Таблица 5. Списък на доказани параметри за EMF-E123 and PV123a

Индуктивен напреженов трансформатор тип EMF-E123 и PV123a

Номинално първично напрежение *Upr*	≤ 115/√3 kV
На-високо напрежение на оборудването *Um*	≤ 126 kV
Номинална честота *fR*	50 Hz
Номинално изолационно ниво	AC 230 kV / LI 550 kV
Изпитание на издръжливост на статично натоварване *FR*	3600 N
Външна изолация – път на утечка на изолатора [1)]	3150 mm ÷4495 mm
Степен на защита срещу механично въздействие на	IK07
Степен на защита на вторичната клемна кутия	IP55
Номинален фактор на напрежение *Fv*/ време	≤1.9 / 8 h
Номинално вторично напрежение *Usr*	≤115 V
Клас на точност на измервателните и защитни намотки	0.1; 0.2; 0.5; 1; 3; 3P; 6P
Ном. мощност на измервателните и защитни намотки *Sr*	≤1000 VA
Номинално напрежение на остатъчната намотка *Usr (da-dn)*	≤ 115 V
Клас на точност на остатъчната намотка	0.5; 1; 3; 3P; 6P
Номинална мощност на остатъчната намотка *Sr*	≤450 VA
Обща мощност *Syth*	4000 VA

Таблица 6. Списък на доказани параметри за EMF-E145 and PV145a

Индуктивен напреженов трансформатор тип EMF-E145 и PV145a	
Номинално първично напрежение *Upr*	≤145/√3 kV
На-високо напрежение на оборудването *Um*	≤145 kV
Номинална честота *fR*	50 Hz
Номинално изолационно ниво	AC 275 kV / LI 650 kV
Изпитание на издръжливост на статично натоварване *FR*	3600 N
Външна изолация – път на утечка на изолатора [1)]	3150 mm ÷4495 mm
Степен на защита срещу механично въздействие на	IK07
Степен на защита на вторичната клемна кутия	IP55
Номинален фактор на напрежение *Fv*/ време	≤ 1.9 / 8 h
Номинално вторично напрежение *Usr*	≤ 115 V
Клас на точност на измервателните и защитни намотки	0.1; 0.2; 0.5; 1; 3; 3P; 6P
Ном. мощност на измервателните и защитни намотки *Sr*	≤ 1000 VA
Номинално напрежение на остатъчната намотка *Usr (da-dn)*	≤ 115 V
Клас на точност на остатъчната намотка	0.5; 1; 3 ; 3P; 6P
Номинална мощност на остатъчната намотка *Sr*	≤ 450 VA
Обща мощност *Syth*	4000 VA

ЗАБЕЛЕЖКИ:

1. [1)] Приложимо за композитни и за порцеланови изолатори
2. [2)] Не е прилогжимо за порцеланови изолатори

AC 117

INSTYTUT ENERGETYKI
Certification Department

PRODUCT EVALUATION REPORT

No. DZC/111c/E/2015-2
revision 4
2016.12.30

Product name and symbol: **Inductive voltage transformers types EMF-E072, EMF-E084, EMF-E123, EMF-E145, PV123a and PV145a.**

Supplier: **ABB Sp. z o. o.**
1 Żegańska Str.
04-713 Warsaw
Poland

Manufacturer: **ABB AB Power Products**
Valhallavägen 2
771 31 Ludvika
Sweden

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

Warsaw, November 2016

Author: Jan Tomaszewski M. Sc. Eng.

Contents

Appendix: Type test, special test and routine test reports (pages not numbered), Manufacturers statements

Non-conformities observed:

None found

General evaluation result:

Positive
On the basis of analysis made, herewith I apply for granting the certificate of conformity to the inductive voltage transformers, type EMF-E072, EMF-E084, EMF-123 and EMF-E145, PV123a and PV145a, according to the Summary.

Jan Tomaszewski — Full name
signature
2016.12.30 — date

1. Introduction

This evaluation report concerning inductive voltage transformers series, type EMF-E... and PV...a was made during the certification processes carried out by the Certification Department of Instytut Energetyki upon the application of ABB Sp. z o.o., Poland (issuance of the certificate for EMF-E... - no. DZC/111c/E/2015, extension of EMF-E... certificate - no. DZC/131c/E/2016 and DZC/187c/E/2016, issuance of a certificate for PV...a – no. DZC/189c/E/2016).

The EMF-E... and PV...a voltage transformers are designed to energize measurement and protection circuits in outdoor electrical grids with highest voltages up to 72.5 kV (EMF-E072), 84 kV (EMF-E084), 126 kV (EMF-E123 and PV123a) and 145 kV (EMF-E145 and PV145a) and frequency 50 Hz.

According to the documents delivered by the Manufacturer (statement about no changes in the design and test reports), new type names of the same voltage transformer construction are introduced. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145 from technical point of view. The former are assembled only in ABB Sp. z o.o., Branch Office in Przasnysz, Poland, while the latter, as well as EMF-E072 and EMF-E084, both in ABB Sp. z o.o., Branch Office in Przasnysz, Poland and in ABB AB Power Products in Ludvika, Sweden. Correctness of drying, assembling and oil filling has been confirmed by appropriate tests which are described in chapter 5 of this report.

The in question inductive voltage transformers have a single-pole construction. The active part of the VT is located in the tank which serves also as the base of the device and which is supposed to be grounded. The VT can have up to six secondary windings which are led out to the terminal box. The grounded tank is separated from the high voltage terminal with a porcelain or composite insulator. The internal insulation of the device is designed as paper-oil.

The construction of housing and the insulator types of EMF-E072 and EMF-E084 is identical. The same applies to EMF-E123, PV123a, EMF-E145 and PV145a.

The type and special tests of the in question voltage transformers have been performed in Instytut Energetyki (Warsaw), Instytut Elektrotechniki (Warsaw) and in the manufacturer's factory facilities in Ludvika, Sweden (under supervision of SATS inspector). The routine tests have been performed in the manufacturer's laboratory in Przasnysz, Poland under supervision of IEn representatives.

The parameters of the whole series of VTs were assigned on the basis of performed tests. The test results confirming the devices' properties are given in test reports listed in cl. 2 of this study. The results were compared with the requirements of following standards:

- IEC 61869-1:2007 (PN-EN 61869-1:2009)
  Instrument transformers – Part 1: General requirements
- IEC 61869-3:2011 (PN-EN 61869-3:2011)
  Instrument transformers – Part 3: Additional requirements for inductive voltage transformers.

- IEC 60529:1989+AMD1:1999+AMD2:2013 CSV (PN-EN 60529:2003/A2:2014-07)
  Degrees of protection provided by enclosures (IP Code)
- IEC 62262:2002 (PN-EN 62262 :2003)
  Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

ABB AB Power Products holds certificates confirming the quality of their management systems in the range of following standards:

- SS-EN ISO 9001:2008 (certificate no. SE004225-1)
- SS-EN ISO 14001:2004 (certificate no. SE004224-1)
- OHSAS 18001:2007 (certificate no. SE004226-1)

issued by Bureau Veritas Certification Sverige AB.

ABB Sp. z o.o. with all its Branch Offices holds a certificate confirming the quality of their management systems in the range of following standards:

- ISO 9001:2015 (certificate no. 01 100 1541800)
- ISO 14001:2015 (certificate no. 01 104 1541809)
- PN-N 18001:2004 (certificate no. 0198 113 00113)

issued by TÜV Rheinland Cert GmbH.

2. List of used documents

Following reports delivered by the Supplier were used to perform the evaluation process of the in question voltage transformers:

D1. Report No. EWP/52/E/2015-1; Temperature-rise test; EMF-E084, SN. 1HSE8851777; High Current Laboratory (EWP) of Instytut Energetyki; October 2015

D2. Report No. EWP/52/E/2015-3; Temperature-rise test; EMF-E145, SN. 1HSE8851772; High Current Laboratory (EWP) of Instytut Energetyki; September 2015

D3. Report No. EWP/52/E/2015-4; Temperature-rise test; EMF-E145, SN. 1HSE8851773; High Current Laboratory (EWP) of Instytut Energetyki; September 2015

D4. Report No. EWN/134/E/15; Impulse voltage withstand test on primary terminal and chopped impulse voltage withstand test on primary terminal; EMF-E145, SN. 1HSE8851773; High Voltage Laboratory (EWN) of Instytut Energetyki; November 2015

D5. Report No. EWN/109/E/15-1; Impulse voltage withstand test on primary terminal, chopped impulse voltage withstand test on primary terminal, transmitted overvoltage test and capacitor discharge test; EMF-E123, SN. 1HSE8851774; High Voltage Laboratory (EWN) of Instytut Energetyki; October 2015

D6. Report No. EWN/109/E/15-3; Impulse voltage withstand test on primary terminal, chopped impulse voltage withstand test on primary terminal and transmitted overvoltage test; EMF-E084, SN. 1HSE8851777; High Voltage Laboratory (EWN) of Instytut Energetyki; October 2015

D7. Report No. EWN/109/E/15-2; Impulse voltage withstand test on primary terminal, chopped impulse voltage withstand test on primary terminal and transmitted overvoltage test; EMF-E072, SN. 1HSE8851776; High Voltage Laboratory (EWN) of Instytut Energetyki; October 2015

D8. Report no. EWN/45/E/16; Impulse and chopped impulse voltage withstand test on primary terminal; PV145a, SN. 2GKP015V1188086; High Voltage Laboratory (EWN) of Instytut Energetyki; May 2016

D9. Report no. EWN/106/E/16-1; Impulse and chopped impulse voltage withstand test on primary terminal; EMF-E072, SN. 2GGKV1190628; High Voltage Laboratory (EWN) of Instytut Energetyki; December 2016

D10. Report no. EWN/106/E/16-2; Impulse and chopped impulse voltage withstand test on primary terminal; PV145a, SN. 2GGKV1190678; High Voltage Laboratory (EWN) of Instytut Energetyki; December 2016

D11. Report No. R Q 15-78; Wet test; EMF-E145, SN. 1HSE8851772; Laboratory of ABB AB Power Products, Ludvika, Sweden; October 2015

D12. Report No. R Q 15-79; Wet test; EMF-E145, SN. 1HSE8851773; Laboratory of ABB AB Power Products, Ludvika, Sweden; October 2015

D13. Report No. R Q 15-74; Wet test; EMF-E084, SN. 1HSE8851777; Laboratory of ABB AB Power Products, Ludvika, Sweden; September 2015

D14. Report No. R Q 15-75; Wet test; EMF-E084, SN. 1HSE8851778; Laboratory of ABB AB Power Products, Ludvika, Sweden; September 2015

D15. Report No. EWN/109/E/15-4; Transmitted overvoltage test and RIV test; EMF-E145, SN. 1HSE8851772; High Voltage Laboratory (EWN) of Instytut Energetyki; November 2015

D16. Report No. EWN/109/E/15-5; RIV test; EMF-E145, SN. 1HSE8851772; High Voltage Laboratory (EWN) of Instytut Energetyki; November 2015

D17. Report No. 8604/NZL/NBR/15; Verification of the degree of protection; Terminal box 2GHV042554; Switchgear Testing Laboratory of Instytut Elektrotechniki; April 2015

D18. Report No. 8606/NZL/NBR/15; Verification of the degree of protection; Terminal box 2GHV042542; Switchgear Testing Laboratory of Instytut Elektrotechniki; April 2015

D19. Report No. EWP/40/E/2015; Verification of the degree of protection against mechanical impact; EMF-E072, SN. 2GKP015V1188091, EMF-E072, SN. 2GKP015V1188038, EMF-E145, SN. 1HSE8849700, EMF-E145, SN. 2GKP013K1486306, EMF-E072, SN. 2GKP015V1188093, EMF-E072, SN. 2GKP015V1188092; High Current Laboratory (EWP) of Instytut Energetyki; October 2015

D20. Report No. 8734/NZL/NBR/15; Short-circuit withstand capability test; EMF-E145, SN. 1HSE8851773; Switchgear Testing Laboratory of Instytut Elektrotechniki; November 2015

D21. Report No. 8733/NZL/NBR/15; Short-circuit withstand capability test; EMF-E084, SN. 1HSE8851778; Switchgear Testing Laboratory of Instytut Elektrotechniki; November 2015

D22. Routine test report before type tests; EMF-E145, SN. 1HSE8851772; Laboratory of ABB Sp. z o.o., Przasnysz; October 2015

D23. Routine test report before type tests; EMF-E145, SN. 1HSE8851773; Laboratory of ABB Sp. z o.o., Przasnysz; October 2015

D24. Routine test report before type tests; EMF-E123, SN. 1HSE8851774; Laboratory of ABB Sp. z o.o., Przasnysz; October 2015

D25. Routine test report before type tests; EMF-E072, SN. 1HSE8851776; Laboratory of ABB Sp. z o.o., Przasnysz; October 2015

D26. Routine test report before type tests; EMF-E084, SN. 1HSE8851777; Laboratory of ABB Sp. z o.o., Przasnysz; October 2015

D27. Routine test report before type tests; EMF-E084, SN. 1HSE8851778; Laboratory of ABB Sp. z o.o., Przasnysz; October 2015

D28. Routine test report after lightning impulse test; EMF-E145, SN. 1HSE8851773; Laboratory of ABB Sp. z o.o., Przasnysz; November 2015

D29. Routine test report after lightning impulse test; EMF-E123, SN. 1HSE8851774; Laboratory of ABB Sp. z o.o., Przasnysz; November 2015

D30. Routine test report after lightning impulse test; EMF-E084, SN. 1HSE8851777; Laboratory of ABB Sp. z o.o., Przasnysz; November 2015

D31. Routine test report after lightning impulse test; EMF-E072, SN. 1HSE8851776; Laboratory of ABB Sp. z o.o., Przasnysz; November 2015

D32. Routine test report after short-circuit withstand capability test; EMF-E145, SN. 1HSE8851773; Laboratory of ABB Sp. z o.o., Przasnysz; November 2015

D33. Routine test report after short-circuit withstand capability test; EMF-E084, SN. 1HSE8851778; Laboratory of ABB Sp. z o.o., Przasnysz; November 2015

D34. Report No. EUR/44/E/16-1; Mechanical test; EMF- E072, SN. 2GGKV1190628; Distribution Equipment Laboratory (EUR) of Instytut Energetyki; November 2016

D35. Report No. EUR/44/E/16-2; Mechanical test; EMF- E072, SN. 2GGKV1190629; Distribution Equipment Laboratory (EUR) of Instytut Energetyki; November 2016

D36. Report No. EUR/44/E/16-3; Mechanical test; EMF- E072, SN. 2GGKV1190649; Distribution Equipment Laboratory (EUR) of Instytut Energetyki; November 2016

D37. Report No. EUR/44/E/16-4; Mechanical test; EMF- E145, SN. 2GGKV1190669; Distribution Equipment Laboratory (EUR) of Instytut Energetyki; December 2016

D38. Report No. EUR/44/E/16-5; Mechanical test; EMF- E145, SN. 2GGKV1190668; Distribution Equipment Laboratory (EUR) of Instytut Energetyki; December 2016

D39. Report No. EUR/44/E/16-6; Mechanical test; EMF- E145, SN. 2GGKV1190670; Distribution Equipment Laboratory (EUR) of Instytut Energetyki; December 2016

3. Competences of the testing laboratories

The type tests, the special tests and the routine tests of the EMF-E voltage transformers were performed in following laboratories:

- Laboratorium Wielkoprądowe (High Current Laboratory), a unit of Instytut Energetyki (Institute of Power Engineering) in Warsaw, holding the PCA Accreditation Certificate of the Research Laboratory PCA No. AB 323

- Laboratorium Wysokich Napięć (High Voltage Laboratory), a unit of Instytut Energetyki (Institute of Power Engineering) in Warsaw, holding the PCA Accreditation Certificate of the Research Laboratory PCA No AB 272.

- ABB AB Power Products Manufacturing Plant Laboratory in Ludvika – tests performed under supervision of the representatives of SATS.

- ABB Sp. z o. o. Manufacturing Plant Laboratory in Przasnysz – OUM Warsaw (District Office of Measures) Verification Unit, routine tests performed under supervision of the representatives of Instytut Energetyki.

- Laboratorium Badawcze Aparatury Rozdzielczej (Switchgear Testing Laboratory), a unit of Instytut Elektrotechniki (Electrotechnical Institute) in Warsaw, holding the PCA Accreditation Certificate of the Research Laboratory PCA No AB 074.

- Laboratorium Urządzeń Rozdzielczych (Distribution Equipment Laboratory), a unit of Instytut Energetyki (Institute of Power Engineering) in Warsaw, holding the PCA Accreditation Certificate of the Research Laboratory PCA No AB 324.

4. Test objects

The manufacturer prepared thirteen VT prototypes to be subjected to the type tests and special tests. The basic parameters of the prototypes are listed in the Table 1.

Table 1. Basic parameters of the test prototypes

No.	Type	Primary voltage U_{Pr}	Voltage factor F_V	Total thermal burden	Rated insulation level (U_m/AC/LI)	Insulator, creepage distance	Serial number
1.	EMF-E145	145/√3 kV	1.9×Un / 8h	4000 VA	145/275/650 kV	composite, 3150 mm	1HSE8851772
2.	EMF-E145	145/√3 kV	1.9×Un / 8h	4000 VA	145/275/650 kV	porcelain, 3075 mm	1HSE8851773
3.	EMF-E123	115/√3 kV	1.9×Un / 8h	4000 VA	123/230/550 kV	composite, 3150 mm	1HSE8851774
4.	EMF-E072	66/√3 kV	1.9×Un / 8h	2000 VA	72.5/140/325 kV	composite, 1813 mm	1HSE8851776
5.	EMF-E084	77/√3 kV	1.9×Un / 8h	2000 VA	84/150/380 kV	porcelain, 1813 mm	1HSE8851777
6.	EMF-E084	77/√3 kV	1.9×Un / 8h	2000 VA	84/150/380 kV	composite, 1813 mm	1HSE8851778
7.	EMF-E145	138/√3 kV	1.9×Un / 8h	4000 VA	145/275/550 kV	composite, 4300 mm	1HSE8849700
8.	EMF-E145	145/√3 kV	1.9×Un / 8h	4000 VA	145/275/550 kV	porcelain, 4250 mm	2GKP013K1486306
9.	EMF-E072	66/√3 kV	1.9×Un / 8h	750 VA	72.5/140/325 kV	composite, 3150 mm	2GKP015V1188092
10.	EMF-E072	66/√3 kV	1.9×Un / 8h	750 VA	72.5/140/325 kV	porcelain, 3075 mm	2GKP015V1188093
11.	EMF-E072	66/√3 kV	1.9×Un / 8h	750 VA	72.5/140/325 kV	composite, 1813 mm	2GKP015V1188038
12.	EMF-E072	66/√3 kV	1.9×Un / 8h	750 VA	72.5/140/325 kV	porcelain, 1813 mm	2GKP015V1188091
13.	PV145a	145/√3 kV	1.9×Un / 8h	4000 VA	145/275/650 kV	composite, 3150 mm	2GKP015V1188086
14.	EMF-E072	66/√3 kV	1.9×Un / 8h	2600 VA	72.5/140/325 kV	porcelain, 3150 mm	2GGKV1190628
15.	EMF-E084	77/√3 kV	1.9×Un / 30s	2000 VA	84/150/380 kV	porcelain, 1813 mm	2GGKV1190678
16.	EMF-E072	66/√3 kV	1.9×Un / 8h	2600 VA	72.5/140/325 kV	composite, 3150 mm	2GGKV1190629
17.	EMF-E072	66/√3 kV	1.9×Un / 8h	2600 VA	72.5/140/325 kV	composite, 3150 mm	2GGKV1190649
18.	EMF-E145	145/√3 kV	1.9×Un / 8h	2600 VA	145/275/650 kV	composite, 4495 mm	2GGKV1190669
19.	EMF-E145	145/√3 kV	1.9×Un / 8h	2600 VA	145/275/650 kV	porcelain, 4495 mm	2GGKV1190668
20.	EMF-E145	145/√3 kV	1.9×Un / 8h	2600 VA	145/275/650 kV	composite, 4495 mm	2GGKV1190670

The detailed drawings and parameters of the prototypes can be found in attached test reports.

To verify if the processes of drying, assembling and oil filling are performed correctly in the factory of ABB Sp. z o.o. in Przasnysz, an additional lightning impulse and chopped lightning impulse tests, as well as routine tests before and after the impulse tests was performed on PV145a, EMF-E072 and EMF-E084 units. It was agreed to be a most valuable source of information in this case. The construction of insulation system of PV123a, as well as its production process is identical to PV145a, thus it is deemed that the additional impulse test performed on a voltage transformer with higher rated voltage value is sufficient. This test also confirms the correctness of assembling process of EMF-E072, EMF-E084, EMF-E123 and EMF-E145 carried out by ABB Sp. z o.o., Branch Office in Przasnysz. EMF-E123 and EMF-E145 are identical to the PV123a and PV145a units.

5. Test results

The tests were performed on chosen EMF-E... and PV...a voltage transformer constructions. The achieved results are valid for the whole series of devices.

5.1. Type tests

5.1.1. Temperature-rise test – IEC 61869-3:2011, cl. 7.2.2

The temperature-rise test was performed in High Current Laboratory (EWP) of Instytut Energetyki in Warsaw. The test was performed on three voltage transformers – Prototype 1 (EMF-E145), Prototype 2 (EMF-E145) and Prototype 5 (EMF-E084). Testing of EMF-E072 and EMF-E123 was deemed unnecessary because of same construction as respectively EMF-E084 and EMF-E145 VTs while the rated voltage values are lower, thus less heat-exposed. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them.

The test procedure was divided in three steps, as indicated in IEC 61869-3:2011, cl. 7.2.2:

- The first step was performed with 120% of rated voltage, rated burden connected to each secondary winding, the residual voltage winding unloaded.
- The second step was performed with 190% of rated voltage, rated burden connected to each secondary winding, the residual voltage winding loaded with the burden corresponding to its rated thermal limiting output.
- The third step should be performed with 100% of rated voltage, the residual voltage winding unloaded, each of secondary windings connected to the burden corresponding to its rated thermal output, one at a time. The Manufacturer however decided to load all of the secondary windings with burden corresponding to their rated thermal limiting output in order to achieve more extreme testing conditions.

The results obtained for the EMF-E084 voltage transformer and the detailed test procedure are given in report D1. The Prototype 5 was successfully submitted to all three testing stages. The results obtained for the EMF-E145 voltage transformers and the detailed test procedure are given in reports D2 and D3. The Prototype 1 was subjected to the stage 1 and 2 of the test, while the Prototype 2 was subjected to the stage 3.

The performed tests confirmed the values of voltage factor and total thermal limiting output declared by the Manufacturer. The rated output during the tests was lower than Manufacturer declares. However, on the basis of recalculating the burden and the voltage of the third step, it was possible to verify that the voltage transformers will also comply with the requirements with the maximum rated output. The assigned parameters can be found in the Summary.

5.1.2. Impulse voltage test on primary terminals – IEC 61869-3:2011, cl. 7.2.3

The impulse voltage tests were performed in High Voltage Laboratory (EWN) of Instytut Energetyki in Warsaw. Four voltage transformers, one of each rated voltage – Prototype 2 (EMF-E145), Prototype 3 (EMF-E123), Prototype 5 (EMF-E084) and Prototype 4 (EMF-E072) – were subjected to this

test. As the lightning impulse voltage test concerns the internal insulation only, this amount of test objects was agreed to be sufficient.

Three additional voltage transformers – Prototype 13 (PV145a), Prototype 14 (EMF-E072) and Prototype 15 (EMF-E084) were additionally tested with lightning impulse to verify if the processes of drying, assembling and oil filling are performed correctly in the factory of ABB Sp. z o.o. in Przasnysz. Testing of PV123a was deemed unnecessary because of same construction as PV145a while the rated voltage value is lower, thus less exposed. This test also confirms the correctness of assembling process of EMF-E123 and EMF-E145 carried out by ABB Sp. z o.o., Branch Office in Przasnysz, which are identical to the PV123a and PV145a units.

The test results and the detailed test procedure are given respectively in reports D4 – D7. The additional reports concerning the VTs assembled in ABB Sp. z o.o. are given in reports D8 – D10. The assigned parameters can be found in the Summary.

5.1.3. Wet test – IEC 61869-3:2011, cl. 7.2.4

The wet tests were performed in Laboratory of ABB AB Power Products in Ludvika, Sweden under supervision of SATS inspectors. Four voltage transformers – Prototype 1 (EMF-E145), Prototype 2 (EMF-E145), Prototype 5 (EMF-E084) and Prototype 6 (EMF-E084) – were subjected to this test because of the higher test voltage values than respectively EMF-E123 and EMF-E072, while the dimensions remain the same. For each rated voltage porcelain and composite insulator with the shortest creepage distance were tested. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them. As the wet test concerns the external insulation only, this amount of test objects was agreed to be sufficient.

The test results and the detailed test procedure are given in reports D11 – D14. The assigned parameters can be found in the Summary.

5.1.4. RIV test – IEC 61869-3:2011, cl. 7.2.5.1

The RIV test was performed in High Voltage Laboratory (EWN) of Instytut Energetyki in Warsaw. This test applies to instrument transformer having $U_m \geq 123$ kV only. Two voltage transformers – Prototype 1 (EMF-E145) and Prototype 2 (EMF-E145) – were chosen for this test because of the higher test voltage values than EMF-E123, while the dimensions remain the same. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them. The test results and the detailed test procedure are given in reports D15 and D16.

