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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.

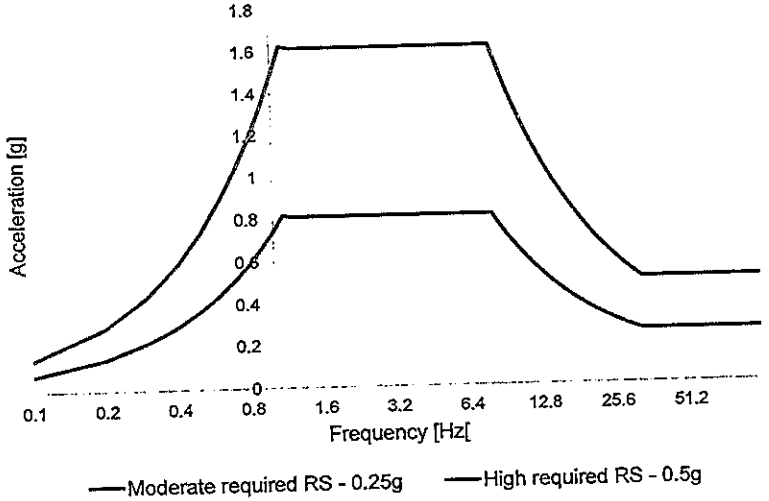


Figure 1. *Design response spectrum (RS) – 2% damping*

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.

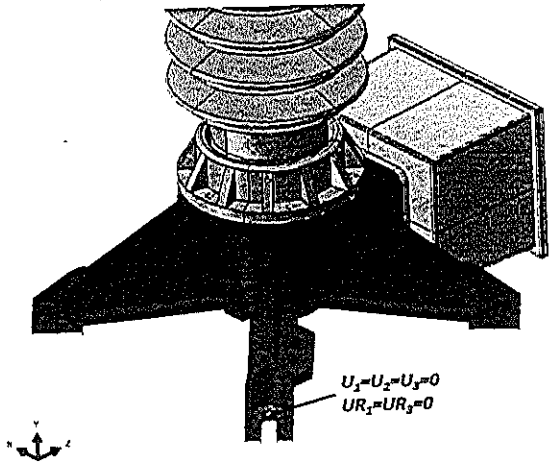


Figure 2. *Boundary conditions – general view*

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.

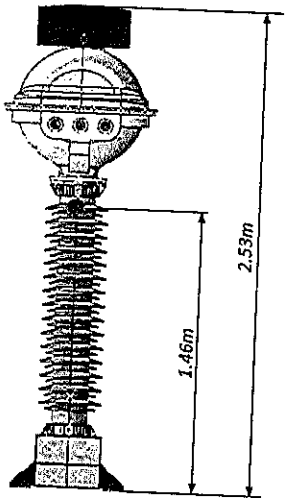


Figure 3. *Simplified representation of the PA 123a/PA 145a transformer*

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.

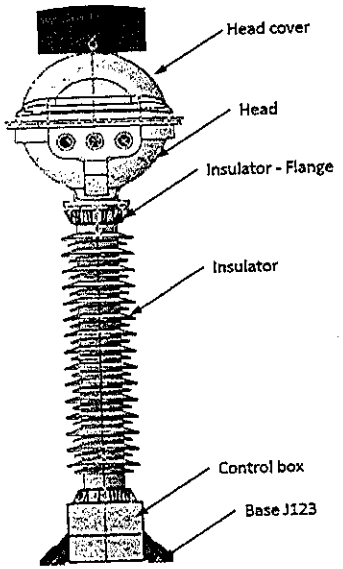


Figure 4. *Assembly – component naming*

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
	Insulator	Porcelain	71	100000	140	
2GKA310404	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.

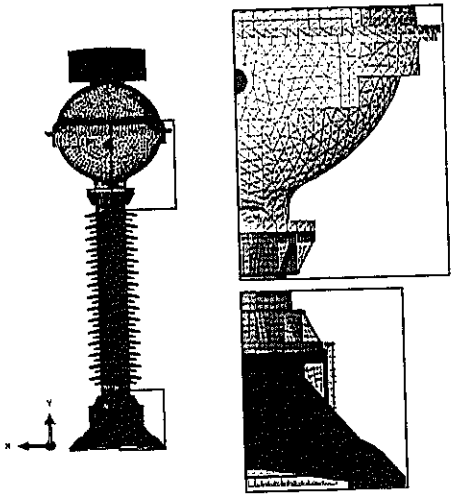


Figure 5. *FE model – general view*

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.

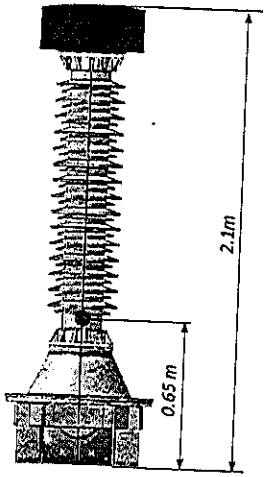


Figure 6. *Simplified representation of the PV 123 transformer*

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.

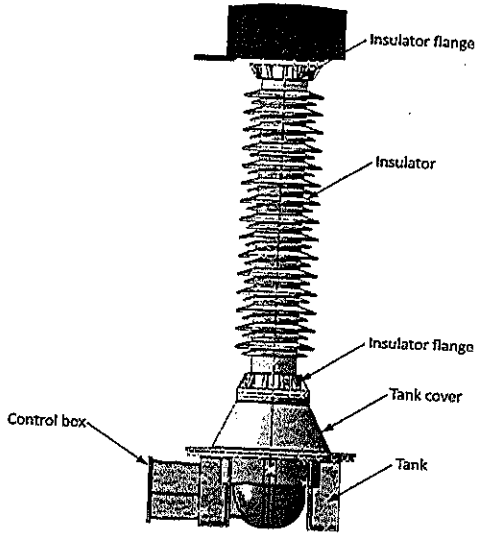


Figure 7. *Assembly – component naming*

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.

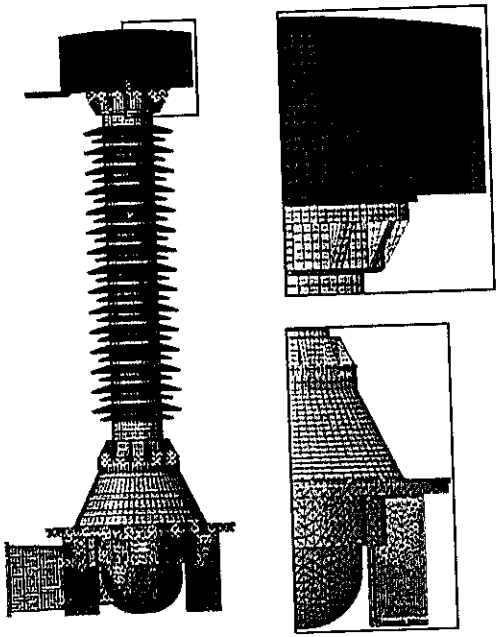


Figure 8. *FE model – general view*

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.

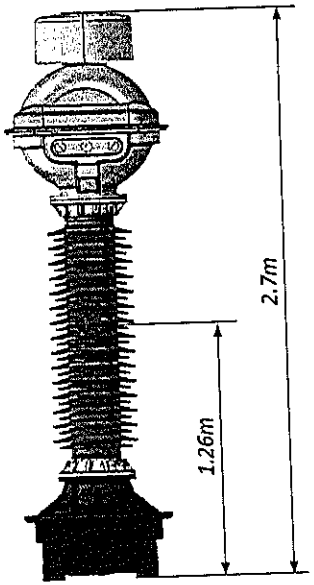


Figure 9. *Simplified representation of the PVA123a /PVA145a transformer*

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

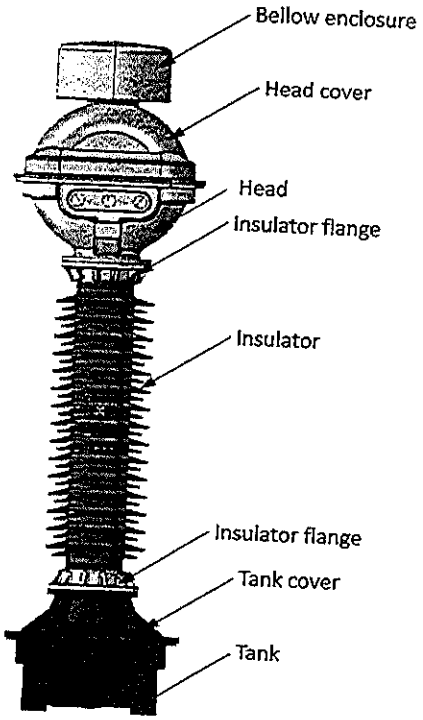


Figure 10. *Assembly – component naming*

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.

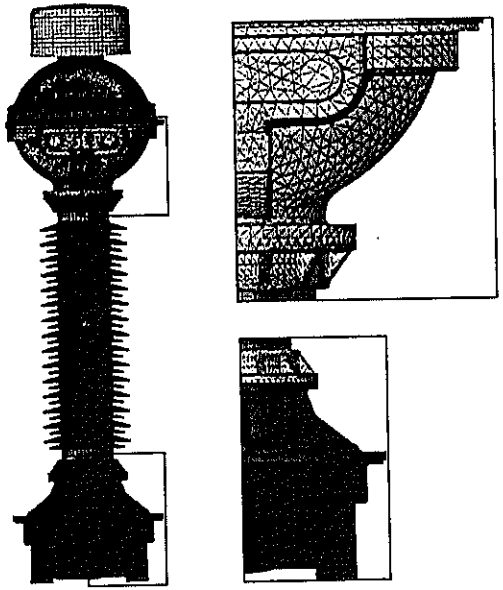


Figure 11. *FE model – general view*

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 includes 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.

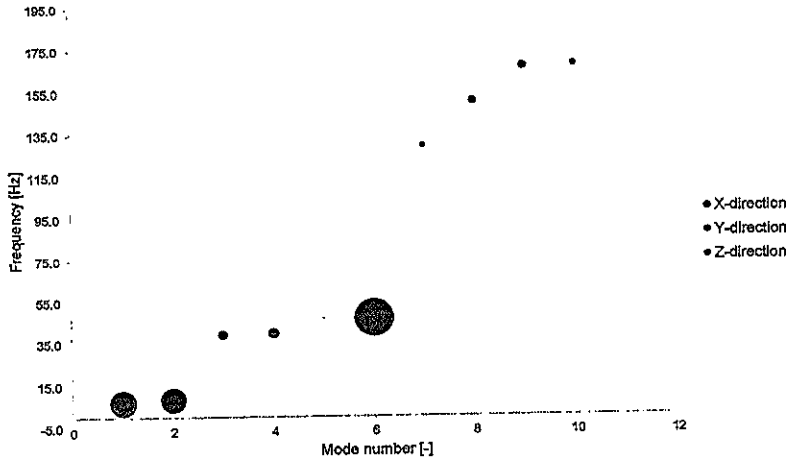


Figure 12. *Natural frequency extraction – effective modal mass*

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

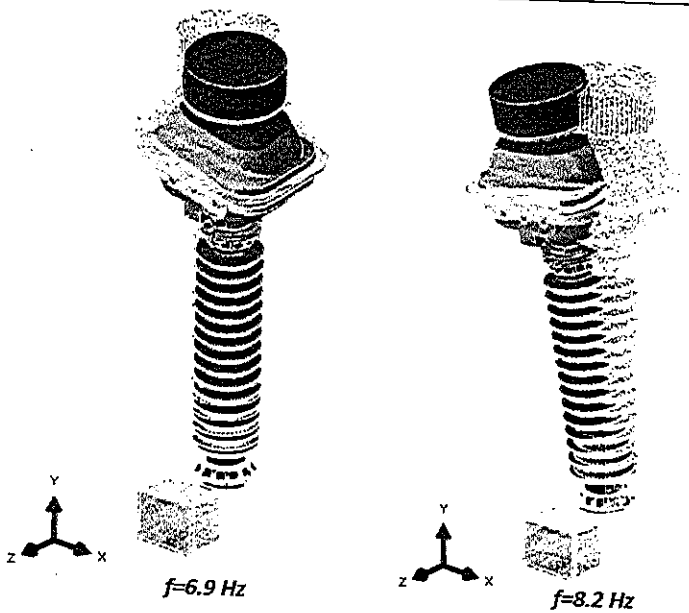


Figure 13. *Natural frequency extraction – mode shapes*

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)*

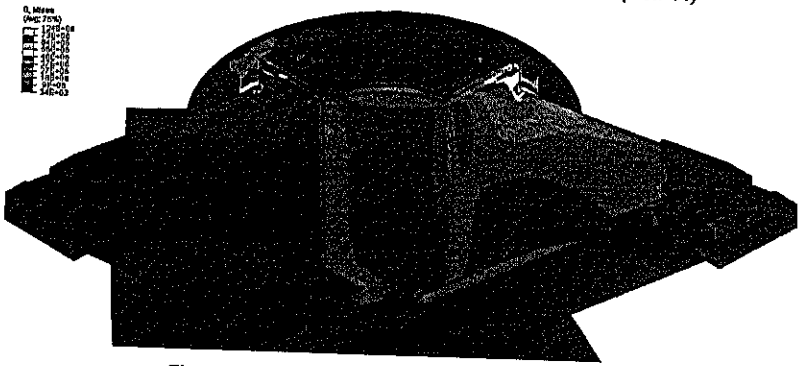


Figure 15. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 16.

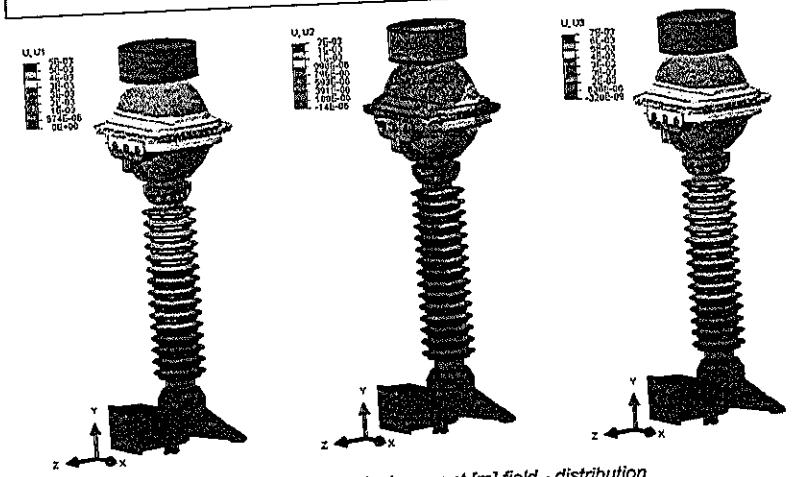


Figure 16. *Displacement [m] field - distribution*

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.

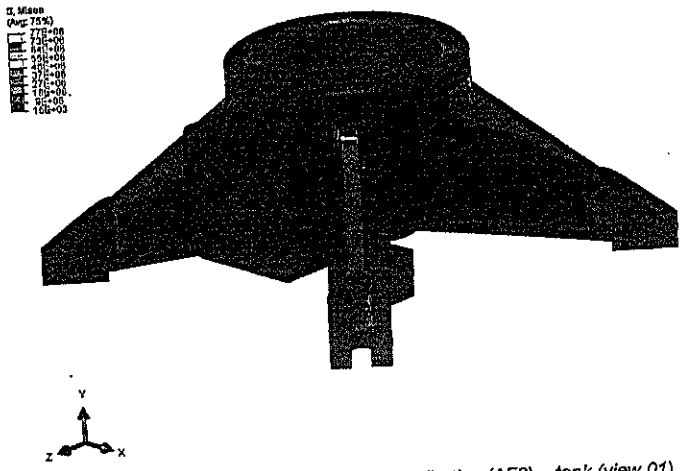


Figure 17. *Von-Mises stress [Pa] distribution (AF3) – tank (view 01)*

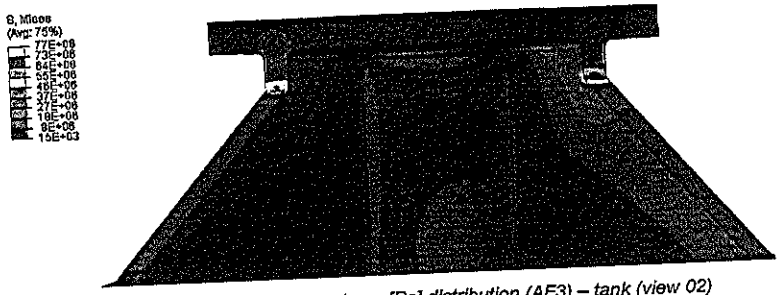


Figure 18. *Von-Mises stress [Pa] distribution (AF3) – tank (view 02)*

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.

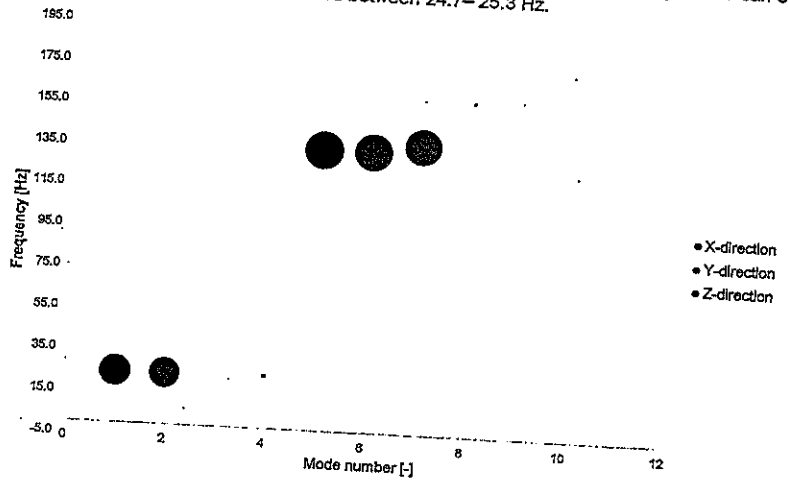
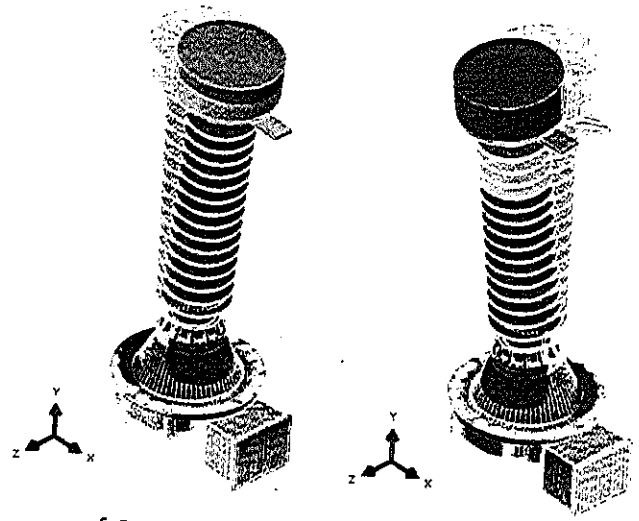


Figure 19. *Natural frequency extraction – effective modal mass*

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. 24 MPa and it was located at vicinity of coupling constraint. Stress level satisfies required safety condition.

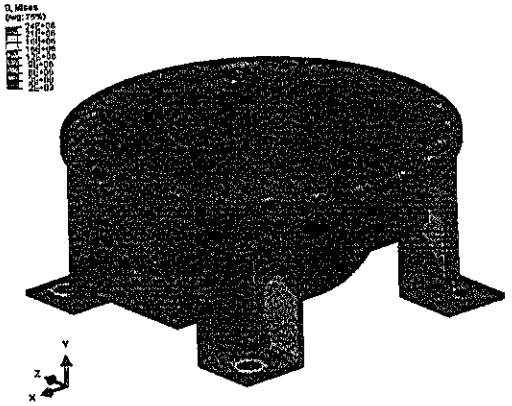


Figure 21. *Von-Mises stress [Pa] distribution – tank (view 01)*

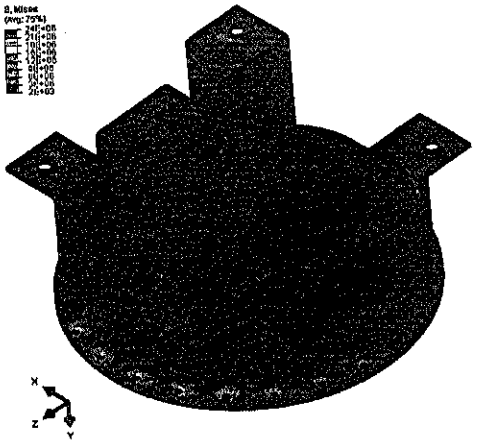


Figure 22. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 23.

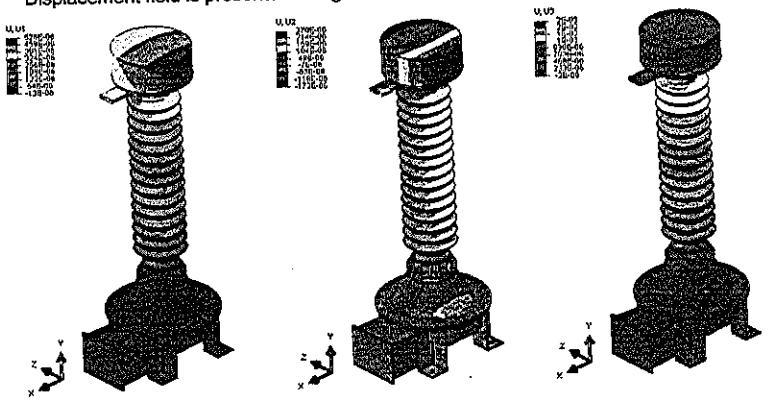


Figure 23.*Displacement [m] field - distribution*

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.

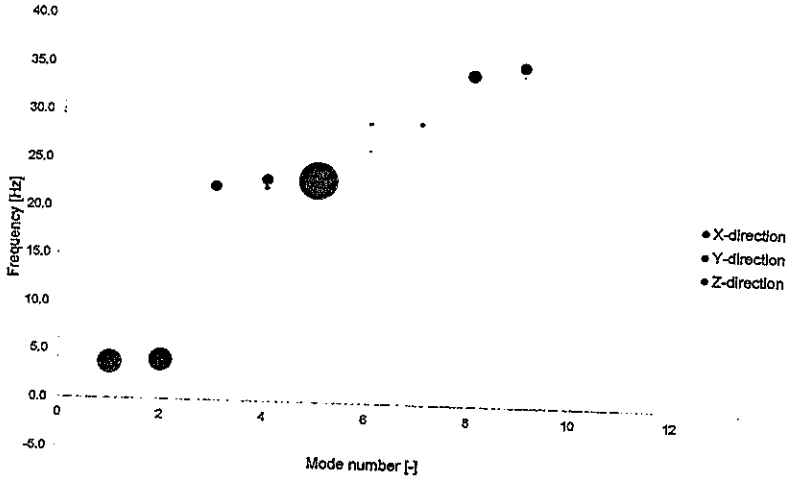
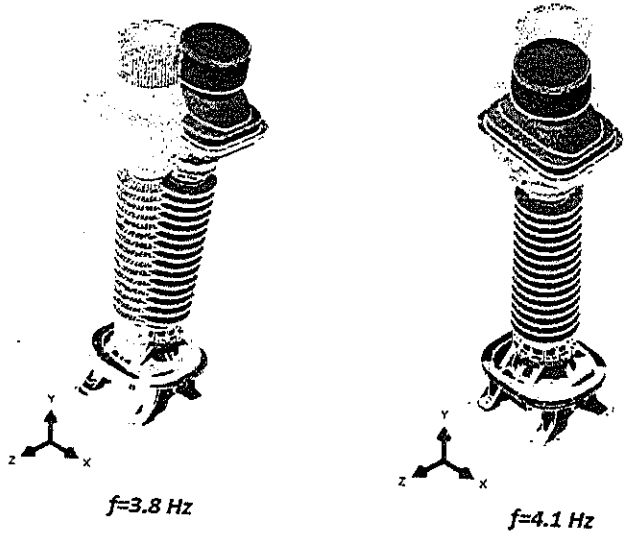


Figure 24. *Natural frequency extraction – effective modal mass*

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.

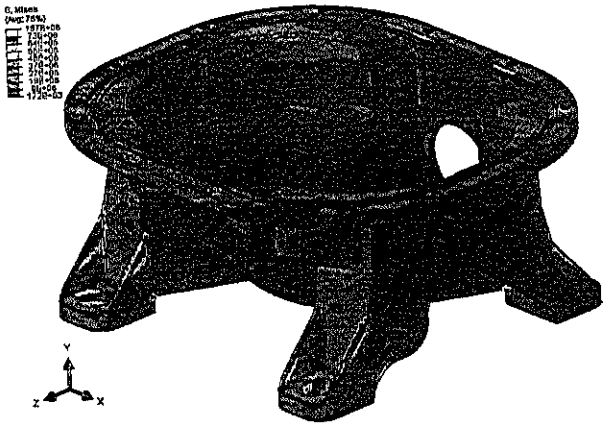


Figure 26. *Von-Mises stress [Pa] distribution – tank (view 01)*

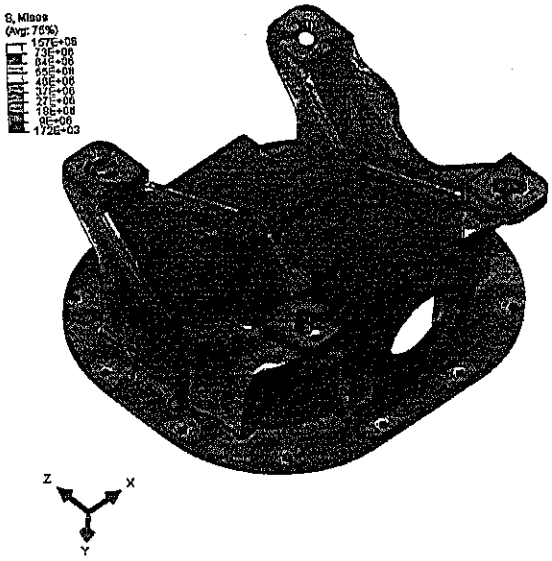


Figure 27. *Von-Mises stress [Pa] distribution – tank (view 02)*

Displacement field is presented in Figure 28.

