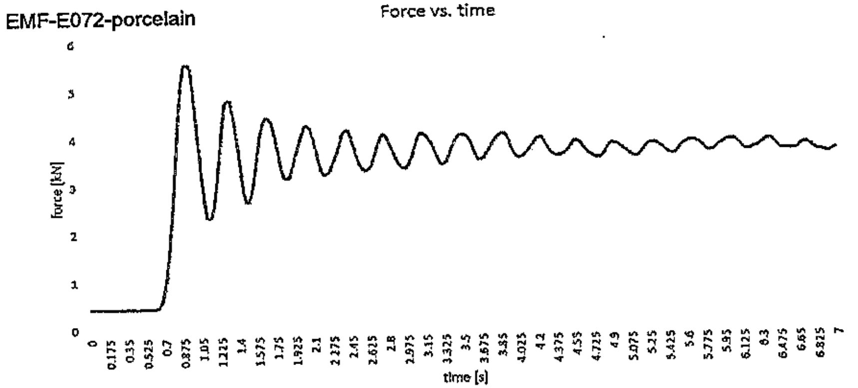

Figure 4. *Force vs. time recorded for transverse direction – 3600N.*

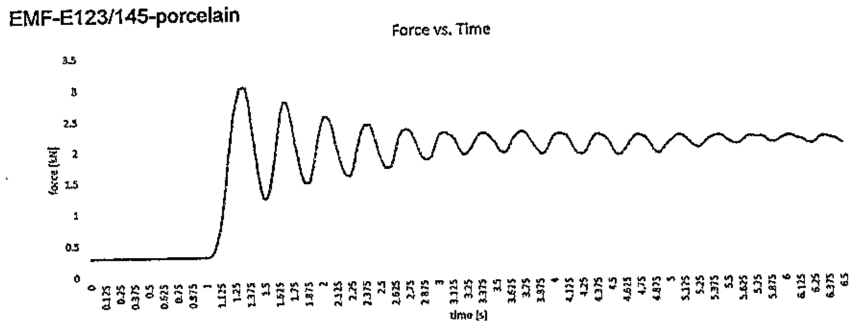

Figure 5. *Force vs. time recorded for longitudinal direction – 2000N.*

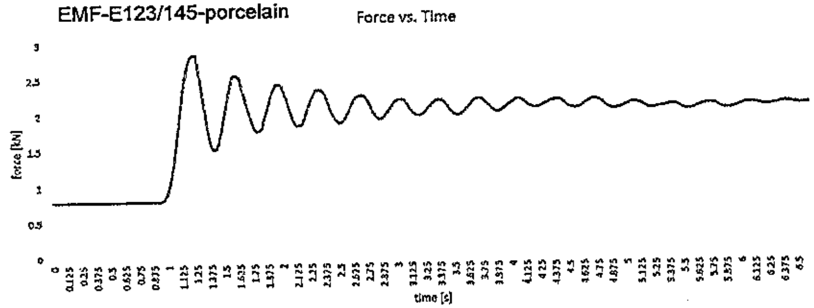

Figure 6. *Force vs. time recorded for transverse direction – 2000N.*

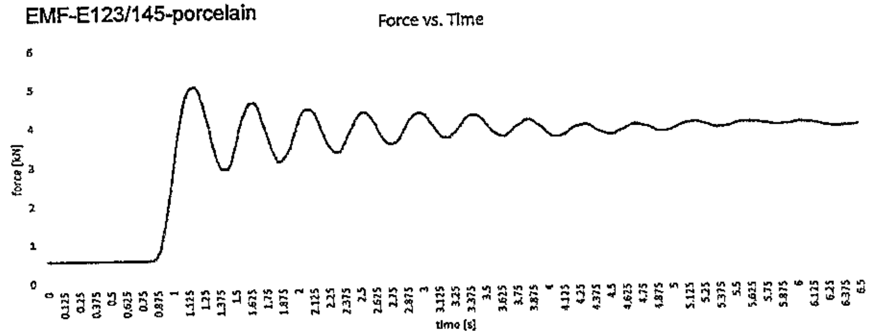

Figure 7. *Force vs. time recorded for longitudinal direction – 3600N.*

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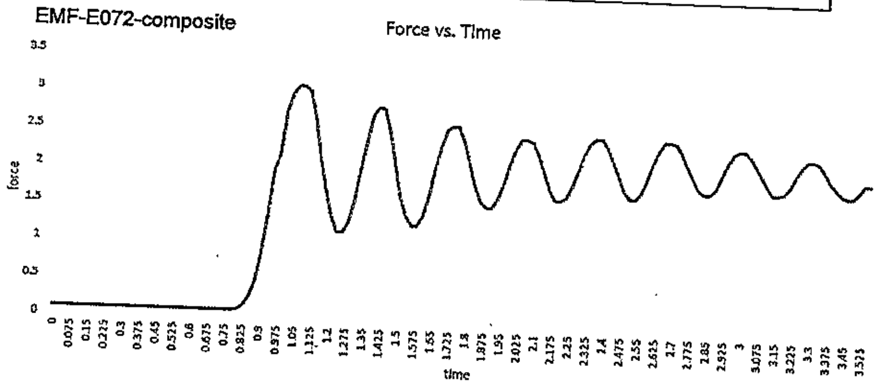