5.1.5. Test for accuracy – IEC 61869-3:2011, cl. 7.2.6

All tests for accuracy were performed in laboratory of ABB Sp. z o. o. in Przasnysz under the supervision of representatives of Instytut Energetyki. All of the prototypes were subjected to this test before the type tests and after the lightning impulse test and short-circuit withstand capability test, as a verification of the test result. The measured errors comply with the requirements of the IEC 61869-3:2011 standard, cl. 5.6. The test results are given in reports D22 – D33. The additional reports concerning the VTs assembled in ABB Sp. z o.o. are attached to the impulse voltage test reports and are given in reports D8 – D10. Testing of PV123a, EMF-E123 and EMF-E145 manufactured by ABB Sp. z o.o., Branch Office in Przasnysz is deemed unnecessary because their active parts are identical to the active part of PV145a. Since the verification of all accuracy classes in combination with different rated outputs wouldn't be economically and technically justified, the obtained results were recalculated to describe all possible combinations. The assigned parameters can be found in the Summary.

5.1.6. Verification of the degree of protection by enclosures – IEC 61869-3:2011, cl. 7.2.7

The tests to confirm the declared IP55 protection degree were performed in Switchgear Testing Laboratory of Instytut Elektrotechniki in Warsaw. Two types of terminal boxes – 2GHV042554 and 2GHV042542 – were tested. The test results and the detailed test procedure are given in reports D17 and D18.

The tests to confirm the declared IK07 protection degree against mechanical impact were performed in High Current Laboratory of Instytut Energetyki in Warsaw. Six voltage transformers – Prototype 7 (EMF-E145), Prototype 8 (EMF-E145), Prototype 9 (EMF-E072), Prototype 10 (EMF-E072), Prototype 11 (EMF-E072), Prototype 12 (EMF-E072) – were tested. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them. The test results and the detailed test procedure are given in report D19. The assigned parameters can be found in the Summary.

5.1.7. Short-circuit withstand capability test – IEC 61869-3:2011, cl. 7.2.301

These tests were performed in Switchgear Testing Laboratory of Instytut Elektrotechniki in Warsaw. Two voltage transformers – Prototype 2 (EMF-E145) and Prototype 6 (EMF-E084) – were subjected to this test because of the higher nominal voltage values than respectively EMF-E123 and EMF-E072. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them. The test results and the detailed test procedure are given in reports D20 and D21.

5.2. Routine tests

The routine tests were performed on all prototypes before the type tests. They were also repeated for the prototypes which were subjected to the lightning impulse tests and short-circuit withstand capability tests in order to confirm that these tests didn't cause any internal damage in the tested VTs. The routine tests were performed in the laboratory of ABB Sp. z o. o. in Przasnysz under supervision of representatives of Instytut Energetyki. Following tests were performed within the routine tests:

- Power-frequency voltage withstand test on primary terminals – IEC 61869-3:2011, cl. 7.3.1

The power-frequency voltage withstand test on primary terminals after the short-circuit withstand capability test was performed with test voltage reduced to 90% of the nominal power-frequency withstand voltage value. After the lightning impulse voltage test, the power-frequency voltage was reduced to 80% of the nominal power-frequency withstand voltage value.

- Partial discharge measurement – IEC 61869-3:2011, cl. 7.3.2

The partial discharge level measured before and after type tests didn't exceed 0.6 pC in any of the tested VTs for both $1.2\times U_m$ and $1.2\times U_m/\sqrt{3}$, while the permissible levels are respectively 10 and 5 pC. The measured values were approximately equal to the measured background noise level.

- Power-frequency voltage withstand test on secondary terminals – IEC 61869-3:2011, cl. 7.3.4

The power-frequency voltage withstand test on secondary terminals was performed with test voltage 3 kV both before and after type tests.

- Test for accuracy – IEC 61869-3:2011, cl. 7.3.5

See cl. 5.1.5.

- Verification of markings – IEC 61869-3:2011, cl. 7.3.6

- Enclosure tightness test at ambient temperature - – IEC 61869-3:2011, cl. 7.3.7

The test results are given in reports D22 – D33. The additional reports concerning the VTs assembled in ABB Sp. z o.o. are attached to the impulse voltage test reports and are given in reports D8 – D10.

5.3. Special tests

5.3.1. Chopped impulse voltage withstand test on primary terminals – IEC 61869-3:2011, cl. 7.4.1

These tests were performed in High Voltage Laboratory (EWN) of Instytut Energetyki in Warsaw. The tests were performed during the impulse voltage tests on primary terminals on all of the VTs tested with full wave impulse voltage. The peak value of the test voltage was equal 115% of the full wave peak

value. The test results and the detailed test procedure are given in reports D4 – D7. The additional reports concerning the VTs assembled in ABB Sp. z o.o. are given in D8 – D10.

5.3.2. Measurement of capacitance and dielectric dissipation factor – IEC 61869-3:2011, cl. 7.4.3

This test is treated by the Manufacturer as a routine test and was performed with other routine tests in laboratory of ABB Sp. z o. o. in Przasnysz under supervision of representatives of Instytut Energetyki. The test voltage values were 10 kV, $U_{Pr}/\sqrt{3}$ and $U_m/\sqrt{3}$. The capacitance and the dielectric dissipation factor did not change significantly with the increase of the voltage or after type tests. The test results are given in reports D22 – D33. The additional reports concerning the VTs assembled in ABB Sp. z o.o. are attached to the impulse voltage test reports and are given in reports D8 – D10.

5.3.3. Transmitted overvoltage test – IEC 61869-3:2011, cl. 7.4.4

These tests were performed in High Voltage Laboratory (EWN) of Instytut Energetyki in Warsaw. Four voltage transformers, one of each rated voltage – Prototype 1 (EMF-E145), Prototype 3 (EMF-E123), Prototype 5 (EMF-E084) and Prototype 4 (EMF-E072) – were subjected this test. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them. The test results and the detailed test procedure are given respectively in reports D15, D5, D6 and D7.

5.3.4. Mechanical test – IEC 61869-3:2011, cl. 7.4.5

The tests were performed in Distribution Equipment Laboratory (EUR) of Instytut Energetyki in Warsaw. Six voltage transformers – Prototype 14 (EMF- E072), Prototype 17 (EMF- E072), Prototype 18 (EMF- E072), Prototype 19 (EMF-E145), Prototype 20 (EMF- E145) and Prototype 21 (EMF- E145) – were subjected to this test to cover the whole range of porcelain and composite insulators and primary terminals used for EMF-E... type voltage transformers. The PV123a and PV145a units are identical to respectively EMF-E123 and EMF-E145, thus this test was deemed unnecessary for them. The static test load was 3600 N.

The test results and the detailed test procedure are given in reports D34 – D39.

5.4. Additional tests

5.4.1. Capacitor discharge test

The capacitor discharge test was performed in High Voltage Laboratory (EWN) of Instytut Energetyki in Warsaw. Prototype 3 (EMF-E123) was subjected to this test. The test procedure was provided by ABB. A 6 μF capacitor has been connected in parallel to the tested VT and discharged ten

times in 2-minutes intervals. The test objective was to check the influence of discharging the capacitor on the winding temperature and overall performance of the voltage transformer. The results and the detailed test procedure is given in report D5.

All tests gave positive results.

6. Summary

On the basis of analyzed test results, it is concluded as follows:

- The EMF-E... and PV...a voltage transformer series meet the requirements of the IEC-61869-3:2011 standard in the range of type and routine tests. They have also passed several special tests and an additional test on request of the Manufacturer.

-The performed tests are sufficient for a complete evaluation of the voltage transformers, type EMF-E... and PV...a

- The Manufacturers to be mentioned in the certificates are:
  - ABB AB Power Products, Valhallavagen 2, 771 31 Ludvika, Sweden for products EMF-E072, EMF-E084, EMF-E123 and EMF-E145
  - ABB Sp. z o.o. Branch Office in Przasnysz, 59 Leszno Str., 06-300 Przasnysz, Poland for products EMF-E072, EMF-E084, EMF-E123, EMF-E145, PV123a and PV145a

- The list of all tests with the tested voltage transformers is given in Table 2.

- The list of parameters assigned to the voltage transformers based on analyzed test results is given in Table 3. (EMF-E072), Table 4. (EMF-E084), Table 5. (EMF-E123 and PV123a) and Table 6. (EMF-E145 and PV145a).

Table 2. List of tests and tested voltage transformers

Item	Test	Requirements	Report numbers	Prototypes
		TYPE TESTS		
1	Temperature-rise test	IEC 61869-3:2011, cl. 7.2.2	EWP/52/E/2015-1 EWP/52/E/2015-3 EWP/52/E/2015-4	1, 2, 5
2	Impulse voltage test on primary terminals	IEC 61869-3:2011, cl. 7.2.3	EWN/134/E/15 EWN/109/E/15-1 EWN/109/E/15-2 EWN/109/E/15-3 EWN/45/E/16 EWN/106/E/16-1 EWN/106/E/16-2	2, 3, 4, 5, 13, 14, 15
3	Wet test	IEC 61869-3:2011, cl. 7.2.4	R Q 15-74 R Q 15-75 R Q 15-78 R Q 15-79	1, 2, 5, 6
4	RIV test	IEC 61869-3:2011, cl. 7.2.5.1	EWN/109/E/15-4 EWN/109/E/15-5	1, 2
5	Tests for accuracy	IEC 61869-3:2011, cl. 7.2.6	Routine test reports from the Laboratory in ABB Sp. z o.o.	1, 2, 3, 4, 5, 6, 13, 14, 15
6	Verification of the degree of protection by enclosures	IEC 61869-3:2011, cl. 7.2.7	8604/NZL/NBR/15 8606/NZL/NBR/15 EWP/40/E/2015	7, 8, 9, 10, 11, 12 Terminal boxes: 2GHV042554 2GHV042542
7	Short-circuit withstand capability test	IEC 61869-3:2011, cl. 7.2.301	8734/NZL/NBR/15 8733/NZL/NBR/15	2, 6
		SPECIAL TESTS		
8	Chopped impulse voltage withstand test on primary terminals	IEC 61869-3:2011, cl. 7.4.1	EWN/134/E/15 EWN/109/E/15-1 EWN/109/E/15-2 EWN/109/E/15-3 EWN/45/E/16 EWN/106/E/16-1 EWN/106/E/16-2	2, 3, 4, 5, 13, 14, 15
9	Measurement of capacitance and dielectric dissipation factor	IEC 61869-3:2011, cl. 7.4.3	Routine test reports from the Laboratory in ABB Sp. z o.o.	1, 2, 3, 4, 5, 6, 13, 14, 15
10	Transmitted overvoltage test	IEC 61869-3:2011, cl. 7.4.4	EWN/109/E/15-1 EWN/109/E/15-2 EWN/109/E/15-3 EWN/109/E/15-4	1, 3, 4, 5
11	Mechanical tests	IEC 61869-3:2011, cl. 7.4.5	EUR/44/E/16-1 EUR/44/E/16-2 EUR/44/E/16-3 EUR/44/E/16-4 EUR/44/E/16-5 EUR/44/E/16-6	14, 17, 18, 19, 20, 21
		ADDITIONAL TESTS		
12	Capacitor discharge test	ABB	EWN/109/E/15-1	3

Table 3. List of evidenced parameters for EMF-E072

Inductive voltage transformer type EMF-E072	
Rated primary voltage U_{Pr}	$\leq 69/\sqrt{3}$ kV
Highest voltage for equipment U_m	≤ 72.5 kV
Rated frequency f_R	50 Hz
Rated insulation level	AC 140 kV / LI 325 kV
Static withstand test load F_R	3600 N
External insulation – creepage distance of insulators [1)]	1813 mm ÷ 3150 mm
Degree of protection against mechanical impact of enclosure [2)]	IK07
Degree of protection of secondary terminals enclosure	IP55
Rated voltage factor F_V / time	≤ 1.9 / 8 h
Rated secondary voltage U_{Sr}	≤ 115 V
Accuracy class of measurements and protection windings	0.1; 0.2; 0.5; 1 ; 3 ; 3P ; 6P
Rated output of measurement and protection windings S_r	≤ 500 VA
Rated voltage of residual voltage winding $U_{Sr\,(da\text{-}dn)}$	≤ 115 V
Accuracy class of residual voltage winding	0.5; 1; 3, 3P, 6P
Rated output of residual voltage winding S_r	≤ 150 VA
Total thermal limiting output S_{Yth}	2000 VA

Table 4. List of evidenced parameters for EMF-E084

Inductive voltage transformer type EMF-E084	
Rated primary voltage U_{Pr}	$\leq 77/\sqrt{3}$ kV
Highest voltage for equipment U_m	≤ 84 kV
Rated frequency f_R	50 Hz
Rated insulation level	AC 150 kV / LI 380 kV
Static withstand test load F_R	3600 N
External insulation – creepage distance of insulators [1)]	1813 mm ÷ 3150 mm
Degree of protection against mechanical impact of enclosure [2)]	IK07
Degree of protection of secondary terminals enclosure	IP55
Rated voltage factor F_V / time	≤ 1.9 / 8 h
Rated secondary voltage U_{Sr}	≤ 115 V;
Accuracy class of measurements and protection windings	0.1; 0.2; 0.5; 1 ; 3 ; 3P ; 6P
Rated output of measurement and protection windings S_r	≤ 500 VA
Rated voltage of residual voltage winding $U_{Sr\,(da\text{-}dn)}$	≤ 115 V
Accuracy class of residual voltage winding	0.5; 1; 3, 3P, 6P
Rated output of residual voltage winding S_r	≤ 150 VA
Total thermal limiting output S_{Yth}	2000 VA

Table 5. List of evidenced parameters for EMF-E123 and PV123a

Inductive voltage transformer type EMF-E123 and PV123a	
Rated primary voltage U_{Pr}	≤ 115/√3 kV
Highest voltage for equipment U_m	≤ 126 kV
Rated frequency f_R	50 Hz
Rated insulation level	AC 230 kV / LI 550 kV
Static withstand test load F_R	3600 N
External insulation – creepage distance of insulators [1)]	3150 mm + 4495 mm
Degree of protection against mechanical impact of enclosure [2)]	IK07
Degree of protection of secondary terminals enclosure	IP55
Rated voltage factor F_V / time	≤ 1.9 / 8 h
Rated secondary voltage U_{Sr}	≤ 115 V
Accuracy class of measurements and protection windings	0.1; 0.2; 0.5; 1; 3; 3P; 6P
Rated output of measurement and protection windings S_r	≤ 1000 VA
Rated voltage of residual voltage winding $U_{Sr\,(da\text{-}dn)}$	≤ 115 V
Accuracy class of residual voltage winding	0.5; 1; 3; 3P; 6P
Rated output of residual voltage winding S_r	≤ 450 VA
Total thermal limiting output S_{Yth}	4000 VA

Table 6. List of evidenced parameters for EMF-E145 and PV145a

Inductive voltage transformer type EMF-E145 and PV145a	
Rated primary voltage U_{Pr}	≤ 145/√3 kV
Highest voltage for equipment U_m	≤ 145 kV
Rated frequency f_R	50 Hz
Rated insulation level	AC 275 kV / LI 650 kV
Static withstand test load F_R	3600 N
External insulation – creepage distance of insulators [1)]	3150 mm + 4495 mm
Degree of protection against mechanical impact of enclosure [2)]	IK07
Degree of protection of secondary terminals enclosure	IP55
Rated voltage factor F_V / time	≤ 1.9 / 8 h
Rated secondary voltage U_{Sr}	≤ 115 V
Accuracy class of measurements and protection windings	0.1; 0.2; 0.5; 1; 3; 3P; 6P
Rated output of measurement and protection windings S_r	≤ 1000 VA
Rated voltage of residual voltage winding $U_{Sr\,(da\text{-}dn)}$	≤ 115 V
Accuracy class of residual voltage winding	0.5; 1; 3 ; 3P; 6P
Rated output of residual voltage winding S_r	≤ 450 VA
Total thermal limiting output S_{Yth}	4000 VA

REMARKS:

1. [1)] Applies to composite and porcelain insulators
2. [2)] Does not apply to porcelain insulators

ABB AB Power Transformers

Rapport - Report

R Q 15-78

Författare-Author
Thomas Carlsson

Godkännare-Approved by
David Håkansson

Uppdragsgivare-Requested by
PPHV/TC/TCI

Från-From PPTR/QT

Datum-Date 2015-10-15

Reg. 2751

Sida-Page 1 (4)

Titel-Title
Power-frequency withstand voltage test, wet condition, on one voltage transformer of type EMF-E145 with composite insulator

☐ Utredning, teoretisk undersökning-Analysis theoretical investigation

☒ Provning, experim. undersökning-Test, experimental investigation

☐ Delrapport-Interim Report

☒ Slutrapport-Final report

Provning/undersökning avslutad
Test investigation finished
2015-10-13

Ordernummer-Ref.No.
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Pkt/Akt

Antal textsidor-No. of pages
4

Antal bilagesidor-No. of supplem. pages

Sammanfattning-Summary

1 TEST OBJECT

One voltage transformer of type EMF-E145 with composite insulator

Serial No:	1HSE 8851772
Dimension drawing:	2GHV025729 Rev. A
Rating plate:	1HSE 22040-PCA Rev. A

2 STANDARDS

IEC 61869-1, IEC 61869-3 and IEC 60060-1, 2010 cl. 4.4.1 and 4.4.2

3 PERFORMED TEST

Power-frequency voltage withstand test in wet condition.
275kV*), 240Hz, 25s.
*) Voltage is corrected for atmospheric conditions

4 RESULT

The voltage transformer passed the wet power-frequency voltage withstand test

5 INSPECTOR

Mr. Lars - Olof Gunnarsson, SATS Certification

SATS Certification
Lars-Olof Gunnarsson
Inspector
Sign: Date: 2015-10-16

About SATS Certification: SATS Certification (www.sats-certification.org) is an certification body accredited in accordance with ISO/IEC 17065 (2012) by Norwegian Accreditation.
SATS (Scandinavian Association for Testing Electrical Power Equipment) is a member of the Short-Circuit Testing Liaison (STL)

This document is hereby approved and certifies that the object specified above have successfully passed the test herein reported, thereby verifying guaranteed data.

Nyckelord /Ämnesord-Key words

Övriga nyckelord

Arkiveringstid Q
☐ 1 år
☐ 2 år
☒ mer än 3 år

Anm Nyckelord/Ämnesord användes när rapporten skrivs på svenska
"Keywords" användes när rapporten skrivs på engelska
Övriga nyckelord användes endast i undantagsfall och avser t. ex. materialbeteckning, produktutveckling, leverantör, kund etc

ABB

1 TEST OBJECT

One voltage transformer of type EMF-E145 with composite insulator

Serial No:	1HSE 8851772	
Dimension drawing:	2GHV025729 Rev. A	See page 3
Rating plate:	1HSE 22040-PCA Rev. A	See page 4

2 STANDARDS

IEC 61869-1, IEC 61869-3 and IEC 60060-1, 2010 cl. 4.4.1 and 4.4.2

3 PERFORMED TEST

Power-frequency voltage withstand test in wet condition.
Test voltage applied on primary winding.
The secondary terminals 1n, 2n, 3n and dn were connected to ground.

Applied test voltage (kV)	Corrected test voltage (kV)	Frequency test voltage Hz	Duration of test	Result
273	275	240	25s	Withstood

Precipitation rate:
1,5 / 1,5 mm/min, (horizontal / vertical component)
Resistivity of water: 97 Ohmm
Conductivity of water: 103 µS/cm

4. ATMOSPHERIC CONDITIONS AND CORRECTION FACTOR

Pressure:	1011 mb
Temperature:	22,2 °C
Correction factor:	k = 0,993

5 RESULT

The voltage transformer passed the wet power-frequency voltage withstand test

6 INSTRUMENTS

Equipment	Reg. No.	Last calibration
Voltage divider	M301908	10-2014
Voltmeter Fluke 187	M296144	04-2015

ABB

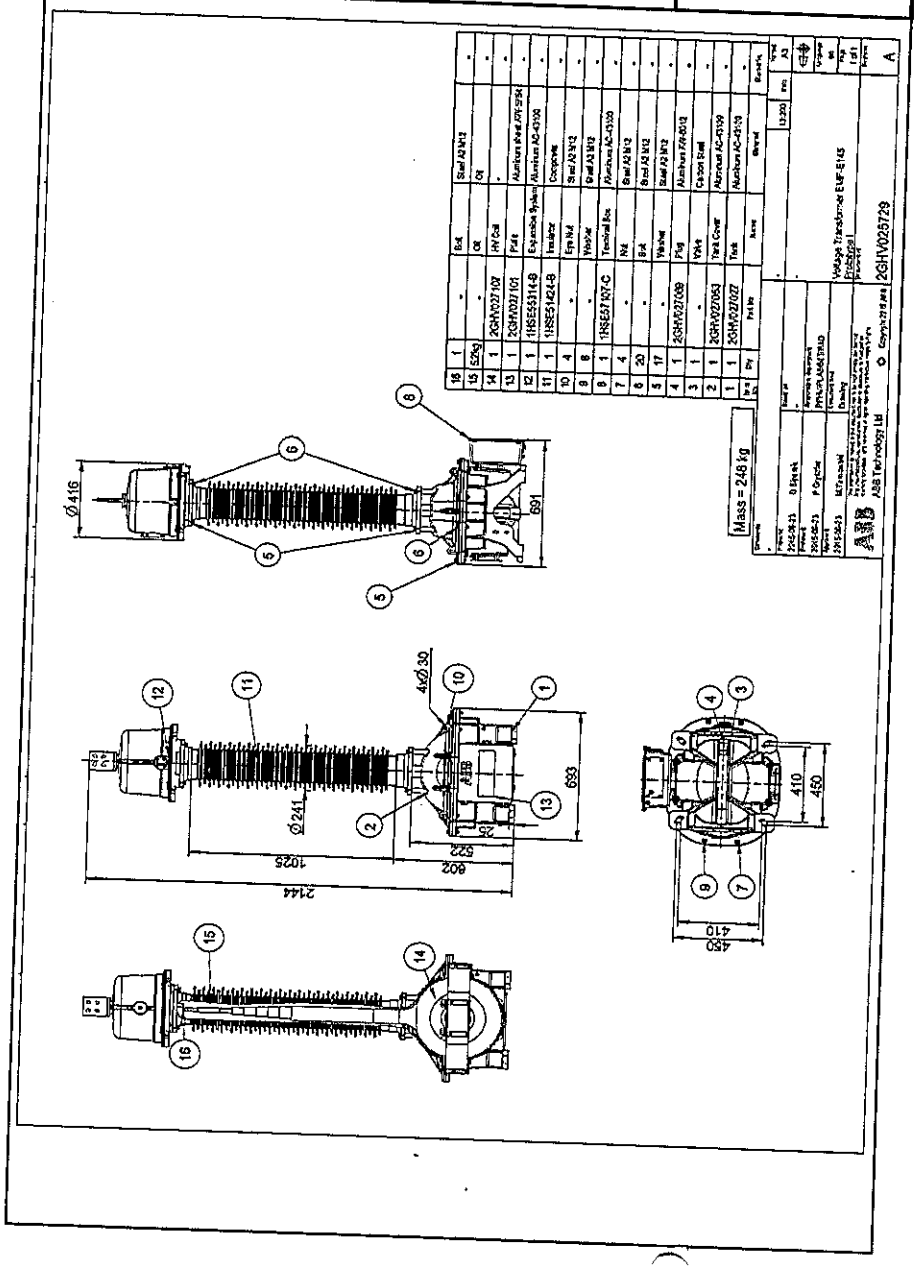
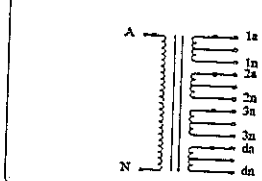


ABB AB — Made in Sweden

Voltage transformer		Type EMF-E145 Production year	2015
Serial number	1HSE nnnnnnn	Standard	IEC 61869-5
Insulation level	275/650 kV	Frequency	50 Hz
Rated primary voltage	145000/√3 V	Temperature range	-40 – +40 °C
Highest voltage for equipment	145 kV	Total mass	248 kg

1HSE 68504-5

Serial number	1HSE nnnnnnn
Insulation oil	IEC 61039: LNTIO-230/50 kg
Voltage factor	1.2 / 8h



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

1HSE 68504-0

Serial number 1HSE nnnnnnn = 1HSE 8851772

Prepared: Gustaf Högberg 2015-06-18	Responsible department: PPHC/IM	Title: Rating plate	
Approved: Björn Sjöström 2015-06-18	Take over department:		Language: en
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ABB AB		Document No.: 1HSE 22040-PCA	Last: 1

ABB AB Power Transformers

Rapport - Report

R Q 15-79

Författare-Author
Thomas Carlsson

Godkännare-Approved by
David Håkansson

Uppdragsgivare-Requested by
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Från-From PPTR/QT

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Antal textsidor-No. of pages
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Antal bilagesidor-No. of supplem. pages

Sammanfattning-Summary

1 TEST OBJECT

One voltage transformer of type EMF-E145 with porcelain insulator

Serial No:	1HSE 8851773
Dimension drawing:	2GHV025799 Rev. A
Rating plate:	1HSE 22040-PCB Rev. A

2 STANDARDS

IEC 61869-1, IEC 61869-3 and IEC 60060-1, 2010 cl. 4.4.1 and 4.4.2

3 PERFORMED TEST

Power-frequency voltage withstand test in wet condition.
275kV*), 240Hz, 25s.
*) Voltage is corrected for atmospheric conditions

4 RESULT

The voltage transformer passed the wet power-frequency voltage withstand test

5 INSPECTOR

Mr. Lars - Olof Gunnarsson, SATS Certification

SATS Certification
Lars-Olof Gunnarsson
Inspector
Sign: Date: 2015-10-19

About SATS Certification: SATS Certification (www.sats-certification.org) is an certification body accredited in accordance with ISO/IEC 17065 (2012) by Norwegian Accreditation.
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ABB

ABB AB Power Transformers

R Q 15-79
Page 2

1 TEST OBJECT

One voltage transformer of type EMF-E145 with porcelain insulator

Serial No:	1HSE 8851773	
Dimension drawing:	2GHV025799 Rev. A	See page 3
Rating plate:	1HSE 22040-PCB Rev. A	See page 4

2 STANDARDS

IEC 61869-1, IEC 61869-3 and IEC 60060-1, 2010 cl. 4.4.1 and 4.4.2

3 PERFORMED TEST

Power-frequency voltage withstand test in wet condition.
Test voltage applied on primary winding.
The secondary terminals 1n, 2n, 3n and dn were connected to ground.