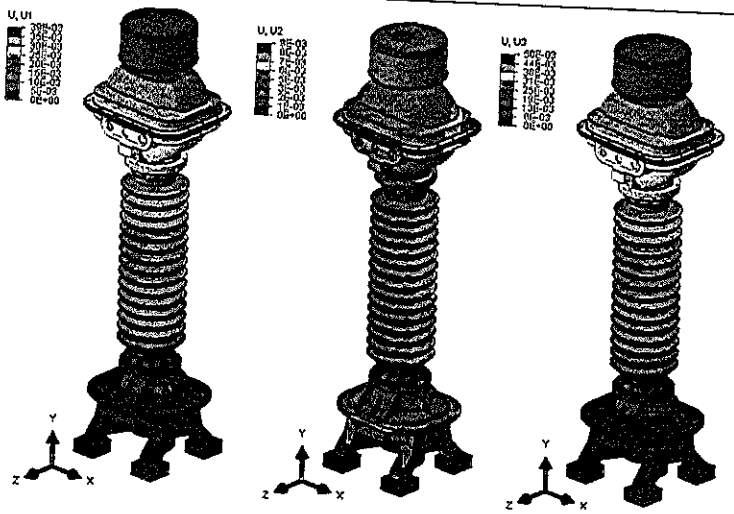


Figure 28. *Displacement [m] field - distribution*

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.

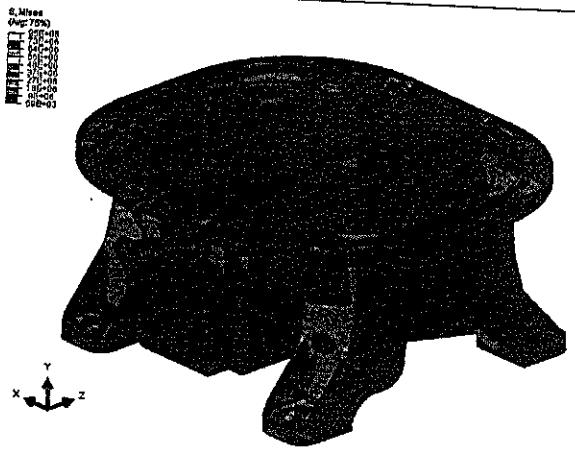


Figure 29. *Von-Mises stress [Pa] distribution – tank (view 01)*

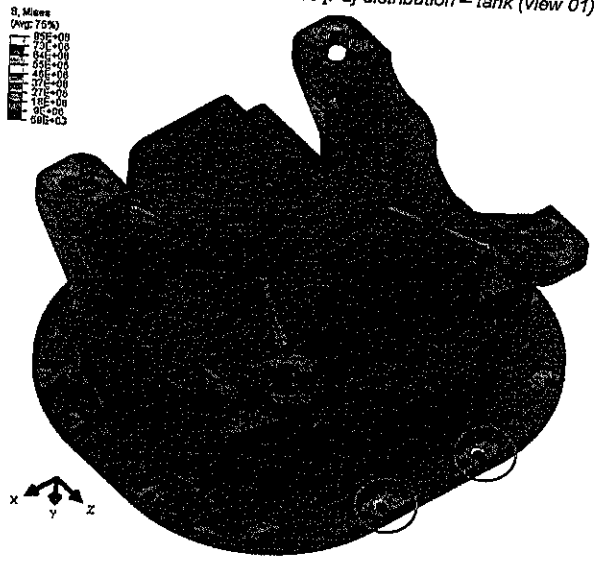


Figure 30. *Von-Mises stress [Pa] distribution – tank (view 02)*

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.

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

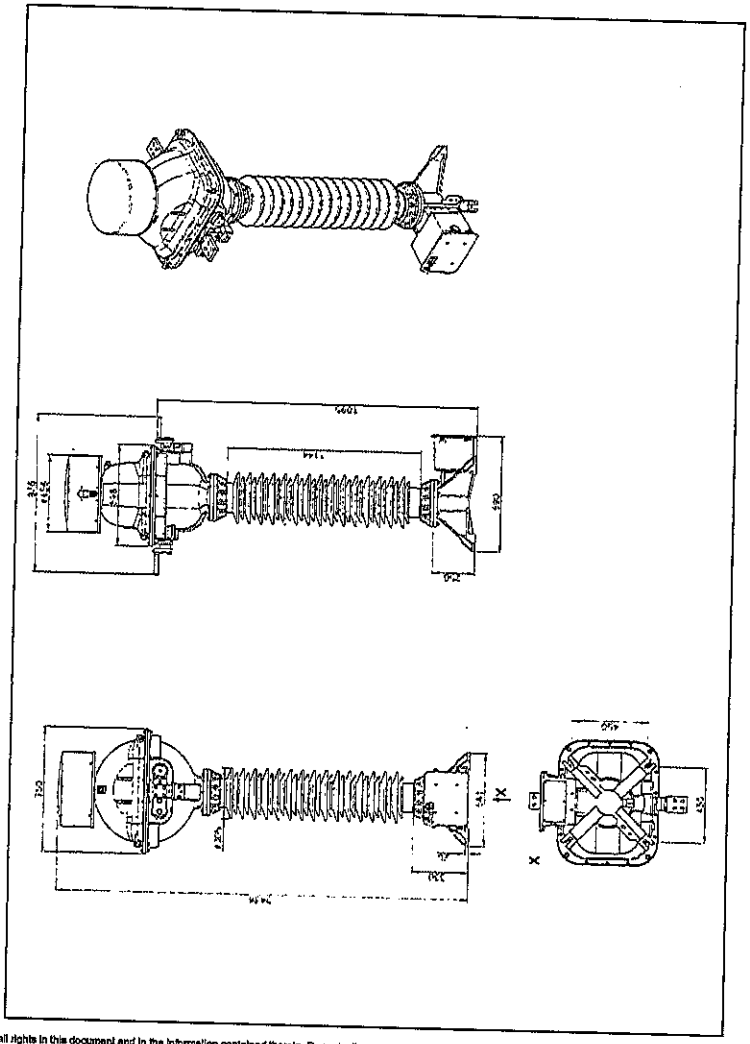
[3] *IEC* **61869-1** – *Instrument transformers – Part 1: General requirements*, International standard, Edition 1.0 2007-10

7 CHANGE HISTORY

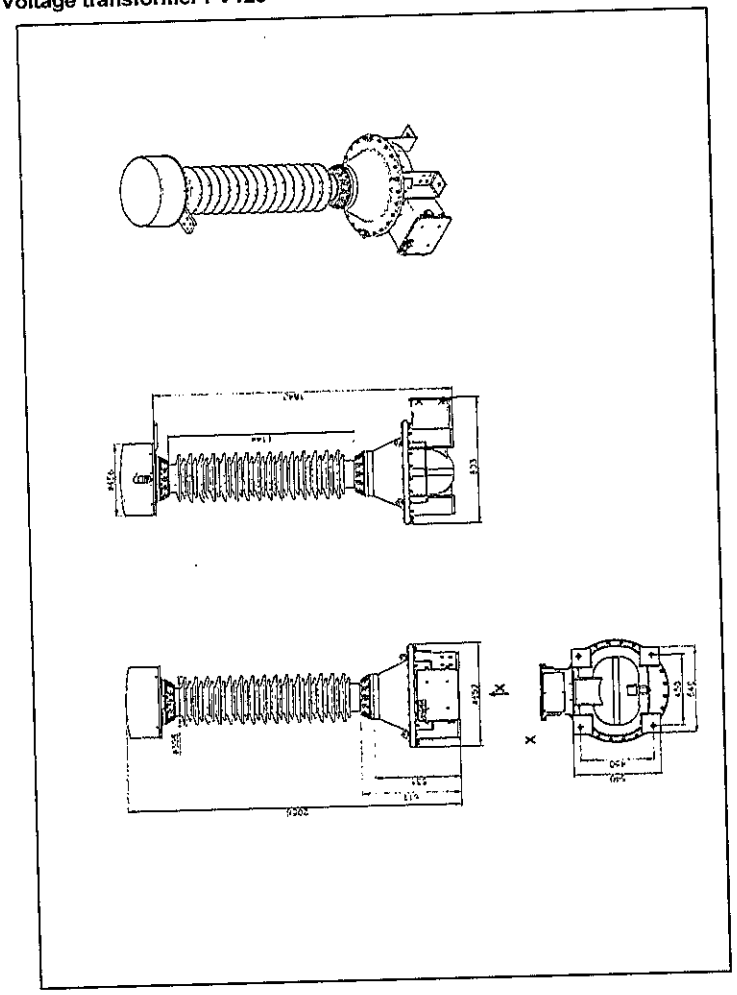
Date	Revision	Author(s)	Change
2015-08-31	Rev. 1	Juszkiewicz Grzegorz	original document

8 APPENDICES

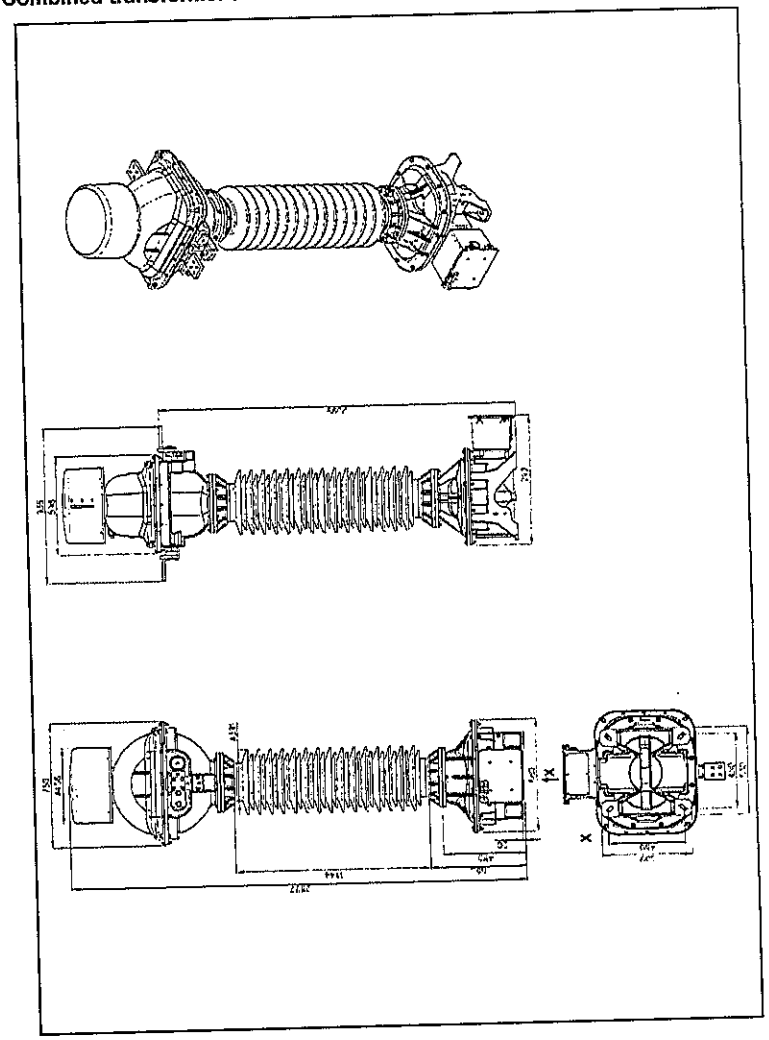
8.1 Current transformer PA123a /PA145a



8.2 Voltage transformer PV123



8.3 Combined transformer PVA123a /PVA145a



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www.ien.com.pl/ewp

TEST REPORT No. EWP/10/E/2014-1e

TEST OBJECT:	Combined instrument transformer type PVA 145a
MANUFACTURER:	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
TESTS ORDERED BY:	Institute of Power Engineering High Voltage Department Internal order No. EWN/145/E/13/14 dated 15.01.2014
TYPE OF TESTS:	**Temperature-rise test (construction)**
TEST PROCEDURE:	IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013, IEC 62271-1:2011, PN-EN 61869-1:2009E, PN-EN 61869-2:2013-06E, PN-EN 61869-3:2011E, PN-EN 62271-1:2009/A1:2011E.
TEST OBJECT DELIVERED:	13.01.2014
DATE OF TESTS:	15.01.2014-16.01.2014
TESTS RESULTS:	**Positive**
THE TESTS WERE WITNESSED BY:	
TEST ENGINEER:	Jacek Tymochowicz M.Sc. Eng.
HEAD OF LABORATORY:	Lidia Gruza M.Sc. Eng.

Warsaw, 21.01.2014r.

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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
9.	Records made during tests

Report contains 17 numbered pages with:	
1	Drawing
2	Photographs
2	Appendixes

1.	Description of the test object
Test object	Combined instrument transformer
Type	PVA 145a
Serial number	2GKP013K1486145
Manufacturer	ABB Sp. z o.o. Power Products 59 Leszno Str. 06–300 Przasnysz, Poland
Year of production	2013
Insulator	Composite Insulator
Number of windings	CT part – 5, CT part –4
Oil type	Nytro Libra
Minimum creepage distance	4495 mm
Insulating oil weight	150 kg
Total weight	540 kg
Dimensions	According to drawing no. 2GKK614123

The laboratory made the identification of test objects on the base of the documentation given in par. 3 – see Appendix.
The test object is shown in the photographs No. 1 and 2. The object was prepared for testing by the Manufacturer.

2.	Technical data declared by the Manufacturer
Maximum operating voltage	145 kV
Rated frequency	50 Hz
Voltage factor and time	$1{,}9U_n/8h$
Rated continuous thermal current, I_{cth}	180-360 A
Rated short-time thermal current, I_{th}/ 1s	20-20 kA
Rated dynamic current, I_{dyn}	50-50 kA

VT part					
Type of secondary winding	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
Rated secondary voltage	110:√3 V	110:√3 V	110:√3 V	110:√3 V	110 V
Rated output	100 VA	100 VA	100 VA	100 VA	200 VA
Accuracy class	1,0	1,0	1/3P	3/3P	3,0
Thermal limiting output	1000 VA	1000 VA	1000 VA	1000 VA	450 VA

CT part				
Type of secondary winding	1S1-1S2	2S1-2S2	3S1-3S2	4S1-4S2
Rated secondary current	5 A	1 A	5 A	1 A
Rated output	30 VA	40 VA	60 VA	60 VA
Accuracy class	0,2	5P	5P	5P
FS/ALF	5	20	20	20
Ext.	120 %	-	-	-

3.	Technical documentation of the test object
1.	Drawing no. 2GKK614123 – Dimensional drawing. Combined instrument transformer PVA 123a – 145a, ABB Sp. z o.o. Power Products, approved 17.12.2013
2.	Routine tests report of combined instrument transformer, typ PVA 145a, serial number: 2GKP013K1486145, ABB Sp. z o.o., Przasnysz, 04.12.2013

4. Scope of the tests

Test programme agreed with Orderer comprised of tests:

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

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

5. Tests and their results

Combined transformer was installed at the test stand, as it was during normal operation.
Electric diagram of terminal box of tested combined transformer is given in Fig. 1.
The rated voltage with a required value was applied to the primary voltage winding.
The secondary voltage windings and the residual voltage winding were loaded with the suitable power, according to the test programme given below, which was agreed with the Orderer.
Primary current terminals P1 and P2/A was bridged at the range of 300 A.
According to Manufacturer's request current in primary current winding was equal to $\mathbf{I_{cth} = 360\ A}$.
The arrangement of the thermocouples is given in Figure No. 2.
The temperature-rises of windings were measured by the resistance rise method.
During the test, the measurements of loaded windings were made every 1 hour and registered the deflection of oil level indicator.
The resistances of all windings were measured before the tests and after of each stage of tests.
The abstract of the protocol of temperature-rise test is given in Table No. 1.
The summary of test results is given in Table 2.

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

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

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EWP/10/E/2014-1e

Stage No. 1 Test at the rated load

Test was performed according to the IEC 61869-1 p. 6.4 i p. 7.2.2; IEC 61869-2 p. 6.4.1 i p. 7.2.2.204; IEC 61869-3 p. 6.4.1 i p.7.2.2; IEC 61869-4 p. 6.4.1 i p. 7.2.2.

The voltage value 1,2 U_n = 91,5 kV was applied to the P2/A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V; 2a-2n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V; 3a-3n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V; 4a-4n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V.
The winding of residual voltage remained open.

The secondary current windings of the CT were loaded as follows: 1S1-1S2 ⇒ 30 VA, cos φ = 1; 2S1-2S2 ⇒ 40 VA, cos φ = 1; 4S1-4S2 ⇒ 60 VA, cos φ = 1.
Supply (current control) was applied to the secondary current winding 3S1-3S2.
Terminals P1 and P2/A were short-circuited at the range 300 A.
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 p. 6.4 i p. 7.2.2; IEC 61869-2 p. 6.4.1 i p. 7.2.2.204; IEC 61869-3 p. 6.4.1 i p.7.2.2; IEC 61869-4 p. 6.4.1 i p. 7.2.2.
The voltage value 1,9 U_n = 144,8 kV was applied to the P2/A terminal.
The secondary voltage windings were loaded as follows: 1a-1n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V; 2a-2n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V; 3a-3n ⇒ 100 VA at the voltage 100/√3 V; 4a-4n ⇒ 100 VA, cos φ = 1, at the voltage 100/√3 V.
The residual winding da-dn was loaded by ⇒ 450 VA, cos φ = 1, at the voltage 100 V.

The secondary windings of the CT part were loaded by powers: 1S1-1S2 ⇒ 30 VA cos φ = 1; 2S1-2S2 ⇒ 40 VA cos φ = 1; 4S1-4S2 ⇒ 60 VA, cos φ = 1.
Supply (current control) was applied to the secondary current winding 3S1-3S2.
Terminals P1 and P2/A were short-circuited at the range 300 A.
The duration of the test was 8 h.

Stage No. 2 Test with thermal limit power

Test was done immediately after Stage No. 2 according to the IEC 61869-1 p. 6.4 i p. 7.2.2; IEC 61869-2 p. 6.4.1 i p. 7.2.2.204; IEC 61869-3 p. 6.4.1 i p.7.2.2; IEC 61869-4 p. 6.4.1 i p. 7.2.2.
The voltage value U_n = 76,2 kV was applied to the P2/A terminal.
According to Manufacturers request secondary voltage windings (1a-1n, 2a-2n, 3a-3n and 4a-4n) were loaded by limit power 1000 VA at cos φ = 1.
The residual winding remained open.

The secondary current winding of the CT part were loaded as follows: 1S1-1S2 ⇒ 30 VA, cos φ = 1; 2S1-2S2 ⇒ 40 VA; 4S1-4S2 ⇒ 60 VA, cos φ = 1.
Supply (current control) was applied to secondary current winding 3S1-3S2.
Terminals P1 and P2/A were short-circuited at the range 300 A.
The test was performed till reaching the steady state of the measured temperatures.

Measuring instruments

The temperatures were measured by means of type K thermocouples (NiCr – NiAl) with accuracy ± 0,6°C[1].
The ambient temperature was measured using four mercurial thermometers immersed into tank filled with oil. These thermometers were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor - the accuracy of measurement ± 0,03°C[2].
The resistance was measured by means of meter type 2291 manufactured by TETTEX Instrument with accuracy 0,01 mΩ[3]

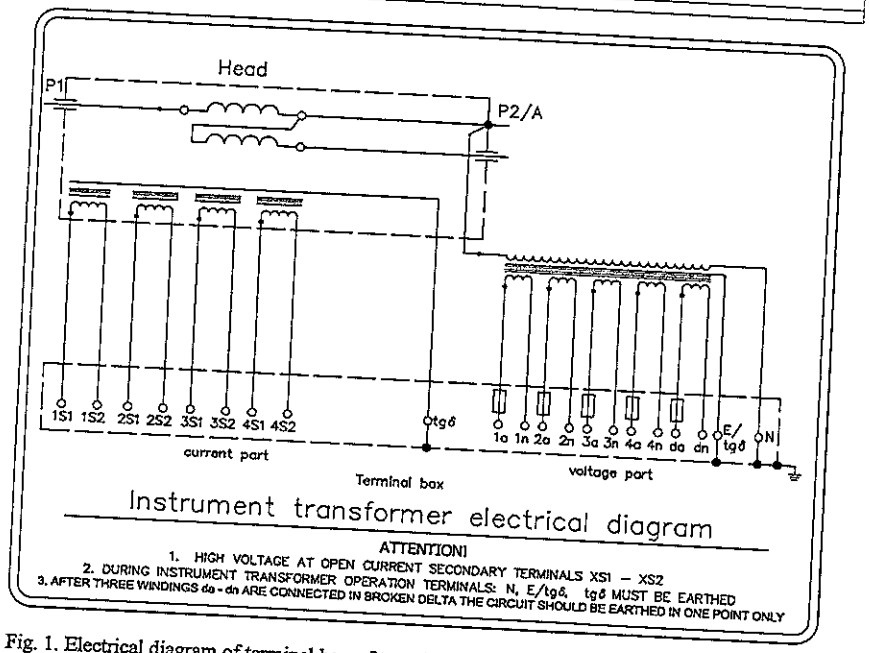

Fig. 1. Electrical diagram of terminal box of tested combined instrument transformer

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

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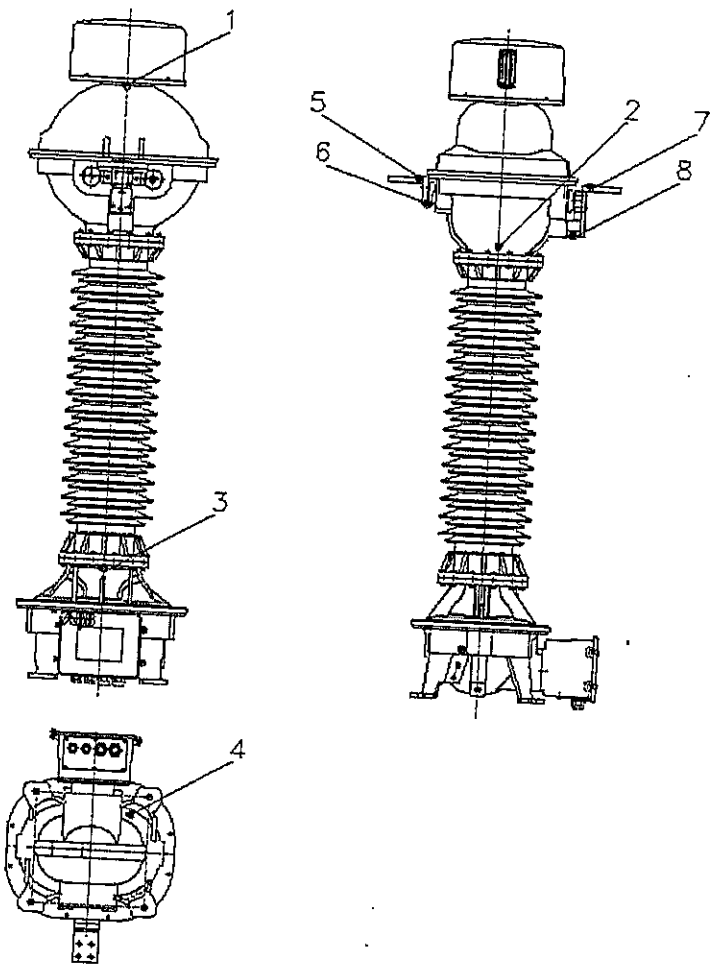

Fig. 2. Arrangement of thermocouples during temperature-rise test:
1 – oil (over current coil), 2 – head (contraction of the flange connecting the head the the insulator), 3 – under the flange of tank lid, 4 — lower tank (placed inside over earthing terminal, 5 – terminal P1, 6 – terminal P1, 7 – terminal P2/A (300A), 8 – terminal P2/A (300A).