Figure 8. *Force vs. time recorded for longitudinal direction – 2000N.*

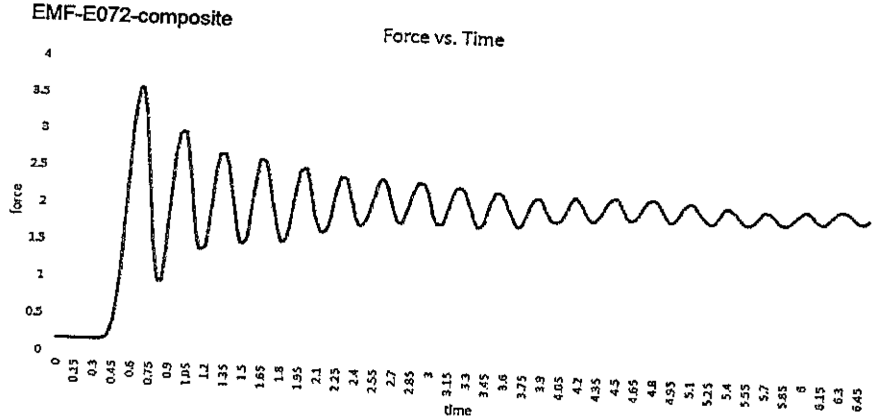

Figure 9. *Force vs. time recorded for transverse direction – 2000N.*

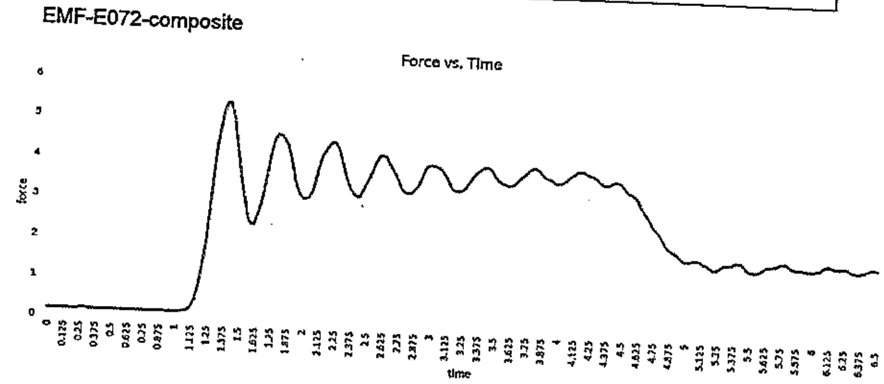

Figure 10. *Force vs. time recorded for longitudinal direction – 3600N.*

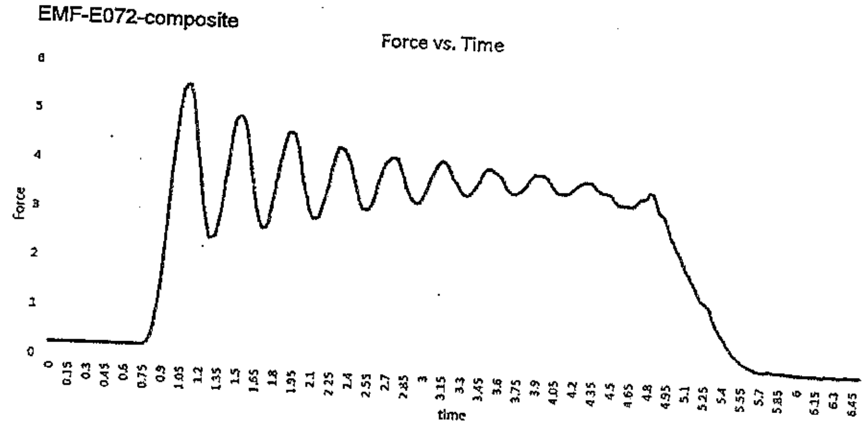

Figure 11. *Force vs. time recorded for transverse direction – 3600N.*

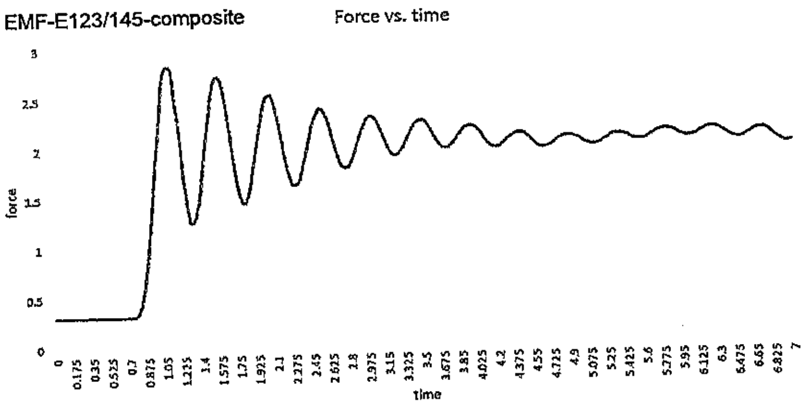

Figure 12. *Force vs. time recorded for longitudinal direction – 2000N.*

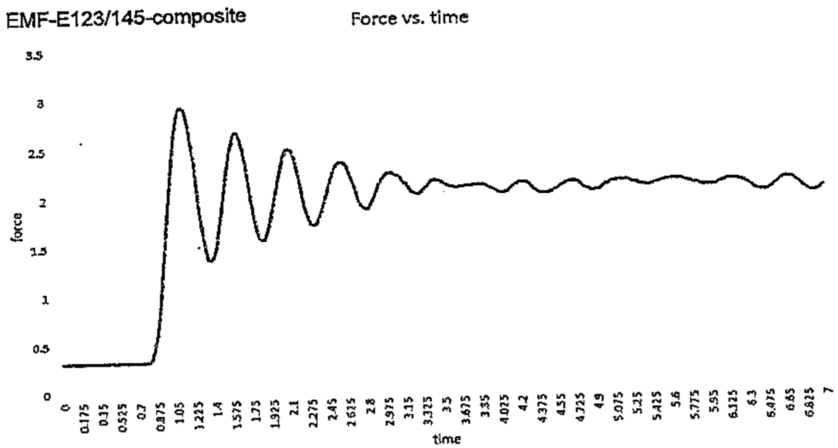

Figure 13. *Force vs. time recorded for transverse direction – 2000N.*

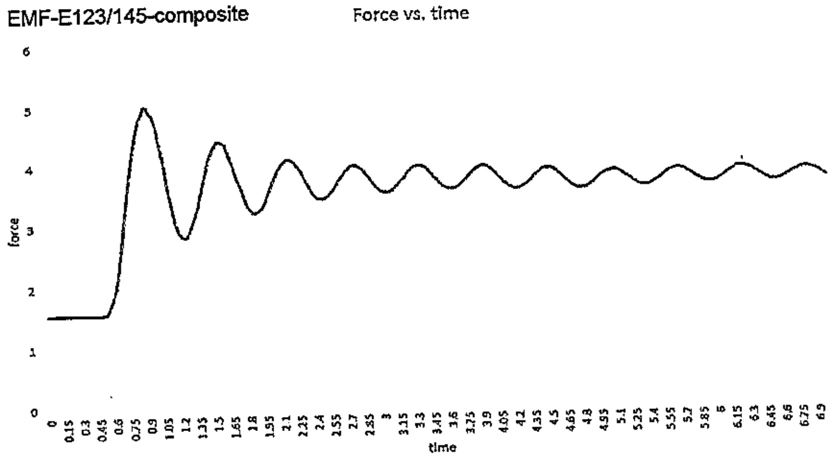

Figure 14. *Force vs. time recorded for longitudinal direction – 3600N.*

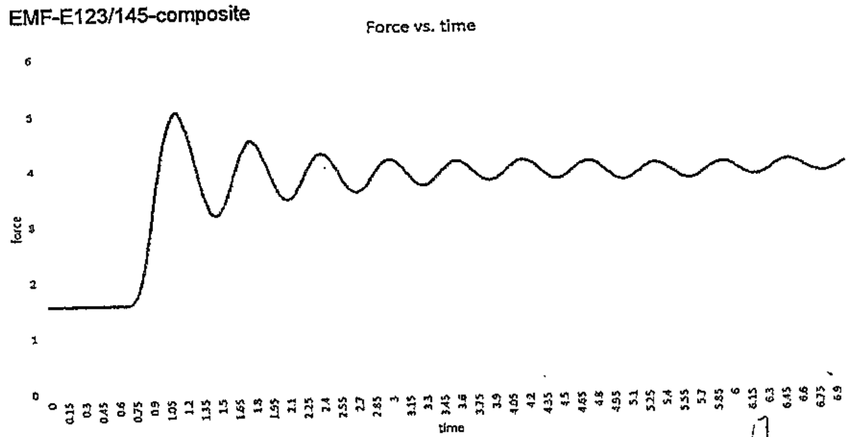

Figure 15. *Force vs. time recorded for transverse direction – 3600N.*

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4 CALCULATIONS

In this chapter, we would like to focus on the method of getting the natural frequencies based on the presented above dynamic charts and method of calculating the damping factors. The method of getting the natural frequencies is presented for the voltage transformer EMF-E072 and EMF-E123/145 with porcelain insulator (see Figure 1 and Figure 5). We will start with the voltage transformer EMF-E072.

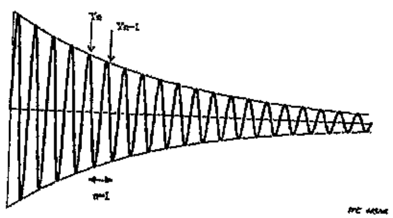
To calculate natural frequencies we have to transform obtained charts (force vs. time) into frequency domain. To do this operation, we have to use fast Fourier transform (FFT). We will do it using Microsoft Excel application based on the information included in the [4] document.