Applied test voltage (kV)	Corrected test voltage (kV)	Frequency test voltage Hz	Duration of test	Result
273	275	240	25s	Withstood

Precipitation rate:
1,5 / 1,3 mm/min, (horizontal / vertical component)
Resistivity of water: 96 Ohmm
Conductivity of water: 104 µS/cm

4. ATMOSPHERIC CONDITIONS AND CORRECTION FACTOR

Pressure:	1011 mb
Temperature:	22,6 °C
Correction factor:	k = 0,991

5 RESULT

The voltage transformer passed the wet power-frequency voltage withstand test

6 INSTRUMENTS

Equipment		Reg. No.	Last calibration
Voltage divider		M301908	10-2014
Voltmeter	Fluke 187	M296144	04-2015

ABB

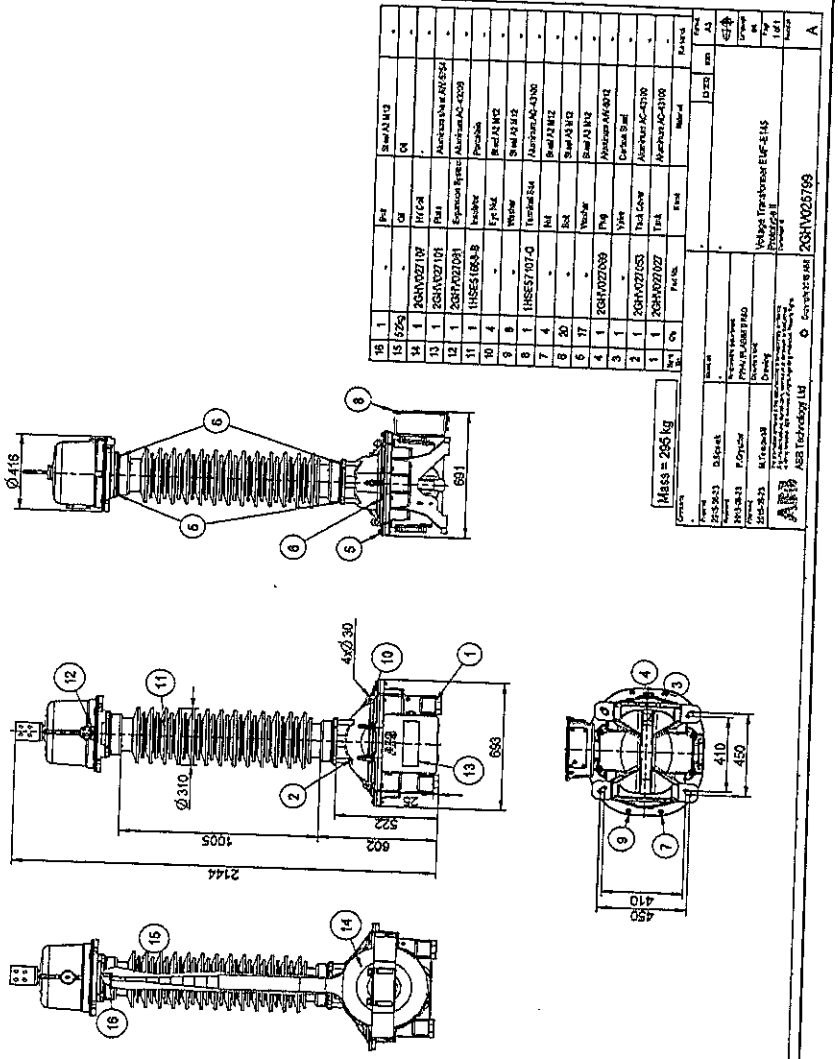
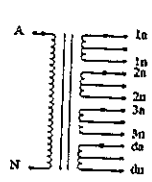


ABB AB — Made in Sweden

Voltage transformer	Type	EMF-E145	Production year 2015
Serial number	Standard		IEC 61869-3
Insulation level	1HSE mmmmm	Frequency	50 Hz
Rated primary voltage	275/650 kV	Temperature range	-40—+40 °C
Highest voltage for equipment	145000/√3 V	Total mass	295 kg
	145 kV		

1HSE 68504-5

Serial number	1HSE mmmmm
Insulation oil	(IEC 61039: CNTIO-286) 80 kg
Voltage factor	1.9 / 8h



Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA
A-N	145000/√3				
1a-1n	115/√3	0.1	25	75	1500+0
1a-1n	115/√3	1.0	75	550	1500+0
2a-2n	115/√3	0.1	25	75	1500+0
2a-2n	115/√3	1.0	75	550	1500+0
3a-3n	115/√3	0.1/3P	75	75	1500+0
3a-3n	115/√3	3.0/5P	500	550	1500+0
da-dn	115	1.0	100	650	450+0
da-dn	115	3P	500	850	450+0

1HSE 68504-6

Serial number 1HSE mmmmm = 1HSE 8851773

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

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Instytut Elektrotechniki
Electrotechnical Institute

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Testing Laboratory is accredited by Polish Centre of Accreditation, signatory of the agreements EA MLA and ILAC MRA.Accreditation No. AB 074

AB 074

TEST REPORT No. 8734/NZL/NBR/15

Test objects:	**Voltage transformer EMF-E145**
Client:	ABB Sp. z o.o. ul. Leszno 59, 06-300 Przasnysz
Manufacturer:	ABB
Test specification:	Short-circuit withstand capability test
Normative document(s):	IEC 61869-3:2011
Reference/Order number:	504-034600/038
Date of tests completion:	October 2015
Test results:	POSITIVE

Authorised by
Michał Babiuch, M.Sc.

Head of Laboratories of the Electrotechnical Institute
Przemysław Berowski, Ph.D.

WARSAW, 16.11.2015

This Test Report comprises 21 sheets in total.

Table of contents

1 List of applicable standards

- **IEC 61869-1:2009** Instrument transformers – Part 1: General requirements
- **IEC 61869-3:2011** Instrument transformers – Part 3: Additional requirements for inductive voltage transformers

Tests were observed by:

Zbigniew Wesołowski ABB

2 Range of tests performed

- Short-circuit withstand capability test by IEC 61869-3:2011 clause 7.2.301

3 Ratings assigned by the manufacturer

Highest system voltage ..... U_m ..... 145 kV
Rated frequency ..... f_r ..... 50 Hz
Rated power-frequency withstand voltage ..... 275 kV
Rated lighting-impulse withstand voltage ..... 650 kV
Rated primary voltage: ..... U_{Pr} ..... 145/√3 kV
Rated secondary voltage: ..... U_{Sr}:

- 1a-1n ..... 115/√3 V
- 2a-2n ..... 115/√3 V
- 3a-3n ..... 115/√3 V
- da-dn ..... 115 V

4 Basic identifications data

Test object:	Voltage transformer
Type:	EMF-E145
Manufacturer:	ABB
Serial No.:	1HSE8851773
Year of manufacture:	2015
Rating plate:	Figure 2, page 11
Design documentation:	Dimensional drawing No. 1HSE8851773

Detailed list of components specified in technical project: Dimensional drawing No. 1HSE8851773

5 Short-circuit withstand capability test

Test performed according to IEC 61869-3:2011 clause 7.2.301

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

Date of test ..... 22, 27 October 2015

Ambient temperature: ..... 17,6°C

Test voltage: ..... 66,4 V

Frequency: ..... 50 Hz

Test object on testing stand: ..... Photo 2, page 10

Test results:

- winding 1a-1n ..... Table 1, page 6, osc. 92073, page 7
- winding 3a-3n ..... Table 2, page 6, osc. 92092, page 8
- winding da-dn ..... Table 3, page 6, osc. 92094, page 9

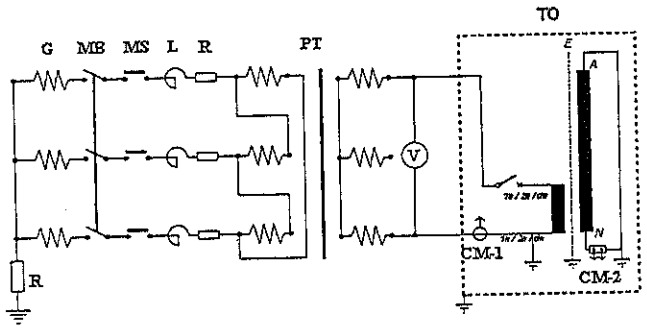


Figure 1 Test circuit

G	- Generator
MB	- Master Breaker
MS	- Making switch
L	- Reactors
R	- Resistors
PT	- Power transformer
V	- Voltage measurement recorder HIOKI no 131011561
CM-1	- Current measurement – Rogowski coil type AMEC AmpFlex 30000-48-2-1, no NWM-801-25900/1
CM-2	- Current measurement – shunt no NWM 008-II-38
TO	- Test object

Table 1 Test result

Tested secondary winding		1a-1n
Oscillogram	Nr	92073
Symmetrical, r.m.s. value of primary voltage	V	66,98
Symmetrical, r.m.s. value of current in primary winding	mA	617,32
Symmetrical, r.m.s. value of current in secondary winding	A	777,50
Duration of short-circuit	s	1,02

Table 2 Test result

Tested secondary winding		3a-3n
Oscillogram	Nr	92092
Symmetrical, r.m.s. value of primary voltage	V	66,42
Symmetrical, r.m.s. value of current in primary winding	mA	746,61
Symmetrical, r.m.s. value of current in secondary winding	A	941,13
Duration of short-circuit	s	1,01

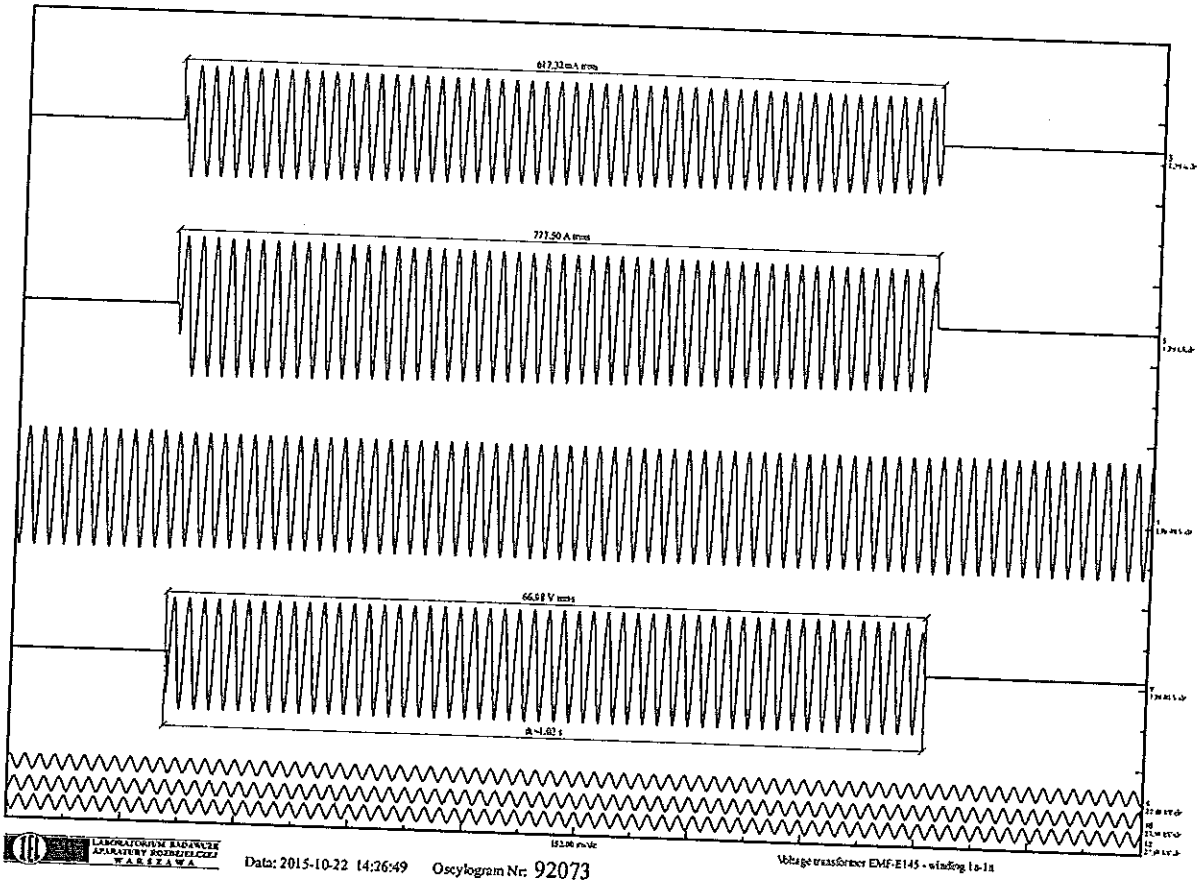
Table 3 Test result

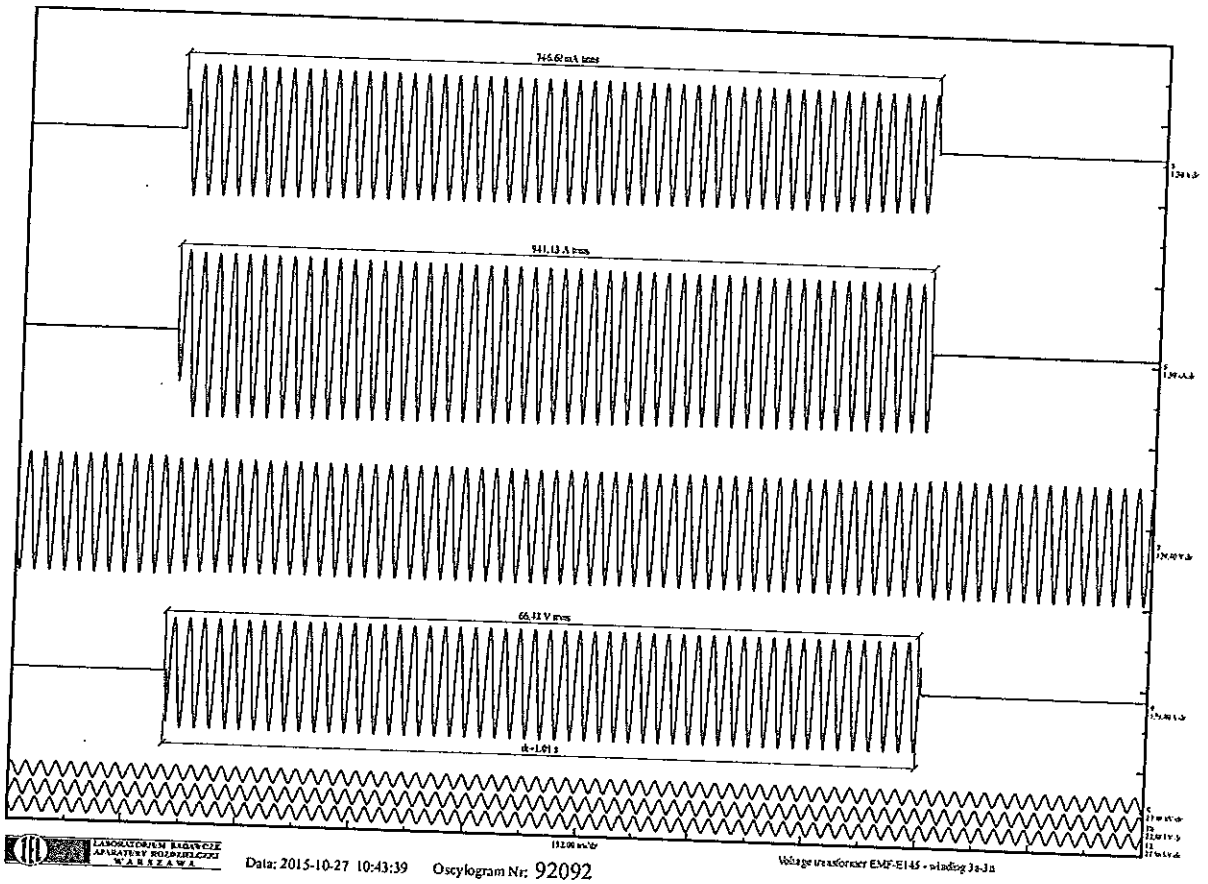
Tested secondary winding		da-dn
Oscillogram	Nr	92094
Symmetrical, r.m.s. value of primary voltage	V	115,46
Symmetrical, r.m.s. value of current in primary winding	mA	677,23
Symmetrical, r.m.s. value of current in secondary winding	A	493,49
Duration of short-circuit	s	1,01

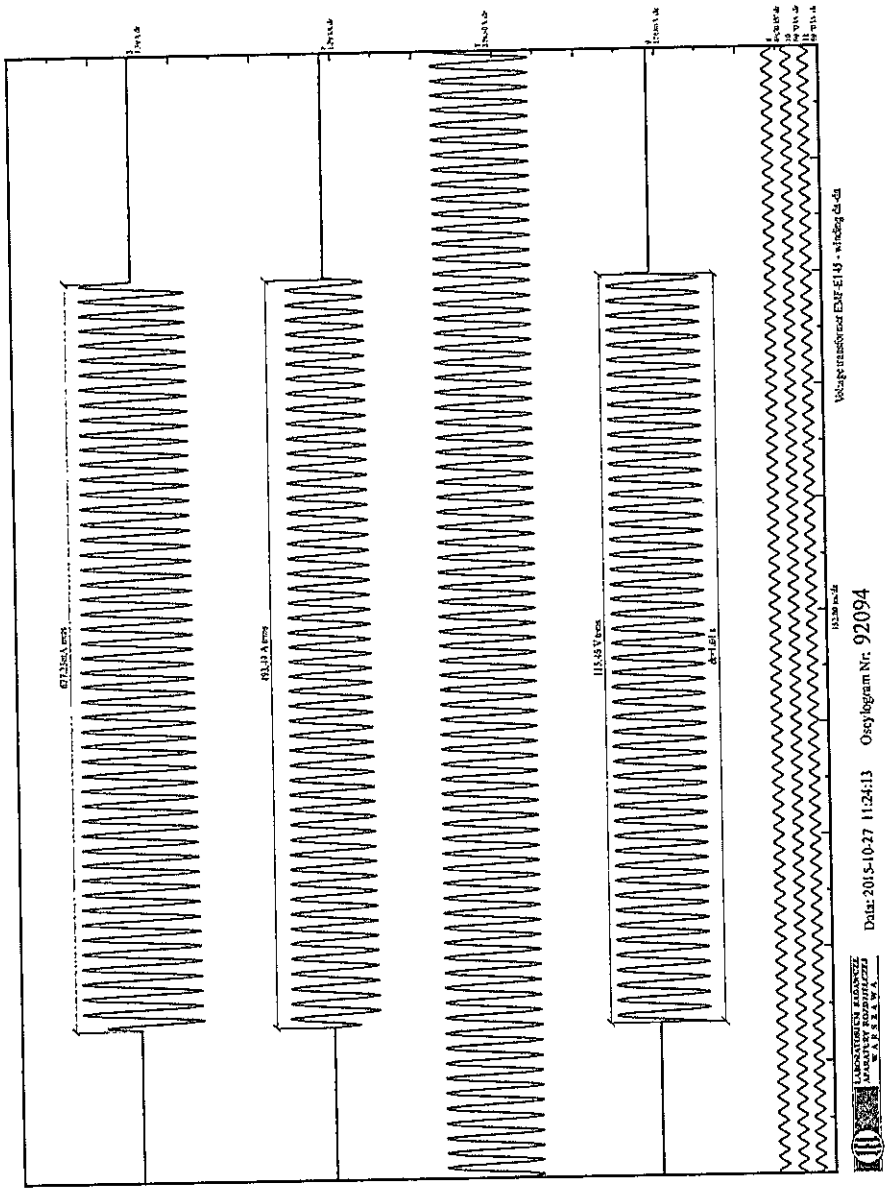
Condition of tested object after test:

- No visibly damages was noted.
- Errors do not differ from those recorded before the tests by more than half the limits of error in its accuracy class.
- Test object withstand the dielectric tests with the test voltage reduced to 90% of those given.

Test result: Object passed the test


817.33 mA rms
777.50 A rms
66.98 V rms
dt=1.60 s
LABORATORIUM BADAWCZE APARATURY ROZDZIELCZEJ WARSZAWA
Data: 2015-10-22 14:26:49
Oscylogram Nr: 92073
Voltage transformer EMF-E145 - winding 1a-1n


745.61 mA rms
941.13 A rms
66.32 V rms
dt=1.61 s
LABORATORIUM BADAWCZE APARATURY ROZDZIELCZEJ WARSZAWA
Data: 2015-10-27 10:43:39
Oscylogram Nr: 92092
Voltage transformer EMF-E145 - winding 3a-3n



6 Photographs

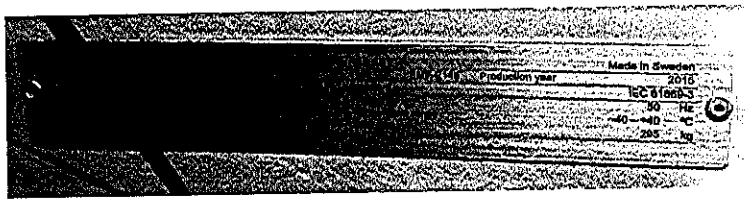


Photo 1 Rating plate of voltage transformer

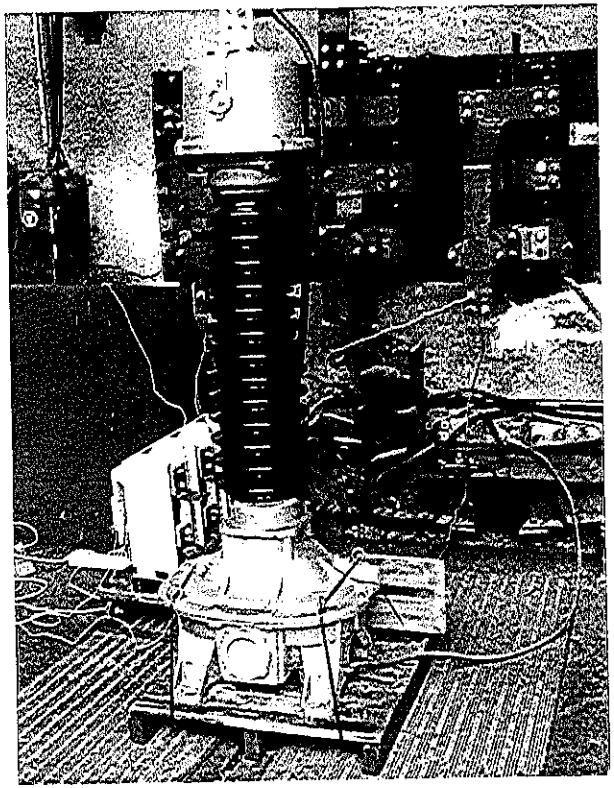


Photo 2 Test object during short-circuit withstand capability test

7 Drawings

ABB CE ABB AB

Voltage transformer		Type	EMF-EI45	Production year	Made in Sweden
Serial number	1HSE nnnnnn	Standard			yyyy
Insulation level	275 / 650 kV	Frequency			IEC 61869-3
Rated primary voltage	145000/√3 V	Temperature range			50 Hz
Highest voltage for equipment	145 kV	Total mass			-40 – +40 °C
					295 kg

1HSE 68504-5

Serial number 1HSE nnnnnn

Insulation oil (IEC 61039; L-NTIO-296) 80 kg
Voltage factor 1.9 / 8h

	Terminal A-N	Voltage V 145000/√3	Class	Burden VA	Total burden VA	Thermal limit VA
A	1a	1a-1n	115/√3	0.1	25	75 1500+0
	1n	1a-2n	115/√3	1.0	25	550 1500+0
	2n	2a-2n	115/√3	0.1	25	75 1500+0
		2a-3n	115/√3	1.0	25	550 1500+0
	3n	3a-3n	115/√3	0.1/3P	25	75 1500+0
	3a	da-dn	115	3.0/3P	500	550 1500+0
		da-dn	115	1.0	100	650 450+0
	3n			3P	300	950 4500+0
	dn					
N	dn					