Table 1. Temperature-rise test results of combined instrument transformer PVA 145a, nr fabr. 2GKP013K1486145

No. of thermocouple	Heating time [h]																	Etap 2			
	Stage 1																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ΔT 1, K	-	0,00	0,60	2,92	2,82	3,65	5,10	6,33	7,30	7,65	8,48	9,38	10,10	11,03	11,03	11,23	11,30	11,35	11,65	12,08	12,39	13,08
ΔT 2, K	-	0,90	2,00	4,37	4,35	4,92	6,05	6,73	7,25	7,35	7,90	8,50	8,98	9,80	9,83	9,88	9,98	10,30	10,68	10,73	10,89	11,33
ΔT 3, K	-	-0,33	0,62	2,30	1,60	1,75	2,55	2,52	2,95	2,65	2,92	3,27	3,32	3,72	3,72	4,00	4,30	4,50	4,55	4,95	5,21	5,70
ΔT 4, K	-	-0,80	0,10	1,40	0,50	0,82	1,27	1,30	1,57	1,42	1,65	1,23	1,45	1,52	1,52	1,55	1,57	1,57	1,65	1,70	1,49	1,65
ΔT 5, K	-	4,45	5,85	7,80	7,45	8,20	8,95	8,95	9,28	9,55	9,53	10,43	10,48	10,93	10,93	10,93	11,33	11,53	11,40	11,45	11,29	10,68
ΔT 6, K	-	5,25	6,90	8,95	9,03	9,40	10,30	10,83	11,15	11,33	11,83	12,10	12,65	13,25	13,28	13,30	13,43	13,68	13,48	13,38	13,51	13,88
ΔT 7, K	-	2,10	3,30	5,25	5,40	5,85	6,68	7,20	7,55	7,78	8,13	8,48	8,85	9,55	9,55	9,60	9,68	10,08	9,98	9,93	10,11	10,25
ΔT 8, K	-	2,30	3,57	5,60	5,77	6,35	7,23	7,75	8,05	8,30	8,70	9,15	9,53	10,23	10,25	10,33	10,50	11,28	10,75	10,73	10,91	11,30
$T_{st.\,6}$, °C	16,50	16,58	16,65	16,73	16,68	16,68	16,70	16,73	16,73	16,75	16,80	16,78	16,80	16,80	16,83	16,83	16,85	16,88	17,03	17,10	17,16	17,15
U_{zas}, kV	91,5																		144,8			
$I_{3S1\text{-}3S2}$, A	0,0	6,10	6,07	6,07	6,07	6,07	6,08	6,07	6,08	6,09	6,04	6,04	6,05	6,07	6,06	6,06	6,05	6,05	6,01	6,06	6,05	6,07
$I_{1S1\text{-}1S2}$, A	0,0	6,080	6,056	6,053	6,072	6,051	6,032	6,042	6,053	6,062	6,024	6,036	6,037	6,090	6,080	6,070	6,050	6,060	6,010	6,060	6,060	6,080
$I_{P1\text{-}P2/A}$, A	0,0	364,8	363,4	363,2	364,3	363,1	361,9	362,5	363,2	363,7	361,4	362,2	362,2	365,4	364,8	364,2	363,0	363,6	360,6	363,6	363,6	364,8
$I_{P2/A\text{-}N}$, mA	0,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,0	15,5	15,5	15,5	15,5
$R_{1S1\text{-}1S2}$ mΩ	234,21	238,16	240,46	242,66	244,83	246,84	248,71	250,47	252,04	253,60	255,05	256,38	257,58	258,62	259,65	260,55	261,37	262,18	262,21	263,14	263,91	264,61
$R_{2S1\text{-}2S2}$ mΩ	7,7998	7,9040	7,7970	8,0661	8,1445	8,2180	8,2858	8,3517	8,4113	8,4674	8,5205	8,5693	8,6139	8,6536	8,6909	8,7253	8,7563	8,7854	8,7876	8,8184	8,8444	8,8690
$R_{3S1\text{-}3S2}$ mΩ	378,94	384,57	389,15	392,89	396,47	400,24	403,03	406,11	409,21	412,89	415,07	416,88	419,12	421,09	423,24	425,43	426,73	426,67	427,18	429,50	430,73	431,79
$R_{4S1\text{-}4S2}$ mΩ	9,2106	9,3358	9,4414	9,5302	9,6258	9,7124	9,7953	9,8706	9,9442	10,010	10,080	10,136	10,195	10,239	10,283	10,324	10,366	10,393	10,398	10,433	10,467	10,495
$R_{P1\text{-}P2/A}$ mΩ	0,8788	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$\Delta T_{1S1\text{-}1S2}$, K	-	4,22	6,67	9,02	11,34	13,48	15,48	17,36	19,03	20,70	22,24	23,66	24,95	26,06	27,16	28,12	28,99	29,86	29,89	30,88	31,70	32,45
$\Delta T_{2S1\text{-}2S2}$, K	-	3,34	-0,09	8,54	11,05	13,40	15,61	17,69	19,60	21,40	23,10	24,66	26,09	27,37	28,56	29,66	30,66	31,59	31,66	32,65	33,48	34,27
$\Delta T_{3S1\text{-}3S2}$, K	-	3,71	6,74	9,20	11,57	14,05	15,89	17,93	19,97	22,40	23,84	25,03	26,51	27,81	29,23	30,67	31,53	31,49	31,83	33,36	34,17	34,87
$\Delta T_{4S1\text{-}4S2}$, K	-	3,40	6,26	8,67	11,27	13,62	15,87	17,91	19,91	21,70	23,60	25,12	26,72	27,91	29,11	30,22	31,36	32,09	32,23	33,18	34,10	34,86
$\Delta T_{P1\text{-}P2/A}$, K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1. cont.

	Heating time [h]																		Etap 2			
	Stage 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
$R_{1S-1S_{zas}}$ mΩ	47,448	47,669	47,886	48,177	49,062	48,464	48,563	48,626	48,700	48,730	48,784	48,828	48,855	48,889	48,904	48,922	48,946	48,952	49,151	49,375	49,548	49,653
$R_{2S-2S_{zas}}$ mΩ	48,790	48,983	49,298	49,500	50,388	49,785	49,887	49,957	50,036	50,067	50,125	50,163	50,190	50,234	50,248	50,267	50,284	50,299	50,488	50,715	50,903	51,016
$R_{3S-3S_{zas}}$ mΩ	50,002	50,298	50,642	50,845	51,574	51,131	51,217	51,325	51,378	51,436	51,496	51,536	51,573	51,596	51,618	51,649	51,657	51,681	51,861	52,087	52,287	52,412
$R_{4S-4S_{zas}}$ mΩ	51,266	51,559	51,900	52,114	52,859	52,419	52,596	52,616	52,672	52,736	52,795	52,832	52,872	52,898	52,916	52,959	52,957	52,987	53,167	53,396	53,697	53,731
$R_{5S-5S_{zas}}$ mΩ	34,300	34,487	34,683	34,821	35,413	35,011	35,071	35,122	35,168	35,208	35,242	35,278	35,289	35,310	35,334	35,344	35,352	35,360	35,478	35,618	35,745	35,827
$R_{P2/A\text{-}N}$ kΩ	20,62	20,76	20,80	20,86	20,88	20,95	21,01	21,08	21,09	21,11	21,14	21,20	21,25	21,28	21,30	21,32	21,34	21,40	21,47	21,49	21,50	21,51
$\Delta T_{1S-1S_{zas}}$ K	-	1,16	2,83	3,84	8,50	5,35	5,87	6,21	6,60	6,75	7,04	7,27	7,41	7,59	7,67	7,77	7,89	7,92	8,97	10,15	11,06	11,62
$\Delta T_{2S-2S_{zas}}$ K	-	0,99	2,60	3,64	8,19	5,10	5,62	5,98	6,38	6,54	6,84	7,04	7,17	7,40	7,47	7,57	7,66	7,73	8,70	9,86	10,83	11,41
$\Delta T_{3S-3S_{zas}}$ K	-	1,48	3,20	4,21	7,86	5,64	6,07	6,61	6,88	7,17	7,47	7,67	7,85	7,97	8,08	8,23	8,27	8,39	9,29	10,42	11,42	12,05
$\Delta T_{4S-4S_{zas}}$ K	-	1,43	3,09	4,14	7,77	5,62	6,49	6,58	6,86	7,17	7,46	7,64	7,83	7,96	8,05	8,26	8,25	8,39	9,27	10,39	11,85	12,02
$\Delta T_{5S-5S_{zas}}$ K	-	1,36	2,79	3,80	8,11	5,18	5,62	5,99	6,33	6,62	6,87	7,13	7,21	7,36	7,54	7,61	7,67	7,73	8,59	9,61	10,53	11,13
$\Delta T_{P2/A\text{-}N}$ K	-	1,70	2,18	2,91	3,15	4,00	4,73	5,58	5,70	5,94	6,30	7,03	7,64	8,00	8,24	8,49	8,73	9,46	10,31	10,55	10,67	10,79
Deflection of the oil level indicator mm	2	4	6	8	10	13	14	16	18	21	23	24	27	29	30	30	31	32	33	35	35	36

Table 1. cont.

No. of thermocouple	Heating time [h]								
	Stage 2				Stage 3				
	22	23	24	25	26	27	28	29	30
ΔT 1, K	13,10	13,30	14,03	14,05	13,75	13,93	14,80	14,40	15,08
ΔT 2, K	10,50	10,85	11,25	11,38	11,00	11,23	11,93	11,70	12,10
ΔT 3, K	5,80	6,13	6,35	6,65	5,95	6,38	6,83	6,28	7,03
ΔT 4, K	1,92	2,32	2,35	2,37	1,10	1,27	1,97	1,22	2,02
ΔT 5, K	10,88	11,35	11,63	11,75	11,38	11,75	12,58	12,00	12,50
ΔT 6, K	13,08	13,53	13,65	13,75	13,80	14,20	14,73	14,73	14,98
ΔT 7, K	9,85	10,43	10,45	10,60	10,30	10,58	11,13	11,10	11,45
ΔT 8, K	10,73	11,20	11,23	11,30	11,13	11,50	11,93	11,90	12,33
$T_{at\ k}$, °C	17,18	17,18	17,18	17,18	17,18	17,23	17,23	16,75	16,75
U_{znv}, kV	144,8				76,2				
$I_{3S1-3S2}$, A	6,05	6,05	6,03	6,06	6,09	6,09	6,08	6,06	6,03
$I_{1S1-1S2}$, A	6,060	6,060	6,040	6,070	6,074	6,061	6,069	6,051	6,020
$I_{P2/A-N}$, mA	363,6	363,6	362,4	364,2	364,4	363,7	364,1	363,1	361,2
$R_{1S1-1S2}$ mΩ	15,5	15,5	15,5	15,5	52,0	52,0	52,0	52,0	52,0
$R_{2S1-2S2}$ mΩ	265,19	265,78	266,27	266,77	267,07	267,35	267,68	267,98	268,22
$R_{3S1-3S2}$ mΩ	8,8894	8,9104	8,9288	8,9459	8,9582	8,9692	8,9804	8,9910	8,9990
$R_{4S1-4S2}$ mΩ	432,20	433,58	434,34	434,45	435,51	436,06	436,34	437,50	438,23
$R_{P1-P2/A}$ mΩ	10,521	10,547	10,570	10,587	10,602	10,618	10,627	10,648	10,655
$\Delta T_{1S1-1S2}$, K	-	-	-	-	-	-	-	-	0,9801
$\Delta T_{2S1-2S2}$, K	33,07	33,70	34,22	34,76	35,08	35,37	35,73	36,05	36,30
$\Delta T_{3S1-3S2}$, K	34,92	35,60	36,19	36,73	37,13	37,48	37,84	38,18	38,44
$\Delta T_{4S1-4S2}$, K	35,14	36,05	36,55	36,62	37,32	37,68	37,87	38,63	39,12
$\Delta T_{P1-P2/A}$, K	35,57	36,27	36,90	37,36	37,77	38,20	38,44	39,01	39,20
	-	-	-	-	-	-	-	-	28,82

Table 1. cont.

Table 1. Temperature-rise test results of combined instrument transformer PVA 145a, nr fabr. 2GKP013K1486145

	Heating time [h]								
	Stage 2				Stage 3				
	22	23	24	25	26	27	28	29	30
R_{1s-1s}, mΩ	49,726	49,809	49,851	49,863	51,118	51,339	51,486	51,623	51,695
R_{2s-2s}, mΩ	51,087	51,170	51,220	51,225	52,713	52,968	53,141	53,286	53,365
R_{3s-3s}, mΩ	52,475	52,556	52,610	52,618	54,183	54,473	54,656	54,818	54,912
R_{4s-4s}, mΩ	53,803	53,890	53,946	53,949	55,615	55,943	56,137	56,308	56,412
R_{5s-5s}, mΩ	35,871	35,932	35,957	35,983	36,918	37,099	37,229	37,337	37,402
$R_{P2/A-N}$, kΩ	21,54	21,55	21,58	21,61	22,51	23,02	23,37	23,51	23,58
ΔT_{1s-1s}, K	12,00	12,44	12,66	12,72	19,34	20,50	21,28	22,00	22,38
ΔT_{2s-2s}, K	11,77	12,20	12,45	12,48	20,10	21,41	22,29	23,04	23,44
ΔT_{3s-3s}, K	12,36	12,77	13,04	13,08	20,90	22,35	23,27	24,08	24,55
ΔT_{4s-4s}, K	12,37	12,80	13,07	13,08	21,21	22,81	23,75	24,59	25,09
ΔT_{5s-5s}, K	11,45	11,90	12,08	12,27	19,08	20,40	21,35	22,14	22,61
$\Delta T_{P2/A-N}$, K	11,15	11,28	11,64	12,00	22,91	29,10	33,34	35,04	35,89
Deflection of the oil level indicator mm	38	39	40	40	41	42	43	44	45

Table 2. **Temperature-rises ΔT [K] given during the tests combined instrument transformer** PVA 145a serial number 2GKP013K1486145

Winding	ΔT after Stage 1	ΔT after Stage 2	ΔT after Stage 3	ΔT_{dop}
1S1-1S2	29,86	34,76	36,30	
2S1-2S2	31,59	36,73	38,44	
3S1-3S2	31,49	36,62	39,12	75 [1),3)]
4S1-4S2	32,09	37,36	39,20	
P1-P2/A	*Not measured*	*Not measured*	28,82	
1a-1n	7,92	12,72	22,38	
2a-2n	7,73	12,48	23,44	
3a-3n	8,39	13,08	24,55	75 [2),3)]
4a-4n	8,39	13,08	25,09	
da-dn	7,73	12,27	22,61	
P2/A-N	9,46	12,00	35,89	

No. of thermo-couple	Location	ΔT after Stage 1	ΔT after Stage 2	ΔT after Stage 3	ΔT_{dop}
1	Oil	11,35	14,05	15,08	55 [1),2),3),4)]
2	Head – top part next to terminal	10,30	11,38	12,10	40 [5)]
3	Under the tank lid from side of terminal box	4,50	6,65	7,03	
4	Enclosure of lower tank	1,57	2,37	2,02	
5	Terminal P1	11,53	11,75	12,50	65 [5)]
6	Terminal P1	13,68	13,75	14,98	
7	Terminal P2/A	10,08	10,60	11,45	
8	Terminal P2/A	11,28	11,30	12,33	

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

$\Delta\vartheta$ - temperature-rise; $\Delta\vartheta_{dop}$ – permitted value in steady state

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6. Summary

In tested combined instrument transformer type PVA 145a, with composite insulator, as results of temperature rise test with current I_{cth}= **360 A**:

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

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

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

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

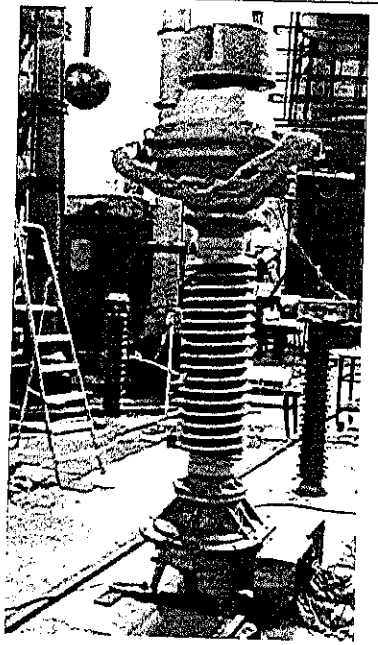
- results of test with thermal limit power (Stage No. 3) at rated load of current windings at cos φ = 1 and supply voltage U_n, and at the same time loading of all voltage windings (without residual windings) with thermal limit power, shows that permitted temperature-rise limits were not exceeded).

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

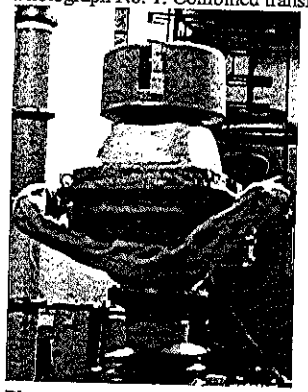
7. Opinions and interpretations

None

8. Photographic documentation



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



Photograph No. 2. The conductors short-circuiting of P1–P2/A terminals.

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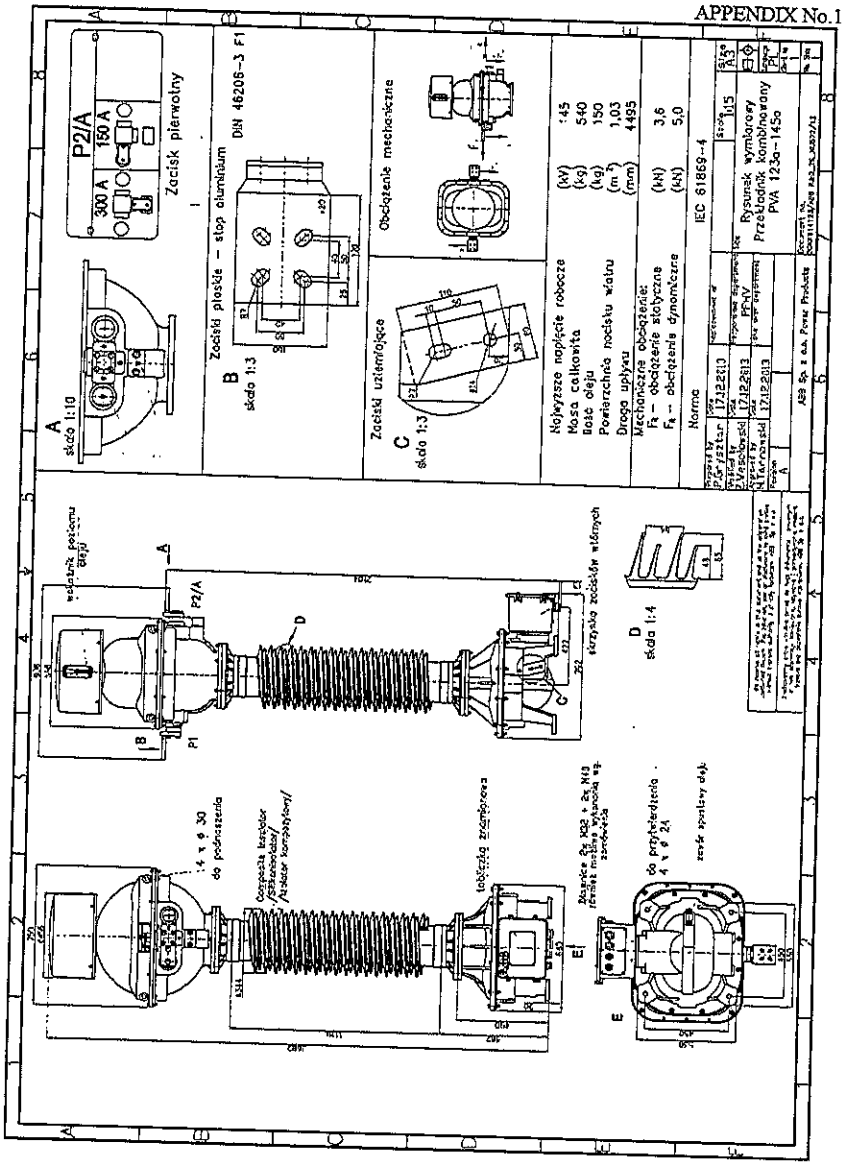
APPENDIX No.1



APPENDIX No.2

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

DECLARATION OF CONFORMITY No. 092/2013 (EN)
(acc. to ISO/IEC 17050-1)

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

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

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

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

Additional information:
Serial numbers: **2GKP013K1486145;**

Place and date of issue of declaration

Przasnysz 13.01.2014

ABB Sp. z o.o.
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NIP: 526-030-44-84; PL 5260304484
Regon 010017165
ODDZIAŁ W PRZASNYSZU
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(9)

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

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

(Name) (Signature)

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AB 323

TEST REPORT No. EWP/47/E/2014-1e

TEST OBJECT: Current instrument transformer type PA 145a

MANUFACTURER: ABB Sp. z o.o.
Branch Office in Przasnysz
59 Leszno Str.
06-300 Przasnysz, Poland

TESTS ORDERED BY: ABB Sp. z o.o.
Branch Office in Przasnysz
59 Leszno Str.
06-300 Przasnysz, Poland
Order No. 4500574872 dated on 22.07.2014

TYPE OF TESTS: Temperature-rise test

TESTS PROCEDURE:: IEC 61869-1:2007, IEC 61869-2:2012, IEC 62271-1:2011, PN-EN 61869-1:2009E, PN-EN 61869-2:2013-06E, PN-EN 62271-1:2009/A1:2011E

OBJECT DELIVERED: 23.07.2014

DATE OF TESTS: 30.07-31.07 2014

TESTS RESULTS: Positive for current I_{cth}=1800 A (at range 1500 A)

THE TESTS WERE WITNESSED BY: –

TEST ENGINEER: Mariusz Sul M. Sc. Eng.

HEAD OF LABORATORY: Lidia Gruza M. Sc. Eng.

TRANSLATED BY Jacek Tymochowicz M. Sc. Eng.

Warsaw, 5.08.2014

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 contains 12 numbered pages with:	
1	drawing
1	photograph
2	appendixes

1.	Description of the test object
Test object	Current instrument transformer
Type	PA 145a
Serial number	2GKP014A1287155
Manufacturer	ABB Sp. z o.o. Branch Office in Przasnysz 59 Leszno Str. 06-300 Przasnysz, Poland
Year of production	2014
Insulator	Composite insulator
Number of windings	5
Oil type	Nytro Libra
Minimum creepage distance	3075 mm
Insulating oil weight	120 kg
Total weight	360 kg
Dimensions	According to drawing no. 2GKA614301

The laboratory made the identification of test objects on the base of the documentation given in sub-cl. 3 – see 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
Maximum operating voltage	145 kV
Rated frequency	50 Hz
Rated continuous thermal current, I_{cth}	1800 A
Rated short-time thermal current, I_{th}/ 1s	63 kA
Rated dynamic current, I_{dyn}	158 kA

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Winding	Rated current winding	Rated output	Accuracy class	FS/ALF	Ext.%
1S1-1S2	5 A	200 VA	0,2	10	120
2S1-2S2	1 A	100 VA	0,1	5	120
3S1-3S2	5 A	20 VA	5P	60	
4S1-4S2	1 A	35 VA	10P	40	
5S1-5S2	1 A	40 VA	10P	20	

3.	Technical documentation of the test object
1.	Drawing no. 2GKA614301 – Dimensional drawing. „Current transformer PA 145a", ABB Sp. z o.o. Power Products, approved 01.08.2014
2.	Drawing no. 2GKK314141 –„Tor prądowy, pręt 40 Cu, rura 60x4 Al. 3600A", ABB Sp. z o.o. Power Products, approved 24.06.2014
3.	Routine tests report of current instrument transformer, type PA 145, serial number: 2GKP014AI287155, ABB Sp. z o.o., Przasnysz, 16.07.2014

4.	Scope of the tests			
Test programme agreed with Orderer comprised of tests:				
No.	**Kind of test**	**Tests according the Standard**		**Location of the test**
1.	Temperature-rise tests	IEC 61869-1:2007 sub-cl. 6.4 and sub-cl. 7.2.2, IEC 61869-2:2012 sub-cl.6.4.1 and sub-cl. 7.2.2.204 IEC 62271-1:2011, table 3	A	EWP

EWP	The test was performed in the High Current Laboratory of the Institute of Power Engineering.
A	The test method accredited by Polish Centre for Accreditation. Accreditation Certificate No. AB 323.

5. Tests and their results

Test was performed according to IEC 61869-1 sub-cl. 6.4 and sub-cl. 7.2.2; IEC 61869-2 sub-cl. 6.4.1 and sub-cl.7.2.2.204. Current transformer was installed at the test stand, as it was during normal operation. Supply was applied to the primary current terminals P1- P2/A.
The secondary windings were loaded with the suitable power: 1S1-1S2 ⇒ 200 VA, cos φ = 1; 2S1-2S2 ⇒ 100 VA, cos φ = 1; 3S1-3S2 ⇒ 20 VA, cos φ = 1; 4S1-4S2 ⇒ 35 VA, cos φ = 1; 5S1-5S2 ⇒ 40 VA, cos φ = 1.

Primary current terminals P1 i P2/A was bridged at the range of 1500 A. According to Manufacturer's request current in primary current winding was equal to I_{cth} = 1800 A.
The test was performed till reaching the steady state of the measured temperatures.

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

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

During the test, the measurements of loaded windings were made every 1 hour and registered the deflection of oil level indicator. The arrangement of the thermocouples is given in Figure No. 1.

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.