Based on the data in time domain, we can say that the time interval between the points is 0.025s. We call this sampling interval T_s. For our analysis we don't take all time points only selected. Regarding the FFT requirements the suit of input data must have a size that is an integral power of 2 (i.e. 16, 32 or 64). In my case the selected number of points equals to 2^8=256. In time domain it is range (1.2 – 7.575) s, that we call the overall sampling window time T_w. The sampling frequency here f_s is 40Hz ($f_s=1/T_s$, f_s=1/0.025s). We have to remember that our signal must meet the Nyquist criterion. In our case the "Nyquist frequency" f_n is 20Hz ($f_n=f_s/2$, f_n=40/2). It means that our frequency range is 0 – 20Hz. According to FEA calculations (for more details see [2]) we know that the expected first natural frequency (f_r) for this voltage transformer is ~29Hz. It means that the sampling rate for this signal is too low. If we want to increase the frequency range we have to change the sampling frequency. Additionally we can't forget that the minimum number of points to describe the sine function is 8. It gives us that T_s should be rather ~0.0043s ($T_s=1/(f_r*8)$, 1/(29*8)) instead of 0.025s.

The same algorithm was used for the voltage transformer EMF-E123/145. In this case the sampling frequency (f_s) is enough because the expected first natural frequency (f_r) is ~12Hz (for more details see [1]). However in this case the second condition is not fulfilled. The minimum number of points to describe the sine function is 8 and it means that that T_s should be rather ~0.010 ($T_s=1/(f_r*8)$, 1/(12*8)) instead of 0.025s.

There are plans to perform new tests with new electronic dynamometer which is able to register data with time interval between the points equals to 0.001s. It should help to catch natural frequencies for both voltage transformers based on the dynamic charts.

The damping factor was calculated based on the standard IEC 1463: 1996-07, Bushings-Seismic qualification. This method in the literature is widely known as the logarithmic decrement. It is the simplest method of calculating the damping factor when we have dynamic chart in time domain.



n represents the number of cycles.

Figure 16. *Typical case of oscillations with damping.*

The following formula was used:

$$\zeta = \frac{1}{2\pi n} * \ln\left(\frac{Y_n}{Y_{n+1}}\right) * 100\%$$

Where:

all parameters are explained in the picture above.

For the calculation, the adjacent peaks (Y_n and Y_{n+1}) were taken so in every case the n which represents the number of cycles equals to 1. The result for every case is arithmetic mean of three damping factors. It means that for every case the damping factors c_1, c_2 and c_3 were calculated. It is always that c_1 is a result of Y_1 peak and Y_2 peak, c_2 is a result of Y_2 peak and Y_3 peak and etc. The tables below present the results. The first result is for the ceramic insulator and the second one is for the composite insulator.

Table 1. *Results of damping factor for the voltage transformer with ceramic insulator.*

Type of voltage transformer	Longitudinal [%]	Transverse [%]	Longitudinal [%]	Transverse [%]
	2000N		3600N	
EMF-E072	1.58	1.67	1.32	1.44
EMF-E123/145	1.21	1.02	0.95	—*

* The test was not done due to oil leakage after the longitudinal test.

Table 2. *Results of damping factor for the voltage transformer with composite insulator.*

Type of voltage transformer	Longitudinal [%]	Transverse [%]	Longitudinal [%]	Transverse [%]
	2000N		3600N	
EMF-E072	1.19	1.57	1.29	1.28
EMF-E123/145	0.89	1.16	1.22	1.05

5 SUMMARY

Taking into account the calculations which are presented in this document, we must be aware of the fact that these values come from the real test so they are the most credible. However, the damping values are the arithmetic mean of the three damping factors (c_1, c_2 and c_3 – see page 12). One example can prove that this approach has also some tricks. For the EMF-E072 voltage transformer, the damping factor for force 2000N in longitudinal direction is 1.58. The partial damping factors are: c_1 is 2.51 c_2 is 1.60 and c_3 is 0.63. It shows that there is an important discrepancy between the partial factors and the damping factors are very unstable. The second conclusion is that the damping factors for the voltage transformer EMF-E072 are averagely 25% (composite insulator) and 44% (ceramic insulator) higher as compared to the voltage transformer EMF-E123/145. It may be caused by the height of the voltage transformers, the EMF-E123/145 VT is much higher than the EMF-E072 VT. Generally, we can say that the damping factors used in FEA simulations are close to the reality. In our analysis, we assume that the damping factor is 2% and according to the test, these values fluctuate between 0.89% and 1.67%.

Disclaimer

The analysis documented herein has been prepared in accordance with reasonable standards of scientific endeavor and the best knowledge of the author(s).

The simulation results may depend on a variety of factors, including quality of input data, applied model simplifications and chosen numerical methods.

6 BIBLIOGRAPHY

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7 CHANGE HISTORY

Date	Revision	Author(s)	Change
2015-10-13	Rev. 1	Bartłomiej Kasprzyk	original document

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„Доставка на електрически апарати 110кV“, реф. № PPD 17-064.

Обособена позиция 3 – Доставка на напреженови измервателни трансформатори 110кV за монтаж на открито – 6бр.