1HSE 68504-6

Serial number 1HSE nnnnnn = 1HSE 8851773

Production year yyyy = Actual year for production

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

Figure 2 Rating plate

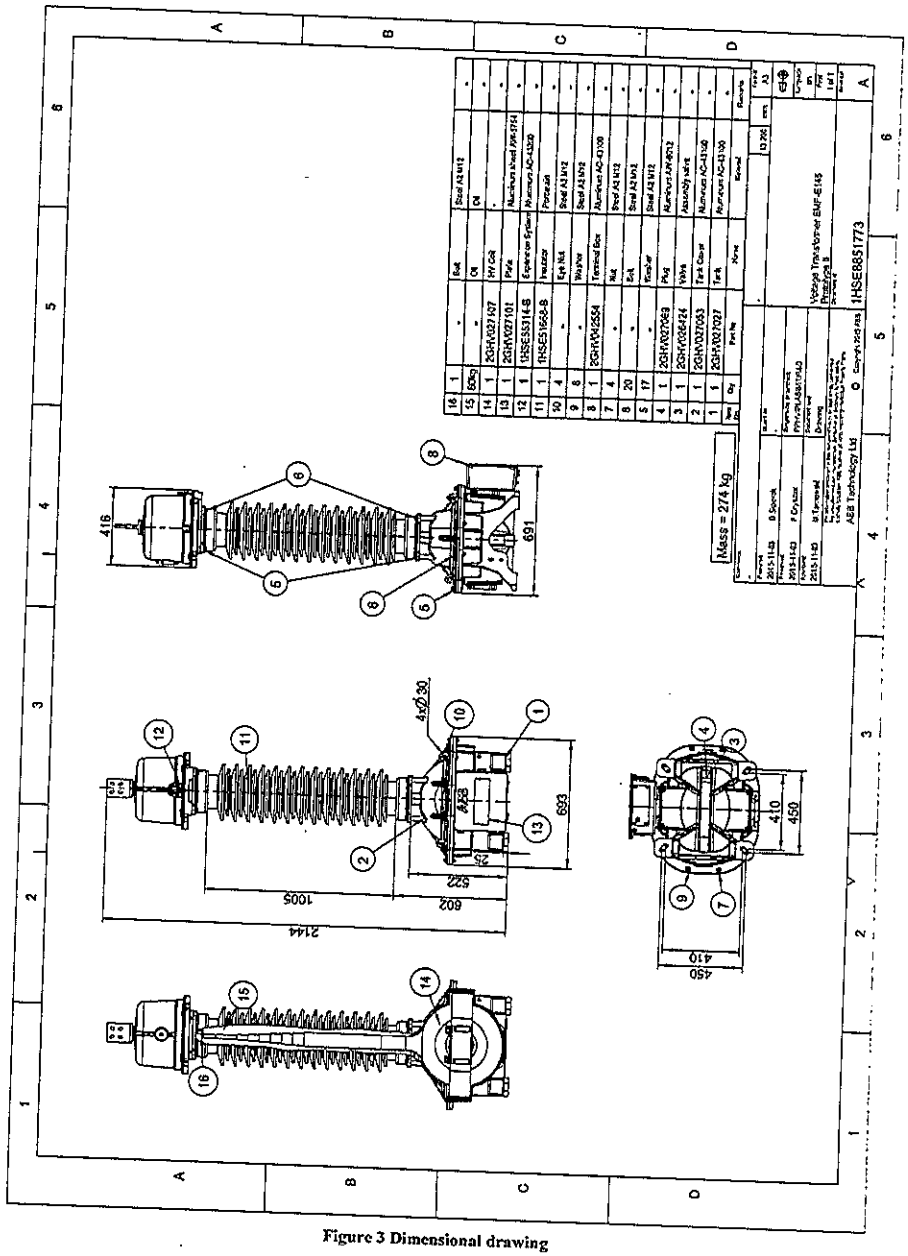


Figure 3 Dimensional drawing

8 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, multimeter*	20 µΩ≤ R ≤ 600 µΩ	<± 5 %
	0,6 mΩ≤ R ≤ 600 mΩ	<± 3 %
	0.6 Ω ≤ R ≤ 100 MΩ	<± 1 %
Frequency f *oscilloscope, recorder TR*	≤ 10 kHz	<± 0.2 %
	10 kHz ≤ f ≤ 1 Mhz	<± 0.5 %
Time t *oscilloscope, recorder 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, recorder*
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

9 Annex A–Routine test report of voltage instrument transformer before short-circuit withstand capability test

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

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

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑☑☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings – A: Up = 275kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑☑☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

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

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

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

Partial discharge measurement

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

Stress voltage: 275 kV / 60 s
Frequency: 120 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	0.5 pC	0.5 pC

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

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

Date of measurement: 2015-10-20

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

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

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

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

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

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

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

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

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.135	-0.099	-0.053	-0.052	-0.051	-0.137
Δφ U	1.0	0.9	0.8	0.8	0.9	-1.3

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.112	-0.072	-0.026	-0.024	-0.023	-0.109
Δφ U	1.2	1.0	0.9	1.0	1.0	-1.2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Date of measurement: 2015-10-20

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

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

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

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

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

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

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

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

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.828	-0.793	-0.740	-0.738	-0.739	-0.985
Δφ U	-1.8	-2.0	-2.0	-2.0	-1.9	-5.5

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.263	-0.248	-0.201	-0.199	-0.199	-0.436
Δφ U	0.5	0.3	0.2	0.3	0.3	-6.2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 23 °C, Frequency: 50 Hz

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

Measurement of windings' resistance

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

Checked by: Y. Kaminski

Przasnysz, 2015-10-20

10 Annex B–Routine test report of voltage instrument transformer after short-circuit withstand capability test

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

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

1. Oil dielectric parameters check before filling (oil after treatment): ☑
   tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings - A: Up = 247,5 kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

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

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

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

Partial discharge measurement

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

Stress voltage: 247,5 kV / 60 s
Frequency: 120 Hz

Test voltage	1,2 Um = 174 kV	1,2 Um / √3 = 100,5 kV
Level of partial discharge	0,6 pC	0,6 pC

Remarks: background noise level: 0,5 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating charge).

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

Date of measurement: 2015-11-10
Ambient temperature: 23 +/- 2°C
Relative air humidity: 24 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.046	-0.045	-0.044
Δφ U	1.2	1.3	1.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.013	-0.012	-0.011
Δφ U	1.1	1.1	1.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.054	-0.052	-0.052
Δφ U	1.1	1.1	1.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.022	-0.021	-0.020
Δφ U	1.0	1.1	1.1

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.139	-0.103	-0.056	-0.055	-0.054	-0.139
Δφ U	1.0	0.8	0.8	0.8	0.9	-1.3

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.114	-0.075	-0.029	-0.028	-0.027	-0.112
Δφ U	1.2	1.0	0.9	1.0	1.0	-1.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.037	0.039	0.039
Δφ U	0.5	0.6	0.6

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

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

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

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

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

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

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

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

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.105	-0.067	-0.020	-0.018	-0.017	-0.103
Δφ U	2.1	1.9	1.8	1.8	1.8	-0.3

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.077	-0.040	0.008	0.009	0.010	-0.076
Δφ U	2.2	2.0	1.9	1.9	1.9	-0.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.234	0.235	0.236
Δφ U	2.0	2.0	2.0

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

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

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

Date of measurement: 2015-11-10
Ambient temperature: 23 +/-
Relative air humidity: 24 +/-

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.385	-0.384	-0.382
Δφ U	-7.5	-7.5	-7.6

1a-1n: 6,25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.352	-0.350	-0.349
Δφ U	-7.8	-7.8	-7.6

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

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

2a-2n: 6,25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

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

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.819	-0.782	-0.734	-0.733	-0.730	-0.976
Δφ U	-2.2	-2.3	-2.3	-2.3	-2.2	-8.7

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.284	-0.247	-0.201	-0.199	-0.199	-0.444
Δφ U	0.4	0.2	0.2	0.2	0.2	-6.4

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

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

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

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

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

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

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

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

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

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

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.784	-0.743	-0.696	-0.694	-0.692	-0.938
Δφ U	-1.0	-1.2	-1.2	-1.2	-1.2	-7.7

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.247	-0.211	-0.164	-0.163	-0.162	-0.407
Δφ U	1.5	1.3	1.2	1.2	1.2	-5.4

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

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

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

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

Measurement of capacitance and dielectric dissipation factor - tg δ
Temperature: 23 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.20	239	0.753
84 kV	0.21	239	6.343
84 kV	0.21	239	6.343

Measurement of windings' resistance

	R (23 °C)	Rct (75 °C)
A-N	17.70 kΩ	21.317 kΩ
1a-1n	52.000 mΩ	62.627 mΩ
2a-2n	50.500 mΩ	60.820 mΩ
3a-3n	32.760 mΩ	39.455 mΩ
da-dn	143.100 mΩ	172.344 mΩ

Checked by: T. Krawczyk OG-4 KJ-58 Przasnysz, 2015-11-10

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

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AB 324

TEST REPORT No. EUR/44/E/16-1

TEST OBJECT: Voltage transformer type EMF-E072 Serial No. 2GGKV1190628 with porcelain insulator

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. 4500774256 dated 07.09.2016

TYPE OF TESTS: Mechanical tests

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

DATE OF TESTS: 18.10.2016

TESTS RESULT: Positive for:
$F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Authorizing Test Engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 24.11.2016

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1. TEST OBJECT

1.1 Description

Voltage transformer type EMF-E072 is used for supplying of measuring and protection circuits in the network of maximum operating voltage 72,5 kV and frequency 50 Hz. The transformer consists of voltage transformer mounted in porcelain enclosure immersed with transformer oil.

1.2 Technical data

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

Maximum operating voltage	72,5 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:

- "EMF-E072 dimensional drawing", no. 2GHV049349A0001 approved 10.11.2016,
- 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. Conformity of manufacturing with constructional documentation No. PL01/2016 is stated in manufacturer's declaration, copy of which presents Annex 3.

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised mechanical tests of voltage transformer with static withstand test load of A terminal in three directions for:

$F_R = 3600$ N

according to requirements of IEC 61869-1:2007 p. 7.4.5.

The test load shall be applied to the centre of the terminal. During the tests deflection of the voltage transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the voltage transformer was completely assembled and filled with oil, installed in a vertical position on the frame rigidly fixed.

During the tests deflection of the transformer's terminal was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm) and the load was measured by electronic dynamometer.

3. TESTS AND THEIRS DETAILED RESULTS

The load was applied to the A terminal in three directions: Longitudinal, Transverse and Vertical (see photographs 1 to 3 in Annex 1). The load was increased and released smoothly (30 – 90 s) and was maintained for 60 s. Tests results are presented in table 1.

During the tests the following records were made:

- phot. 1 to 3 – voltage transformer during mechanical tests,
- phot. 4 – A terminal after tests,
- phot. 5 – voltage transformer after tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3650 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	A	Longitudinal	60	During the static load deflection was 6,3 mm. Residual deflection was 0,1 mm.
2	A	Transverse	60	During the static load deflection was 5,8 mm. Residual deflection was 0,8 mm.
3	A	Vertical	60	During the static load deflection was 1,1 mm. Residual deflection was 0,1 mm.

After the tests no damage nor oil leak was stated.

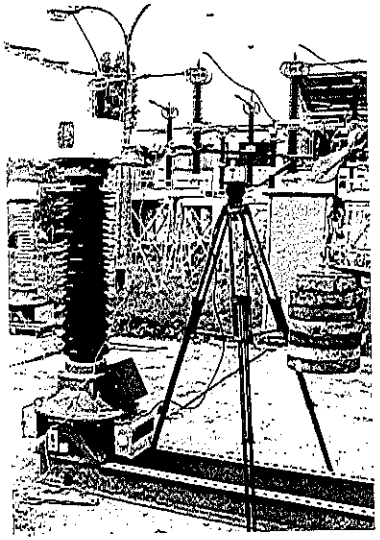
4. TESTS RESULTS EVALUATION

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

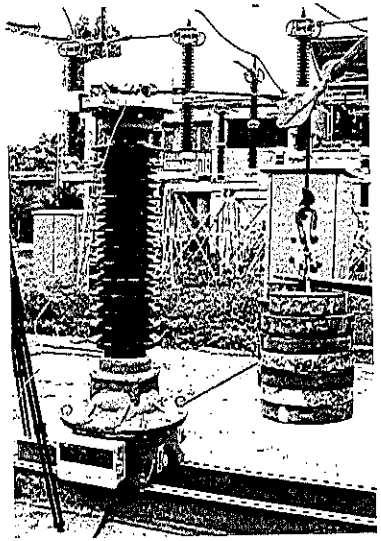
$F_R = 3600$ N.

ANNEX 1

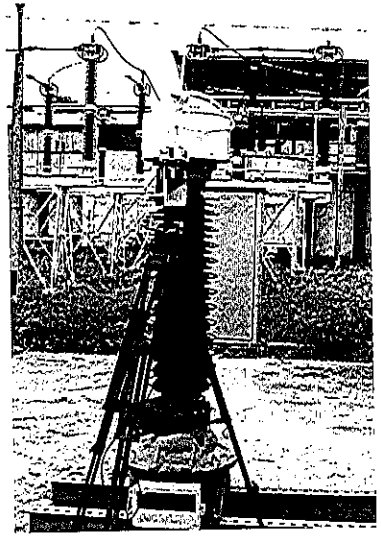
Photographs taken during the tests



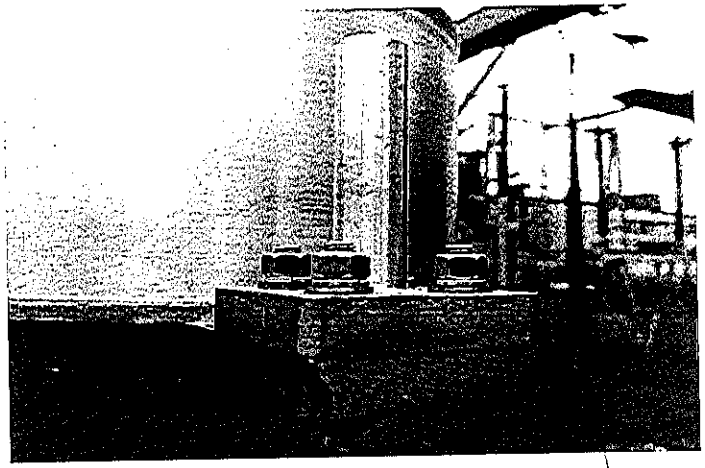
Phot. 1. Longitudinal load of A terminal



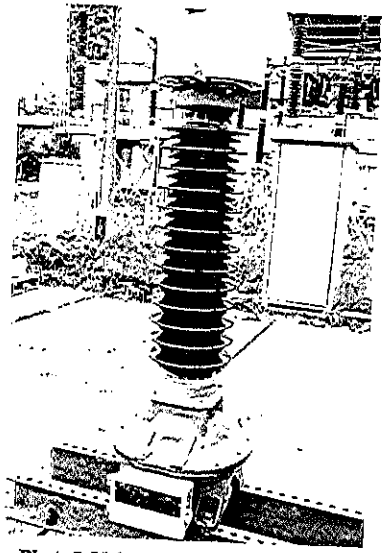
Phot. 2. Transverse load of A terminal



Phot. 3. Vertical load of A terminal



Phot. 4. A terminal after tests



Phot. 5. Voltage transformer after tests

ANNEX 2 **Documentations delivered by orderer**

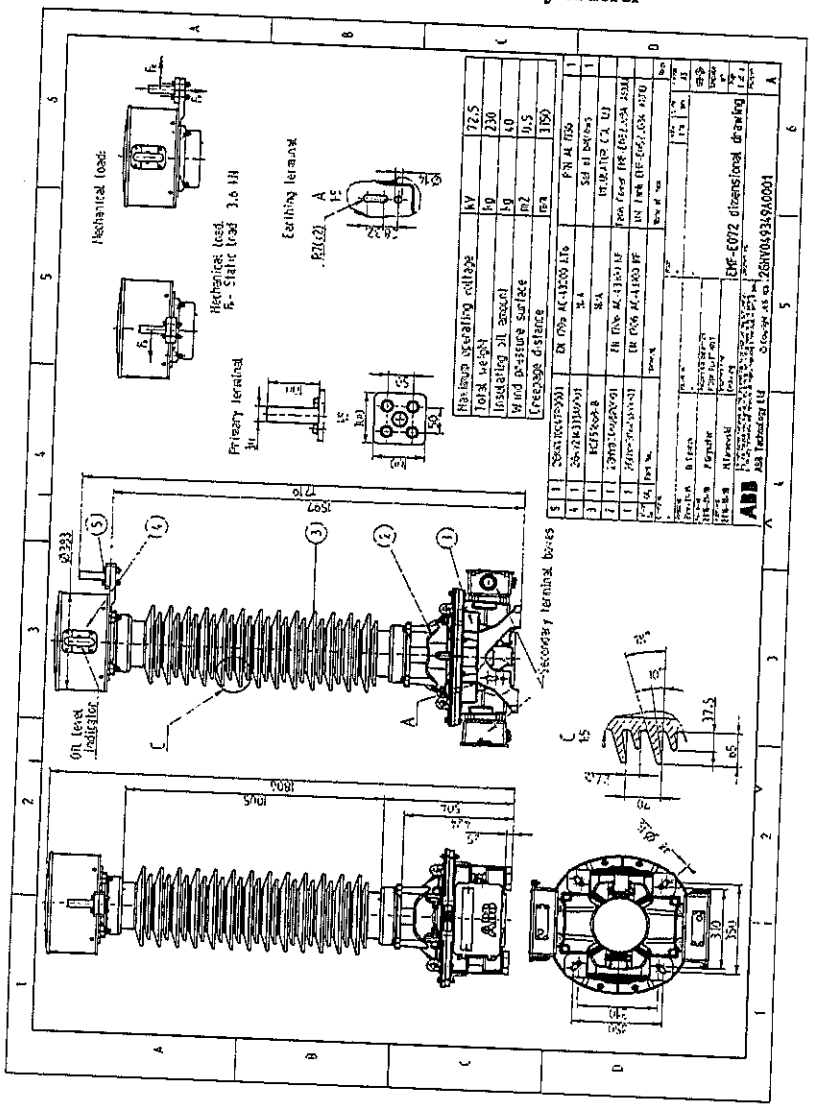


ABB Voltage transformer

Type EMF-E072 S/N 2GGKV1190628 A-N 66/√3 kV

Insulation level 72,5/140/325 kV Standard IEC 61869-3 1a-1n 110/√3V 1-50VA kl.0,2/3P 1300VAs

f_R 50Hz F 3,6kN F_V 1,9 / 8n 2a-2n 110/√3V 1-50VA kl.0,2/3P 1300VAs

Transportation Vertical Temp. range -40/+40°C

Insulation class A Year 2016

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

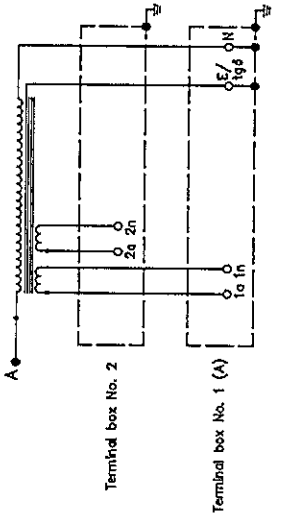
■ – Windings' terminal in the second box

Total weight 230kg Oil weight 40kg

Oil type Nynas Nytro Libra ISO-L-NTUO-2960130

Instrument transformer electrical diagram

ATTENTION!
1. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/tgδ MUST BE EARTHED.



ANNEX 3 **Declaration of Conformity**

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

DECLARATION OF CONFORMITY No. PL01/2016 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o., Leszno 59 Str., 06-300 Przasnysz

Product: Voltage Instrument Transformer EMF-E072

Above mentioned product conforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2016

Additional information:
Serial numbers: **2GGKV1190628, 2GGKV1190629, 2GGKV1190649,**

Place and date of issue of declaration

Przasnysz 07.11.2016

Kierownik Jakości Grupy Produktowej Przekładników WN ABB Sp. z o.o.
Krzysztof Lubecki
(Name)

Dyrektor Lokalnej Jednostki Biznesu Wysokich Napięć ABB Sp. z o.o.
Paweł Radecki
(Signature)

INSTITUTE OF POWER ENGINEERING
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tel. +48 22 345-13-86
http://www.ien.com.pl/eur

AB 324

TEST REPORT No. EUR/44/E/16-2

TEST OBJECT: Voltage transformer type EMF-E072 Serial No. 2GGKV1190629 with composite insulator

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. 4500774256 dated 07.09.2016

TYPE OF TESTS: Mechanical tests

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

DATE OF TESTS: 18.10.2016

TESTS RESULT: Positive for:
$F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Authorizing Test Engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 24.11.2016

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1. TEST OBJECT

1.1 Description

Voltage transformer type EMF-E072 is used for supplying of measuring and protection circuits in the network of maximum operating voltage 72,5 kV and frequency 50 Hz. The transformer consists of voltage transformer mounted in composite enclosure immersed with transformer oil.

1.2 Technical data

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

Maximum operating voltage	72,5 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:

- "EMF-E072 dimensional drawing", no. 2GHV040937A0001 approved 10.11.2016,
- 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. Conformity of manufacturing with constructional documentation No. PL01/2016 is stated in manufacturer's declaration, copy of which presents Annex 3.

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised mechanical tests of voltage transformer with static withstand test load of A terminal in three directions for:

$F_R = 3600$ N

according to requirements of IEC 61869-1:2007 p. 7.4.5.

The test load shall be applied to the centre of the terminal. During the tests deflection of the voltage transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the voltage transformer was completely assembled and filled with oil, installed in a vertical position on the frame rigidly fixed.

During the tests deflection of the transformer's terminal was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm) and the load was measured by electronic dynamometer.

3. TESTS AND THEIRS DETAILED RESULTS

The load was applied to the A terminal in three directions: Longitudinal, Transverse and Vertical (see photographs 1 to 3 in Annex 1). The load was increased and released smoothly (30 – 90 s) and was maintained for 60 s. Tests results are presented in table 1.

During the tests the following records were made:

- phot. 1 to 3 – voltage transformer during mechanical tests,
- phot. 4 – A terminal after tests,
- phot. 5 – voltage transformer after tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3650 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	A	Longitudinal	60	During the static load deflection was 16,2 mm. Residual deflection was 0,9 mm.
2	A	Transverse	60	During the static load deflection was 17,3 mm. Residual deflection was 0,5 mm.
3	A	Vertical	60	During the static load deflection was 2,9 mm. Residual deflection was 0,0 mm.

After the tests no damage nor oil leak was stated.

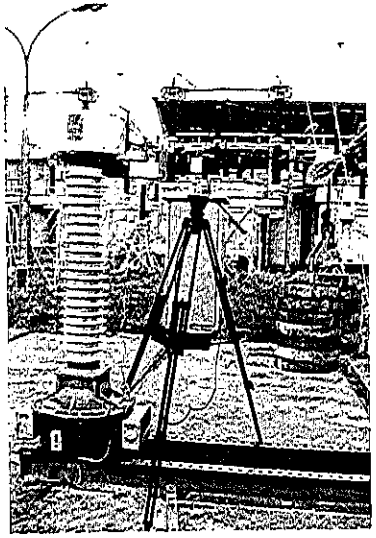
4. TESTS RESULTS EVALUATION

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

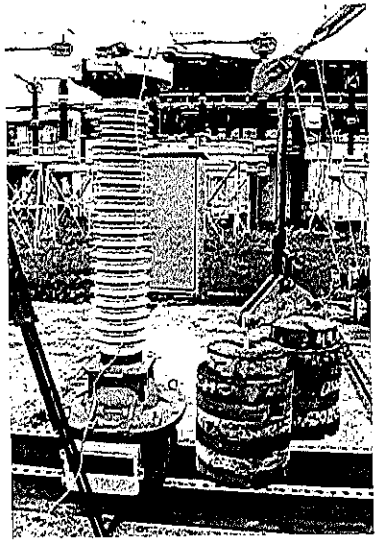
$F_R = 3600$ N.