Measuring instruments

The temperatures were measured by means of type K thermocouples (NiCr – NiAl) with accuracy ± 0,3°C[1].
The ambient temperature was measured using four mercurial thermometers immersed into tank filled with oil. These thermometers were placed in the distance of 1 meter from the tested transformer at the height of 1 meter above floor- the accuracy of measurement ± 0,3°C[1].
The resistance was measured by means of meter type 2291 manufactured by TETTEX Instrument with accuracy ± 0,001 mΩ[1]

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

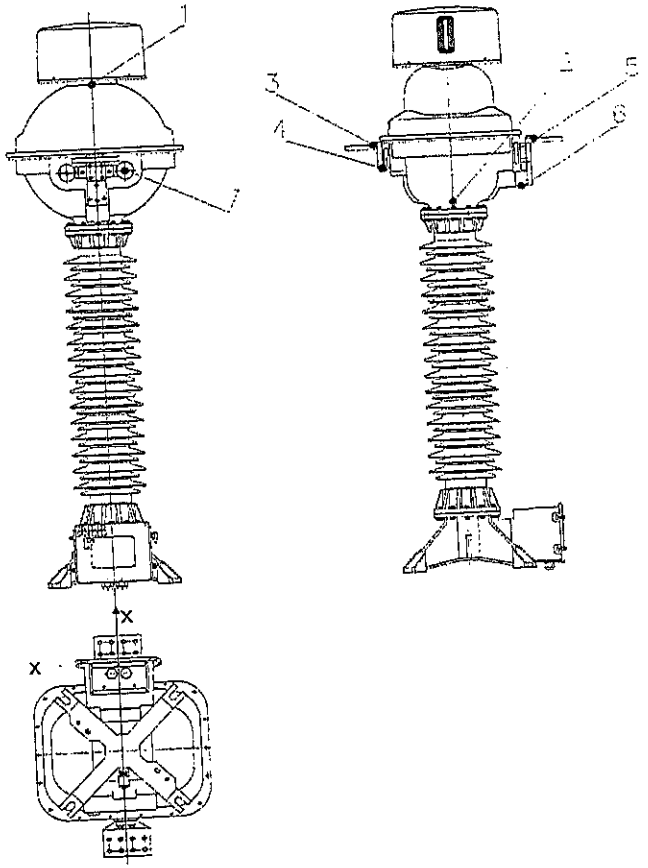

Fig. 1. Arrangement of thermocouples during temperature-rise test:
1 – oil (over current coil), 2 – head (contraction of the flange connecting the head with the insulator), 3 – terminal P1, 4 – terminal P1, 5 – terminal P2/A, 6 – terminal P2/A,
7 – thermocuple inside instrument transformer current path 3000 A.

Table 1. Results of the temperature-rise test of current instrument transformer PA 145a, serial number 2GKP014A1287155

No. of thermocouple	Heating time [h]																						
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
ΔT 1, K	-	2,2	7,8	13,7	18,0	20,8	22,6	24,8	26,6	28,0	29,2	30,3	31,2	31,8	32,5	33,2	33,6	34,1	34,6	35,0	35,3	35,8	
ΔT 2, K	-	4,3	8,4	11,9	14,6	16,6	18,0	19,7	21,0	21,7	22,8	23,6	24,3	24,8	25,4	26,0	26,4	26,8	27,2	27,4	27,6	27,9	
ΔT 3, K	-	23,2	28,6	31,5	33,0	34,5	35,3	36,7	37,2	37,8	38,5	39,0	39,5	39,8	40,2	40,6	40,7	41,0	41,2	41,5	41,6	41,6	
ΔT 4, K	-	28,1	33,6	36,7	38,5	40,2	41,5	43,2	43,7	44,6	45,4	46,2	46,5	47,2	47,4	48,0	48,3	48,7	49,1	49,3	49,6	49,6	
ΔT 5, K	-	18,9	24,9	28,4	30,2	31,7	32,5	33,9	34,5	34,9	35,7	36,1	36,5	36,7	37,0	37,5	37,6	38,0	38,3	38,4	38,7	38,8	
ΔT 6, K	-	20,5	26,6	30,2	32,4	34,2	35,2	36,8	37,3	38,1	38,7	39,4	39,8	40,2	40,6	40,9	41,1	41,6	41,7	42,0	42,3	42,3	
ΔT 7, K	-	15,5	21,9	26,7	29,9	32,7	34,6	36,9	38,2	39,5	40,7	41,7	42,5	43,4	44,0	44,7	45,2	45,8	46,3	46,7	47,1	47,4	
$T_{amb\ av}$ °C	23,5	23,8	24,4	25,0	25,2	25,4	25,9	25,7	25,8	25,9	26,0	26,0	26,1	26,1	26,2	26,2	26,3	26,3	26,3	26,4	26,4	26,5	
$R_{1S1-1S2}$ mΩ	456,16	464,59	470,27	477,78	485,33	493,04	499,86	506,57	513,30	518,85	524,43	529,73	533,95	538,40	542,29	545,68	548,90	551,77	554,33	556,79	559,01	561,03	
$R_{2S1-2S2}$ Ω	5,5170	5,5999	5,6680	5,7649	5,8571	5,9507	6,0409	6,1256	6,2065	6,2819	6,3514	6,4180	6,4736	6,5272	6,5784	6,6199	6,6608	6,6984	6,7309	6,7621	6,7909	6,8160	
$R_{3S1-3S2}$ mΩ	594,58	605,83	613,91	623,22	633,06	642,73	652,00	660,94	669,79	677,38	684,75	691,84	697,03	702,99	708,27	712,54	716,84	720,86	724,22	727,58	730,37	733,36	
$R_{4S1-4S2}$ Ω	5,7350	5,7923	5,8617	5,9541	6,0492	6,1462	6,2402	6,3307	6,4152	6,4934	6,5667	6,6349	6,6943	6,7507	6,8024	6,8469	6,8887	6,9274	6,9611	6,9945	7,0227	7,0507	
$R_{5S1-5S2}$ Ω	6,0568	6,1347	6,2117	6,3102	6,4123	6,5140	6,6128	6,7085	6,7957	6,8779	6,9536	7,0248	7,0863	7,1449	7,2000	7,2454	7,2885	7,3288	7,3644	7,3990	7,4288	7,4580	
$R_{P1-P2/A}$ mΩ (tracer 1500 A)	0,0657	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
$\Delta T_{1S1-1S2}$, K	-	4,6	7,7	11,8	16,0	20,2	24,0	27,6	31,3	34,4	37,4	40,3	42,6	45,1	47,2	49,1	50,8	52,4	53,8	55,2	56,4	57,5	
$\Delta T_{2S1-2S2}$, K	-	3,8	6,8	11,2	15,4	19,7	23,7	27,6	31,2	34,7	37,8	40,8	43,3	45,8	48,1	50,0	51,8	53,5	55,0	56,4	57,7	58,9	
$\Delta T_{3S1-3S2}$, K	-	4,7	8,1	12,0	16,2	20,2	24,1	27,9	31,6	34,8	37,9	40,9	43,1	45,6	47,8	49,6	51,4	53,1	54,5	55,9	57,1	58,4	
$\Delta T_{4S1-4S2}$, K	-	2,5	5,5	9,6	13,7	17,9	22,0	26,0	29,7	33,1	36,3	39,2	41,8	44,3	46,5	48,5	50,3	52,0	53,4	54,9	56,1	57,4	
$\Delta T_{5S1-5S2}$, K	-	3,2	6,4	10,5	14,7	18,9	22,9	26,9	30,5	33,9	37,0	40,0	42,5	44,9	47,2	49,1	50,8	52,5	54,0	55,4	56,6	57,8	
Deflection of the oil level indicator mm.	0	2	4	5	8	10	13	15	18	21	23	25	26	27	29	30	31	32	32	33	33	33	
$I_{1S1-1S2}$, A	0	6,05	6,06	6,04	6,03	6,05	6,05	6,00	6,04	6,06	6,04	6,04	6,03	6,04	6,04	6,05	6,05	6,03	6,03	6,03	6,03	6,03	
$I_{P1-P2/A}$, kA	0	1,815	1,818	1,810	1,806	1,812	1,816	1,801	1,809	1,819	1,815	1,809	1,804	1,806	1,806	1,809	1,809	1,807	1,803	1,803	1,805	1,805	

Table 1. Cont.

Table 1. Results of the temperature-rise test of current instrument transformer PA 145a, serial number 2GKP014A1287155

No. of thermocouple	Heating time [h]				
	22	23	24	25	26
ΔT 1, K	36,1	36,1	36,5	36,6	37,1
ΔT 2, K	28,2	27,8	28,1	28,2	28,5
ΔT 3, K	42,0	42,1	42,2	42,1	42,4
ΔT 4, K	50,0	50,3	50,3	50,5	50,8
ΔT 5, K	38,9	39,1	39,2	39,2	39,5
ΔT 6, K	42,4	42,6	43,1	43,2	43,6
ΔT 7, K	47,7	47,8	48,2	48,3	48,8
$T_{amb\ av}$ °C	26,5	26,6	26,8	27,0	27,1
$R_{1S1-1S2}$ mΩ	563,10	565,09	566,66	567,97	569,32
$R_{2S1-2S2}$ Ω	6,8419	6,8629	6,8853	6,9064	6,9209
$R_{3S1-3S2}$ Ω	735,81	738,66	741,07	743,13	745,24
$R_{4S1-4S2}$ mΩ	7,0754	7,0989	7,1208	7,1417	7,1608
$R_{5S1-5S2}$ Ω	7,4834	7,5095	7,5322	7,5530	7,5748
$R_{P1-P2/A}$ mΩ (tracer 1500 A)	-	-	-	-	0,0881
$\Delta T_{1S1-1S2}$, K	58,6	59,7	60,6	61,3	62,0
$\Delta T_{2S1-2S2}$, K	60,0	61,0	62,0	63,0	63,6
$\Delta T_{3S1-3S2}$, K	59,4	60,6	61,6	62,5	63,3
$\Delta T_{4S1-4S2}$, K	58,4	59,5	60,4	61,3	62,2
$\Delta T_{5S1-5S2}$, K	58,9	60,0	60,9	61,8	62,7
Deflection of the oil level indicator mm.	34	34	34	35	35
$I_{1S1-1S2}$, A	6,05	6,01	6,04	6,05	6,04
$I_{P1-P2/A}$, A	1,809	1,803	1,807	1,807	1,807

Table 2. Temperature-rises given during the tests current instrument transformer PA 145a serial number 2GKP014A1287155

Winding		ΔT [K]	ΔT_{dop} [K]
1S1-1S2		62,0	65 [1), 2)]
2S1-2S2		63,6	
3S1-3S2		63,3	
4S1-4S2		62,2	
5S1-5S2		62,7	
Thermocouple		ΔT [K]	ΔT_{dop} [K]
No.	**Location**		
1	Oil	37,1	55 [1), 2)]
2	Head (contraction of the flange connecting the head with the insulator)	28,5	40 [3)]
3	Terminal P1	42,4	65 [3)]
4	Terminal P1	50,8	
5	Terminal P2/A 3000 A	39,5	
6	Terminal P2/A 3000 A	43,6	
7	Current path 3000 A	48,8	65 [1), 2)]

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

6. Summary

In tested current instrument transformer type PA 145a with composite insulator, as results of temperature rise test with current I_{cth}= **1800** A in steady state at range of 1500 A, permitted temperature-rise limits were not exceeded. The tested current transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012 i IEC 62271-1:2011.

7. Opinions and interpretations

None

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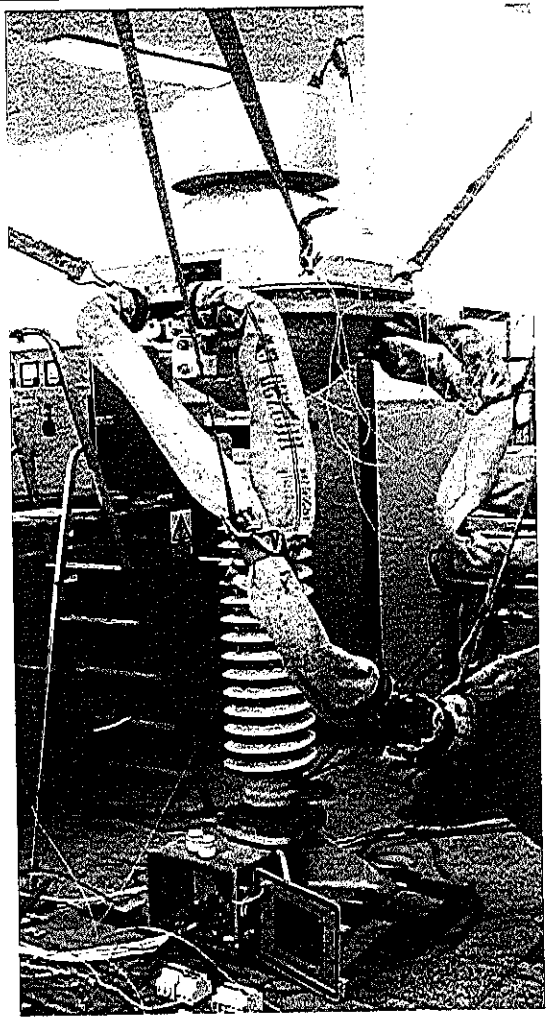
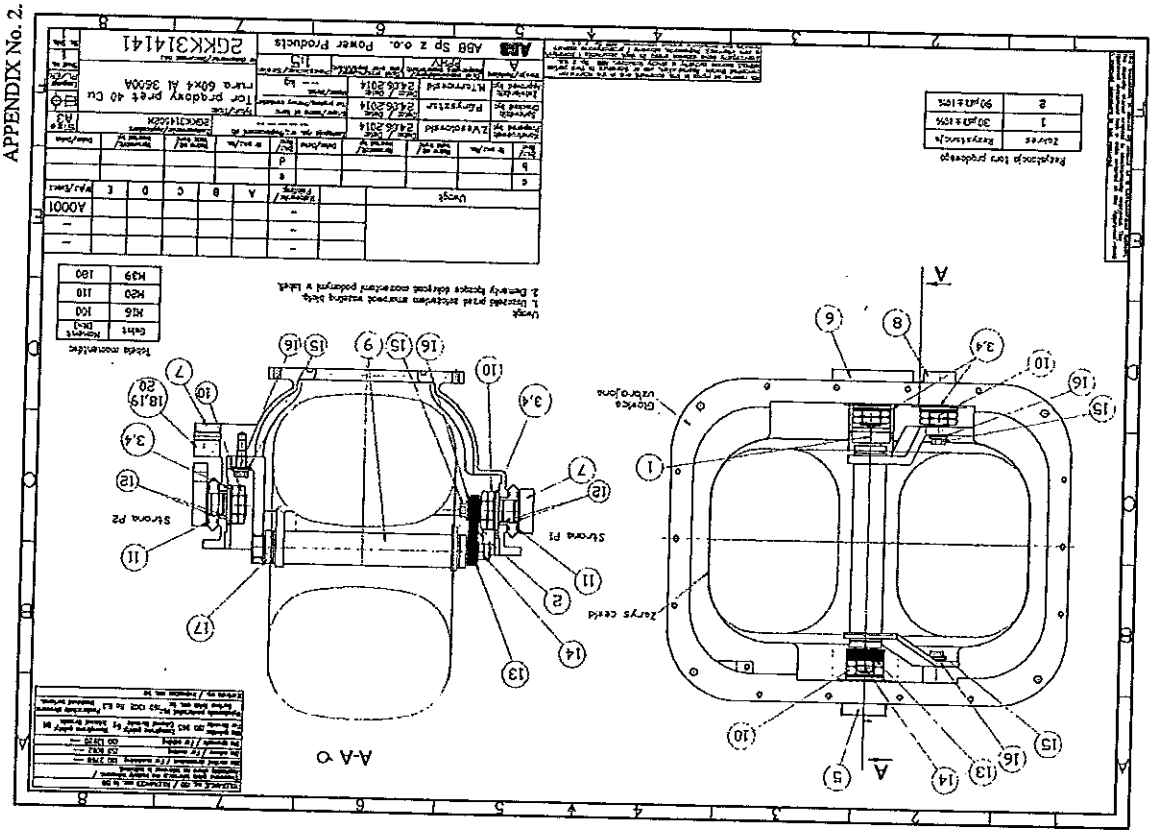
8. Photographic documentation

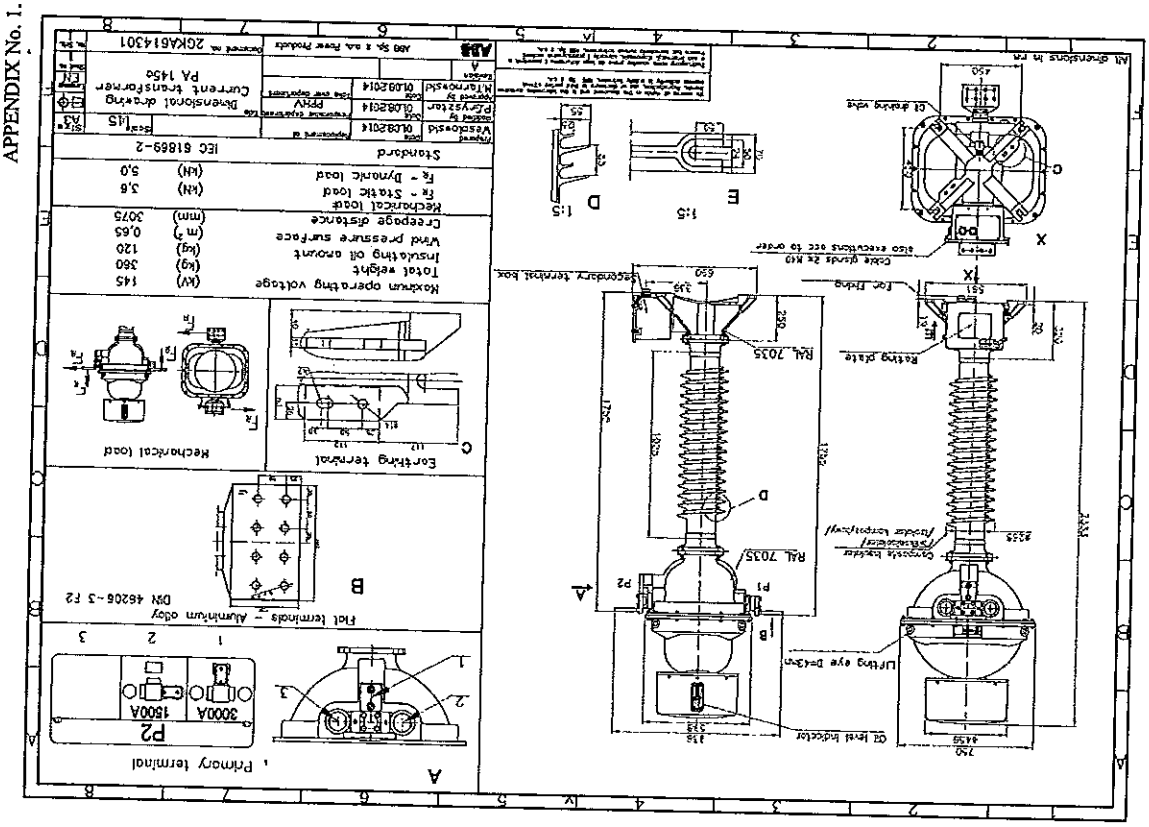


Photograph No. 1. Current transformer on the test stand during temperature-rise test.

APPENDIX No. 2.



APPENDIX No. 1.



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

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

Warsaw, 19.02.2014r.

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

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

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

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

VT part, variant 1

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

VT part, variant 2

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

CT part

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

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

4. Scope of the tests

Test programme agreed with Orderer comprised of tests:

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

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

5. Tests and their results

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

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

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

Stage No. 1: Test at the rated load

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

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

Stage No. 2: Test of 8 h

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

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

The duration of the test was 8 h.

Stage No. 3: Test with thermal limit power

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

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

Measuring instruments

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

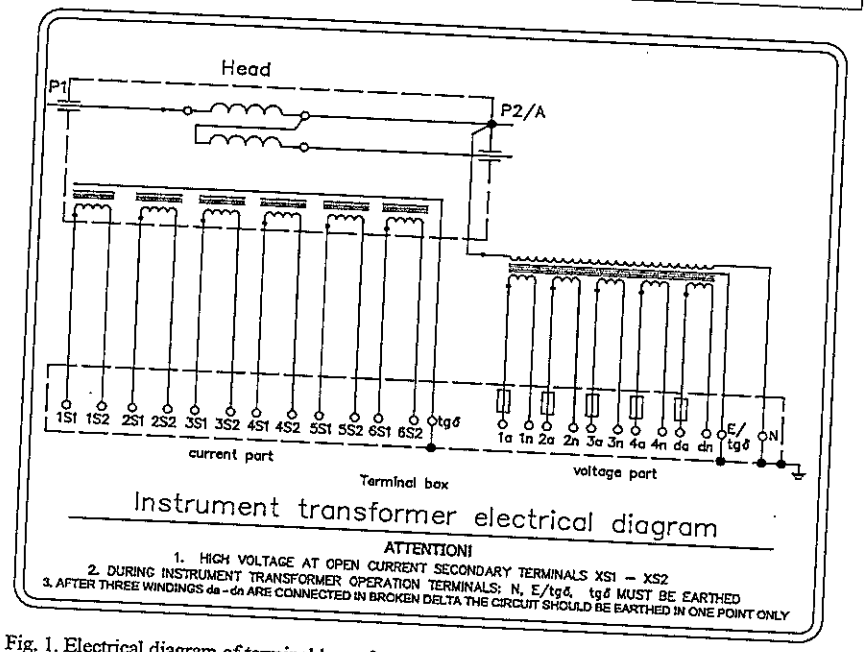

Fig. 1. Electrical diagram of terminal box of tested combined instrument transformer

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

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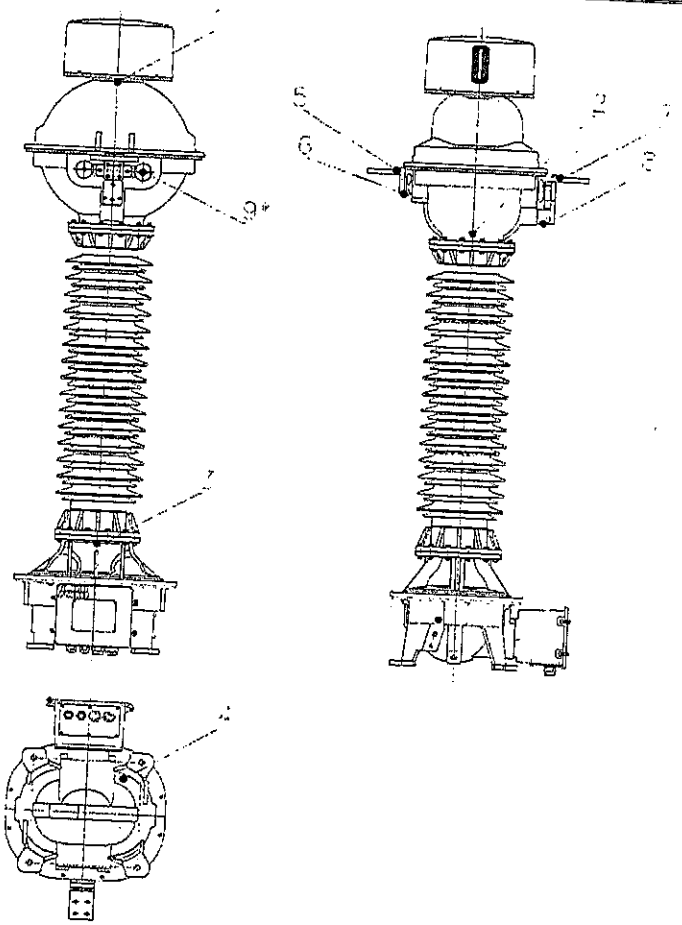

Fig. 2. Arrangement of thermocouples during temperature-rise test:
1 – oil (over current coil), 2 – head (contraction of the flange connecting the head the the insulator), 3 – under the flange of tank lid, 4 – lower tank (placed inside over earthing terminal), 5 – terminal P1, 6 – terminal P1, 7 – terminal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