ПРИЛОЖЕНИЕ 5

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ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

PCA
POLSKIE CENTRUM AKREDYTACJI

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ
НА ЛАБОРАТОРИЯ ЗА КАЛИБРИРАНЕ
№ АР 168

Това е, за да се потвърди, че:

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Лаборатория за калибриране
АББ Продукти Високо Напрежение клон в Пшашниш
ул. Лешно 59, 06-300 Пшашниш, Полша

отговаря на изискванията на стандарт PN-EN ISO/IEC 17025:2005

Акредитирана дейност се определя в обхвата на акредитация № АР 168

Тази акредитация остава в сила, при условие че Лабораторията съблюдава изискванията на органа за акредитация, определени в договор № АР 168

Сертификатът за акредитация е валиден до 20.12.2020 г.

Директор
Лучина Олборска

Варшава, 21 Декември2016 г.

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POLSKIE CENTRUM AKREDYTACJI

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI
LABORATORIUM WZORCUJĄCEGO
ACCREDITATION CERTIFICATE OF CALIBRATION LABORATORY
Nr AP 168

Potwierdza się, że: / This is to confirm that:

ABB Sp. z o.o.
ul. Żegańska 1, 04-713 Warszawa
Laboratorium Wzorcujące
ABB PGHV w Przasnyszu
ul. Leszno 59, 06-300 Przasnysz

spełnia wymagania normy PN-EN ISO/IEC 17025:2005
meets requirements of the PN-EN ISO/IEC 17025:2005 standard

Akredytowana działalność jest określona w Zakresie Akredytacji Nr AP 168
Accredited activity is defined in the Scope of Accreditation No AP 168

Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AP 168
This accreditation remains in force provided the Laboratory observes the requirements of Accreditation Body defined in the Contract No AP 168

Certyfikat akredytacji ważny do dnia 20.12.2020 r.
The certificate of accreditation is valid until 20.12.2020

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

LUCYNA OLBORSKA

Warszawa, dnia 21 grudnia 2016 roku

433

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ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

PCA POLSKIE CENTRUM AKREDYTACJI

Подписваща страна ЕА MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ НА СЕРТИФИЦИРАЩ ОРГАН ЗА ПРОДУКТИ

№ АС 117

Това е, за да се потвърди, че:

ИНСТИТУТ ПО ЕНЕРГЕТИКА
ИНСТИТУТ ЗА ИЗСЛЕДВАНИЯ
отдел СЕРТИФИЦИРАНЕ
ул. Мори 8, 01-330 Варшава

отговаря на изискванията на стандарт PN-EN ISO/IEC 17065:2013-03

Акредитирана дейност се определя в обхвата на акредитация № АС 177

Тази акредитация остава в сила, при условие че Организацията съблюдава изискванията на органа за акредитация, определени в договор № АС 117

Сертификатът за акредитация е валиден до 03.02.2021 г.

Акредитацията е предоставена на 04.02.2005 г.

р.о. Директор
Лучина Олборска

Варшава, 27 Януари 2017 г.

435

ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

PCA Polskie Centrum Akredytacji

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ НА ЛАБОРАТОРИЯ ЗА ИЗПИТАНИЯ

№ АВ 323

Това е, за да се потвърди, че:

ИНСТИТУТ ПО ЕНЕРГЕТИКА
Лаборатория Високо Напрежение
ул. Мори 8, 01-330 Варшава

отговаря на изискванията на стандарт PN-EN ISO/IEC 17025:2005

Акредитирана дейност се определя в обхвата на акредитация № АВ 323

Тази акредитация остава в сила, при условие че Лабораторията съблюдава изискванията на органа за акредитация, определени в договор № АВ 323

Сертификатът за акредитация е валиден до 27.12.2019 г.

Акредитацията е предоставена на 28.12.2000 г.

ДИРЕКТОР
ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ
Луцина Олборска

Варшава, 16 Ноември 2015 г.

ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ НА ЛАБОРАТОРИЯ ЗА ИЗПИТАНИЯ

№ АВ 324

Това е, за да се потвърди, че:

ИНСТИТУТ ПО ЕНЕРГЕТИКА
Лаборатория Разпределителни Устройства
ул. Мори 8, 01-330 Варшава

отговаря на изискванията на стандарт PN-EN ISO/IEC 17025:2005

Акредитирана дейност се определя в обхвата на акредитация № АВ 324

Тази акредитация остава в сила, при условие че Лабораторията съблюдава изискванията на органа за акредитация, определени в договор № АВ 324

Сертификатът за акредитация е валиден до 27.12.2019 г.

Акредитацията е предоставена на 28.12.2000 г.

ДИРЕКТОР
ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ
Луцина Олборска

Варшава, 24 Ноември 2015 г.