ANNEX 1

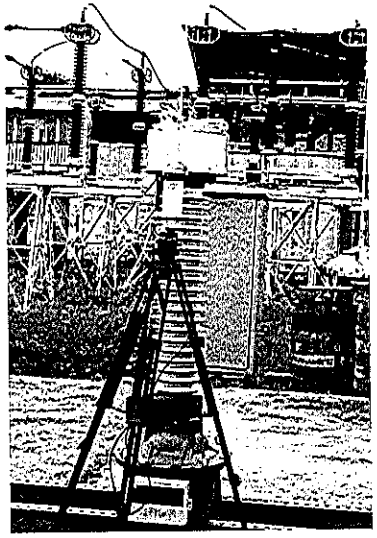
Photographs taken during the tests



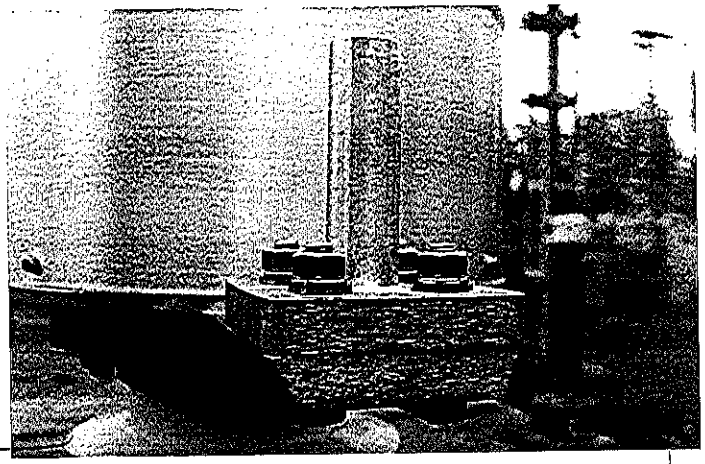
Phot. 1. Longitudinal load of A terminal



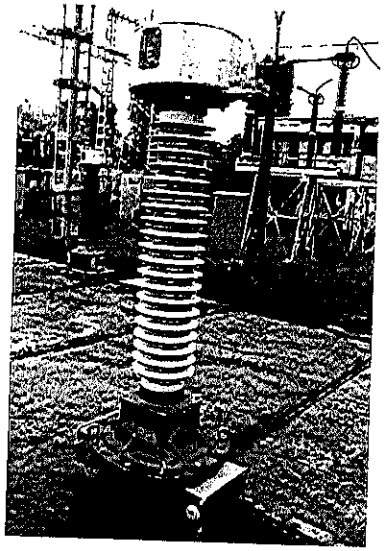
Phot. 2. Transverse load of A terminal



Phot. 3. Vertical load of A terminal

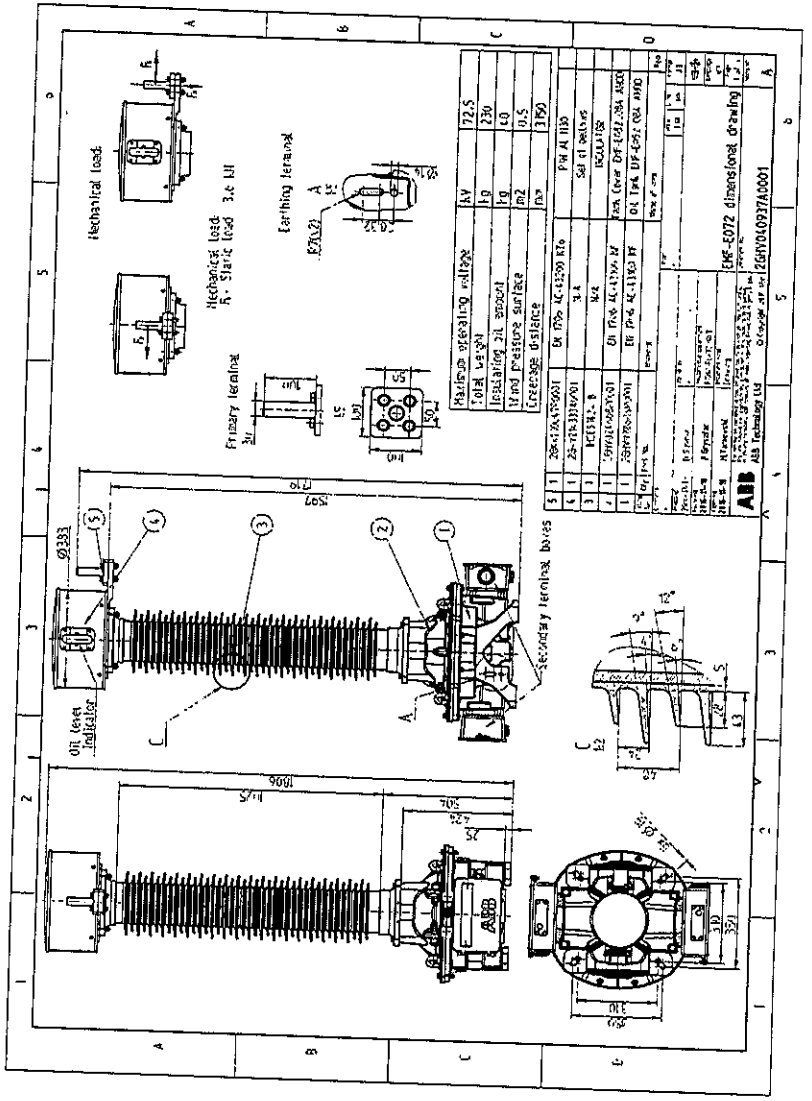


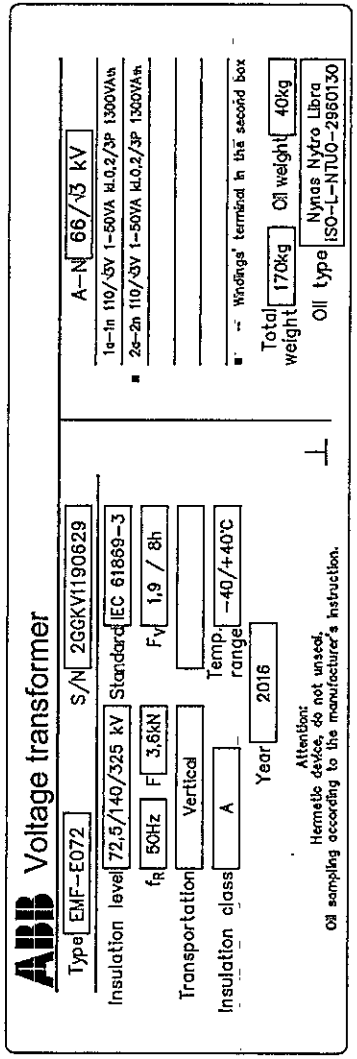
Phot. 4. A terminal after tests

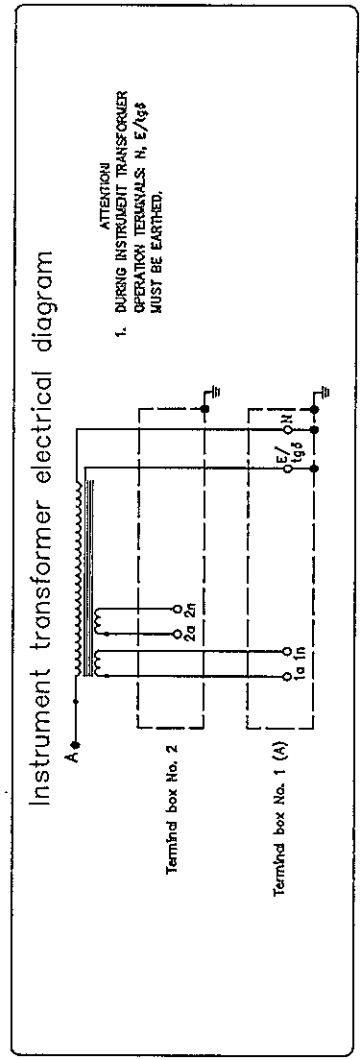


Phot. 5. Voltage transformer after tests

ANNEX 2 **Documentations delivered by orderer**







ANNEX 3 **Declaration of Conformity**

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

DECLARATION OF CONFORMITY No. PL01/2016 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o., Leszno 59 Str., 06-300 Przasnysz

Product: Voltage Instrument Transformer EMF-E072

Above mentioned product conforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2016

Additional information:
Serial numbers: **2GGKV1190628, 2GGKV1190629, 2GGKV1190649,**

Place and date of issue of declaration

Przasnysz 07.11.2016

Kierownik Jakości Grupy Produktowej Przekładników WN ABB Sp. z o.o.
Krzysztof Lubecki

Dyrektor Lokalnej Jednostki Biznesu Wysokich Napięć ABB Sp. z o.o.
Paweł Radecki

(Name) (Signature)

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

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tel. +48 22 345-13-86
http://www.ien.com.pl/eur

AB 324

TEST REPORT No. EUR/44/E/16-3

TEST OBJECT: Voltage transformer type EMF-E072 Serial No. 2GGKV1190649 with composite insulator

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. 4500774256 dated 07.09.2016

TYPE OF TESTS: Mechanical tests

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

DATE OF TESTS: 21.11.2016

TESTS RESULT: Positive for:
$F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Authorizing Test Engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 24.11.2016

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1. TEST OBJECT

1.1 Description

Voltage transformer type EMF-E072 is used for supplying of measuring and protection circuits in the network of maximum operating voltage 72,5 kV and frequency 50 Hz. The transformer consists of voltage transformer mounted in composite enclosure immersed with transformer oil.

1.2 Technical data

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

Maximum operating voltage	72,5 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:

- "EMF-E072 dimensional drawing", no. 2GHV038596P0001 approved 10.11.2016,
- 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. Conformity of manufacturing with constructional documentation No. PL01/2016 is stated in manufacturer's declaration, copy of which presents Annex 3.

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised mechanical tests of voltage transformer with static withstand test load of A terminal in three directions for:

F_R = 3600 N

according to requirements of IEC 61869-1:2007 p. 7.4.5.

The test load shall be applied to the centre of the terminal. During the tests deflection of the voltage transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the voltage transformer was completely assembled and filled with oil, installed in a vertical position on the frame rigidly fixed.

During the tests deflection of the transformer's terminal was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm) and the load was measured by electronic dynamometer.

3. TESTS AND THEIRS DETAILED RESULTS

The load was applied to the A terminal in three directions: Longitudinal, Transverse and Vertical (see photographs 1 to 3 in Annex 1). The load was increased and released smoothly (30 – 90 s) and was maintained for 60 s. Tests results are presented in table 1.

During the tests the following records were made:

- phot. 1 to 3 – voltage transformer during mechanical tests,
- phot. 4 – A terminal after tests,
- phot. 5 – voltage transformer after tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3650 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	A	Longitudinal	60	During the static load deflection was 26,0 mm. Residual deflection was 0,9 mm.
2	A	Transverse	60	During the static load deflection was 26,1 mm. Residual deflection was 1,4 mm.
3	A	Vertical	60	During the static load deflection was 0,8 mm. Residual deflection was 0,2 mm.

After the tests no damage nor oil leak was stated.

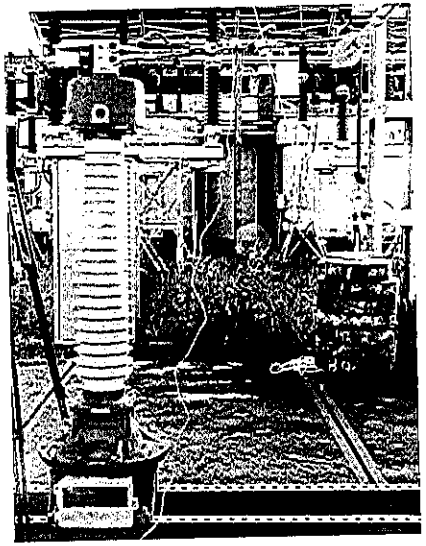
4. TESTS RESULTS EVALUATION

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

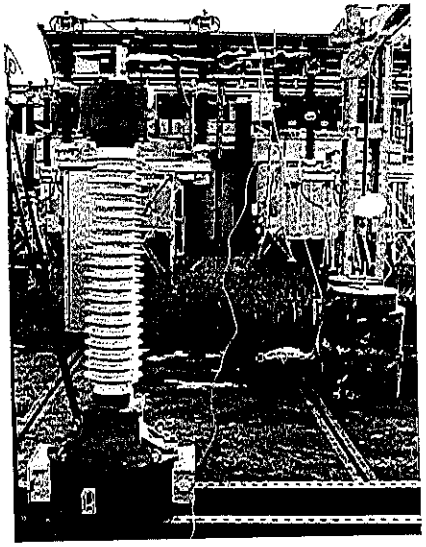
F_R = 3600 N.

ANNEX 1

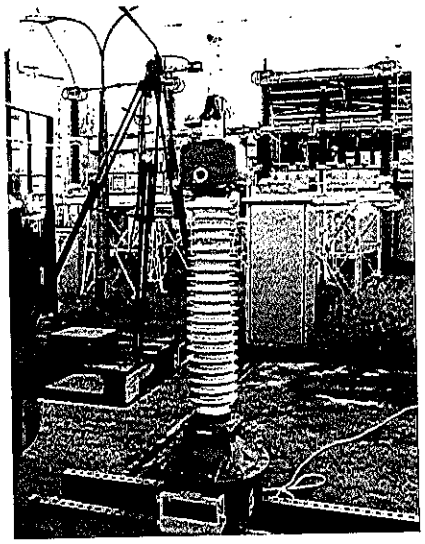
Photographs taken during the tests



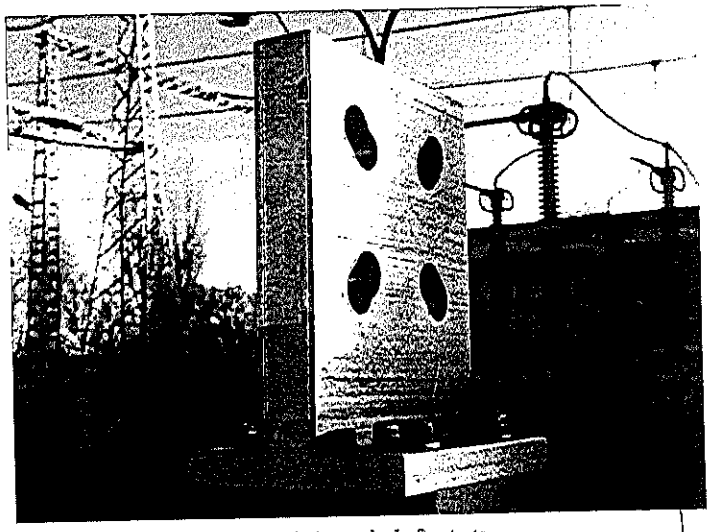
Phot. 1. Longitudinal load of A terminal



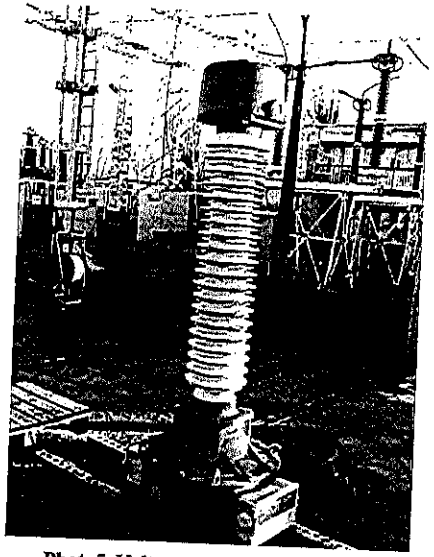
Phot. 2. Transverse load of A terminal



Phot. 3. Vertical load of A terminal



Phot. 4. A terminal after tests



Phot. 5. Voltage transformer after tests

ANNEX 2 **Documentations delivered by orderer**

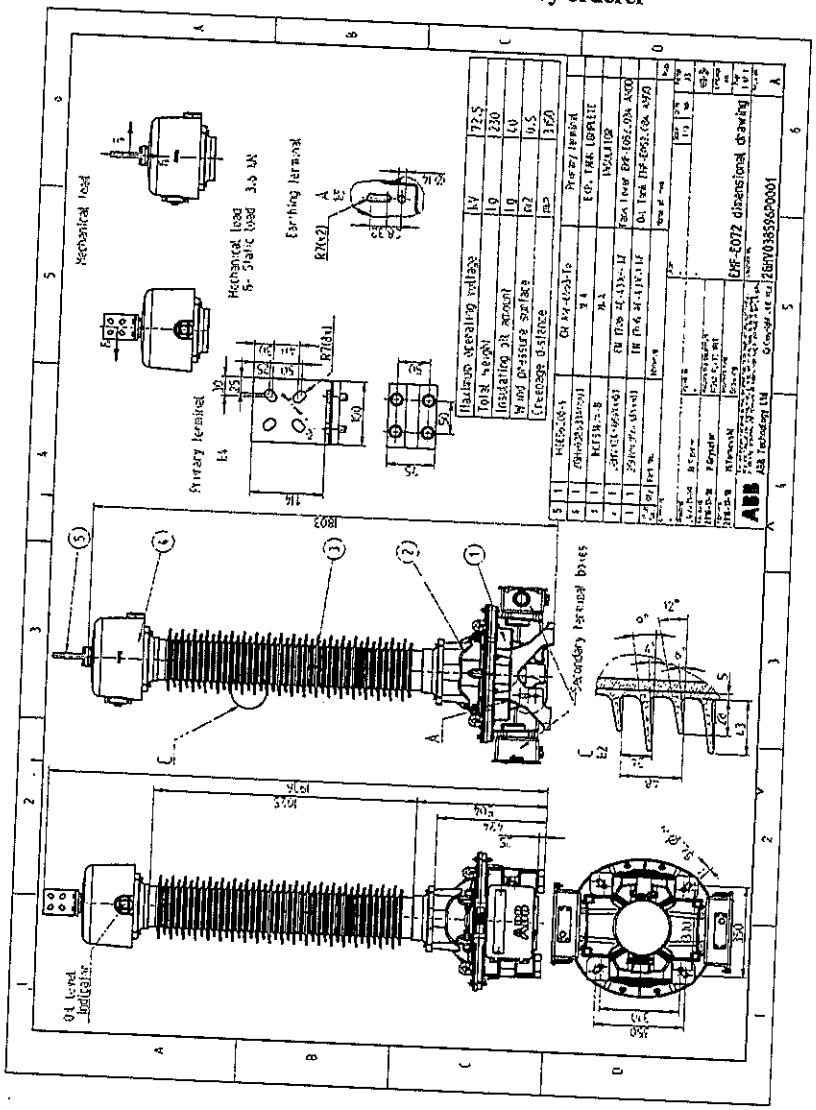


ABB Voltage transformer

Type EMF-E072 S/N 2GGKV1190649

Insulation level 72,5/140/325 kV Standard IEC 61869-3

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

Transportation Vertical Temp. range -40/+40°C

Insulation class A Year 2016

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

A-N 66/√3 kV

1a-1n 110/√3V 1-50VA kl.0,2/3P 1300VAm

2a-2n 110/√3V 1-50VA kl.0,2/3P 1300VAm

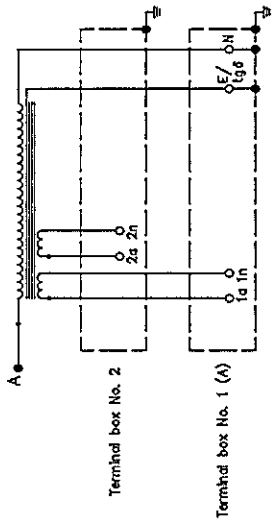
- Windings' terminal in the second box

Total weight 170kg Oil weight 40kg

Oil type Nynas Nytro Libra ISO-L-NTUO-2960130

Instrument transformer electrical diagram

1. DURING INSTRUMENT TRANSFORMER OPERATION TERMINALS: N, E/1g6 MUST BE EARTHED.



ANNEX 3 **Declaration of Conformity**

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

DECLARATION OF CONFORMITY No. PL01/2016 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o., Leszno 59 Str., 06-300 Przasnysz

Product: Voltage Instrument Transformer EMF-E072

Above mentioned product conforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2016

Additional information:
Serial numbers: **2GGKV1190628, 2GGKV1190629, 2GGKV1190649,**

Place and date of issue of declaration

Przasnysz 07.11.2016

Kierownik Jakości Grupy Produktowej Przekładników WN ABB Sp. z o.o.
Krzysztof Lubecki
(Name)

Dyrektor Lokalnej Jednostki Biznesu Wysokich Napięć ABB Sp. z o.o.
Paweł Radecki
(Signature)

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tel. +48 22 345-13-86
http://www.ien.com.pl/cur

AB 324

TEST REPORT No. EUR/44/E/16-4

TEST OBJECT: Voltage transformer type EMF-E145 Serial No. 2GGKV1190669 with composite insulator

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. 4500774256 dated 07.09.2016

TYPE OF TESTS: Mechanical tests

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

DATE OF TESTS: 12.12.2016

TESTS RESULT: Positive for:
$F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Authorizing Test Engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 16.12.2016

Contents

Report contents:

numbered pages	10
tables	1
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1. TEST OBJECT

1.1 Description

Voltage transformer type EMF-E145 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 voltage transformer mounted in composite enclosure 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:

- "EMF-E145 dimensional drawing", no. 2GHV036167A0001 approved 29.11.2016,
- 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. Conformity of manufacturing with constructional documentation No. PL02/2016 is stated in manufacturer's declaration, copy of which presents Annex 3.

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised mechanical tests of voltage transformer with static withstand test load of A terminal in three directions for:

$F_R = 3600$ N

according to requirements of IEC 61869-1:2007 p. 7.4.5.

The test load shall be applied to the centre of the terminal. During the tests deflection of the voltage transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the voltage transformer was completely assembled and filled with oil, installed in a vertical position on the frame rigidly fixed.

During the tests deflection of the transformer's terminal was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm) and the load was measured by electronic dynamometer.

3. TESTS AND THEIRS DETAILED RESULTS

The load was applied to the A terminal in three directions: Longitudinal, Transverse and Vertical (see photographs 1 to 3 in Annex 1). The load was increased and released smoothly (30 – 90 s) and was maintained for 60 s. Tests results are presented in table 1.

During the tests the following records were made:

- phot. 1 to 3 – voltage transformer during mechanical tests,
- phot. 4 – A terminal after tests,
- phot. 5 – voltage transformer after tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3650 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	A	Longitudinal	60	During the static load deflection was 72,8 mm. Residual deflection was 2,7 mm.
2	A	Transverse	60	During the static load deflection was 75,8 mm. Residual deflection was 4,2 mm.
3	A	Vertical	60	During the static load deflection was 1,2 mm. Residual deflection was 0,9 mm.

After the tests no damage nor oil leak was stated.

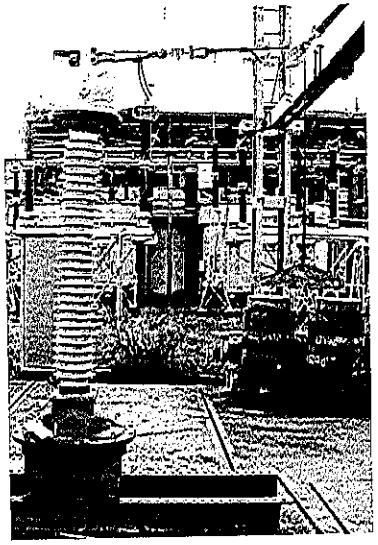
4. TESTS RESULTS EVALUATION

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

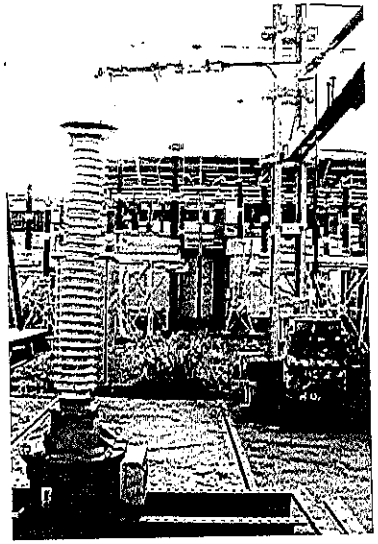
$F_R = 3600$ N.