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

No. of thermo-couple	Heating time [h] Stage No. 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ΔT 1, K	-	4,30	8,13	11,55	15,95	18,88	21,35	23,13	24,96	26,33	26,96	28,11	28,65	28,98	30,23	30,96	31,51	32,23	32,71	32,33	33,25	33,48
ΔT 2, K	-	5,70	9,30	12,10	14,78	16,63	18,03	19,01	20,30	21,53	22,18	22,88	23,43	23,71	24,48	25,03	25,81	26,15	26,56	26,20	27,23	27,13
ΔT 3, K	-	-0,60	0,00	0,32	0,55	1,05	1,52	1,50	2,00	2,32	1,80	2,05	2,15	1,90	2,05	2,35	2,55	2,02	2,52	2,27	3,00	2,97
ΔT 4, K	-	-1,00	-1,68	-1,68	-1,45	-1,43	-1,55	-1,40	-1,35	-1,10	-2,00	-1,45	-1,28	-1,53	-1,53	-1,43	-1,03	-0,98	-1,10	-1,33	-0,63	-0,65
ΔT 5, K	-	35,41	45,41	47,06	46,06	49,73	45,94	47,19	47,50	48,74	48,48	48,28	49,72	49,26	48,67	48,21	48,16	48,61	49,48	49,89	50,86	51,81
ΔT 6, K	-	37,58	50,85	51,65	50,01	55,31	48,56	50,75	50,80	52,79	51,89	51,79	53,11	52,94	51,96	50,86	53,43	52,96	52,33	53,33	54,76	56,59
ΔT 7, K	-	21,31	27,96	30,11	30,70	33,03	32,21	33,01	33,53	34,63	34,55	34,86	35,63	35,63	35,53	35,35	36,35	36,44	36,01	36,69	37,51	37,56
ΔT 8, K	-	22,28	29,75	31,58	31,93	34,94	33,21	32,28	35,03	36,50	36,43	36,79	37,74	37,71	37,53	37,21	38,83	38,56	38,53	38,98	40,01	40,74
ΔT 9, K	-	18,63	26,13	29,06	30,73	34,21	33,48	35,26	36,43	38,21	38,68	39,33	40,43	40,79	40,91	41,01	40,86	42,46	42,66	43,16	44,40	44,59
$T_{ot\,fin}$ °C	16,83	16,93	17,05	17,15	17,20	17,20	17,15	17,15	17,20	17,30	17,25	17,23	17,30	17,38	17,38	17,38	17,55	17,58	17,45	17,43	17,50	17,50
U_{zas} kV	91,5																					
$I_{451-452}$ A	0	6,33	6,31	6,56	6,58	6,75	6,73	6,84	6,83	6,87	6,89	6,95	7,35	7,11	7,24	7,11	7,42	7,24	7,52	7,47	7,41	7,45
$I_{151-151}$ A	0	6,006	6,008	6,018	6,014	6,039	6,008	6,036	6,015	6,016	6,009	6,005	6,063	6,014	6,023	6,015	6,025	6,006	6,025	6,029	6,01	6,018
I_{P2-P2A} A	0	2402,4	2403,2	2407,2	2405,6	2415,6	2403,2	2414,4	2406	2406,4	2403,6	2402	2425,2	2405,6	2409,2	2406	2410	2402,4	2410	2411,6	2404	2407,2
$I_{P2/A-N}$ mA	0	10,5	10,5	10,5	10,25	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5	10,5
$R_{151-152}$ mΩ	444,21	452,88	458,42	465,52	471,76	478,60	485,03	491,11	497,19	502,42	507,16	511,68	515,94	519,66	523,04	526,13	532,41	535,39	536,17	536,99	542,39	543,23
$R_{351-352}$ Ω	6,0164	6,1404	6,2261	6,3211	6,4117	6,5001	6,5948	6,6847	6,7725	6,8460	6,9125	6,9794	7,0384	7,0905	7,1381	7,1736	7,2834	7,3222	7,3381	7,3344	7,3912	7,3935
$R_{551-552}$ Ω	3,2628	3,3120	3,3582	3,4079	3,4571	3,5099	3,5585	3,6060	3,6532	3,6940	3,7315	3,7659	3,8001	3,8292	3,8552	3,8789	3,9001	3,9198	3,9381	3,9552	3,9706	3,9853
$R_{451-452}$ mΩ	383,11	395,03	400,84	406,72	411,66	418,16	423,71	429,11	434,47	438,99	443,19	447,08	451,73	454,48	457,24	460,30	462,44	464,51	466,63	468,72	470,40	472,32
$R_{551-552}$ Ω	3,5543	3,5920	3,6387	3,6918	3,7463	3,8032	3,8565	3,9082	3,9599	4,0042	4,0456	4,0843	4,1198	4,1523	4,1808	4,2069	4,2299	4,2515	4,2715	4,2899	4,3068	4,3225
$R_{651-652}$ Ω	3,8092	3,8579	3,9096	3,9677	4,0259	4,0869	4,1437	4,1985	4,2536	4,3010	4,3445	4,3846	4,4229	4,4577	4,4880	4,5159	4,5400	4,5629	4,5841	4,6036	4,6216	4,6385
R_{P1-P2A} mΩ	0,0474	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$\Delta T_{151-151}$ K	-	4,88	8,00	11,99	15,51	19,35	22,97	26,40	29,82	32,76	35,43	37,97	40,37	42,46	44,37	46,10	49,64	51,32	51,75	52,22	55,26	55,73
$\Delta T_{251-252}$ K	-	5,15	8,71	12,66	16,43	20,10	24,03	27,77	31,42	34,47	37,24	40,02	42,47	44,63	46,61	48,09	52,65	54,26	54,92	54,77	57,13	57,22
$\Delta T_{351-352}$ K	-	3,77	7,31	11,12	14,89	18,93	22,66	26,30	29,91	33,04	35,91	38,55	41,17	43,40	45,39	47,21	48,83	50,34	51,74	53,05	54,23	55,36
$\Delta T_{451-452}$ K	-	7,78	11,57	15,41	18,63	22,87	26,49	30,02	33,52	36,46	39,21	41,74	44,78	46,57	48,37	50,37	51,77	53,12	54,50	55,87	56,96	58,21
$\Delta T_{551-552}$ K	-	2,65	5,94	9,67	13,50	17,51	21,26	24,89	28,53	31,64	34,56	37,28	39,78	42,06	44,07	45,90	47,52	49,04	50,45	51,74	52,93	54,03
$\Delta T_{651-652}$ K	-	3,20	6,59	10,40	14,22	18,23	21,95	25,55	29,17	32,28	35,13	37,76	40,28	42,56	44,55	46,38	47,96	49,47	50,86	52,14	53,32	54,43
ΔT_{P1-P2A} K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY

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Table No. 1, cont.

	Heating time [h] Stage No. 1																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R_{1a-1a_2} mΩ	47,659	48,146	48,448	50,302	50,810	48,913	49,002	49,076	49,146	49,202	49,251	49,284	49,327	49,357	49,375	49,429	49,424	49,436	49,450	49,463	49,473	49,369
R_{2a-2a_2} mΩ	49,128	49,622	49,937	50,592	50,814	50,430	50,517	50,601	50,680	50,730	50,788	50,821	50,866	50,897	50,920	50,835	50,966	50,980	50,994	51,012	51,020	51,189
R_{3a-3a_2} mΩ	50,125	50,564	50,936	51,156	51,309	51,443	51,551	51,635	51,715	51,775	51,807	51,870	51,901	51,951	51,956	51,987	52,016	52,025	52,042	52,064	52,071	52,098
R_{4a-4a_2} mΩ	51,407	52,004	52,220	52,448	52,602	52,741	52,848	52,928	53,016	53,077	53,108	53,176	53,205	53,255	53,267	53,302	53,322	53,340	53,359	53,377	53,390	53,410
R_{da-da_2} mΩ	112,14	113,21	113,98	114,48	114,83	115,17	115,41	115,54	115,81	115,95	116,07	116,18	116,27	116,36	116,78	116,47	116,51	116,55	116,78	116,64	116,66	116,70
$R_{P2/A-N}$ kΩ	21,22	21,56	21,73	21,91	21,91	22,05	22,09	22,01	22,11	22,07	22,15	22,21	22,28	22,41	22,10	22,01	22,03	22,04	22,09	22,12	22,18	22,24
ΔT_{1a-1a_2}	-	2,55	4,14	13,86	16,53	6,58	7,04	7,43	7,80	8,09	8,35	8,52	8,75	8,91	9,00	9,28	9,26	9,32	9,39	9,46	9,52	8,97
ΔT_{2a-2a_2}	-	2,51	4,12	7,45	8,58	6,63	7,07	7,50	7,90	8,15	8,45	8,62	8,84	9,00	9,12	8,69	9,35	9,42	9,50	9,59	9,63	10,49
ΔT_{3a-3a_2}	-	2,19	4,04	5,14	5,91	6,57	7,11	7,53	7,93	8,23	8,39	8,70	8,86	9,11	9,13	9,29	9,43	9,48	9,56	9,67	9,71	9,84
ΔT_{4a-4a_2}	-	2,90	3,95	5,06	5,81	6,49	7,01	7,40	7,82	8,12	8,27	8,60	8,74	8,99	9,05	9,22	9,31	9,40	9,49	9,58	9,64	9,74
ΔT_{da-da_2}	-	2,39	4,10	5,22	6,00	6,75	7,29	7,58	8,18	8,49	8,76	9,01	9,21	9,41	10,34	9,65	9,74	9,83	10,34	10,03	10,08	10,17
$\Delta T_{P2/A-N}$	-	4,01	6,01	8,13	8,13	9,78	10,25	9,31	10,49	10,01	10,96	11,66	12,49	14.02	10,37	9,31	9,54	9,66	10,25	10,60	11,31	12,02
Deflection of the oil level indicator, mm	0	0	15	19	23	26	29	30	33	35	37	39	40	41	43	43	44	45	46	47	47	48

Table No. 1, cont.

No. of thermo-couple	Heating time [h]																	
	Stage No. 1			Stage No. 2									Stage No. 3					
	22	23	24	25	26	27	28	29	30	31	32		33	34	35	36	37	38
ΔT 1, K	33,25	34,25	35,06	34,91	34,33	33,49	33,96	33,68	33,18	33,73	34,00		34,41	35,61	35,48	36,75	36,55	37,08
ΔT 2, K	27,05	27,93	28,20	28,38	27,61	27,15	27,23	27,20	26,78	27,08	27,31		28,63	30,19	30,14	31,73	31,33	32,14
ΔT 3, K	2,65	2,92	3,37	3,57	4,02	4,07	5,20	5,40	5,55	5,83	6,08		5,73	5,07	5,10	5,73	5,15	6,05
ΔT 4, K	-0,98	-0,63	-0,33	-0,55	-0,50	-0,93	-0,30	-0,30	-1,18	-0,95	-0,75		-0,20	-0,90	-0,98	-0,65	-0,90	-0,38
ΔT 5, K	51,33	52,01	52,30	49,06	48,43	48,44	49,40	49,96	48,42	49,03	48,34		50,81	51,81	53,29	55,58	54,38	54,98
ΔT 6, K	55,86	55,81	56,57	52,35	51,98	52,62	53,64	54,49	51,61	53,00	52,13		54,91	54,73	56,46	59,53	58,29	58,81
ΔT 7, K	37,49	37,91	38,20	35,54	35,13	35,33	35,41	35,71	35,44	35,25	35,23		37,34	38,41	39,16	40,91	39,85	40,51
ΔT 8, K	40,51	40,93	41,43	39,71	38,98	38,88	39,05	39,56	38,54	38,83	38,76		41,03	41,80	42,68	45,11	44,01	44,63
ΔT 9, K	44,88	45,49	46,03	44,88	44,47	44,35	44,44	45,15	44,25	44,39	44,59		45,58	46,24	47,09	49,04	48,68	48,93
$T_{oil\ fp}$ °C	17,58	17,58	17,55	17,55	17,55	17,58	17,60	17,68	17,73	17,75	17,75		17,83	17,90	17,93	18,13	18,13	17,93
U_{max} kV	91,5			144,8									76,2					
$I_{S1\text{-}S2_P}$ A	7,48	7,53	7,51	7,65	7,7	7,65	7,66	7,83	7,73	7,82	8,25		7,68	7,76	7,95	8,3	8,43	8,32
$I_{S1\text{-}1S1_P}$ A	6,024	6,018	6,027	6,01	6,011	6,016	6,017	6,013	6,005	6,001	6,035		6,001	6,003	6,025	6,021	6,015	6,011
$I_{P2/A\text{-}N}$ mA	2409,6	2407,2	2410,8	2404	2404,4	2406,4	2406,8	2405,2	2402	2400,4	2414		2400,4	2401,2	2410	2408,4	2406	2404,4
$R_{1S1\text{-}1S2}$ mΩ	10,7	10,7	10,7	27	27	27	27	27	27	27	27		50	50	50	50	50	50
$R_{2S1\text{-}2S2}$ Ω	544,06	545,76	547,37	549,14	550,33	549,19	549,07	549,49	550,69	551,35	551,94		551,69	552,24	553,16	555,08	556,16	557,23
$R_{3S1\text{-}3S2}$ Ω	7,4370	7,4762	7,4978	7,5125	7,5395	7,4903	7,4964	7,5156	7,5259	7,5347	7,5361		7,5373	7,5475	7,5664	7,5982	7,6071	7,6237
$R_{4S1\text{-}4S2}$ mΩ	3,9985	4,0121	4,0238	4,0328	4,0412	4,0477	4,0524	4,0585	4,0680	4,0724	4,0777		4,0771	4,0813	4,0873	4,1050	4,1116	4,1176
$R_{5S1\text{-}5S2}$ Ω	473,83	475,47	476,73	477,09	478,15	479,02	479,12	480,38	482,33	481,92	482,93		482,26	483,08	484,08	489,66	487,12	487,58
$R_{6S1\text{-}6S2}$ Ω	4,3380	4,3515	4,3647	4,3754	4,3846	4,3913	4,3971	4,4033	4,4121	4,4181	4,4239		4,4238	4,4278	4,4336	4,4485	4,4592	4,4668
$R_{P1\text{-}P2/A}$ mΩ	4,6539	4,6693	4,6831	4,6943	4,7042	4,7115	4,7174	4,7238	4,7335	4,7400	4,7457		4,7453	4,7498	4,7564	4,7724	4,7840	4,7917
$\Delta T_{1S1\text{-}1S2_P}$ K	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	0,0583
$\Delta T_{2S1\text{-}2S2_P}$ K	56,20	57,15	58,06	59,05	59,72	59,08	59,01	59,25	59,93	60,30	60,63		60,49	60,80	61,32	62,40	63,01	63,61
$\Delta T_{3S1\text{-}3S2_P}$ K	59,03	60,66	61,56	62,17	63,29	61,25	61,50	62,30	62,72	63,09	63,15		63,20	63,62	64,41	65,73	66,10	66,79
$\Delta T_{4S1\text{-}4S2_P}$ K	56,37	57,41	58,31	59,00	59,64	60,14	60,50	60,97	61,70	62,03	62,44		62,39	62,71	63,17	64,53	65,04	65,50
$\Delta T_{5S1\text{-}5S2_P}$ K	59,20	60,27	61,09	61,33	62,02	62,59	62,65	63,47	64,75	64,48	65,14		64,70	65,24	65,89	69,53	67,87	68,17
$\Delta T_{6S1\text{-}6S2_P}$ K	55,12	56,07	57,00	57,75	58,40	58,87	59,28	59,72	60,34	60,76	61,17		61,16	61,44	61,85	62,90	63,65	64,18
$\Delta T_{P1\text{-}P2/A_P}$ K	55,44	56,45	57,35	58,09	58,74	59,22	59,61	60,03	60,66	61,09	61,46		61,44	61,73	62,17	63,22	63,98	64,48
	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	57,49

Table No. 1, cont.

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

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

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

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

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

6. Summary

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

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

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

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

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

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

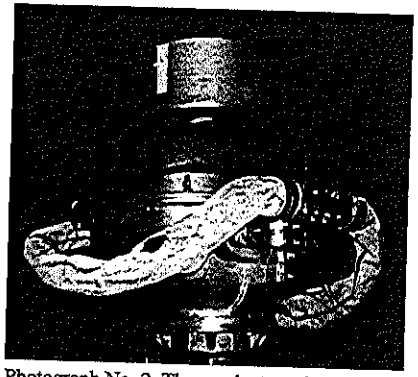
The tested combined transformer met requirements of IEC 61869-1:2007, IEC 61869-2:2012, IEC 61869-3:2011, IEC 61869-4:2013 and IEC 62271-1:2011 standards.

7. Opinions and interpretations

None

8. Photographic documentation

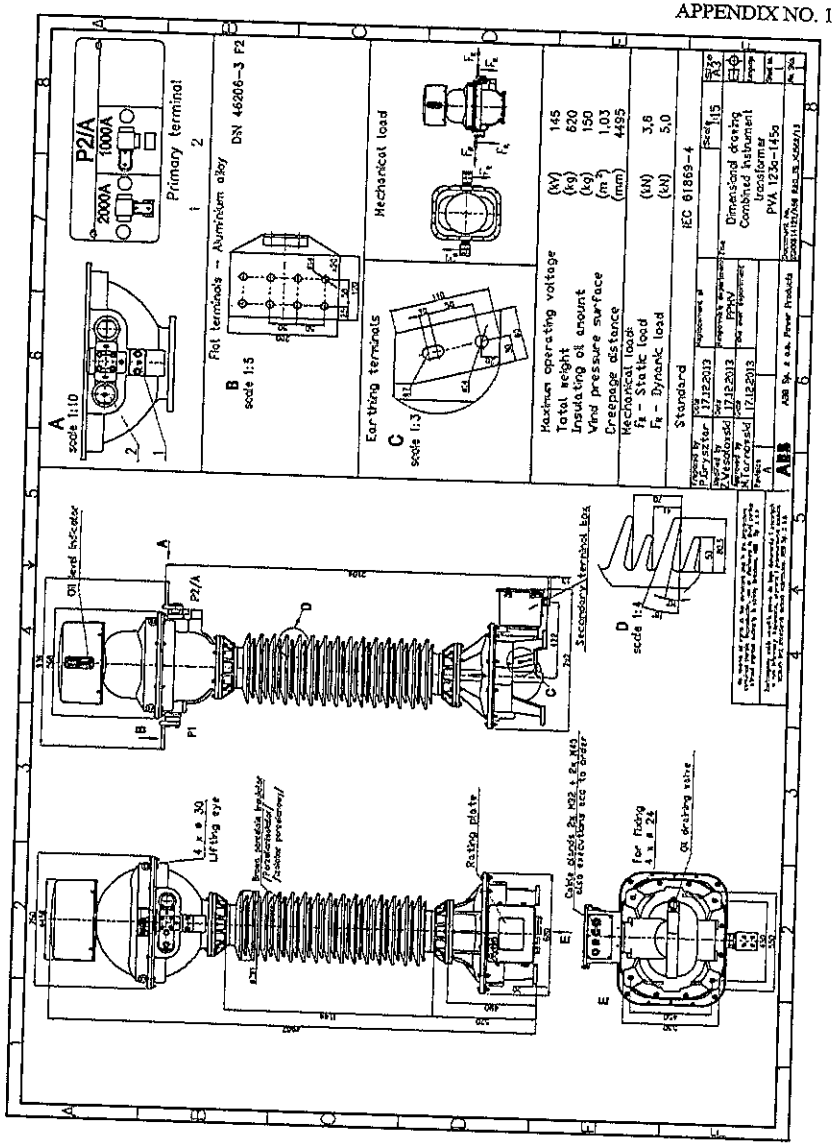
Photograph No. 1. Combined transformer on the test stand during temperature-rise test.



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

INSTITUTE OF POWER ENGINEERING
HIGH CURRENT LABORATORY
Test Report No.
EWP/35/E/2013-1E

APPENDIX NO. 1



APPENDIX NO. 2

ABB

Combined Instrument Transformer | Type PVA 145a

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

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

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

CURRENT PART — VOLTAGE PART

K_n 1000-2000 / 5-1-1-5-1-1 A/A — A-N 132:√3 kV

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

I_{cth} 1200 - 2400 A

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

	1a-1n	2a-2n	3a-3n	4a-4n	da-dn
V	110:√3	110:√3	110:√3	110:√3	110
VA	25	25	25	25	150
Klasa	0,2	0,2	0,2/3P	3/3P	1,0
VA	(25)	(25)	(500)	(25)	(400)
Klasa	(3)	(3)	(3/3P)	(3/3P)	(3P)
VAsn	1000	1000	1000	1000	450

Transportation Vertical/Horizontal

APPENDIX NO. 3

ABB Sp. z o.o.

Declaration of conformity

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

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

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

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

Product: Combined Instrument Transformer PVA 145a

Above mentioned product comforms with the following standard :

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

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

Place and date of issue of declaration

Przasnysz 13.01.2014

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

ABB
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NIP: 526-030-44-84; PL 5260304484
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Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Łuberski

(Name) (Signature)

Instytut Elektrotechniki
Electrotechnical Institute

ZESPÓŁ LABORATORIÓW INSTYTUTU ELEKTROTECHNIKI
LABORATORIUM BADAWCZE APARATURY ROZDZIELCZEJ
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Laboratorium Badawcze akredytowane przez Polskie Centrum Akredytacji,
sygnatariusza porozumień EA MLA i ILAC MRA. Nr akredytacji AB 074

AB 074

SPRAWOZDANIE Z BADAŃ nr 8624/NZL/NBR/15

Obiekt badań:	**Przekładnik prądowy PA 145a**
Zleceniodawca:	ABB Sp. z o.o. ul. Leszno 59, 06-300 Przasnysz
Producent:	ABB Sp. z o.o. ul. Leszno 59, 06-300 Przasnysz
Zlecone badania:	Sprawdzenie przyrostów temperatury
Według norm:	PN-EN 61869-2:2013-06
Numer tematu / zlecenia:	504-028100/038
Data zakończenia badań:	02 kwiecień 2015 r.
Wynik badań:	POZYTYWNY

Autoryzował

mgr inż. Michał Babiuch

Kierownik Zespołu Laboratoriów Instytutu Elektrotechniki

dr inż. Przemysław Berowski

WARSZAWA, 06.05.2015

Sprawozdanie zawiera 12 stronic

Spis treści

1 Spis norm mających zastosowanie 3
2 Program badań 4
3 Parametry techniczne deklarowane przez producenta 4
4 Podstawowe dane identyfikacyjne obiektu badań 5
5 Sprawdzenie przyrostów temperatury 9
6 Zdjęcia 10
7 Rysunki techniczne 12
8 Niepewność pomiaru wielkości elektrycznych i nieelektrycznych w laboratorium NBR 12

1 Spis norm mających zastosowanie

- PN-EN 61869-1:2009 Przekładniki - Część 1: Wymagania ogólne
- PN-EN 61869-2:2013-06 Przekładniki – Część 2: Wymagania szczegółowe dotyczące przekładników prądowych

2 Program badań

- Sprawdzenie przyrostów temperatury wg PN-EN 61869-2:2013-06 pkt. 7.2.2

3 Parametry techniczne deklarowane przez producenta

Znamionowy prąd pierwotny	I_{pr}	300 – 600 A
Znamionowy długotrwały prąd cieplny	I_{cth}	450 – 900 A
Częstotliwość znamionowa	f_r	50 Hz
Najwyższe napięcie robocze	U_m	145 kV
Napięcie znamionowe wytrzymywane o częstotliwości sieciowej		275 kV
Napięcie znamionowe udarowe wytrzymywane		650 kV
Znamionowy krótkotrwały prąd cieplny	I_{th}	40 – 40 kA
Znamionowy prąd dynamiczny	I_{dyn}	100 – 100 kA
Czas znamionowy trwania zwarcia	t_k	1 s

4 Podstawowe dane identyfikacyjne obiektu badań

Obiekt badany:	Przekładnik prądowy
Typ:	PA 145a
Producent:	ABB Sp. z o.o., ul. Leszno 59, 06-300 Przasnysz
Numer fabryczny:	2GKP014A1287181
Rok produkcji:	2014
Tabliczka znamionowa:	Rysunek 4, str. 10
Dokumentacja techniczna:	Rysunek wymiarowy nr 2GKA612003

Wykaz wyposażenia i jego dokładne parametry zawiera dokumentacja: Rysunek wymiarowy nr 2GKA612003

5 Sprawdzenie przyrostów temperatury

Badanie wykonano wg PN-EN 61869-2:2013-06 pkt. 7.2.2

Stan obiektu przed próbami: ..... Nowy

Data badań: ..... 1 kwiecień 2015 r.

Temperatura otoczenia:

- Przed próbą ..... 14,9°C
- Po próbie ..... 16,5°C

Czas trwania próby: ..... 16 h 25 min.

Prąd: ..... 900 A

Częstotliwość: ..... 50 Hz

Zakres przekładnika: ..... 600 A

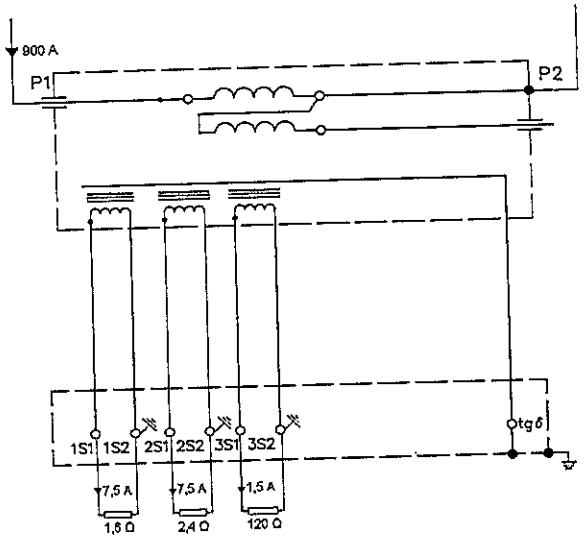
Połączenia zasilające: ..... szyna miedziana 1x1000 mm^2

Rozmieszczenie termopar: ..... Rysunek 2; strona 6

Obiekt na stanowisku probierczym: ..... Zdjęcie 1; strona 9

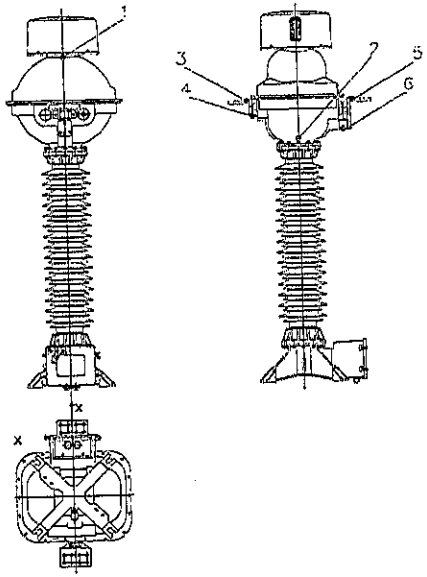
Pomiary przyrostu temperatur wykonano rejestratorem HIOKI 8423, nr inw. NBR-801-30600 oraz termoparami typu K.