437

POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

PCA POLSKIE CENTRUM AKREDYTACJI

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI
JEDNOSTKI CERTYFIKUJĄCEJ WYROBY
ACCREDITATION CERTIFICATE FOR PRODUCT CERTIFICATION BODY
Nr AC 117

Potwierdza się, że: / This is to confirm that:

INSTYTUT ENERGETYKI
INSTYTUT BADAWCZY
ZESPÓŁ ds. CERTYFIKACJI
ul. Mory 8, 01-330 Warszawa

spełnia wymagania normy PN-EN ISO/IEC 17065:2013-03
meets requirements of the PN-EN ISO/IEC 17065:2013-03 standard

Akredytowana działalność jest określona w Zakresie Akredytacji Nr AC 117
Accredited activity is defined in the Scope of Accreditation No AC 177

Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AC 117
This accreditation remains in force provided the Body observes the requirements of Accreditation Body defined in the Contract No AC 117

Certyfikat akredytacji ważny do dnia 03.02.2021 r.
The certificate of accreditation is valid until 03.02.2021

Akredytacji udzielono dnia 04.02.2005 r.
Accreditation was granted on 04.02.2005

POLSKIE CENTRUM AKREDYTACJI * 1 *

005287

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

LUCYNA OLBORSKA

Warszawa, 27 stycznia 2017 roku

POLSKIE CENTRUM AKREDYTACJI

POLISH CENTRE FOR ACCREDITATION

PCA
POLSKIE CENTRUM AKREDYTACJI

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI

LABORATORIUM BADAWCZEGO

ACCREDITATION CERTIFICATE OF TESTING LABORATORY

Nr AB 324

Potwierdza się, że: / This is to confirm that:

INSTYTUT ENERGETYKI
LABORATORIUM URZĄDZEŃ ROZDZIELCZYCH
ul. Mory 8, 01-330 Warszawa

spełnia wymagania normy PN-EN ISO/IEC 17025:2005
meets requirements of the PN-EN ISO/IEC 17025:2005 standard

Akredytowana działalność jest określona w Zakresie Akredytacji Nr AB 324
Accredited activity is defined in the Scope of Accreditation No AB 324

Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AB 324
This accreditation remains in force provided the Laboratory observes the requirements of Accreditation Body defined in the Contract No AB 324

Certyfikat akredytacji ważny do dnia 27.12.2019 r.
The certificate of accreditation is valid until 27.12.2019

Akredytacji udzielono dnia 28.12.2000 r.
Accreditation was granted on 28.12.2000

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

LUCYNA OLBORSKA

POLSKIE CENTRUM AKREDYTACJI
PCA
1

ABB
ABB Sp. z o.o.
...ańska 1, 04-713 Warszawa
...526-030-44-84, PL 5260304484
Regon 010017168
ODDZIAŁ W PRZASNYSZU
ul. Leszno 50, 06-300 Przasnysz
tel. (22) 223 8849, fax (22) 223 8958
(16)

Warszawa, 24 listopada 2015 roku

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POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

PCA POLSKIE CENTRUM AKREDYTACJI

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI
LABORATORIUM BADAWCZEGO
ACCREDITATION CERTIFICATE OF TESTING LABORATORY
Nr AB 323

Potwierdza się, że: / This is to confirm that:

INSTYTUT ENERGETYKI
LABORATORIUM WIELKOPRĄDOWE
ul. Mory 8, 01-330 Warszawa

spełnia wymagania normy PN-EN ISO/IEC 17025:2005
meets requirements of the PN-EN ISO/IEC 17025:2005 standard

Akredytowana działalność jest określona w Zakresie Akredytacji Nr AB 323
Accredited activity is defined in the Scope of Accreditation No AB 323

Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AB 323
This accreditation remains in force provided the Laboratory observes the requirements of Accreditation Body defined in the Contract No AB 323

Certyfikat akredytacji ważny do dnia 27.12.2019 r.
The certificate of accreditation is valid until 27.12.2019

Akredytacji udzielono dnia 28.12.2000 r.
Accreditation was granted on 28.12.2000

ABB
ABB Sp. z o.o.
Żegańska 1, 04-713 Warszawa
NIP 526-030-44-84, PL 5260304484
Regon 010017168
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
(22) 223 8849, fax (22) 223 8958
(16)

POLSKIE CENTRUM AKREDYTACJI PCA * 1 *

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

LUCYNA OLBORSKA

Warszawa, 16 listopada 2015 roku

442

„Доставка на електрически апарати 110кV“, реф. № PPD 17-064.

Обособена позиция 3 – Доставка на напреженови измервателни трансформатори 110кV за монтаж на открито – 6бр.

ПРИЛОЖЕНИЕ 6

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ABB

ROUTINE TEST PLAN for Voltage Transformers

План за рутинни изпитания на Напреженов Трансформатор

-- units of Voltage Transformers (--брой Напреженови Трансформатори)

Number / *Номер*	Page / Страница 1
2GKV614153	Pages / Общо 2
Type/ Тип	
Valid for order ………. / KU …. *Валидно за поръчка ………. / KU ….*	