ANNEX 1

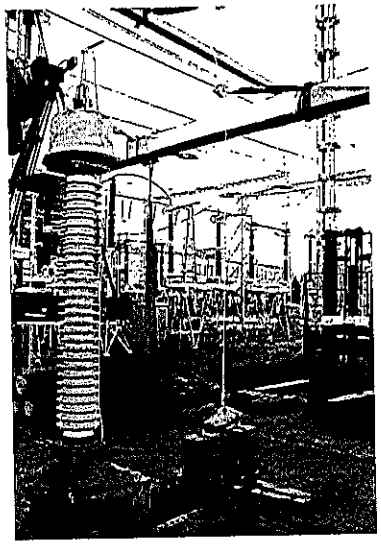
Photographs taken during the tests



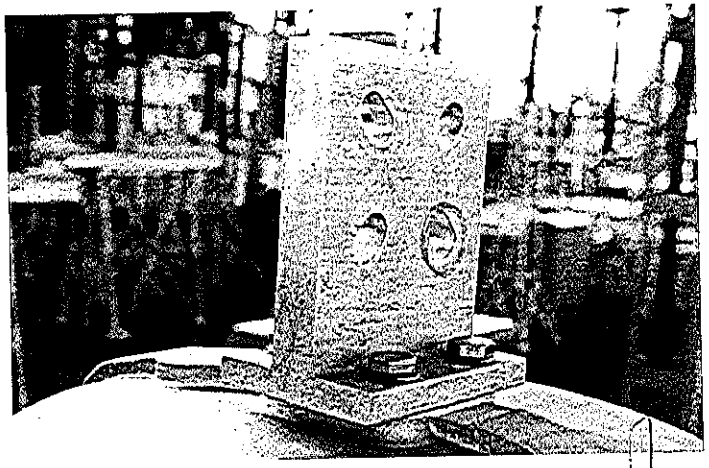
Phot. 1. Longitudinal load of A terminal



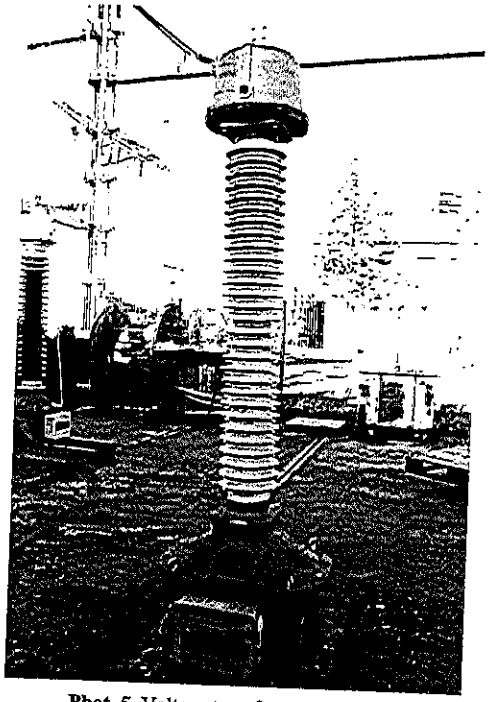
Phot. 2. Transverse load of A terminal



Phot. 3. Vertical load of A terminal

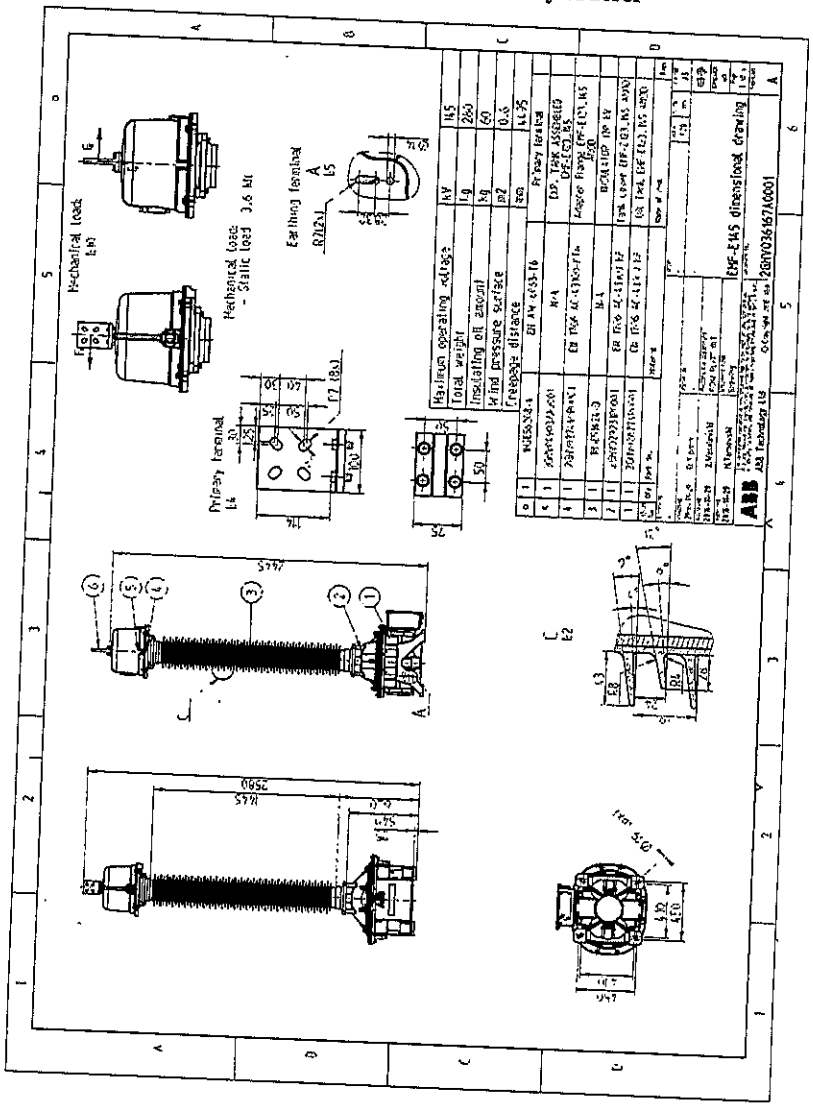


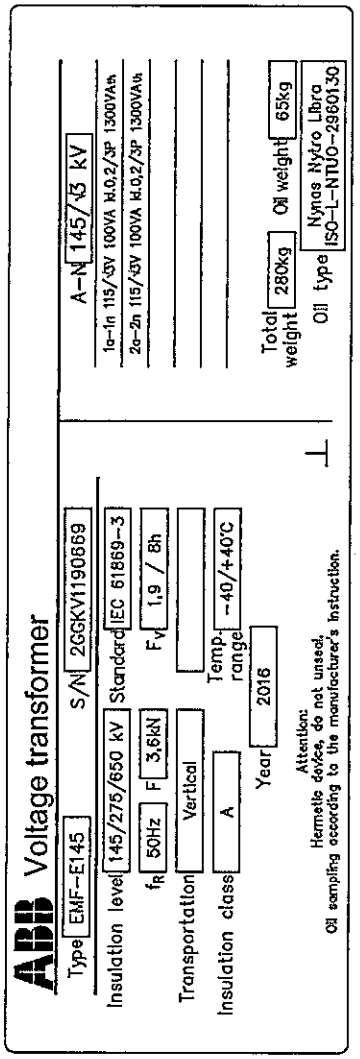
Phot. 4. A terminal after tests

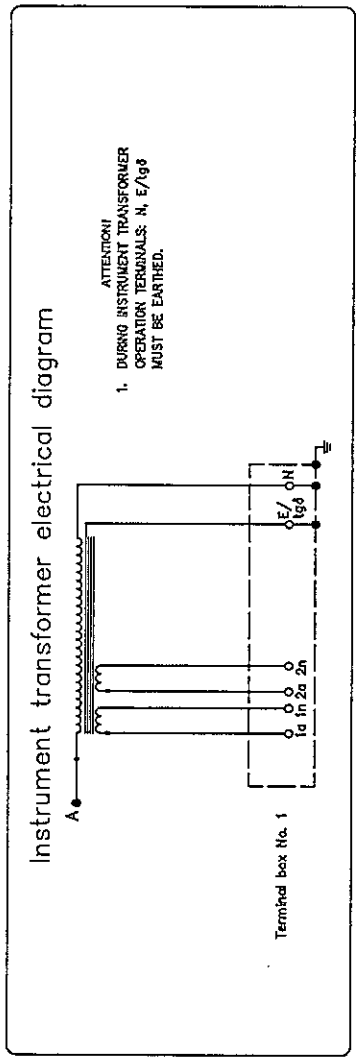


Phot. 5. Voltage transformer after tests

ANNEX 2 **Documentations delivered by orderer**







ANNEX 3 **Declaration of Conformity**

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

DECLARATION OF CONFORMITY No. PL02/2016 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o., Leszno 59 Str., 06-300 Przasnysz

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product conforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2016

Additional information:
Serial numbers: **2GGKV1190668, 2GGKV1190669, 2GGKV1190670,**

Place and date of issue of declaration

Przasnysz 25.11.2016

Kierownik Zespołu Grupy Produktowej Przekładników WN ABB Sp. z o.o.
Krzysztof Lubecki
(Name)

Dyrektor Lokalnej Jednostki Biznesu Wysokich Napięć ABB Sp. z o.o.
Paweł Radocki
(Signature)

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

01-330 Warsaw, ul Mory 8
tel.fax. +48 22 836-73-35
tel. +48 22 345-13-86
http://www.ien.com.pl/eur

AB 324

TEST REPORT No. EUR/44/E/16-5

TEST OBJECT:	Voltage transformer type EMF-E145 Serial No. 2GGKV1190668 with porcelain insulator
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. 4500774256 dated 07.09.2016
TYPE OF TESTS:	Mechanical tests
TESTS PROCEDURE:	According to IEC 61869-1:2007 p. 7.4.5
DATE OF TESTS:	12.12.2016
TESTS RESULT:	Positive for: $F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Authorizing Test Engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 16.12.2016

Contents

Report contents:

numbered pages	10
tables	1
photographs	5

1. TEST OBJECT

1.1 Description

Voltage transformer type EMF-E145 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 voltage transformer mounted in porcelain enclosure 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:

- "EMF-E145 dimensional drawing", no. 2GHV040205A0001 approved 29.11.2016,
- 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. Conformity of manufacturing with constructional documentation No. PL02/2016 is stated in manufacturer's declaration, copy of which presents Annex 3.

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised mechanical tests of voltage transformer with static withstand test load of A terminal in three directions for:

$F_R = 3600$ N

according to requirements of IEC 61869-1:2007 p. 7.4.5.

The test load shall be applied to the centre of the terminal. During the tests deflection of the voltage transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the voltage transformer was completely assembled and filled with oil, installed in a vertical position on the frame rigidly fixed.

During the tests deflection of the transformer's terminal was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm) and the load was measured by electronic dynamometer.

3. TESTS AND THEIRS DETAILED RESULTS

The load was applied to the A terminal in three directions: Longitudinal, Transverse and Vertical (see photographs 1 to 3 in Annex 1). The load was increased and released smoothly (30 – 90 s) and was maintained for 60 s. Tests results are presented in table 1.

During the tests the following records were made:

- phot. 1 to 3 – voltage transformer during mechanical tests,
- phot. 4 – A terminal after tests,
- phot. 5 – voltage transformer after tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3650 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	A	Longitudinal	60	During the static load deflection was 13,8 mm. Residual deflection was 0,6 mm.
2	A	Transverse	60	During the static load deflection was 11,7 mm. Residual deflection was 0,1 mm.
3	A	Vertical	60	During the static load deflection was 1,6 mm. Residual deflection was 0,2 mm.

After the tests no damage nor oil leak was stated.

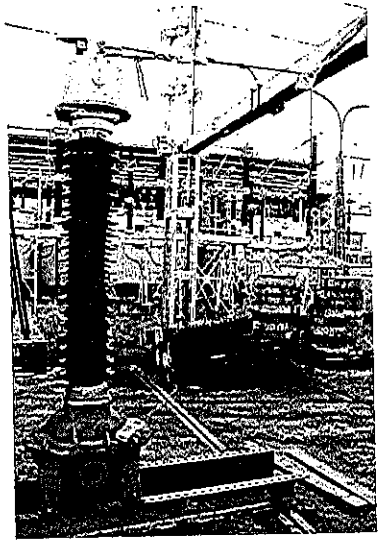
4. TESTS RESULTS EVALUATION

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

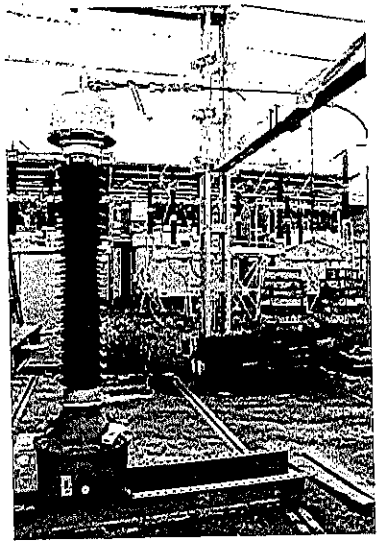
$F_R = 3600$ N.

ANNEX 1

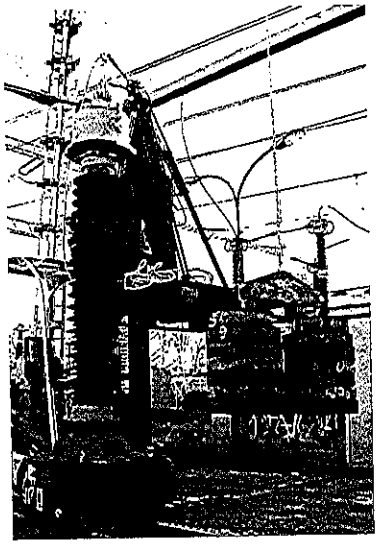
Photographs taken during the tests



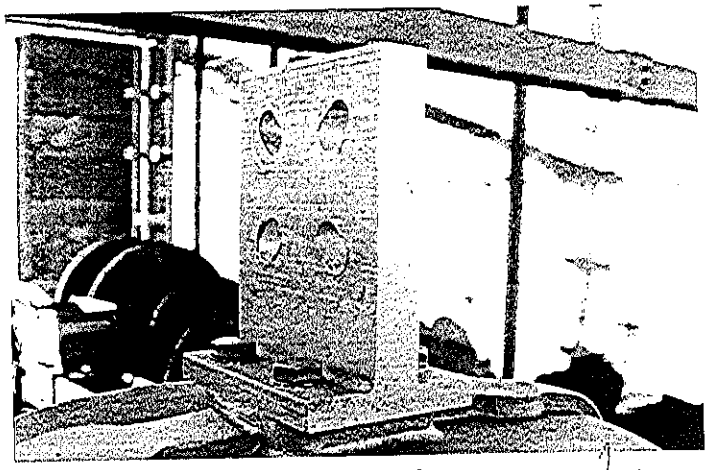
Phot. 1. Longitudinal load of A terminal



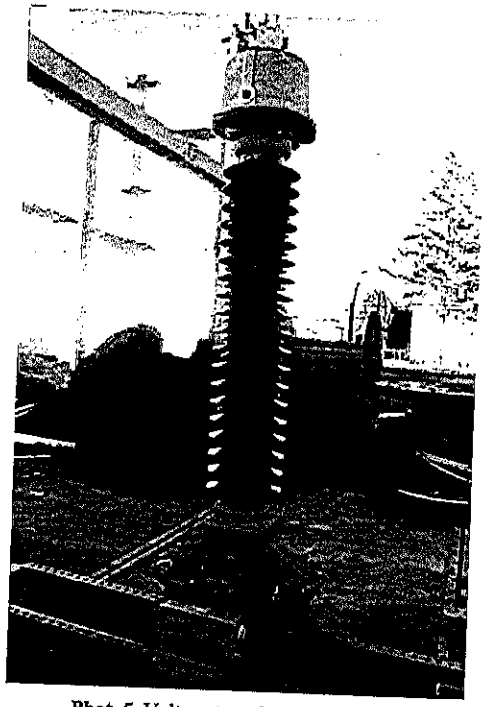
Phot. 2. Transverse load of A terminal



Phot. 3. Vertical load of A terminal

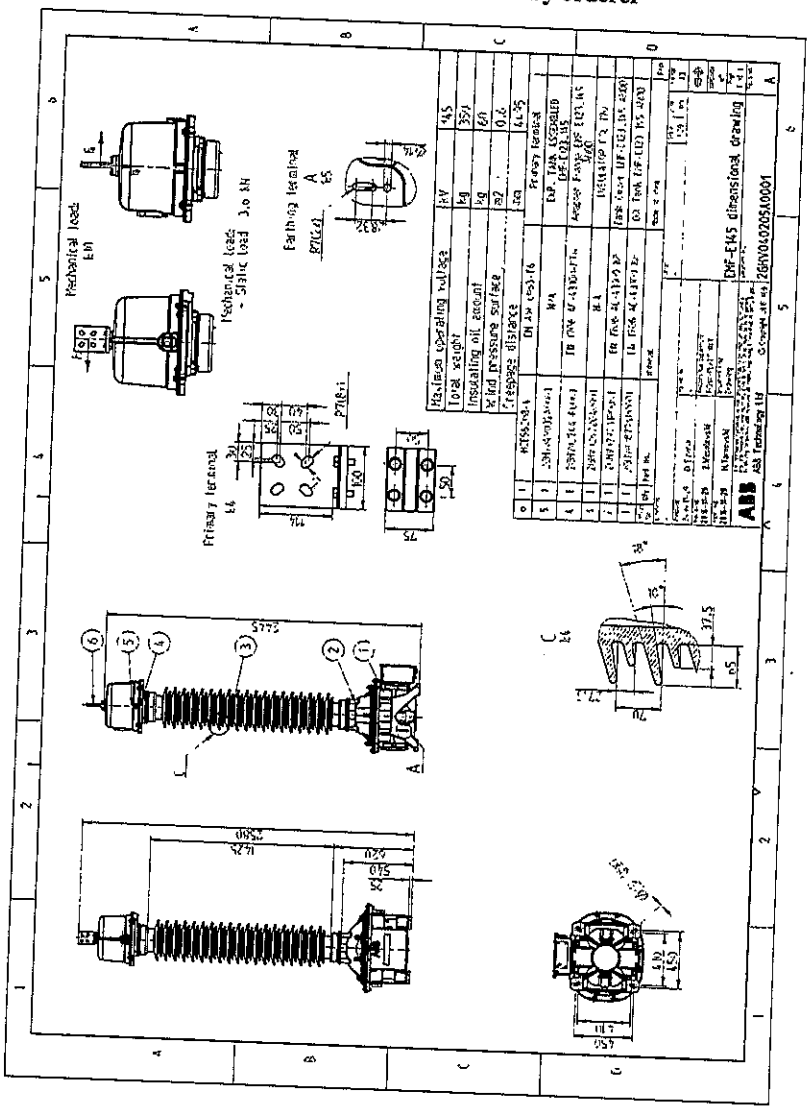


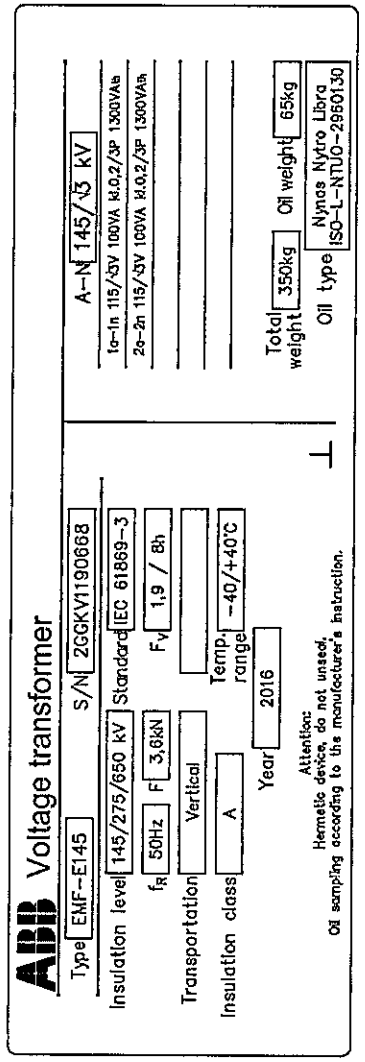
Phot. 4. A terminal after tests

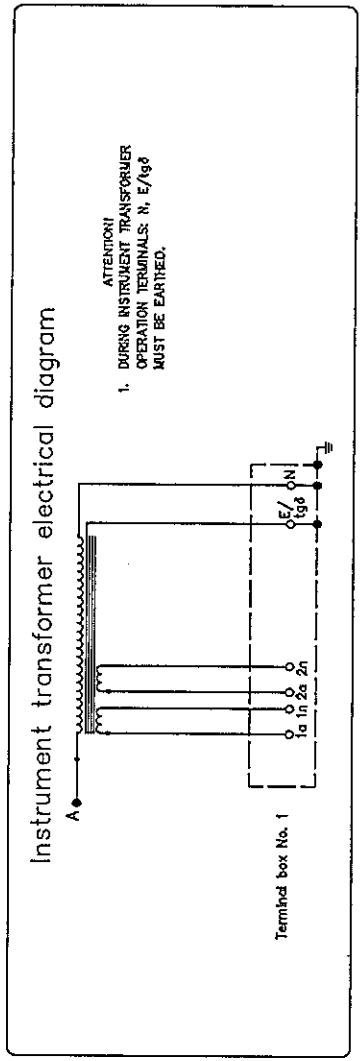


Phot. 5. Voltage transformer after tests

ANNEX 2 **Documentations delivered by orderer**







ANNEX 3 **Declaration of Conformity**

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

DECLARATION OF CONFORMITY No. PL02/2016 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o., Leszno 59 Str., 06-300 Przasnysz

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product conforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2016

Additional information:
Serial numbers: **2GGKV1190668, 2GGKV1190669, 2GGKV1190670,**

Place and date of issue of declaration

Przasnysz 25.11.2016

Kierownik Jednostki Grupy Produktowej Przekładników WN ABB Sp. z o.o.
Krzysztof Lubecki
(Name)

Dyrektor Lokalnej Jednostki Biznesu Wysokich Napięć ABB Sp. z o.o.
Paweł Rodocki
(Signature)

INSTITUTE OF POWER ENGINEERING
DISTRIBUTION EQUIPMENT LABORATORY

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tel. +48 22 345-13-86
http://www.ien.com.pl/eur

AB 324

TEST REPORT No. EUR/44/E/16-6

TEST OBJECT:	Voltage transformer type EMF-E145 Serial No. 2GGKV1190670 with composite insulator
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. 4500774256 dated 07.09.2016
TYPE OF TESTS:	Mechanical tests
TESTS PROCEDURE:	According to IEC 61869-1:2007 p. 7.4.5
DATE OF TESTS:	21.12.2016
TESTS RESULT:	Positive for: $F_R = 3600$ N

Tests result refers only to the test object

THE TESTS WERE WITNESSED BY: -

Authorizing Test Engineer

Tomasz Kaczmarczyk

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 23.12.2016

Contents

Report contents:

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1. TEST OBJECT

1.1 Description

Voltage transformer type EMF-E145 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 voltage transformer mounted in composite enclosure 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:

- "EMF-E145 dimensional drawing", no. 2GHV036269A0001 approved 29.11.2016,
- 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. Conformity of manufacturing with constructional documentation No. PL02/2016 is stated in manufacturer's declaration, copy of which presents Annex 3.

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised mechanical tests of voltage transformer with static withstand test load of A terminal in three directions for:

$F_R = 3600$ N

according to requirements of IEC 61869-1:2007 p. 7.4.5.

The test load shall be applied to the centre of the terminal. During the tests deflection of the voltage transformer shall be recorded.

3. TEST AND MEASURING CIRCUITS

For the tests the voltage transformer was completely assembled and filled with oil, installed in a vertical position on the frame rigidly fixed.

During the tests deflection of the transformer's terminal was recorded by laser displacement sensor (accuracy of measurement ± 0,1 mm) and the load was measured by electronic dynamometer.

3. TESTS AND THEIRS DETAILED RESULTS

The load was applied to the A terminal in three directions: Longitudinal, Transverse and Vertical (see photographs 1 to 3 in Annex 1). The load was increased and released smoothly (30 – 90 s) and was maintained for 60 s. Tests results are presented in table 1.

During the tests the following records were made:

- phot. 1 to 3 – voltage transformer during mechanical tests,
- phot. 4 – A terminal after tests,
- phot. 5 – voltage transformer after tests.

(Annex 1 presents the photographs)

Table 1. Results of static load withstand tests at F = 3650 N

Test No.	Terminal	Load direction	Test time	Observations
-	-	-	s	-
1	A	Longitudinal	60	During the static load deflection was 39,9 mm. Residual deflection was 0,3 mm.
2	A	Transverse	60	During the static load deflection was 44,6 mm. Residual deflection was 1,7 mm.
3	A	Vertical	60	During the static load deflection was 4,1 mm. Residual deflection was 0,5 mm.

After the tests no damage nor oil leak was stated.

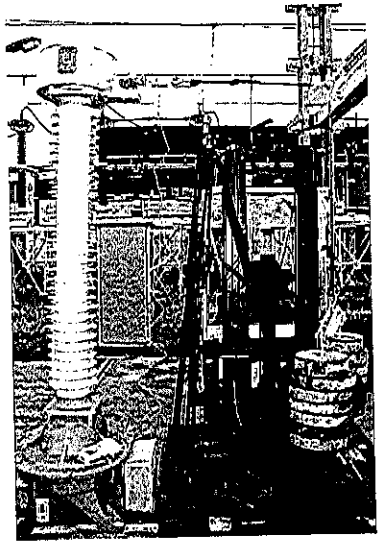
4. TESTS RESULTS EVALUATION

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

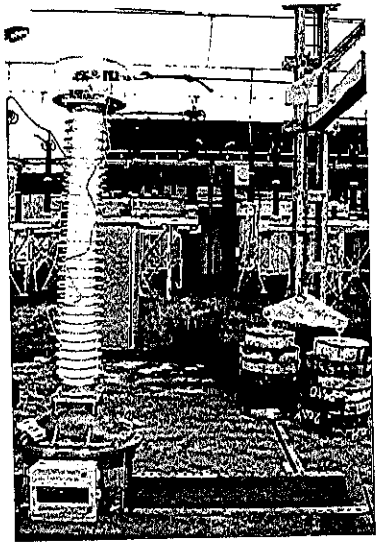
$F_R = 3600$ N.