Próba była kontynuowana aż do czasu gdy przyrost temperatury osiągnął stabilną wartość.



Rysunek 1 Schemat obwodu przekładnika podczas próby

Punkty pomiaru temperatur



Rysunek 2 Rozmieszczenie termopar

Sprawdzenie przyrostów temperatury prądem 900 A / 50 Hz - wyniki

Tabela 1 Wyniki pomiarów przyrostów temperatury

Miejsce pomiaru	Numer termopary	Przyrost temperatury [K]	
		Zmierzony	Dopuszczalny
Obudowa pomiędzy głowicą i mieszkiem	1	37,70	—
Głowica	2	24,90	—
Zacisk P1- podstawa zacisku ruchomego	3	40,60	75
Zacisk P1 – podstawa zacisku stałego	4	44,25	75
Zacisk P2 – podstawa zacisku ruchomego	5	32,7	75
Zacisk P2 – podstawa zacisku najwyższego zakresu	6	35,85	75
Olej w komorze głównej	7	35,55	55

Tabela 2 Wyniki pomiarów rezystancji i przyrosty temperatury uzwojeń obwodów wtórnych przekładnika

Godz. [h]	Pomiary							
	T_{otoc} [°C]	$R_{1S1-1S2}$ [mΩ]	$R_{2S1-2S2}$ [mΩ]	$R_{3S1-3S2}$ [Ω]	$\Delta T_{1S1-1S2}$ [K]	$\Delta T_{2S1-2S2}$ [K]	$\Delta T_{3S1-3S2}$ [K]	Wychylenie wskaźnika poziomu oleju [mm]
0	14,90	389,8	431,2	9,20	0	0	0	0
1	15,34	402,9	442,6	9,42	8,40	6,60	5,95	4
2	15,76	409,6	450,0	9,58	12,75	10,95	10,30	13
3	15,99	416,0	456,9	9,76	16,85	14,95	15,25	20
4	16,25	423,5	465,9	9,94	21,70	20,20	20,05	26
5	16,38	430,3	473,8	10,11	26,10	24,85	24,80	31
6	16,55	436,1	480,2	10,28	29,90	28,60	29,45	38
7	16,60	442,9	488,3	10,44	34,25	33,30	33,85	41
8	16,45	448,5	494,7	10,58	37,85	37,05	37,65	45
9	16,63	453,6	500,7	10,72	41,20	40,55	41,50	47
10	16,58	458,3	506,1	10,84	44,20	43,70	44,80	50
11	16,39	462,8	511,2	10,96	47,10	46,65	48,05	54
12	16,56	466,5	515,6	11,06	49,50	49,25	50,80	55
13	16,48	474,0	520,0	11,16	54,30	51,80	53,50	56
14	16,41	473,4	523,6	11,24	53,90	53,85	55,70	56
15	16,53	476,3	527,0	11,31	55,80	55,90	57,60	56
16	16,50	478,9	530,0	11,38	57,50	57,65	59,55	56
Dopuszczalny przyrost temperatury					65 K			

Tabela 3 Pomiar rezystancji i przyrost temperatury uzwojenia obwodu pierwotnego przekładnika

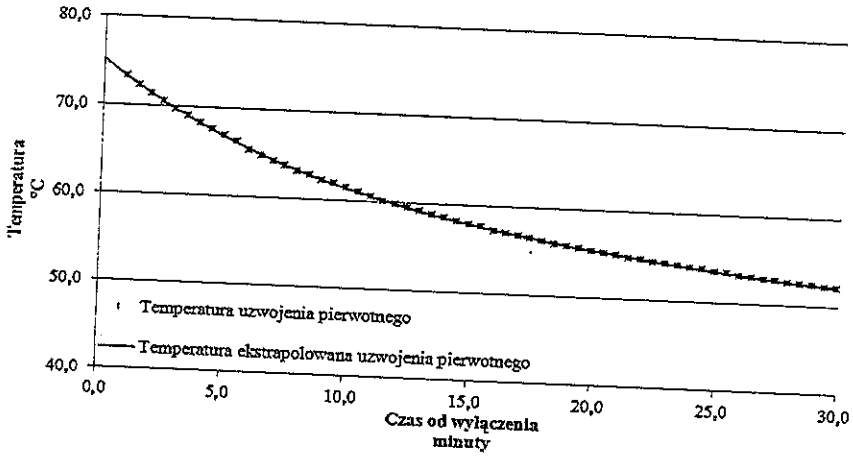
	Przed próbą	Po próbie
Data pomiaru	01.04.2015	02.04.2015
$R_{P1-P2/A}$, [μΩ]	347,9	429,3
Temperatura otoczenia [°C]	14,9	16,5
Temperatura uzwojenia pierwotnego [°C] (po ekstrapolacji)	—	75,2
Przyrost temperatury [K]	—	58,7
Dopuszczalny przyrost temperatury [K]	—	65

Pomiary rezystancji wykonano prądem stałym o wartości: ..... obwód pierwotny: 100 A

..... obwody wtórne 5 A: 0,5 A

..... obwody wtórne 1 A: 0,1 A

Pomiary wykonano za pomocą przyrządu pomiarowego typu RMO100GP nr 14G743G



Rysunek 3 Temperatura uzwojenia przekładnika po wyłączeniu

Zgodnie z normą PN-EN 61862-2 pkt. 7.2.2.203 wyznaczono stałe czasowe z próby nagrzewania, jako czas, jaki upłynął do osiągnięcia 63% wartości maksymalnego zmierzonego przyrostu temperatury.

Tabela 4 Wyznaczone wartości stałych czasowych

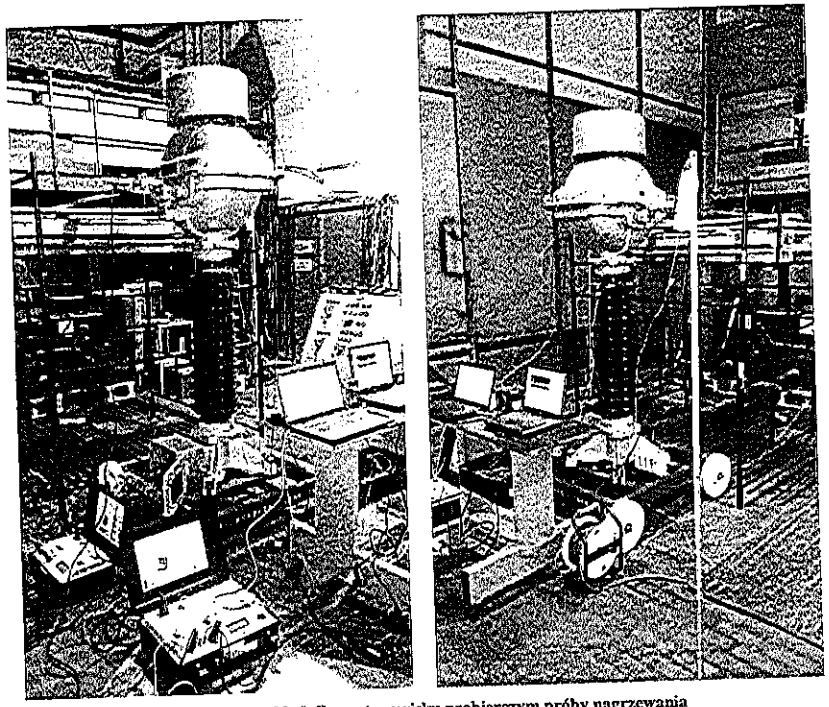
Miejsce pomiaru	Numer termopary	Stała czasowa T_o [h]
Obudowa pomiędzy głowicą i mieszkiem	1	5
Głowica	2	5,5
Zacisk P1- zacisk ruchomy	3	1,8
Zacisk P1 – zacisk stały	4	1,8
Zacisk P2 – zacisk ruchomy (600 A)	5	2,8
Zacisk P2 – zacisk stały (600 A)	6	4
Olej w komorze głównej	7	6

Stan obiektu po badaniach:

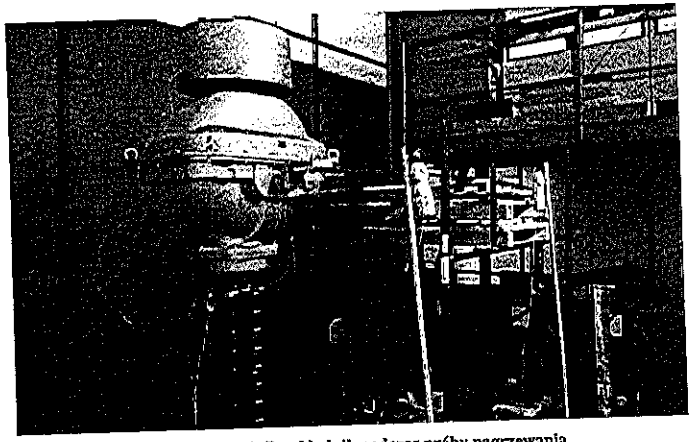
- Przyrosty temperatury różnych części aparatu nie przekroczyły wartości podanych w normie PN-EN 61869-1:2009, pkt. 6.4.1, tabela 5.
- Nie zauważono żadnych zniszczeń oraz uszkodzeń.

Wynik próby: Pozytywny

6 Zdjęcia



Zdjęcie 1 Przekładnik na stanowisku probierczym próby nagrzewania



Zdjęcie 2 Przekładnik podczas próby nagrzewania

7 Rysunki techniczne

ABB

Przekładnik prądowy | Typ: PA 145a

Poziom izolacji	145/275/650 kV	Norma	PN-EN 61869-2	fn	50 Hz
Typ oleju	Nytro Libra	Waga	420 / 120 kg	Temperatura pracy	-40°C — +40°C
NF	2GKP014A1287181				

K_n 300-600/5-5-1 A/A

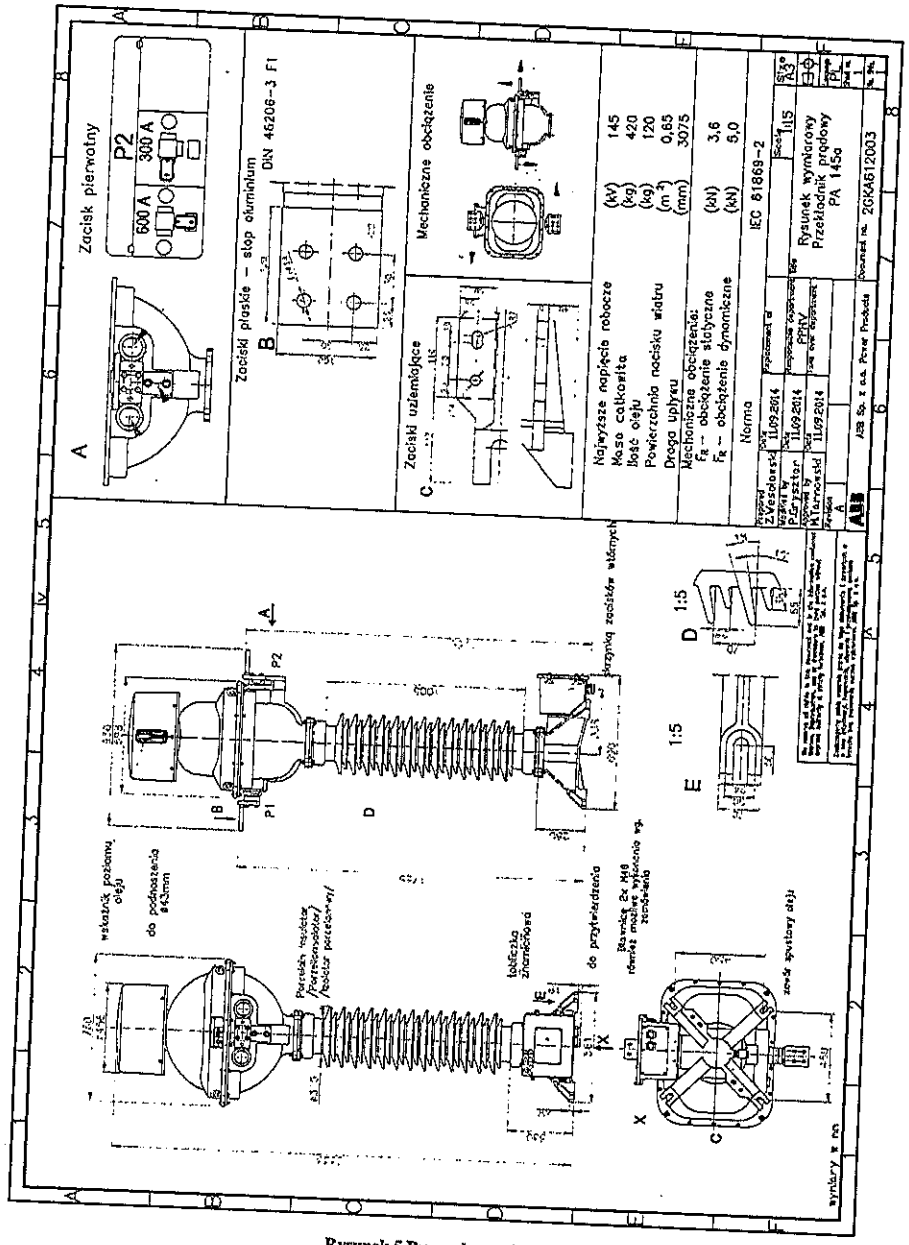
I_{th}/1s 40-40 kA I_{dyn} 100-100 kA

I_{cth} 450-900 A

	A	VA	Klasa	FS/ALF	Ext.%
1S1-1S2	5	40	0,2	5	150
2S1-2S2	5	60	5P	20	
3S1-3S2	1	120	10P	15	
4S1-4S2					
5S1-5S2					
6S1-6S2					

Transport Pionowy/Poziomy

Rysunek 4 Tabliczka znamionowa



Rysunek 5 Rysunek wymiarowy

8 Niepewność pomiaru wielkości elektrycznych i nieelektrycznych w laboratorium NBR

Wielkość mierzona / rodzaj przyrządu	*Zakres*	*Częstotliwość*	*Parametr mierzony / niepewność w [%]*			
Napięcie U / *dzielnik RC*	0 ≤ U ≤ 1000V	dc - 20kHz	RMS	< ±1.5	Peak	< ±1.0
		> 20kHz	RMS	< ±2.5	Peak	< ±2.0
	1000 V ≤ U ≤ 10kV	dc - 20kHz	RMS	< ±2.0	Peak	< ±1.5
		> 20kHz	RMS	< ±2.5	Peak	< ±2.0
	U > 10kV	50Hz - 20kHz	RMS	< ±3.0	Peak	< ±2.5
		> 20kHz	RMS	< ±3.5	Peak	< ±3.0
Prąd I / *bocznik*	0 ≤ I ≤ 100A	dc - 5kHz	RMS	< ±1.5	Peak	< ±1.0
			Całka Joule'a	< ±2.0	Peak – Peak/√8	< ±2.0
		> 5kHz	RMS	< ±2.0	Peak	< ±1.5
			Całka Joule'a	< ±3.0	Peak – Peak/√8	< ±3.0
	100 A ≤ I ≤ 10kA	dc - 5kHz	RMS	< ±1.5	Peak	< ±1.0
			Całka Joule'a	< ±2.0	Peak – Peak/√8	< ±2.0
		> 5kHz	RMS	< ±2.0	Peak	< ±1.5
			Całka Joule'a	< ±3.0	Peak – Peak/√8	< ±3.0
	I > 10kA	dc - 5kHz	RMS	< ±2.0	Peak	< ±1.5
			Całka Joule'a	< ±3.0	Peak – Peak/√8	< ±3.0
		> 5kHz	RMS	< ±2.5	Peak	< ±2.0
			Całka Joule'a	< ±3.5	Peak – Peak/√8	< ±3.5
Prąd I / *przekładnik*	0 ≤ I ≤ 100A	50Hz - 5kHz	RMS	< ±2.0	Peak	< ±1.5
			Całka Joule'a	< ±2.5	Peak – Peak/√8	< ±2.5
		> 5kHz	RMS	< ±2.5	Peak	< ±2.0
			Całka Joule'a	< ±3.0	Peak – Peak/√8	< ±3.0
	100 A ≤ I ≤ 10kA	50Hz - 5kHz	RMS	< ±2.0	Peak	< ±1.5
			Całka Joule'a	< ±2.5	Peak – Peak/√8	< ±2.5
		> 5kHz	RMS	< ±2.5	Peak	< ±2.0
			Całka Joule'a	< ±3.0	Peak – Peak/√8	< ±3.0
	10kA ≤ I ≤ 30kA	50Hz - 5kHz	RMS	< ±3.0	Peak	< ±2.5
			Całka Joule'a	< ±3.5	Peak – Peak/√8	< ±3.5
		> 5kHz	RMS	< ±3.5	Peak	< ±3.0
			Całka Joule'a	< ±4.0	Peak – Peak/√8	< ±3.5

Rezystancja R */ mostek, multimetr*	20 µΩ ≤ R ≤ 600 µΩ	< ±5 %
	0.6 mΩ ≤ R ≤ 600 mΩ	< ±3 %
	0.6 Ω ≤ R ≤ 100 MΩ	< ±1 %
Częstotliwość f */ oscyloskop, rejestrator TR*	≤ 10 kHz	< ±1 %
	10 kHz ≤ f ≤ 1 Mhz	< ±0.2 %
Czas t */ oscyloskop, rejestrator TR*	≤ 1 µs	< ±0.5 %
	1 µs ≤ t ≤ 1 ms	< ±20 %
	> 1 ms	< ±10 %
Temperatura t */ termometry, termopary*	-50 °C ≤ t ≤ 100 °C	< ±1ms
	-100 °C ≤ t ≤ 200 °C	< ±0.2°C - *(termometr)*
Wilgotność względna	20 % do 90% RH	< ±0.8 °C - *(termopary K, rejestrator)*
Odległości długości l */ suwmiarki, przymiary*	≤ 1 mm	< ±5 % RH
	1 mm ≤ l ≤ 30 mm	< ±0.05 mm
	> 30 mm	< ±0.1 mm
Ciśnienie gazów p */ czujniki, układ pomiarowy*	≤ 20 bar	< ±5 %
	20 bar ≤ p ≤ 200 bar	< ±5 %
Ciśnienie atmosferyczne		< ±10 %
		< ±0.01 MPa

Instytut Elektrotechniki
Electrotechnical Institute

ZESPÓŁ LABORATORIÓW INSTYTUTU ELEKTROTECHNIKI
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Testing Laboratory is accredited by Polish Centre of Accreditation, signatory of EA MLA. No. AB 074

AB 074

TEST REPORT No. 8595/A/NZL/NBR/15

Test objects:	**Current transformer PA 145a**
Client:	ABB Sp. z o.o. ul. Leszno 59, 06-300 Przasnysz
Manufacturer:	ABB Sp. z o.o. ul. Leszno 59, 06-300 Przasnysz
Test specification:	Temperature rise test
Normative document(s):	PN-EN 61869-2:2013-06
Reference/Order number:	504-021300/038
Date of tests completion:	15 January 2015 r.
Test results:	POSITIVE

Authorised by

Przemysław Berowski, Ph.D.

Head of Laboratories of the Electrotechnical Institute

Robert Franaszek, M.Sc.

WARSAW, 11.02.2015

This Test Report comprises 12 sheets in total.

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1 List of applicable standards 3
2 Range of tests performed 4
3 Ratings assigned by the manufacturer 5
4 Temperature rise test 9
5 Photographs 10
6 Drawings 12
7 Uncertainty electrical and non electrical quantities in laboratory 12

1 List of applicable standards

- **PN-EN 61869-1:2009** Instrument transformers – Part 1: General requirements
- **PN-EN 61869-2:2013-06** Instrument transformers – Part 2: Additional requirements for current transformers

2 Range of tests performed

- Temperature rise test by PN-EN 61869-2:2013-06 clause 7.2.2

3 Ratings assigned by the manufacturer

Test object:	Current transformer
Type:	PA 145a
Manufacturer:	ABB Sp. z o.o., ul. Leszno 59, 06-300 Przasnysz
Serial No.:	2GKP014A1287155
Year of manufacture:	2014
Rating plate:	Figure 1, page 10
Design documentation:	1. Dimensional drawing No. 2GKA612004 2. Drawing of current circuit No. 2GKK314159A0001

Rated primary current	I_{pr}	1500 – 3000 A
Rated continuous thermal current	I_{cth}	1800 – 3000 A
Rated frequency	f_r	50 Hz
Highest system voltage	U_m	145 kV
Rated power-frequency withstand voltage		275 kV
Rated lighting-impulse withstand voltage		650 kV
Rated short-time thermal current	I_{th}	63 – 63 kA
Rated dynamic current	I_{dyn}	158 – 158 kA
Rated duration of short circuit	t_k	1 s

Detailed list of components specified in technical project:

1. Dimensional drawing No. 2GKA612004
2. Drawing of current circuit No. 2GKK314159A0001

4 Temperature rise test

Test performed according to PN-EN 61869-2:2013-06 clause 7.2.2

Condition of test object before test: ..... New

Date of test: ..... 14 January 2015 r.

Ambient temperature:

- Before test ..... 20,4°C
- After test ..... 18,8°C

Duration of the test: ..... 24 h 25 min.

Test current: ..... 1. 3 600 A

..... 2. 3 000 A – after 16 hours

Frequency: ..... 50 Hz

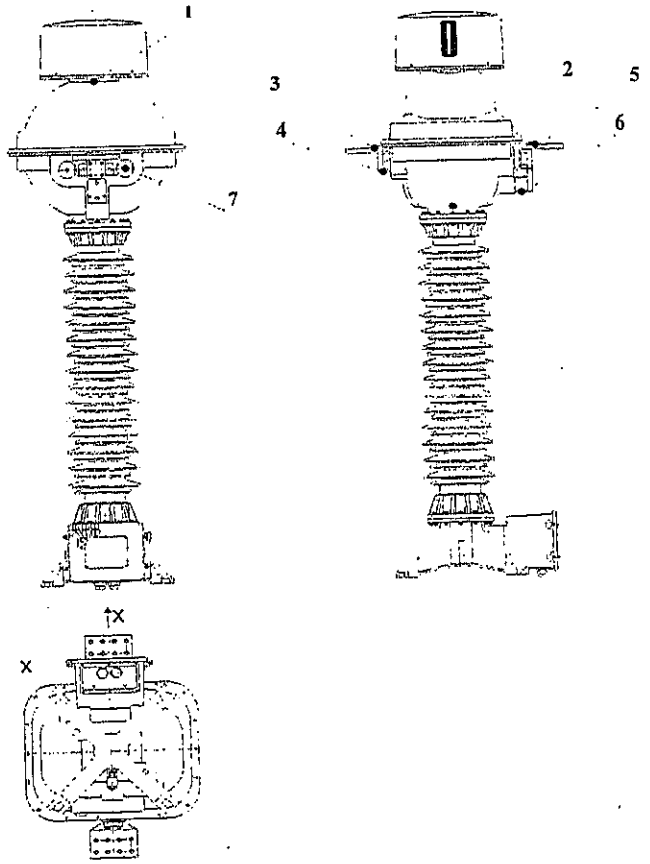
Primary current range: ..... 3000 A

Supply connection: ..... Bars Cu 3x1000 mm^2

Test object on testing stand: ..... Phot. 1 – 2, page 9

The temperatures were measured with used of recorder HIOKI 8423, No. NBR-801-30600 and thermocouples type K.