Sl. №	Test *Изпитание*	Test according to: *Изпитание съгл.:*	Requirement according to: *Изисквания*	Place of test *Място на*	Remarks *Забележки*	*Date* *Дата*	Acceptance *Приемане*	Signature *Подпис*
1	Enclosure tightness test at ambient temperature *Изпитване за херметичност при температура на околната среда*	IEC 61869-1	Cl. 7.3.7.2	Quality control - ABB Przasnysz *Контрол на качеството*				
2	Verification of terminal markings and technical parameters *Проверка на маркировката на клемите и техническите параметри*	IEC 61869-1 IEC 61869-3	Cl. 6.13 Cl. 6.13	Quality control - ABB Przasnysz *Контрол на качеството*				
3	Power-frequency voltage withstand tests on primary windings and partial discharge measurement *Обявено издържано напрежение с промишлена честота за изолацията на първичната*	IEC 61869-1 IEC 61869-3 IEC 60270	Cl. 7.3.1; 7.3.2 Cl. 7.3.1; 7.3.2	Quality control - ABB Przasnysz *Контрол на качеството*				
4	Measurement of windings' internal resistance and ambient temperature *Измерване на вътрешното съпротивление на намотките и температурата*	– –	Order (if special requirements) *Поръчка (при специални изисквания)*	Quality control ABB Przasnysz *Контрол на качеството*				

Prepared by Подготвено от	Date *Дата*	Checked by *Проверено от*	Date *Дато*	Approved by *Одобрено от*	Date *Дата*
Ł. Lubieniecki	27.07.2015	J. Duzdowski	27.07.2015	P. Dębski	27.07.2015

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ABB	ROUTINE TEST PLAN for Voltage Transformers *План за рутинни изпитания на Напреженов Трансформатор*	Number / *Номер* 2GKV614153	Page / Страница 1 Pages / Общо 2
		Type/ Тип	
	-- units of Voltage Transformers (--брой Напреженови Трансформатори)	Valid for order ………. / KU …. *Валидно за поръчка ………. / KU ….*	

Sl. №	Test *Изпитание*	Test according to: *Изпитание*	Requirement according to: *Изисквания*	Place of test *Място на*	Remarks *Забележки*	*Date* *Дата*	Acceptance *Приемане*	Signature *Подпис*
5	Power-frequency voltage withstand tests on secondary windings *Обявено издържано напрежение с промишлена честота за изолацията на вторичните намотки*	IEC 61869-1	Cl. 7.3.3; 7.3.4	Quality control - ABB Przasnysz *Контрол на качеството*				
6	Capacitance and dielectric dissipation factor measurement *Измерване на капацитет и фактор на диелектрично разсейване*	IEC 61869-1 IEC 61869-3	Cl. 7.4.3 Cl. 7.4.3	Quality control - ABB Przasnysz *Контрол на качеството*				☐
7	Test for accuracy of the voltage transformer Изпитание на точността на НТ	IEC 61869-3	Cl. 7.3.5.301; 7.3.5.302	Quality control - ABB Przasnysz *Контрол на качеството*				☐
8	Inspection : visual check & verification of parameters according to order Инспекция: Визуална проверка и проверка на параметрите по поръчка	-- --	Order *Поръчка*	Quality control - ABB Przasnysz *Контрол на качеството*				☐

Prepared by Подготвено от	Date *Дата*	Checked by *Проверено от*	Date *Дато*	Approved by *Одобрено от*	Date *Дата*
Ł. Lubieniecki	27.07.2015	J. Duzdowski	27.07.2015	P. Dębski	27.07.2015

ABB	ROUTINE TEST PLAN for Voltage Transformers *Plan próby wyrobu dla Przekładników Napięciowych*	Number / *Numer* 2GKV614153	Page / *Strona* 1 Pages / *Stron* 2
		Type/ Typ	
	-- units of Voltage Transformers (-- szt. Przekładników Napięciowych)	Valid for order ………. / KU …. *Obowiązuje do zam. dla ……… / KU ….*	

Sl. **No**	**Test** ***Badanie***	**Test according to:** ***Badanie według:***	**Requirement according to:** ***Wymaganie według:***	**Place of test** ***Miejsce badania***	**Remarks** ***Uwagi***	***Date*** ***Data***	**Acceptance** ***Akceptacja***	**Signature** ***Podpis***
1	Enclosure tightness test at ambient temperature *Sprawdzenie szczelności obudowy w temperaturze otoczenia*	IEC 61869-1	Cl. 7.3.7.2	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
2	Verification of terminal markings and technical parameters *Sprawdzenie oznakowania zacisków i parametrów technicznych*	IEC 61869-1 IEC 61869-3	Cl. 6.13 Cl. 6.13	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
3	Power-frequency voltage withstand tests on primary windings and partial discharge measurement *Próba izolacji uzwojeń pierwotnych napięciem o częstotliwości sieciowej oraz wyładowań niezupełnych.*	IEC 61869-1 IEC 61869-3 IEC 60270	Cl. 7.3.1; 7.3.2 Cl. 7.3.1; 7.3.2	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
4	Measurement of windings' internal resistance and ambient temperature *Pomiar wewnętrznych rezystancji uzwojeń i temperatury otoczenia*	– --	Order (if special requirements) *Zamówienie (jeśli są specjalne wymagania)*	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	

Prepared by *Opracował*	Date *Data*	Checked by *Sprawdził*	Date *Data*	Approved by *Zatwierdził*	Date *Data*
Ł. Lubieniecki	27.07.2015	J. Duzdowski	27.07.2015	P. Dębski	27.07.2015

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ABB

ROUTINE TEST PLAN for Voltage Transformers

Plan próby wyrobu dla Przekładników Napięciowych

Number / *Numer* 2GKV614153

Type/ Typ

-- units of Voltage Instrument Transformers (-- szt. Przekładników Napięciowych)

Valid for order .... / KU ....
Obowiązuje do zam. dla .... / KU ....