ANNEX 1

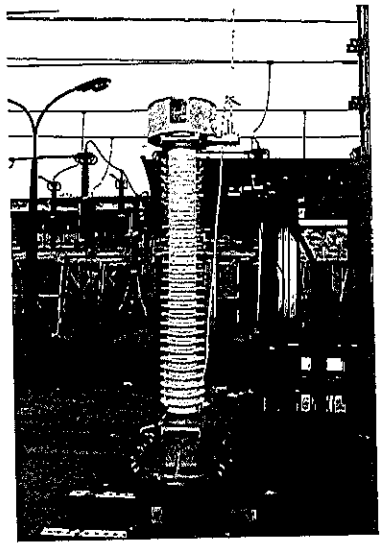
Photographs taken during the tests



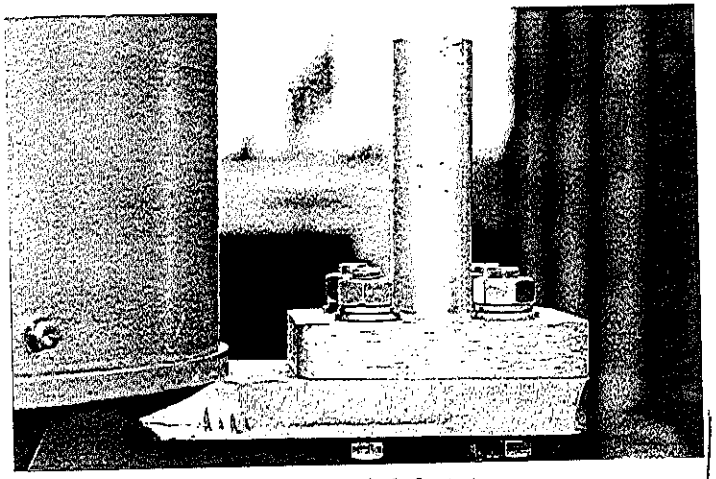
Phot. 1. Longitudinal load of A terminal



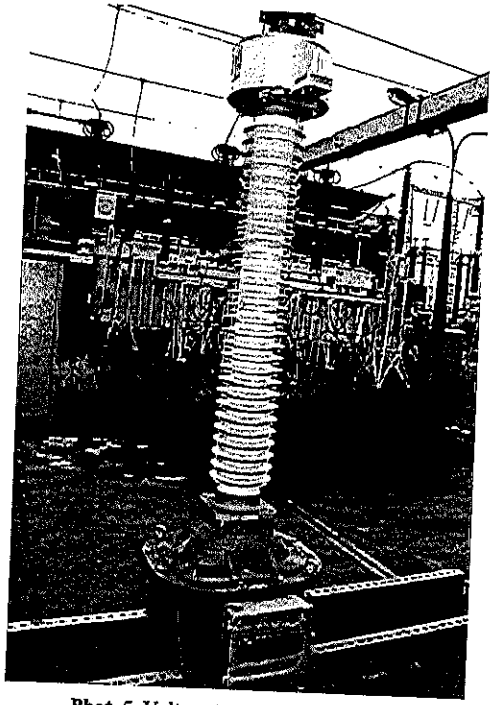
Phot. 2. Transverse load of A terminal



Phot. 3. Vertical load of A terminal

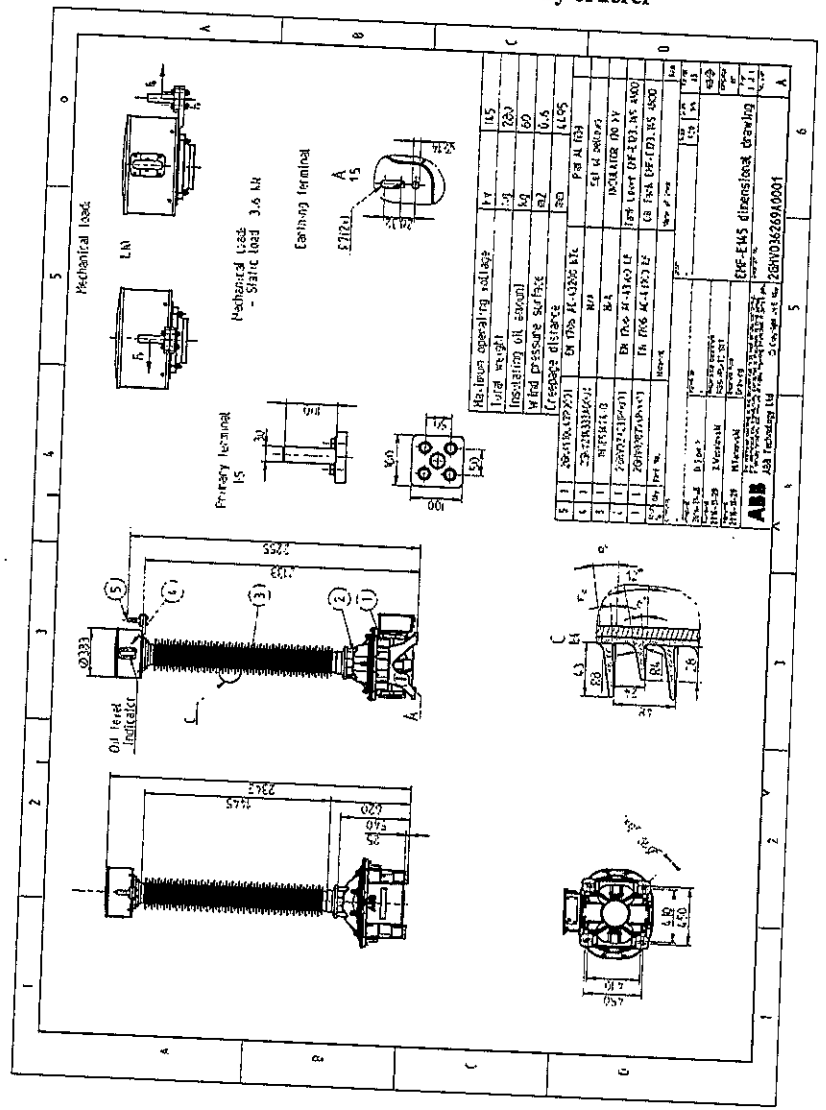


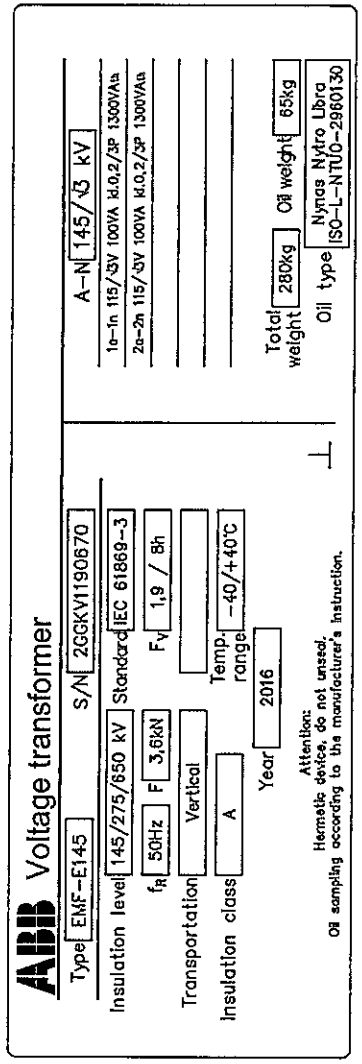
Phot. 4. A terminal after tests

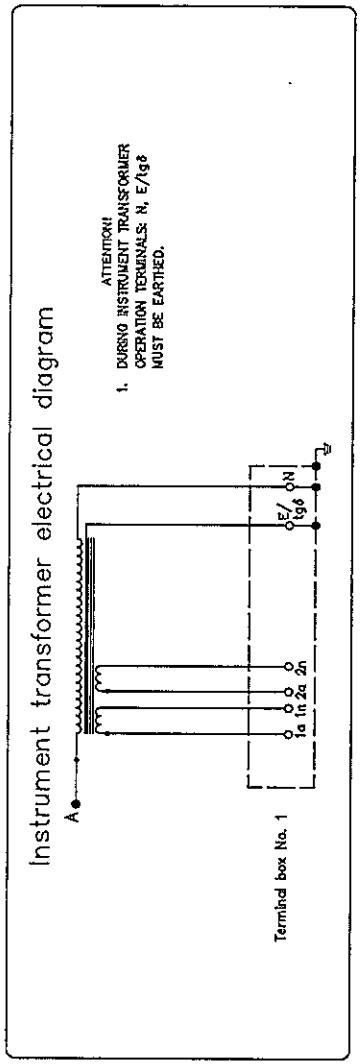


Phot. 5. Voltage transformer after tests

ANNEX 2 **Documentations delivered by orderer**







ANNEX 3 **Declaration of Conformity**

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

DECLARATION OF CONFORMITY No. PL02/2016 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB Sp. z o.o., Leszno 59 Str., 06-300 Przasnysz

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product conforms with the following standard :

Standard	Title	Edition/Date
IEC 61869 - 3	Voltage Instrument Transformers	2016

Additional Information:
Serial numbers: **2GGKV1190668, 2GGKV1190669, 2GGKV1190670,**

Place and date of issue of declaration

Przasnysz 25.11.2016

Kierownik Zakładu Grupy Produktowej Przekładników WN ABB Sp. z o.o.
Krzysztof Lubecki
(Name)

Dyrektor Lokalnej Jednostki Biznesu Wysokich Napięć ABB Sp. z o.o.
Paweł Radocki
(Signature)

HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/45/E/16

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

Warsaw, May 2016

TEST REPORT EWN/45/E/16

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

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

Warsaw, May 2016.

CONTENTS

Test report includes:

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

Attached to the test report:

Annex 1: Dimensional drawing (1 page);

Annex 2: Reports of routine test and determination of errors (8 pages);

Annex 3: Lightning impulse test protocol (7 pages);

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

1 COMPETENCE OF THE LABORATORY

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

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

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

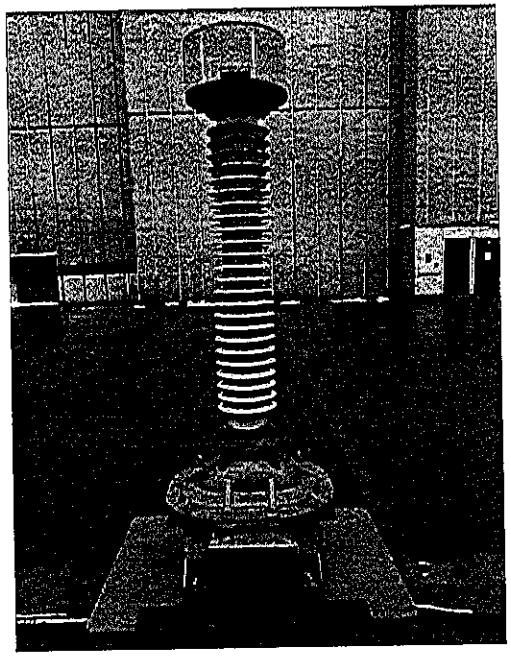
2 TEST OBJECT DESCRIPTION

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

Type – PV145a

Serial number: 2GKP015V1188086

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



Phot. 1: Tested voltage transformer PV145a – general view

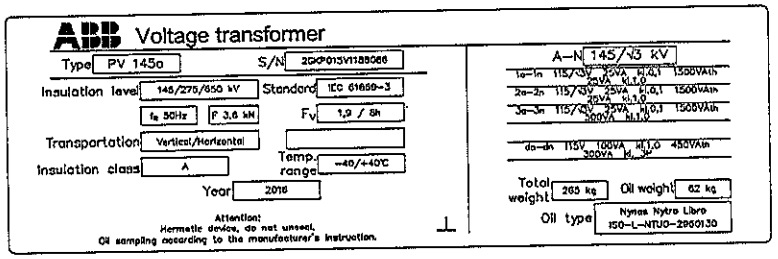


Fig. 1: Tested voltage transformer PV145a – rating plate

3 SCOPE OF TESTS AGREED UPON

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

Tab. 1: Scope of tests of voltage instrument transformer

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

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

Tests were carried out according to:

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

3.1 Impulse voltage withstand test on primary terminal

3.1.1 Method of testing and acceptance criteria

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

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

3.1.2 Test arrangement

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

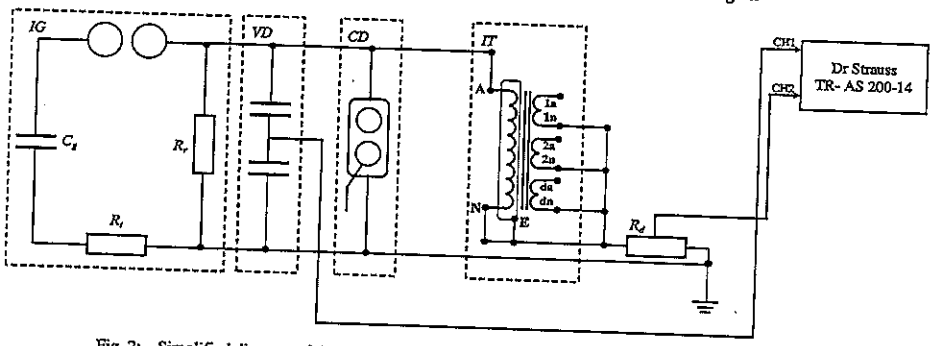


Fig. 2: Simplified diagram of the lightning impulse measurement system (for one step of the generator): *IG* – impulse generator; *VD* – voltage divider; C_g, R_f, R_r – generator elements; *CD* – chopping device; *IT* - instrument transformer (general schematic representation); R_d – detection resistance

3.1.3 Test conditions

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

Tab. 2: Parameters of the lightning impulse measurement system

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

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

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

3.1.4 Test results

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

TEST RESULT: POSITIVE

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

EWN/45/E/16

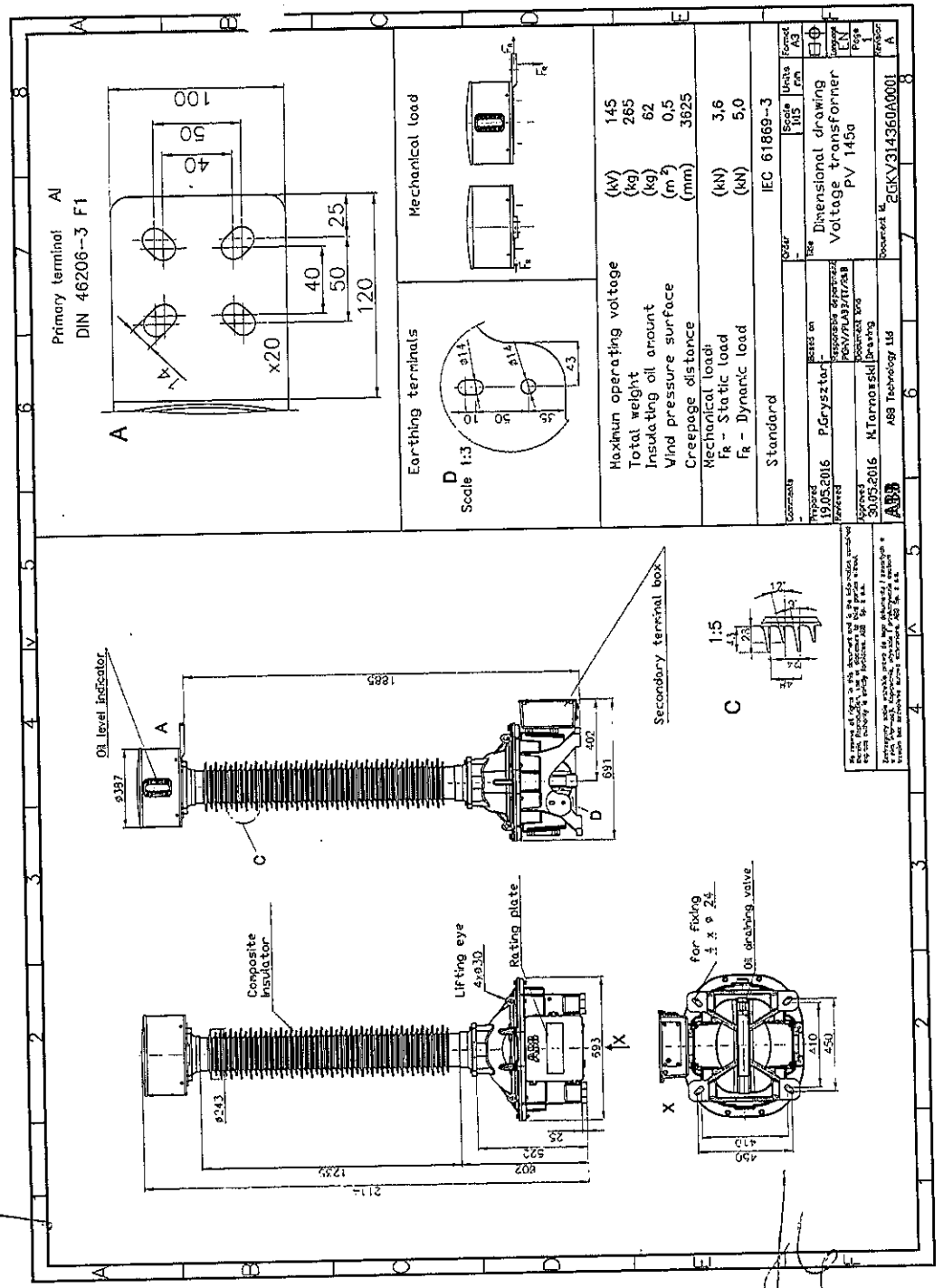
Annex 1

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

(1 page)

Dimensional drawing:

- ID: 2GKV314360A0001



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

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

(8 pages)

Reports of routine test and determination of errors:

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

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

Rating 1				
Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	0.1	1500
2a - 2n	0,115:√3	25	0.1	1500
3a - 3n	0,115:√3	25	0.1	1500
da - dn	0,115	100	1.0	450

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

List of performed tests

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

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)
  Stress voltage: 275 kV / 60 s
  Frequency: 120 Hz

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Measurement of windings' resistance

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

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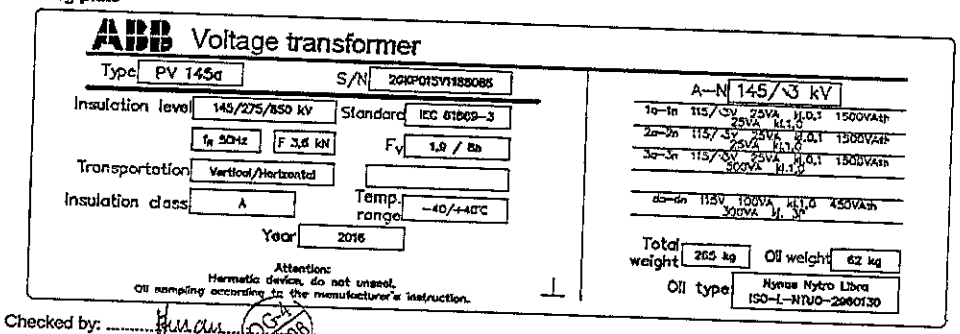
Rating plate



Checked by: .....

Przasnysz, 2016-05-17

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

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

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

List of performed tests

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

Partial discharge measurement

- Measurement according to procedure A (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)
  Stress voltage: 220 kV / 60 s
  Frequency: 120 Hz

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Measurement of windings' resistance

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

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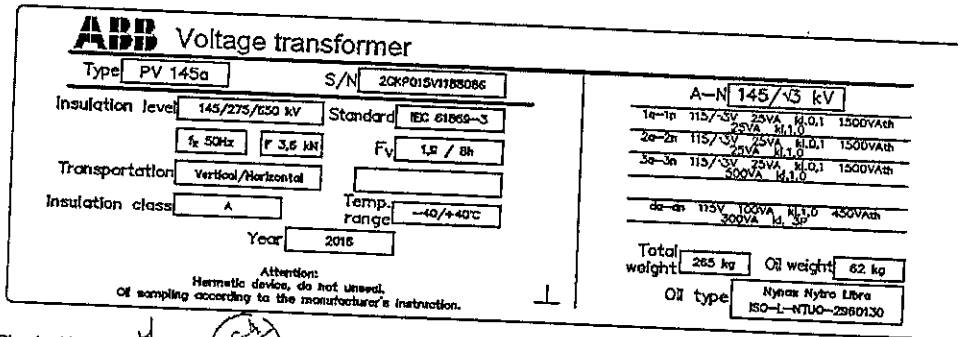
Rating plate



Checked by: .....

Przasnysz, 2016-05-30

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EWN/45/E/16

Annex 3

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

(8 pages)

Lightning impulse test protocol:

- ewn45e16

HIGH VOLTAGE LABORATORY
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fax: (+4822) 836-80-48, mail: ewn@len.com.pl

project : ewn45e16 test date 19-05-2016

Test - object - data

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

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

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

LI lightning-impulse

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

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project : ewn45e16

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

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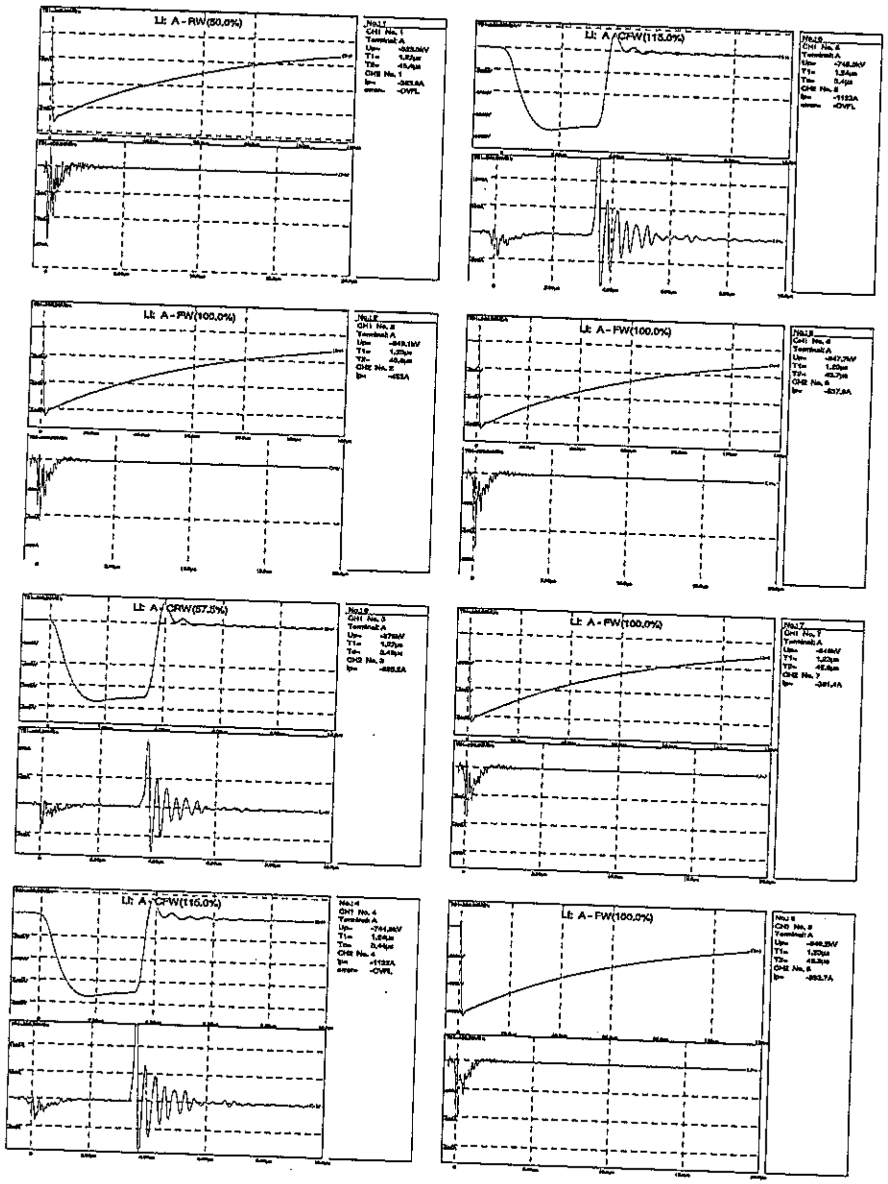
project : ewn45e16



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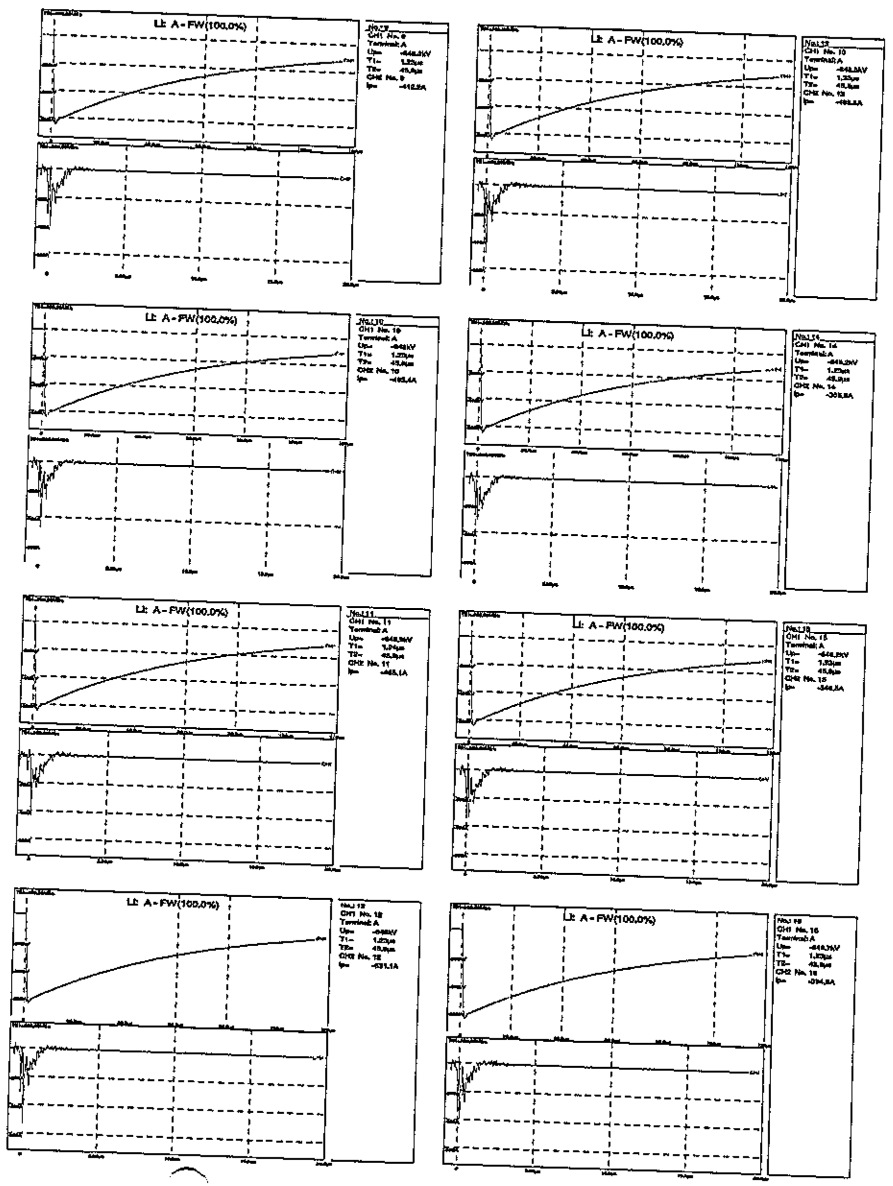