Measurement points



Temperature rise test at current 3000 A / 50 Hz - results

Table 1 Temperature rise test results

Thermocouple location	Thermocouple No.	Stabilized temperature rise [K]	
		Measured	Permitted
Oil in top core	1	31,80	55
Head	2	29,45	—
Connection terminal P1	3	54,25	75
Bolt connection P1	4	56,25	75
Connection terminal P2	5	48,95	75
Bolt connection P2	6	47,70	75
Current circuit 3000 A	7	49,15	—

Table 2 Resistance and temperature rise of secondary windings test results

Heating time [h]	Measurements									
	T_a [°C]	$R_{1S1-1S2}$ [mΩ]	$R_{2S1-2S2}$ [Ω]	$R_{3S1-3S2}$ [mΩ]	$R_{4S1-4S2}$ [Ω]	$\Delta T_{1S1-1S2}$ [K]	$\Delta T_{2S1-2S2}$ [K]	$\Delta T_{3S1-3S2}$ [K]	$\Delta T_{4S1-4S2}$ [K]	Deflection of the oil level indicator [mm]
0	17,20	450,2	5,458	587,5	5,675	0	0	0	0	0
1	18,15	463,2	5,540	601,5	5,722	7,30	3,65	5,70	2,00	4
2	19,00	467,9	6,601	608,2	5,789	10,00	6,40	8,50	4,90	8
3	19,50	474,1	5,676	616,3	5,863	13,50	9,95	12,00	8,20	12
4	19,85	480,4	5,756	624,7	5,946	17,10	13,75	15,75	11,95	15
5	20,15	487,3	5,841	633,5	6,034	21,00	17,95	19,80	16,10	18
6	20,25	493,7	5,923	642,2	6,119	24,65	22,10	23,95	20,25	19
7	20,35	500,3	6,003	650,8	6,203	28,40	26,30	28,15	24,50	21
8	20,40	506,1	6,076	658,5	6,280	31,70	30,20	32,05	28,45	22
9	20,50	511,7	6,147	665,8	6,354	34,90	34,05	35,85	32,40	23
10	20,50	516,9	6,211	672,8	6,421	37,85	37,65	39,60	36,10	25
11	20,55	521,6	6,270	678,9	6,483	40,55	41,00	42,95	39,55	26
12	20,55	525,6	6,323	684,7	6,540	42,80	44,05	46,15	42,85	27
13	20,60	529,8	6,375	690,0	6,593	45,20	47,10	49,20	45,95	28
14	20,65	533,3	6,420	694,8	6,641	47,20	49,75	52,00	48,85	28
15	20,60	536,7	6,463	699,5	6,685	49,10	52,30	54,75	51,55	28
16	20,70	539,8	6,501	703,3	6,725	50,90	54,65	57,10	54,05	29
17	20,60	540,6	6,517	704,4	6,749	51,35	55,55	57,80	55,40	28
18	20,50	541,5	6,529	705,6	6,764	51,80	56,30	58,55	56,35	26
19	20,45	541,2	6,535	706,2	6,771	51,65	56,55	58,90	56,75	25
20	20,15	542,0	6,537	701,4	6,775	52,05	56,75	59,05	57,00	25
21	18,75	541,7	6,537	706,3	6,773	51,55	56,65	59,00	56,90	25
22	18,35	541,7	6,533	706,2	6,769	51,50	56,45	58,90	56,65	24
23	18,60	541,1	6,528	705,8	6,764	51,20	56,10	58,60	56,35	24
24	18,85	541,0	6,523	705,0	6,758	51,20	55,85	58,15	55,95	23
Permitted temperature rise						65 K				

Table 3 Resistance and temperature rise of primary windings test results

	Before test	After test
Date of test	14.01.2015	15.01.2015
$R_{P1-P2/A}$, [μΩ]	29	34,5
Ambient temperature [°C]	20,4	18,8
Temperature rise [K]	—	48,1
Permitted temperature rise [K]	—	65

Resistance was measured at direct current : ..... primary circuit: 100 A
..... secondary circuit 5 A: 0,5 A
..... secondary circuit 1 A: 0,1 A

The measuring instrument type RMO100GP No. 14G743G

According to PN-EN 61862-2 clause 7.2.2.203 was estimated thermal time constants as the time elapsed until 63% of maximum estimated temperature rise.

Table 4 Thermal time constants

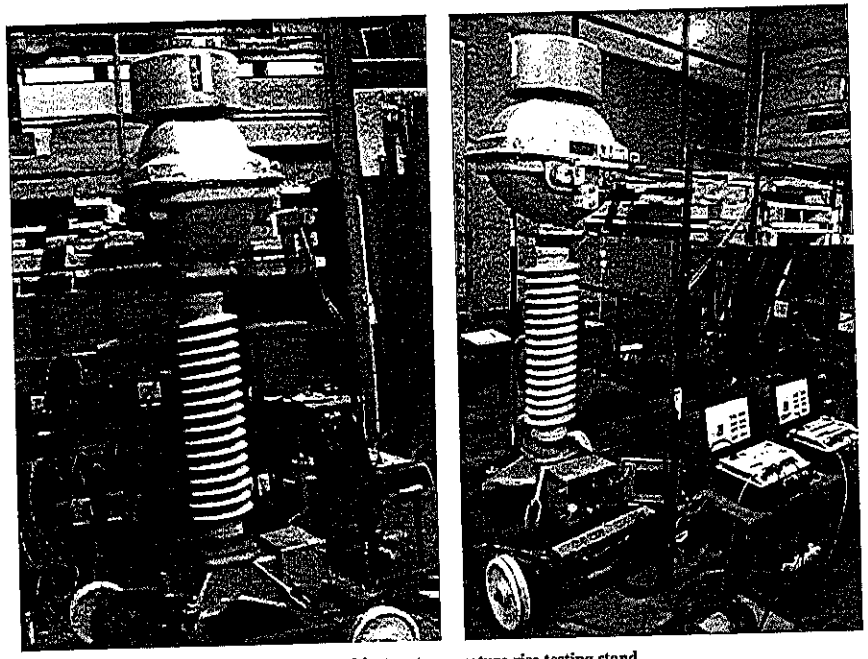
Thermocouple location	Thermocouples No.	Time constant T_e [h]
Oil in top core	1	6
Head	2	4
Connection terminal P1	3	1
Bolt connection P1	4	1
Connection terminal P2	5	1,5
Bolt connection P2	6	1,8
Current circuit 3000 A	7	2,5

Condition of tested object after the test:

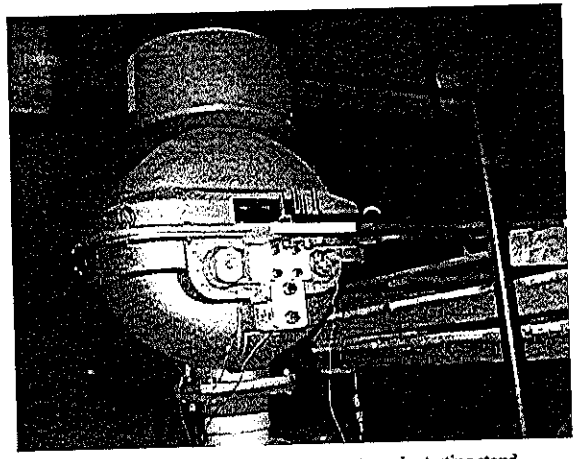
- The stabilized temperature rise of various parts of the current transformer did not exceed the values specified in the PN-EN 61869-1:2009, clause 6.4.1, table 5.
- No deterioration and failure was noted.

Test result: Object passed the test

5 Photographs



Phot. 1 Test object on temperature rise testing stand



Phot. 2 Test object on temperature rise testing stand

6 Drawings

ABB

Current Transformer | Type: PA 145a

Insulation level	145/275/650 kV	Standard	PN-EN 61869-2	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	360 / 120 kg	Temp. range	-40°C → +40°C
S/N	2GKP014A1287155				

K_n 1500-3000/5-1-5-1-1 A/A

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

I_{cth} 1800-3000 A

	A	VA	Class	FS/ALF	Ext.%
1S1-1S2	5	200	0,2	10	120
2S1-2S2	1	100	0,1	5	120
3S1-3S2	5	20	5P	60	
4S1-4S2	1	35	10P	40	
5S1-5S2					
6S1-6S2					

Transportation: Vertical / Horizontal

Figure 1 Rating plate

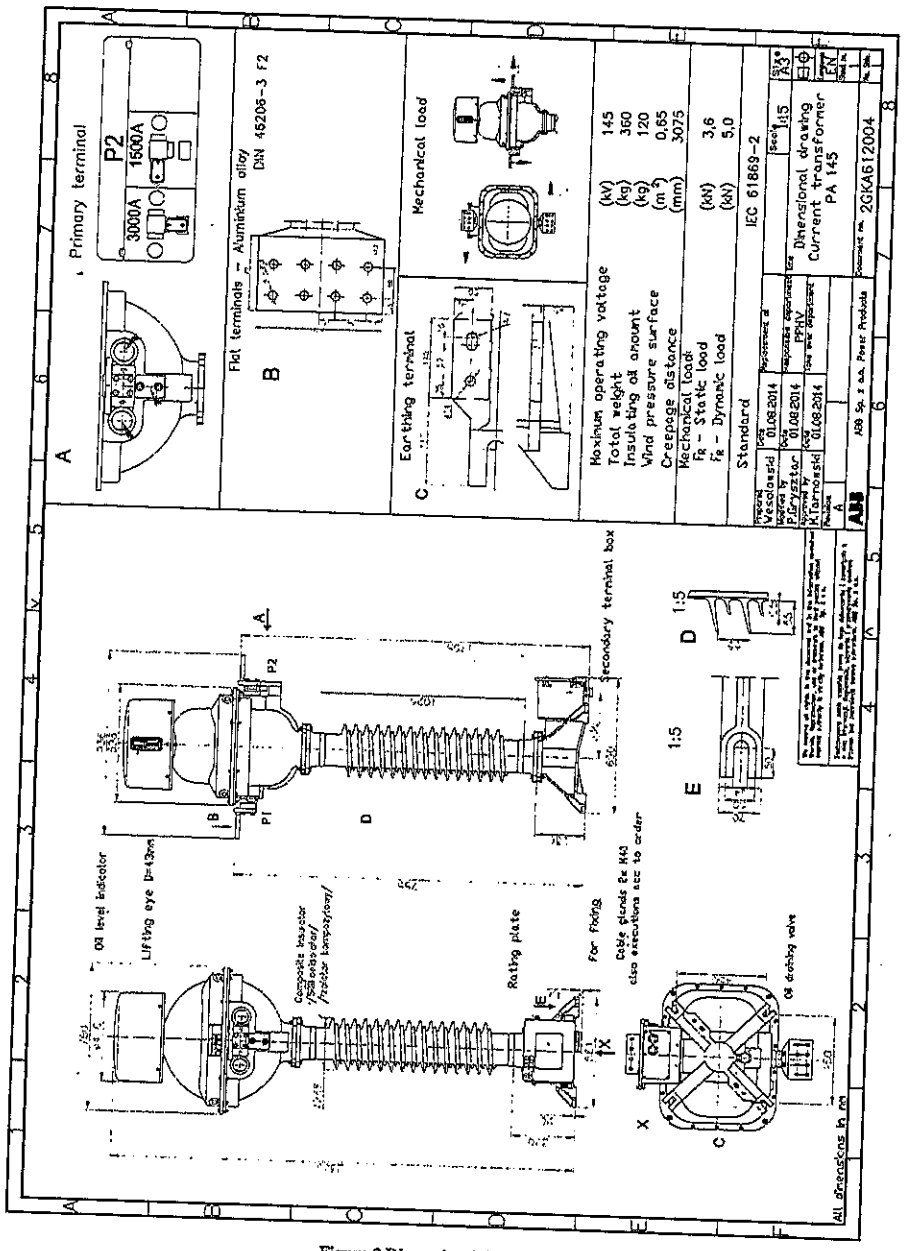


Figure 2 Dimensional drawing

7 Uncertainty electrical and non electrical quantities in laboratory

Measured quantity	*Range*	*Frequency*	*Measured parameter / uncertainty [%]*			
Voltage U / Divider RC	0 ≤ U ≤ 1000 V	dc - 20kHz	RMS	≤ ± 1.5	Peak	≤ ± 1.0
		> 20kHz	RMS	≤ ± 2.5	Peak	≤ ± 2.0
	1000 V ≤ U ≤ 10 kV	dc - 20kHz	RMS	≤ ± 2.0	Peak	≤ ± 1.5
		> 20kHz	RMS	≤ ± 2.5	Peak	≤ ± 2.0
	U > 10 kV	50Hz - 20kHz	RMS	≤ ± 3.0	Peak	≤ ± 2.5
		> 20kHz	RMS	≤ ± 3.5	Peak	≤ ± 3.0
Current I / Shunt	0 ≤ I ≤ 100 A	dc - 5kHz	RMS	≤ ± 1.5	Peak	≤ ± 1.0
			Joule Integral	≤ ± 2.0	Peak – Peak/√8	≤ ± 2.0
		> 5kHz	RMS	≤ ± 2.0	Peak	≤ ± 1.5
			Joule Integral	≤ ± 3.0	Peak – Peak/√8	≤ ± 3.0
	100 A≤ I ≤ 10 kA	dc - 5kHz	RMS	≤ ± 1.5	Peak	≤ ± 1.0
			Joule Integral	≤ ± 2.0	Peak – Peak/√8	≤ ± 2.0
		> 5kHz	RMS	≤ ± 2.0	Peak	≤ ± 1.5
			Joule Integral	≤ ± 3.0	Peak – Peak/√8	≤ ± 3.0
	I > 10 kA	dc - 5kHz	RMS	≤ ± 2.0	Peak	≤ ± 1.5
			Joule Integral	≤ ± 3.0	Peak – Peak/√8	≤ ± 3.0
		> 5kHz	RMS	≤ ± 2.5	Peak	≤ ± 2.0
			Joule Integral	≤ ± 3.5	Peak – Peak/√8	≤ ± 3.5
Current I / Current transformer	0 ≤ I ≤ 100 A	50Hz - 5kHz	RMS	≤ ± 2.0	Peak	≤ ± 1.5
			Joule Integral	≤ ± 2.5	Peak – Peak/√8	≤ ± 2.5
		> 5kHz	RMS	≤ ± 2.5	Peak	≤ ± 2.0
			Joule Integral	≤ ± 3.0	Peak – Peak/√8	≤ ± 3.0
	100 A≤ I ≤ 10 kA	50Hz - 5kHz	RMS	≤ ± 2.0	Peak	≤ ± 1.5
			Joule Integral	≤ ± 2.5	Peak – Peak/√8	≤ ± 2.5
		> 5kHz	RMS	≤ ± 2.5	Peak	≤ ± 2.0
			Joule Integral	≤ ± 3.0	Peak – Peak/√8	≤ ± 3.0
	10 kA ≤ I ≤ 30 kA	50Hz - 5kHz	RMS	≤ ± 3.0	Peak	≤ ± 2.5
			Joule Integral	≤ ± 3.5	Peak – Peak/√8	≤ ± 3.5
		> 5kHz	RMS	≤ ± 3.5	Peak	≤ ± 3.0
			Joule Integral	≤ ± 4.0	Peak – Peak/√8	≤ ± 3.5

Resistance R *bridge, multimotor*	20 µΩ≤ R ≤ 600 µΩ	≤ ± 5 %
	0.6 mΩ≤ R ≤ 600 mΩ	≤ ± 3 %
	0.6 Ω ≤ R ≤ 100 MΩ	≤ ± 1 %
Frequency f *oscilloscope, recordor TR*	≤ 10 kHz	≤ ± 0.2 %
	10 kHz ≤ f ≤ 1 Mhz	≤ ± 0.5 %
Time t *oscilloscope, recordor TR*	≤ 1 µs	≤ ± 20 %
	1 µs≤ t ≤ 1 ms	≤ ± 10 %
	> 1 ms	≤ ± 10%
Temperature T thermocouples	-50 °C≤ t ≤ 100 °C	≤ ± 0.2°C - *thermometer*
	-100 °C≤ t ≤ 200 °C	≤ ± 0.8 °C - *thermocouples K, recordor*
Relative humidity	20 % do 90% RH	≤ ± 5 % RH
Length Lengthmeter	≤ 1 mm	≤ ± 0.05 mm
	1 mm≤ l ≤30 mm	≤ ± 0.1 mm
	>30 mm	≤ ± 5 %
Gas pressure p	≤ 20 bar	≤ ± 5 %
	20 bar ≤ p ≤ 200 bar	≤ ± 10 %
Atmosph. pressure		≤ ± 0.01 MPa

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TEST REPORT No. EUR/34/E/14-1 E

TEST OBJECT: Current transformer type PA 145a with spiral composite insulator
Serial No. 2GKP014A1287155

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

TESTS ORDERED BY: ABB Sp. z o.o., ul. Żegańska 1, 04-713 Warszawa
order No. 4500574872 dated 22.07.2014

TYPE OF TESTS: Mechanical tests

TESTS PROCEDURE: According to IEC 61869-1:2007 p. 7.4.5

DATE OF TESTS: 21.08.2014

TESTS RESULT: Positive for
F_R = 3600 N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 05.09.2014

Contents

		Page
1.	Test object	3
1.1.	Description	3
1.2.	Technical data	3
1.3.	Technical documentation	3
1.4.	Preparation for tests	3
2.	Scope of tests	3
3.	Test and measuring circuits	3
4.	Tests and theirs detailed results	4
5.	Test results evaluation	4
Annexes: 1.	Photographs taken during the tests	5
2.	Documentations delivered by orderer	8

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tables	1
photographs	6

1. TEST OBJECT

1.1 Description

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

1.2 Technical data

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

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

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing current instrument transformer PA 145, No. 2GKA612004, 01.08.2014,
- rating plate,
- instrument transformer electrical diagram

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

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

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-1:2007:
- mechanical tests acc. to item 7.4.5 of above standard for F_R = 3600 N of P1 and P2 3000 A terminals.

During the tests deflection of the transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand.
Mechanical tests were performed applying the load consecutively to the transformer's P1 and P2 3000 A terminals as shown on photographs in Annex 1.

4. TESTS AND THEIRS DETAILED RESULTS

Tests results presents table 1. The load was increased and released smoothly (30 – 90 s) and was maintained 60 s. During the tests deflection of the transformer was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm).

During the tests the following records were made:
- phot. 1 to 6 - current transformer during mechanical tests.

(Annex 1 presents the photographs)

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

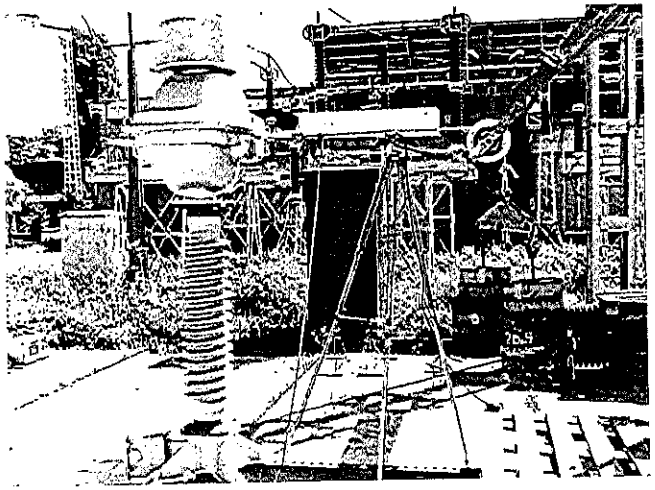
Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	P1	longitudinal	60	During the static load deflection was 16,9 mm. Residual deflection was 0,2 mm. After tests no damage nor oil leak was stated.
2	P1	transverse	60	During the static load deflection was 21,4 mm. Residual deflection was 1,3 mm. After tests no damage nor oil leak was stated.
3	P1	vertical	60	During the static load deflection was 4,9 mm. Residual deflection was 0,2 mm. After tests no damage nor oil leak was stated.
4	P2 3000 A	longitudinal	60	During the static load deflection was 16,3 mm. Residual deflection was 1,3 mm. After tests no damage nor oil leak was stated.
5	P2 3000 A	transverse	60	During the static load deflection was 20,9 mm. Residual deflection was 0,3 mm. After tests no damage nor oil leak was stated.
6	P2 3000 A	vertical	60	During the static load deflection was 3,9 mm. Residual deflection was 0,1 mm. After tests no damage nor oil leak was stated.

5. TESTS RESULTS EVALUATION

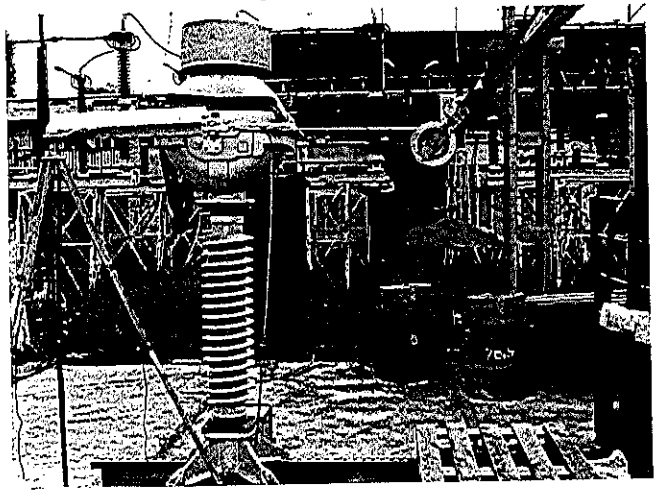
According to criteria given in IEC 61869-1:2007 p. 7.4.5 the results of tests of tested current transformer is positive for:

F_R = 3600 N.

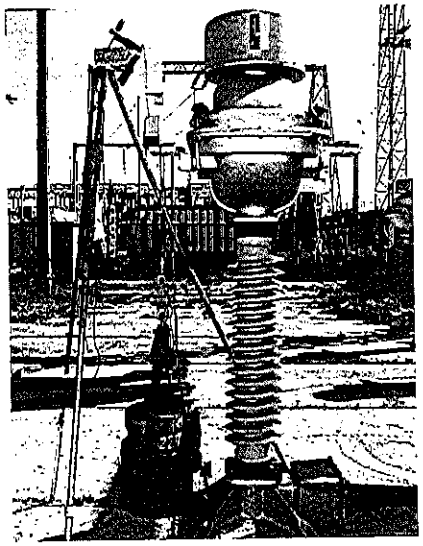
ANNEX 1 **Photographs taken during the tests**



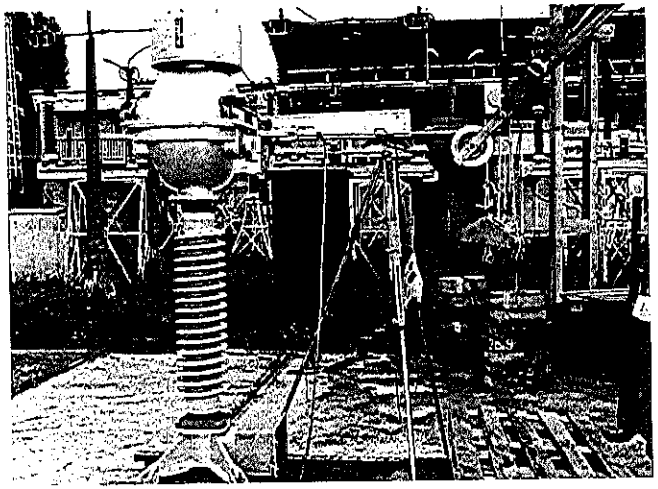
Phot. 1. Longitudinal load of terminal P1



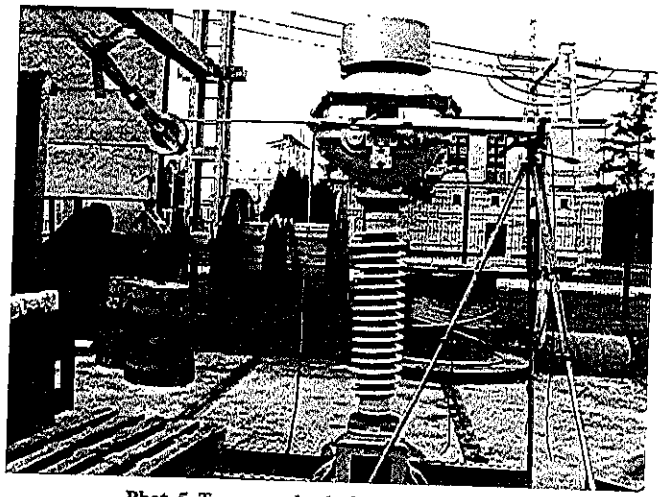
Phot. 2. Transverse load of terminal P1



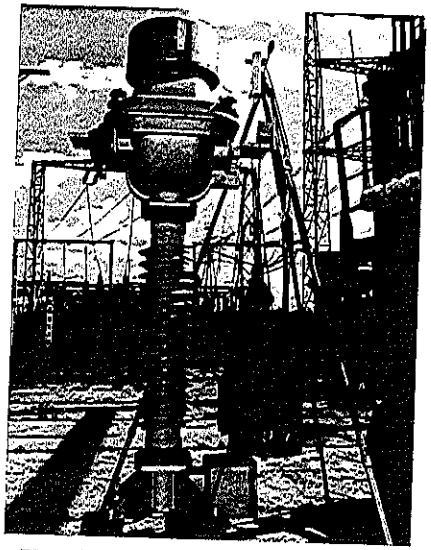
Phot. 3. Vertical load of terminal P1



Phot. 4. Longitudinal load of terminal P2 3000 A

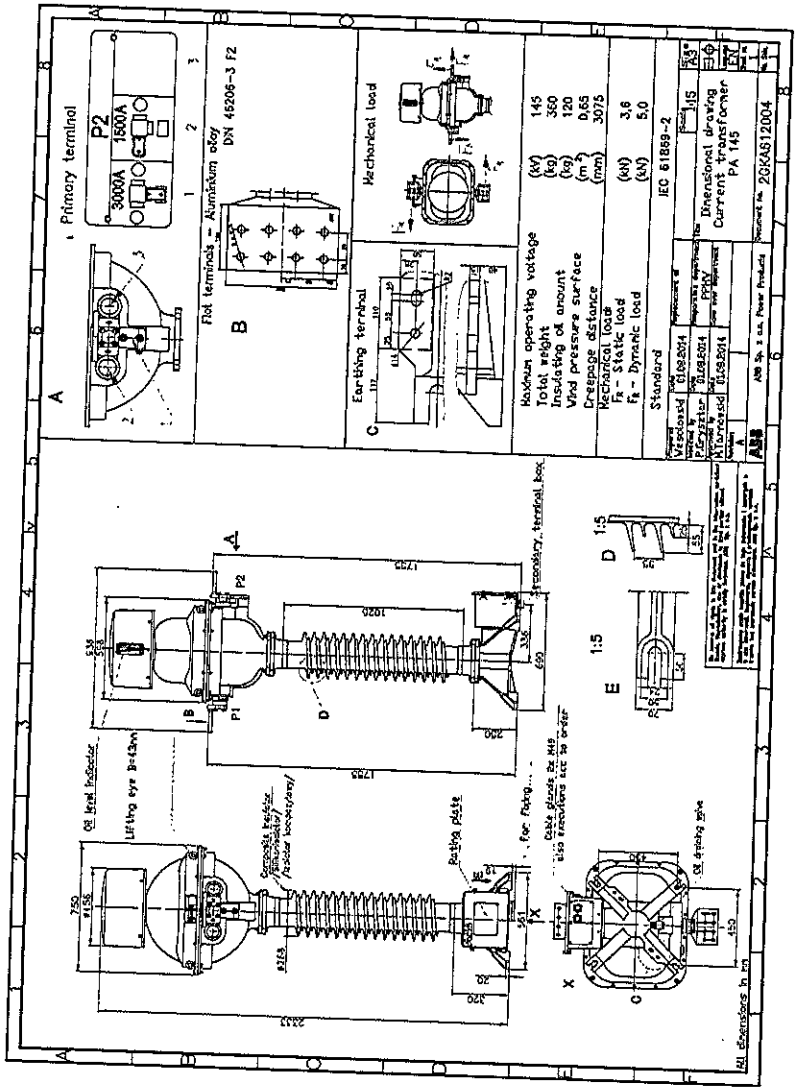


Phot. 5. Transverse load of terminal P2 3000 A



Phot. 6. Vertical load of terminal P2 3000 A

ANNEX 2 **Documentations delivered by orderer**



ABB

Current Transformer

				Type	PA 145a
Insulation level	145/275/650 kV	Standard	PN-EN 61869-2	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	360 / 120 kg	Temp. range	-40°C ⇾ +40°C
S/N	2GKP014A1287155				

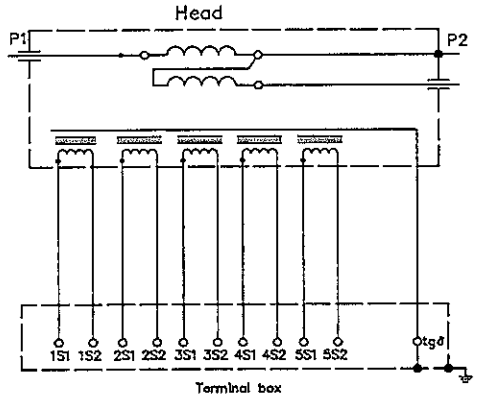
K_n 1500-3000/5-1-5-1-1 A/A

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

I_{cth} 1800-3600 A

	A	VA	Class	FS/ALF	Ext.%
1S1-1S2	5	200	0,2	10	120
2S1-2S2	1	100	0,1	5	120
3S1-3S2	5	20	5P	60	
4S1-4S2	1	35	10P	40	
5S1-5S2	1	40	10P	20	
6S1-6S2					

Transportation Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!