Sl. No	Test *Badanie*	Test according to: *Badanie według:*	Requirement according to: *Wymaganie według:*	Place of test *Miejsce badania*	Remarks *Uwagi*	*Date* *Data*	Acceptance *Akceptacja*	Signature *Podpis*
5	Power-frequency voltage withstand tests on secondary windings *Próba izolacji uzwojeń wtórnych napięciem o częstotliwości sieciowej*	IEC 61869-1	Cl. 7.3.3; 7.3.4	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
6	Capacitance and dielectric dissipation factor measurement *Pomiar pojemności i współczynnika strat dielektrycznych*	IEC 61869-1 IEC 61869-3	Cl. 7.4.3 Cl. 7.4.3	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
7	Test for accuracy of the voltage transformer *Sprawdzenie dokładności części napięciowej przekładnika*	IEC 61869-3	Cl. 7.3.5.301; 7.3.5.302	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
8	Inspection : visual check & verification of parameters according to order *Oględziny – sprawdzenie zgodności parametrów z zamówieniem*	– –	Order *Zamówienie*	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	

Prepared by *Opracował*	Date *Data*	Checked by *Sprawdził*	Date *Data*	Approved by *Zatwierdził*	Date *Data*
Ł. Lubieniecki	27.07.2015	J. Duzdowski	27.07.2015	P. Dębski	27.07.2015

ABB

ДЕКЛАРАЦИЯ

за приемане на условията в проекта на договор

Долуподписаните Екехарт Нойрайтер и Стефан Минчев в качеството ни на представляващи АББ България ЕООД участник в обществена поръчка с предмет: **„Доставка на електрически апарати 110кV"**, реф. № PPD 17-064 **Обособена позиция 3 -** Доставка на напреженови измервателни трансформатори 110 kV за монтаж на открито – 6 бр.

Д Е К Л А Р И Р А М Е, ЧЕ:

Приемаме условията в проекта на договор, приложен в документацията за участие.

Дата: 11.07.2017

Декларатор: ....
Екехарт Нойрайтер
Управител
АББ България ЕООД

....
Стефан Минчев
Управител
АББ България ЕООД

ABB Bulgaria EOOD
Main Office
9, Hristofor Kolumb Blvd., fl. 3
Mladost, Sofia-grad
1592 Sofia, Bulgaria
Phone: +359 (0) 2 807 55 00
Fax: +359 (0) 2 807 55 99
Web: www.abb.bg
E-mail: office@bg.abb.com

UIC: 831133152
VAT Nr.: BG 831133152
Bank details:
ING Bank, branch Sofia
IBAN: BG13INGB91451000027317 (BGN)
IBAN: BG60INGB91451400027311 (EUR)
BIC: INGBBGSF

SGS SGS SGS

03.2017

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ДЕКЛАРАЦИЯ
за срока на валидност на офертата

Долуподписаните,

Екехарт Бернхард Нойрайтер, притежаващ лична карта ID N: L8XH0JRMR издадена на 11.03.2013 – Германия, адрес гр. София, бул. Христофор Колумб № 9, ет.3,

в качеството ми на Управител на АББ България ЕООД

и

Стефан Василев Минчев, притежаващ лична карта №641790843, издадена на 11.01.2011 от МВР – гр. София, адрес: гр. София, бул. Христофор Колумб № 9, ет.3,

в качеството ми на Управител на АББ България ЕООД,

участник в процедура за възлагане на обществена поръчка с предмет: **„Доставка на електрически апарати 110kV"**, реф. № PPD 17-064, **Обособена позиция 3 -** Доставка на напреженови измервателни трансформатори 110 kV за монтаж на открито – 6 бр.

ДЕКЛАРИРАМЕ, ЧЕ:

С подаване на настоящата оферта, направените от нас предложения и поети ангажименти са валидни за срока, посочен в обявлението, считано от крайния срок за подаване на офертите.

Дата: 11.07.2017

Декларатор: ....
Екехарт Нойрайтер
Управител
АББ България ЕООД

....
Стефан Минчев
Управител
АББ България ЕООД

ABB Bulgaria EOOD
Main Office
9, Hristofor Kolumb Blvd., fl. 3
Mladost, Sofia-grad
1592 Sofia, Bulgaria
Phone: +359 (0) 2 807 55 00
Fax: +359 (0) 2 807 55 99
Web: www.abb.bg
E-mail: office@bg.abb.com

UIC: 831133152
VAT Nr.: BG 831133152
Bank details:
ING Bank, branch Sofia
IBAN: BG13INGB91451000027317 (BGN)
IBAN: BG60INGB91451400027311 (EUR)
BIC: INGBBGSF

SGS SGS SGS
03.2017