1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINAL tgδ MUST BE EARTHED

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TEST REPORT No. EUR/34/E/14-2 E

TEST OBJECT: Current transformer type PA 145a with composite insulator
Serial No. 2GKP014A1287180

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

TESTS ORDERED BY: ABB Sp. z o.o., ul. Żegańska 1, 04-713 Warszawa
order No. 4500574872 dated 22.07.2014

TYPE OF TESTS: Mechanical tests

TESTS PROCEDURE: According to IEC 61869-1:2007 p. 7.4.5

DATE OF TESTS: 22.08.2014

TESTS RESULT: Positive for
F_R = 3600 N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Test engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 23.09.2014

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1. TEST OBJECT

1.1 Description

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

1.2 Technical data

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

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

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimensional drawing current instrument transformer PA 145a, No. 2GKK612002, 11.09.2014,
- rating plate,
- instrument transformer electrical diagram

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

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

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of IEC 61869-1:2007:
- mechanical tests acc. to item 7.4.5 of above standard for F_R = 3600 N of P1 and P2 2000 A terminals.

During the tests deflection of the transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand.
Mechanical tests were performed applying the load consecutively to the transformer's P1 and P2 2000 A terminals as shown on photographs in Annex 1.

4. TESTS AND THEIRS DETAILED RESULTS

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

During the tests the following records were made:
- phot. 1 to 6 - current transformer during mechanical tests.

(Annex 1 presents the photographs)

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

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	P1	longitudinal	60	During the static load deflection was 32,5 mm. Residual deflection was 0,8 mm. After tests no damage nor oil leak was stated.
2	P1	transverse	60	During the static load deflection was 42,5 mm. Residual deflection was 0,5 mm. After tests no damage nor oil leak was stated.
3	P1	vertical	60	During the static load deflection was 4,5 mm. Residual deflection was 0,2 mm. After tests no damage nor oil leak was stated.
4	P2 2000 A	longitudinal	60	During the static load deflection was 36,3 mm. Residual deflection was 1,1 mm. After tests no damage nor oil leak was stated.
5	P2 2000 A	transverse	60	During the static load deflection was 39,8 mm. Residual deflection was 0,4 mm. After tests no damage nor oil leak was stated.
6	P2 2000 A	vertical	60	During the static load deflection was 7,0 mm. Residual deflection was 0,1 mm. After tests no damage nor oil leak was stated.

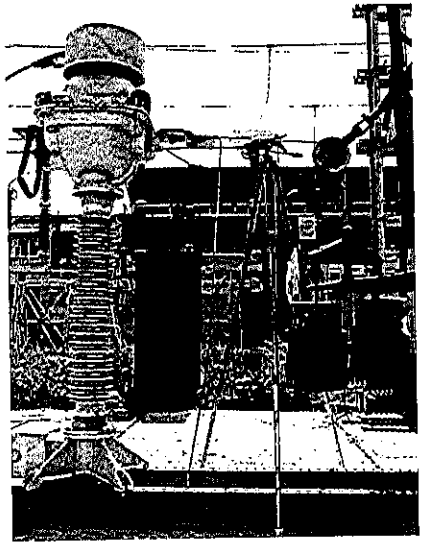
5. TESTS RESULTS EVALUATION

According to criteria given in IEC 61869-1:2007 p. 7.4.5 the results of tests of tested current transformer is positive for:

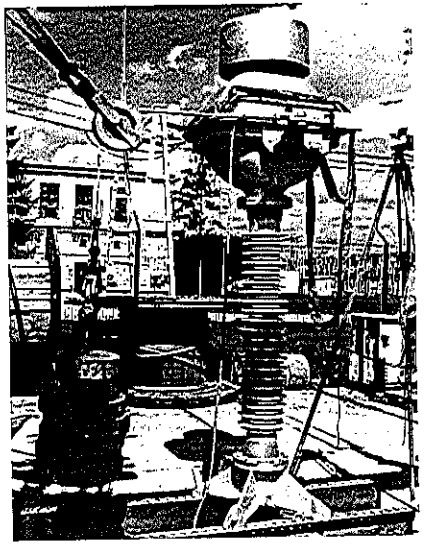
F_R = 3600 N.

ANNEX 1

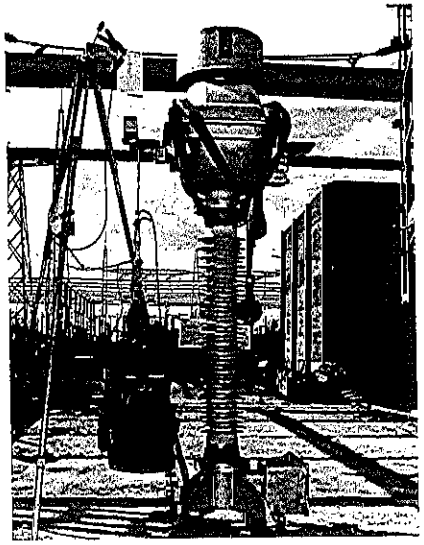
Photographs taken during the tests



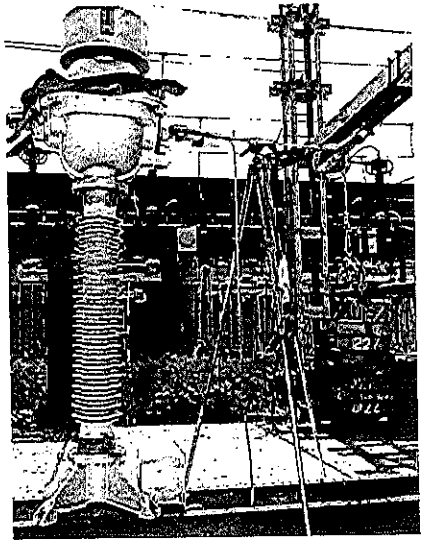
Phot. 1. Longitudinal load of terminal P1



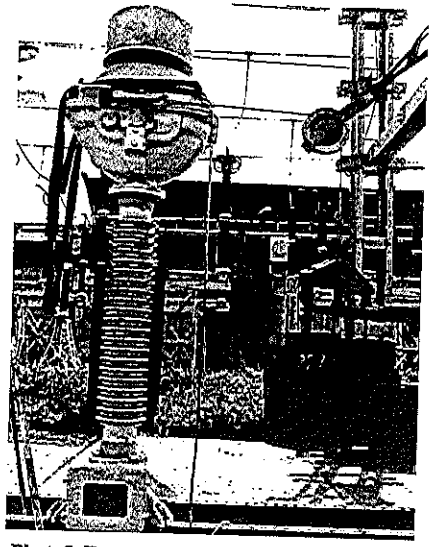
Phot. 2. Transverse load of terminal P1



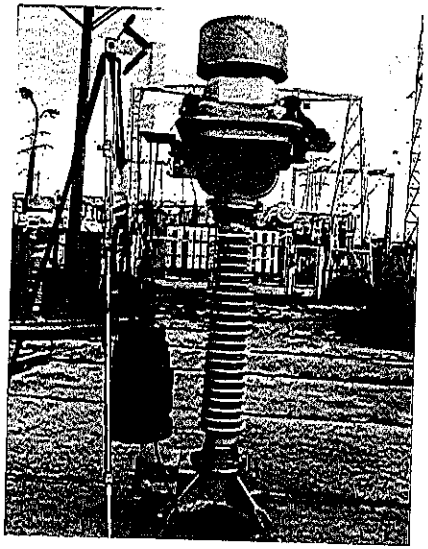
Phot. 3. Vertical load of terminal P1



Phot. 4. Longitudinal load of terminal P2 2000 A

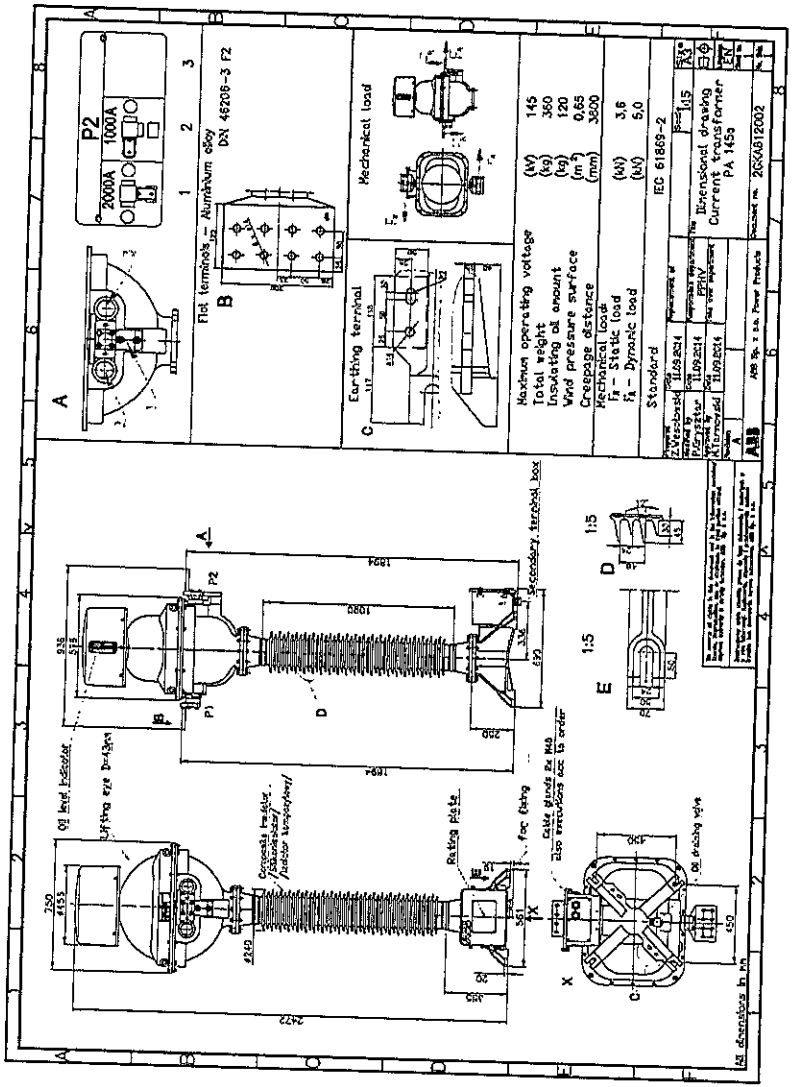


Phot. 5. Transverse load of terminal P2 2000 A



Phot. 6. Vertical load of terminal P2 2000 A

ANNEX 2 **Documentations delivered by orderer**



ABB

Current Transformer

Type: PA 145a

Insulation level	145/275/650 kV	Standard	PN-EN 61869-2	fn	50 Hz
Oil type	Nytro Libra	Weight / Oil weight	360 / 120 kg	Temp. range	-40°C ÷ +40°C
S/N	2GKP014A1287180				

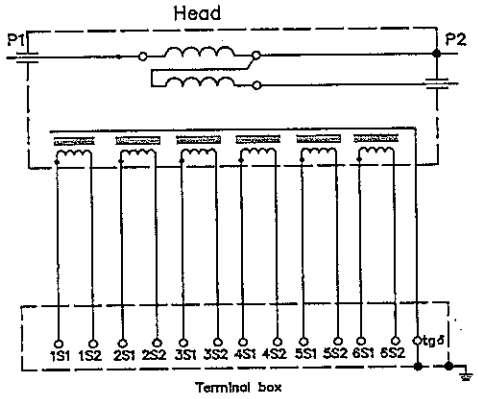
K_n 1000-2000/5-1-1-5-1-1 A/A

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

I_{cth} 1200-2400 A

	A	VA	Class	FS/ALF	Ext.%
1S1-1S2	5	100	0,2	10	120
2S1-2S2	1	70	0,1	5	120
3S1-3S2	1	35	5P	20	
4S1-4S2	5	15	5P	60	
5S1-5S2	1	30	5P	30	
6S1-6S2	1	10	5P	20	

Transportation: Vertical / Horizontal



Instrument transformer electrical diagram

ATTENTION!

1. HIGH VOLTAGE AT OPEN CURRENT SECONDARY TERMINALS XS1 – XS2
2. DURING INSTRUMENT TRANSFORMER OPERATION TERMINAL tgδ MUST BE EARTHED

„Доставка на електрически апарати 110kV“, реф. № PPD 17-064.

Обособена позиция 2 – Доставка на токови измервателни трансформатори 110kV за монтаж на открито – 21бр.

ПРИЛОЖЕНИЕ 5

ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ
НА ЛАБОРАТОРИЯ ЗА КАЛИБРИРАНЕ
№ AP 168

Това е, за да се потвърди, че:

ABB Sp. Z o.o.,
Ул. Зеганска 1, 04-713 Варшава
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 № AP 168

Тази акредитация остава в сила, при условие че Лабораторията съблюдава изискванията на органа за акредитация, определени в договор № AP 168

Сертификатът за акредитация е валиден до 20.12.2020 г.

Директор
Лучина Олборска

Варшава, 21 Декември2016 г.

POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

ABB Sp. z o.o.
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REGON 010171158
ODDZIAŁ W PRZASNYSZU
ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8849, fax (22) 223 8958
(16)

PCA 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 OLBÓRSKA

Warszawa, dnia 21 grudnia 2016 roku

4/13

ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ НА СЕРТИФИЦИРАЩ ОРГАН ЗА ПРОДУКТИ

№ AC 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 № AC 177

Тази акредитация остава в сила, при условие че Организацията съблюдава изискванията на органа за акредитация, определени в договор № AC 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.

ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ НА ЛАБОРАТОРИЯ ЗА ИЗПИТАНИЯ

№ AB 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 № AB 323

Тази акредитация остава в сила, при условие че Лабораторията съблюдава изискванията на органа за акредитация, определени в договор № AB 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.

416

ПОЛСКИ ЦЕНТЪР ЗА АКРЕДИТАЦИЯ

Подписваща страна EA MLA

СЕРТИФИКАТ ЗА АКРЕДИТАЦИЯ НА ЛАБОРАТОРИЯ ЗА ИЗПИТАНИЯ

№ AB 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 № AB 324

Тази акредитация остава в сила, при условие че Лабораторията съблюдава изискванията на органа за акредитация, определени в договор № AB 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.

POLSKIE CENTRUM AKREDYTACJI

POLISH CENTRE FOR ACCREDITATION

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

005287

POLSKIE CENTRUM AKREDYTACJI * 1 *

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

LUCYNA OLBORSKA

Warszawa, 27 stycznia 2017 roku

POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

PCA

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*

Warszawa, 24 listopada 2015 roku

ABB Sp. z o.o.
ul. Żelazna 1, 04-713 Warszawa
PL 5260304464
ODZIAŁ W PRZASNYSZU
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tel. (22) 223 8849, fax (22) 223 8958
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POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

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

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

LUCYNA OLBORSKA

POLSKIE CENTRUM AKREDYTACJI PCA *1*

Warszawa, 16 listopada 2015 roku

ABB
ABB Sp. z o.o.
Żegańska 1, 04-713 Warszawa
[illegible]
Regon 010017168
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ul. Leszno 59, 06-300 Przasnysz
tel. (22) 223 8849, fax (22) 223 8958
(16)

422

„Доставка на електрически апарати 110kV“, реф. № PPD 17-064.

Обособена позиция 2 – Доставка на токови измервателни трансформатори 110kV за монтаж на открито – 21бр.

ПРИЛОЖЕНИЕ 6

ROUTINE TEST PLAN for Current Transformers

Plan próby wyrobu Przekładników Prądowych

Number / *Numer*	Page / *Strona* 1
2GKA614153	Pages / *Stron* 3
Type/ Typ	

– units of Current Transformers (-- szt. Przekładników Prądowych)

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 61869-2	Cl. 6.13; 7.3.6 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 61869-2 IEC 60270	Cl. 7.3.1; 7.3.2 Cl. 7.3.1	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
4	Measurement of windings' internal resistance and ambient temperature *Pomiar wewnętrznych rezystancji uzwojeń i temperatury otoczenia*	IEC 61869-2 –	Cl. 7.3.201 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

ABB	**ROUTINE TEST PLAN for Current Transformers** ***Plan próby wyrobu dla Przekładników Prądowych***	Number / *Numer* **2GKA614153**	Page / *Strona* 2 Pages / *Stron* 3
		Type/ Typ	
	-- units of Current Transformers (-- szt. Przekładników Prądowych)	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 terminals and between sections (if applicable) *Próba izolacji uzwojeń wtórnych oraz między sekcjami uzwojeń (jeśli ma zastosowanie) napięciem o częstotliwości sieciowej*	IEC 61869-1	Cl. 7.3.3; 7.3.4	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
6	Measurement of factors: FS/ALF/Ts/Ek/Ie/Kr and magnetizing characteristic *Pomiar współczynników: FS/ALF/Ts/Ek/Ie/Kr i charakterystyki magnesowania*	IEC 61869-2 –	Cl. 7.2.6.202; 7.3.5.203; 7.3.5.205; 7.3.202; 7.3.203; 7.2.6.206 Order *Zamówienie*	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
7	Inter-turn overvoltage test *Próba izolacji międzyzwojowej*	IEC 61869-2	Cl. 7.3.204	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
8	Capacitance and dielectric dissipation factor measurement *Pomiar pojemności i współczynnika strat dielektrycznych*	IEC 61869-1 IEC 61869-2	Cl. 7.4.3 Cl. 7.4.3	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	**ROUTINE TEST PLAN for Current Transformer** ***Plan próby wyrobu dla Przekładników Prądowych***	Number / *Numer* **2GKA614153**	Page / *Strona* 3 Pages / *Stron* 3
		Type/ Typ	
	-- units of Current Transformers (-- szt. Przekładników Prądowych)	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*
9	Test for accuracy of the current transformer: • Tests for ratio error and phase displacement of measuring CT; • Tests for ratio error and phase displacement of class P; PR; TPX; TPY and TPZ protective CT • Test for turns ratio error for class PX and PXR protective CT *Próby dokładności przekładnika prądowego:* • *Próby błędu przekładni i przesunięcia kątowego przekładnika pomiarowego;* • *Próby błędu przekładni i przesunięcia kątowego przekładnika zabezpieczeniowego o klasach P; PR; TPX; TPY; TPZ* • *Próba błędu przekładni zwojowej dla klas PX i PXR przekładnika zabezpieczeniowego*	IEC 61869-2	Cl. 7.3.5.201, 7.3.5.202, 7.3.5.204, 7.3.5.206	Quality control - ABB Przasnysz *Kontrola Jakości*			☐	
10	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	**ROUTINE TEST PLAN for Current Transformers** ***План за рутинни изпитания на Токов Трансформатор***	Number /Номер **2GKA614153**	Page / *Страница* 1 Pages / *Общо* 3
		Type/ Тип	
	-- units of Current Transformers (-- брой Токови Трансформатори)	Valid for order ..... / KU .... *Валидно за поръчка ..... / KU ....*	

Sl. №	Test *Изпитание*	Test according to: *Изпитание съгл.:*	Requirement according to: *Изисквания съгласно:*	Place of test *Място на изпитанието*	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 61869-2	Cl. 6.13; 7.3.6 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 намотка и измерване на частичните разряди.*	IEC 61869-1 IEC 61869-2 IEC 60270	Cl. 7.3.1; 7.3.2 Cl. 7.3.1	Quality control - ABB Przasnysz *Контрол на качеството*				
4	Measurement of windings' internal resistance and ambient temperature *Измерване на вътрешното съпротивление на намотките и температурата*	IEC 61869-2 --	Cl. 7.3.201 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 *Дата*	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 Current Transformers

План за рутинни изпитания на Токов Трансформатор

-- units of Current Transformers (-- брой Токови Трансформатори)

Number /Номер **2GKA614153**

Page / *Страница* 1
Pages / *Общо* 3

Type/ Тип

Valid for order ..... / KU ....
Валидно за поръчка ..... / KU ....

Sl. №	Test *Изпитание*	Test according to: *Изпитание съгл.:*	Requirement according to: *Изисквания съгласно:*	Place of test *Място на изпитанието*	Remarks *Забележки*	*Date* *Дата*	Acceptance *Приемане*	Signature *Подпис*
5	Power-frequency voltage withstand tests on secondary terminals and between sections (if applicable) *Обявено издържано напрежение с промишлена честота за изолацията на вторичните клеми и между секциите (ако е приложимо)*	IEC 61869-1	Cl. 7.3.3; 7.3.4	Quality control - ABB Przasnysz *Контрол на качеството*				
6	Measurement of factors: FS/ALF/Ts/Ek/Ie/Kr and magnetizing characteristic *Измерване на фактори: FS/ALF/Ts/Ek/Ie/Kr и намагнитващите характеристики*	IEC 61869-2 --	Cl. 7.2.6.202; 7.3.5.203; 7.3.5.205; 7.3.202; 7.3.203; 7.2.6.206 Order *Поръчка*	Quality control - ABB Przasnysz *Контрол на качеството*				
7	Inter-turn overvoltage test *Изпитание на пренапрежение на вътрешните навивки*	IEC 61869-2	Cl. 7.3.204	Quality control - ABB Przasnysz *Контрол на качеството*				
8	Capacitance and dielectric dissipation factor measurement *Измерване на капацитет и фактор на диелектрично разсейване*	IEC 61869-1 IEC 61869-2	Cl. 7.4.3 Cl. 7.4.3	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	[illegible]owski	27.07.2015	[illegible]ębski	27.07.2015

ABB	**ROUTINE TEST PLAN for Current Transformers** ***План за рутинни изпитания на Токов Трансформатор***	Number /Номер **2GKA614153**	Page / *Страница* 1 Pages / *Общо* 3
		Type/ Тип	
	-- units of Current Transformers (-- брой Токови Трансформатори)	Valid for order ..... / KU .... *Валидно за поръчка ..... / KU ....*	

Sl. №	Test *Изпитание*	Test according to: *Изпитание съгл.:*	Requirement according to: *Изисквания съгласно:*	Place of test *Място на изпитанието*	Remarks *Забележки*	*Date* *Дата*	Acceptance *Приемане*	Signature *Подпис*
9	Test for accuracy of the current transformer: • Tests for ratio error and phase displacement of measuring CT; • Tests for ratio error and phase displacement of class P; PR; TPX; TPY and TPZ protective CT • Test for turns ratio error for class PX and PXR protective CT *Изпитание на точността на ТТ:* *Изпитание на грешката и фазовото отместване на ТТ за мерене ;* • *Изпитание на грешката и фазовото отместване на клас P; PR; TPX; TPY; TPZ на ТТ за защита* • *Проверка за грешка в съотношението на навивките за клас PX и PXR на ТТ за защита*	IEC 61869-2	Cl. 7.3.5.201, 7.3.5.202, 7.3.5.204, 7.3.5.206	Quality control - ABB Przasnysz *Контрол на качеството*				
10	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

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 2 -** Доставка на токови измервателни трансформатори 110 kV за монтаж на открито – 21 бр.

Д Е К Л А Р И Р А М Е, Ч Е:

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
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BIC: INGBBGSF

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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 110кV"**, реф. № PPD 17-064, **Обособена позиция 2** - Доставка на токови измервателни трансформатори 110 kV за монтаж на открито – 21 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
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