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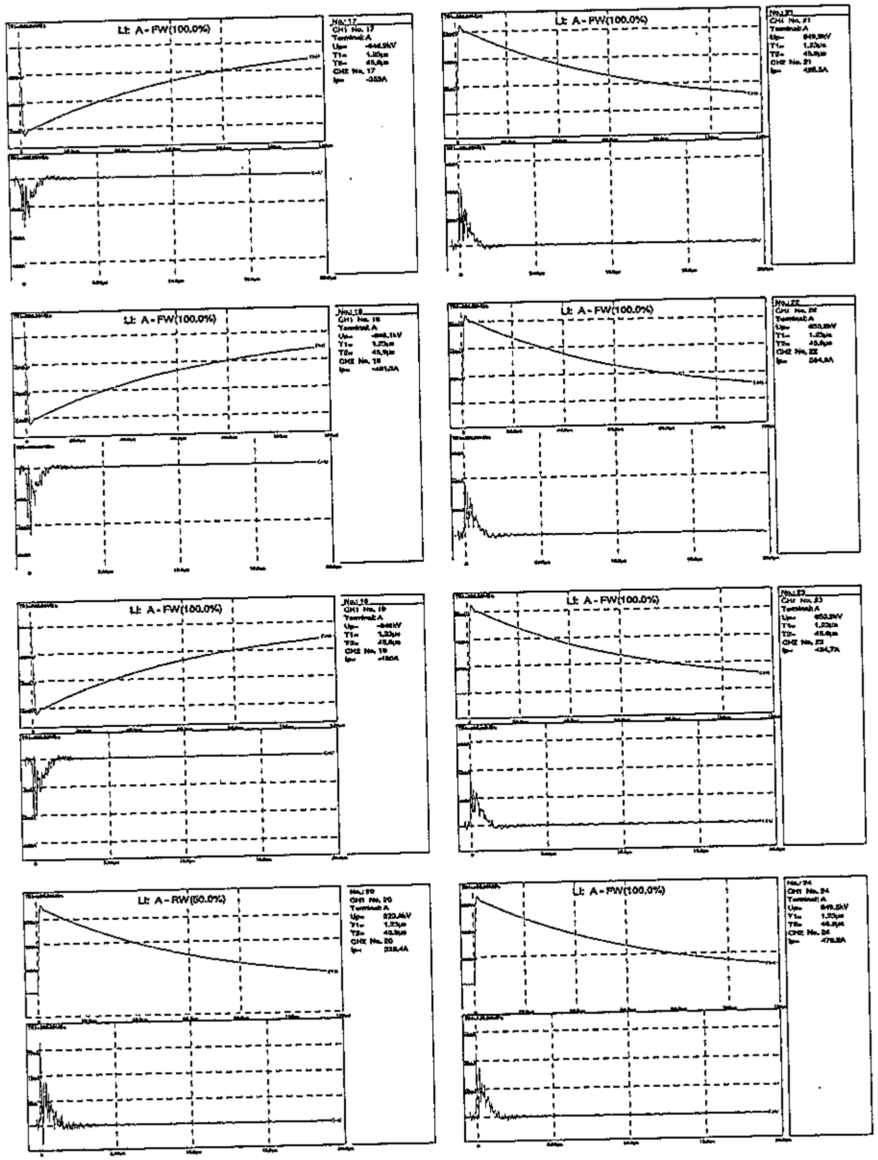

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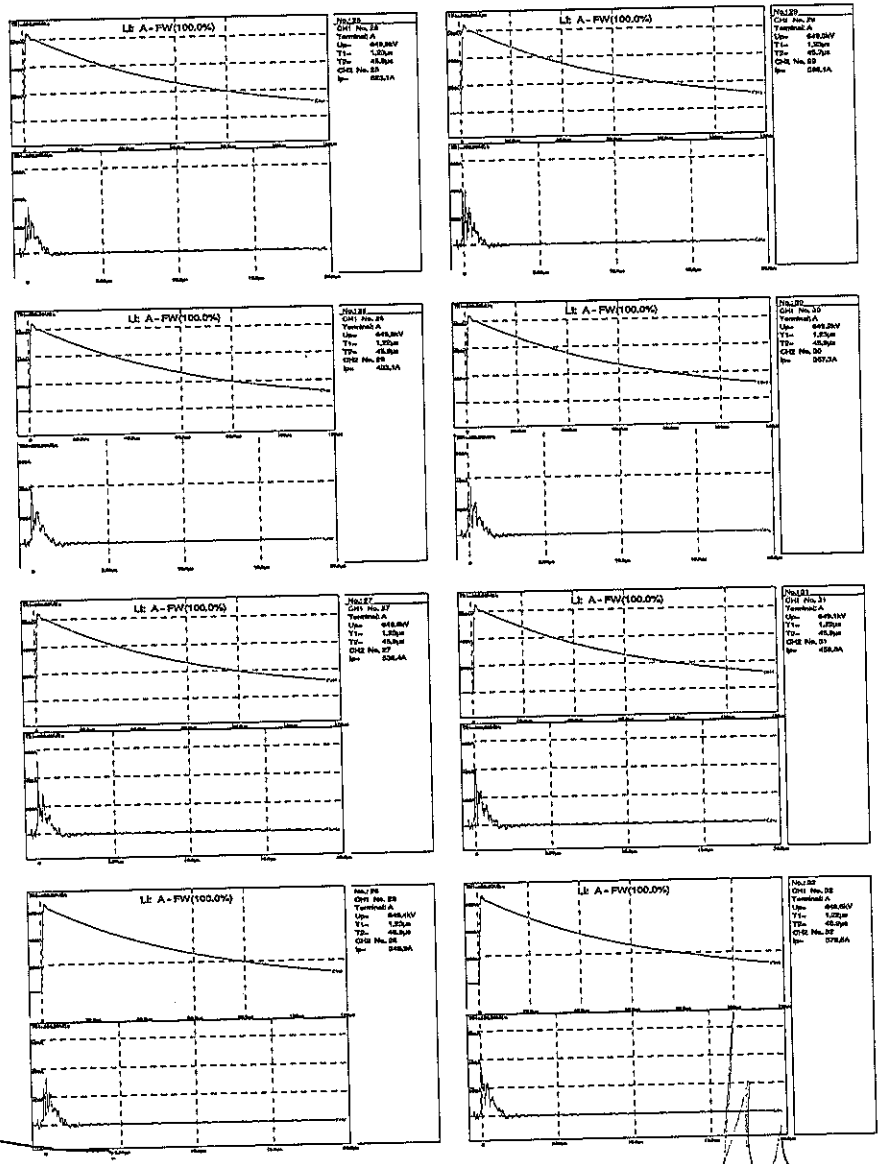

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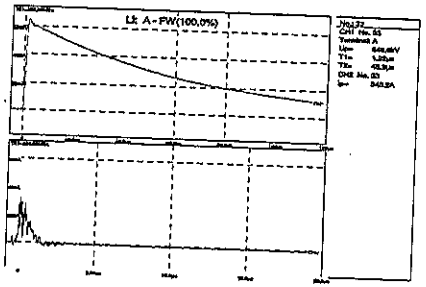

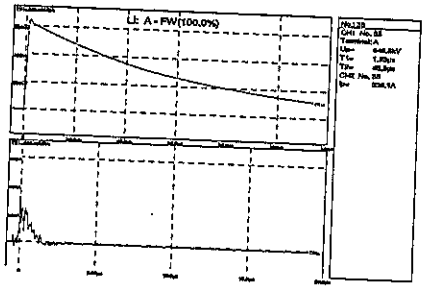

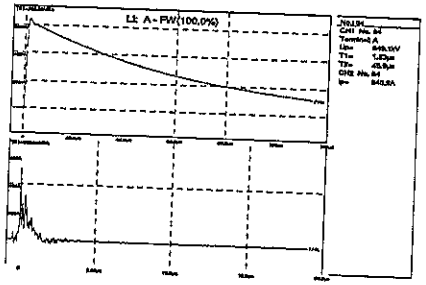

HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/109/E/15-1

**Impulse voltage withstand test on primary terminal,
chopped impulse voltage withstand test on primary terminal,
transmitted overvoltage test,
discharge capacitor test
of voltage instrument transformer type EMF-E123**

Warsaw, October 2015

TEST REPORT EWN/109/E/15-1

TEST OBJECT:	**Voltage instrument transformer type EMF-E123**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500678253 (15.09.2015)**
TEST TYPE:	**Impulse voltage withstand test on primary terminal,** **Chopped impulse voltage withstand test on primary terminal,** **Transmitted overvoltage test,** **Discharge capacitor test**
TEST PROCEDURE:	**According to:** **PN-EN/IEC 61869-1** **PN/EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**05.10.2015 – 14.10.2015**
TEST RESULT:	**POSITIVE - details are presented in following parts of report**

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

Warsaw, October 2015.

CONTENTS

Test report includes:

13 numbered pages;
4 figures;
1 photograph;
7 tables.

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

Annex 2: Reports of routine test and determination of errors (8 pages);

Annex 3: Lightning impulse test protocol (8 pages);

Annex 4: Transmitted overvoltage test protocol (4 pages);

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1 COMPETENCE OF THE LABORATORY

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

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

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

Note

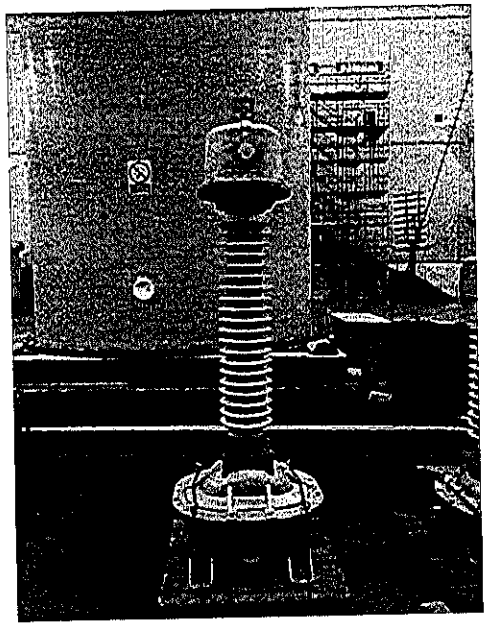
Tests described in sub-clauses 5.2 and 6.1 of this Report don't comply with the scope of Laboratory accreditation.

2 TEST OBJECT DESCRIPTION

The tested objects was instrument voltage transformer type EMF-E123 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 3 – EMF-E123
Serial number: 1HSE8851774

- Highest voltage for equipment 126 kV
- Rated primary voltage 115000 / √3 V
- Insulation level 230 / 550 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 248 kg



Phot. 1: Tested voltage transformer EMF-E123

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E123 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested object should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Impulse voltage withstand test on primary terminal	PN-EN/IEC 61869-1, p.7.2.3
SPECIAL TESTS		
2	Chopped impulse voltage test on primary terminal	PN-EN/IEC 61869-1, p.7.4.1
3	Transmitted overvoltage test	PN-EN/IEC 61869-1, p.7.4.4
ADDITIONAL TESTS		
4	Discharge capacitor test	C=6μF, U=1.1·√2·115/√3 No breakdown and temperature rise over 65 K.

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o. in the presence of a representative of the High Voltage Department of Institute of Power Engineering. Detailed results are presented in Annex 2.

Tests were carried out according to:

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

4 TYPE TEST

4.1 Impulse voltage withstand test on primary terminal

4.1.1 Method of testing and acceptance criteria

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

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

4.1.2 Test arrangement

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

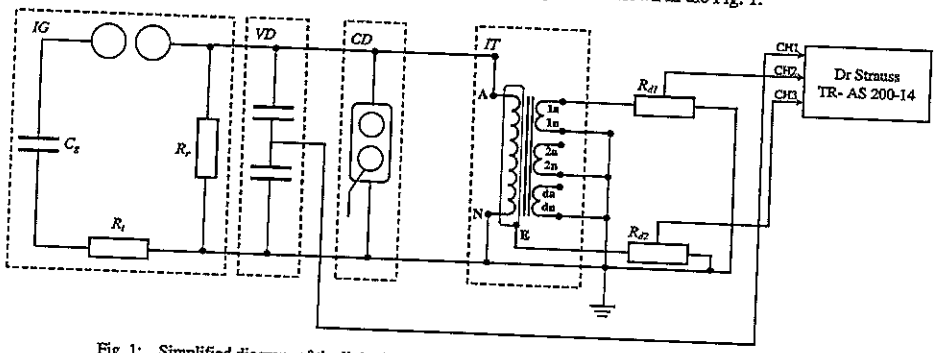


Fig. 1: Simplified diagram of the lightning impulse measurement system (for one step of the generator): *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; *CD* – chopping device; *IT* - instrument transformer (general schematic representation); R_{d1}, R_{d2} – detection resistance

4.1.3 Test conditions

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

Tab. 2: Parameters of the lightning impulse measurement system

IMPULSE GENERATOR			
Number of steps	n	-	5
General capacitance	C_g	μF	0,150
Discharge resistance	R_r	Ω	445
Damping resistance	R_t	Ω	160
VOLTAGE DIVIDER			
HV unit capacitance	C_u'	pF	~1200
LV unit capacitance	C_u''	μF	1,103
Scale factor	ϑ_V	-	927,0
DETECTION RESISTORS			
Detection resistance	R_{d1}	Ω	0,707
	R_{d2}	Ω	2,970

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

Full impulse test voltage	RW = 275 kV FW = 550 kV	
Chopped impulse test voltage	CRW = 316,25 kV CFW = 478,26 kV	
Sequence of impulses	Positive polarity 1 reduced full impulse (RW), 15 full impulses (FW).	Negative polarity 1 reduced full impulse (RW), 1 full impulse (FW), 1 reduced chopped impulse (CRW), 2 chopped impulses (CFW), 14 full impulses (FW).
Registration	Transients of test voltage (channel 1) Current flowing through secondary winding 1a-1n (channel 2) Current flowing through primary winding screen E (channel 3)	

4.1.4 Test results

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

TEST RESULT: POSITIVE

5 SPECIAL TESTS

5.1 Chopped impulse voltage withstand test on primary terminal

Chopped impulse test on the primary winding was combined with the negative polarity lightning impulse test. Detailed results of this test are presented in Section 4.1 and Annex 3 of this report.

TEST RESULT: POSITIVE

5.2 Transmitted overvoltage test

5.2.1 Method of testing and acceptance criteria

Transmitted overvoltage test was performed according to IEC 61869-3, IEC 61869-1 clause 7.4.4 and 6.11.4. During the test type „A" impulse (U_1) was applied between the primary terminal A and earth. Measurements of transmitted voltage (U_2) were carried out for all the secondary windings of the voltage instrument transformer.
It is considered that the instrument voltage transformer passed the test with a positive result if the value of the transmitted voltage (U_S) does not exceed 1,6 kV (IEC 61869-3 clause 6.11.4 Table 9).

5.2.2 Test arrangement

Arrangement for transmitted overvoltage measurement was based on one step of Marx impulse generator made by HAEFELY. Measurement of the voltage U_1 applied to the primary terminal of the instrument transformer was performed with impulse voltage measuring system Dr Strauss TR-AS 200-14, in connection with a resistive voltage divider Siemens SMR 10/770. The transmitted voltage U_2 measurement was also performed with impulse voltage measuring system Dr Strauss TR-AS 200-14. For both measured voltages U_1 and U_2 impulse peak value measuring uncertainty doesn't exceed 2% of the measured value for the confidence interval 95% and coverage factor k=2. Simplified diagram of the measurement system is shown in the Fig. 2.

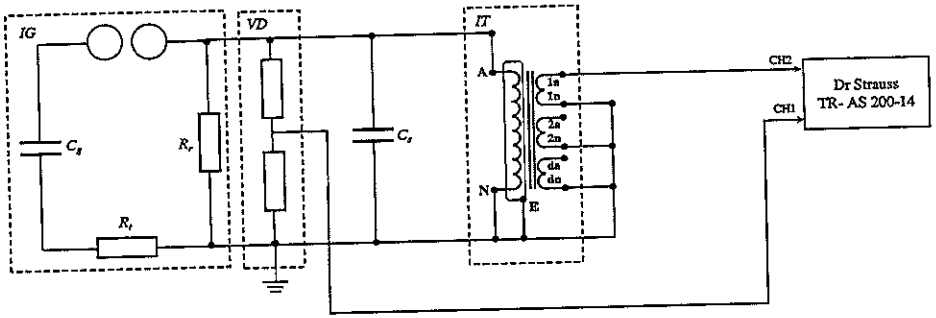


Fig. 2: Simplified diagram of the transmitted overvoltage measurement system *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; C_s – front shaping capacitor; *IT* - instrument transformer (general schematic representation);

5.2.3 Test conditions

Test conditions for transmitted overvoltage test (parameters of the measurement system and value of test voltage) are presented in Tab. 4. The influence of atmospheric condition on test voltage value was not taken into consideration.

Tab. 4: Parameters of the transmitted overvoltage measurement system and parameters of the test voltage

IMPULSE GENERATOR			
Number of steps	n	-	1
General capacitance	C_g	μF	0,750
Discharge resistance	R_r	Ω	150
Damping resistance	R_t	Ω	89
VOLTAGE DIVIDER			
HV unit resistance	R_u'	Ω	10098,96
LV unit resistance	R_u''	Ω	10,06
Scale factor	$\dot{U}_V$	-	1005
FRONT SHAPING CAPACITOR			
Front shaping capacitor	C_S	pF	500
PARAMETERS OF THE TEST VOLTAGE			
Peak value of applied voltage	U_1	kV	16,3
Conventional front time	T_1	μs	0,48
Time to half-value	T_2	μs	73

5.2.4 Test results

Results of the transmitted overvoltage measurement are presented in Tab. 5. The oscillograms of all applied and registered impulses are present in Annex 4 of hereby Report.

Tab. 5: Transmitted overvoltage measurement results

terminal	U_1	U_2	U_s	$U_{s\%}$
	kV	V	V	%
1a - 1n	16,29	129	1272,5	79,5
2a - 2n	16,27	135	1333,3	83,3
3a - 3n	16,25	133	1315,2	82,2
4a - 4n	16,32	111	1092,9	68,3
da - dn	16,27	88	869,1	54,3

Note:
U_1 – peak value of applied voltage
U_2 – maximal value of transmitted voltage
U_S – maximal value of transmitted voltage for specified overvoltage U_p
U_p – specified overvoltage $U_p=1,6 \cdot U_m \cdot \sqrt{2}/\sqrt{3}$
$U_{s\%}$ – percent of permissible overvoltage $U_{s\%}=U_s/1600 \cdot 100\%$

TEST RESULT: POSITIVE

6 ADDITIONAL TESTS

6.1 Discharge capacitor test

6.1.1 Method of testing and acceptance criteria

Discharge capacitor test was performed according to internal ABB specifications. Test consists of ten capacitor discharges. Before tests and before each discharge the resistance of winding was measured and rise of the temperature was calculated.. The discharges were performed at two-minute intervals (the shortest possible time required to complete measurements and charge the capacitor). In order to determine the cooling characteristics of the transformer additional measurements were performed (3 measurements of the resistance of winding performed within 15 minutes after the last discharge).

It is considered that the instrument voltage transformer passed the test with a positive result if:

- calculated rise of the temperature is less than 65 K;
- instrument transformer behavior during testing does not indicate any damages;
- there was no damage of instrument transformer after the test;
- metrological properties of instrument transformer after the test are comply assigned accuracy classes.

6.1.2 Test arrangement

Discharge capacitor test was carried out in a measuring system shown in the Fig. 3. For the measured arithmetic mean voltage values uncertainty in this system doesn't exceed 2% of the measured value for the confidence interval 95% and coverage factor k=2.

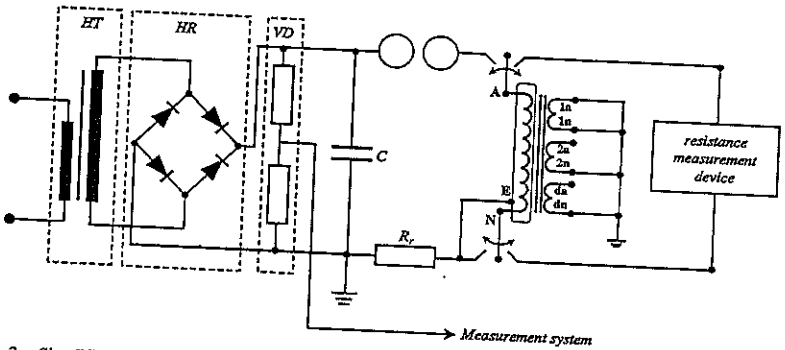


Fig. 3: Simplified diagram of the discharge capacitor measurement system: *HT* – high voltage transformer; *HR* – high voltage rectifier; *VD* – voltage divider; *C* – discharge capacitor; R_r – dumping resistance (R_r=14,5 Ω);

6.1.3 Test conditions

Test conditions for discharge capacitor test are presented in Tab. 6.

Tab. 6: Test conditions for discharge capacitor test

Ambient temperature	°C	6,1
Air pressure	hPa	1013
Relative humidity	%	50,0
Winding temperature	°C	6,1±1
Test voltage	kV	$1,1 \cdot 115 \cdot \sqrt{2}/\sqrt{3} = 103,3$
Capacitance	μF	6

6.1.4 Test results

Results of the discharge capacitor test are presented in Tab. 7.

Tab. 7: Rise of the temperature during discharge capacitor test

t	min	0	2	4	6	8	10	12	14	16	18	20	22	24	26
R	Ω	13040	13190	13360	13470	13620	13740	13880	13990	14100	14200	14310	14230	14190	14160
ΔR	Ω	0	150	320	430	580	700	840	950	1060	1160	1270	1190	1150	1120
ΔT	°C	0,0	2,9	6,1	8,0	10,8	12,8	15,3	17,1	18,9	20,6	22,4	20,8	20,2	19,7

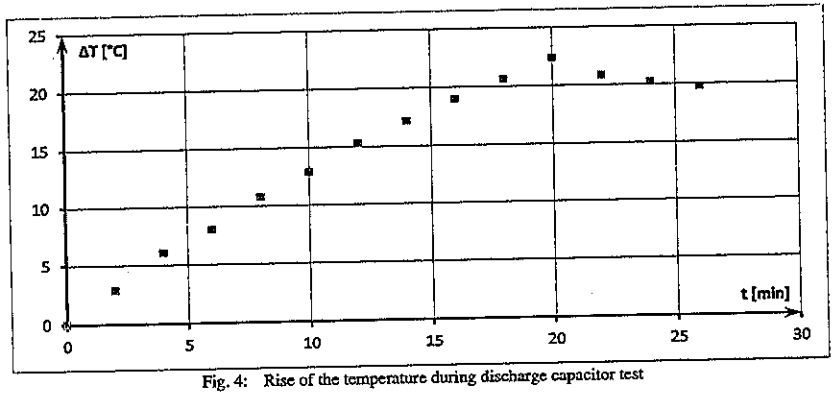


Fig. 4: Rise of the temperature during discharge capacitor test

TEST RESULT: POSITIVE

ANNEX 1 for test report EWN/109/E/15-1

(3 pages)

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

- Declaration of conformity – No. 100/2015 (EN),
- Rating plate – Document No. 1HSE 22040-PCC,
- Technical drawing – Document id. 1HSE8851774.

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

DECLARATION OF CONFORMITY No. 100/2015 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E123

Above mentioned product comforms with the following standard :

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

Additional information:
Serial numbers: **1HSE 8851774;**

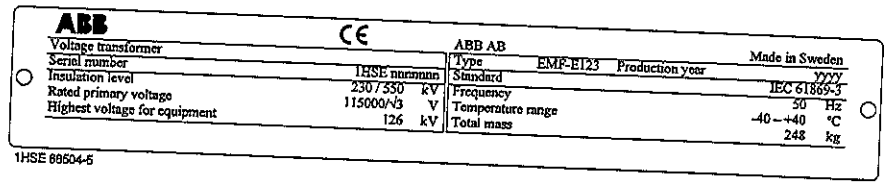
Place and date of issue of declaration

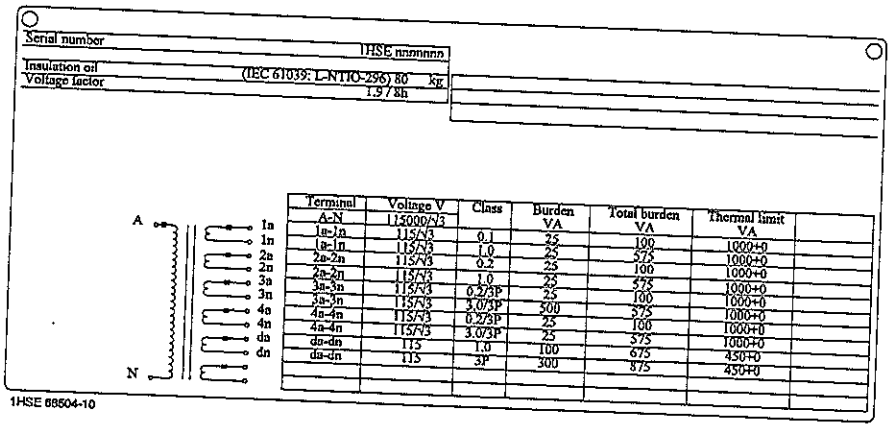
Przasnysz 05.10.2015

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

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

(Name) (Signature)



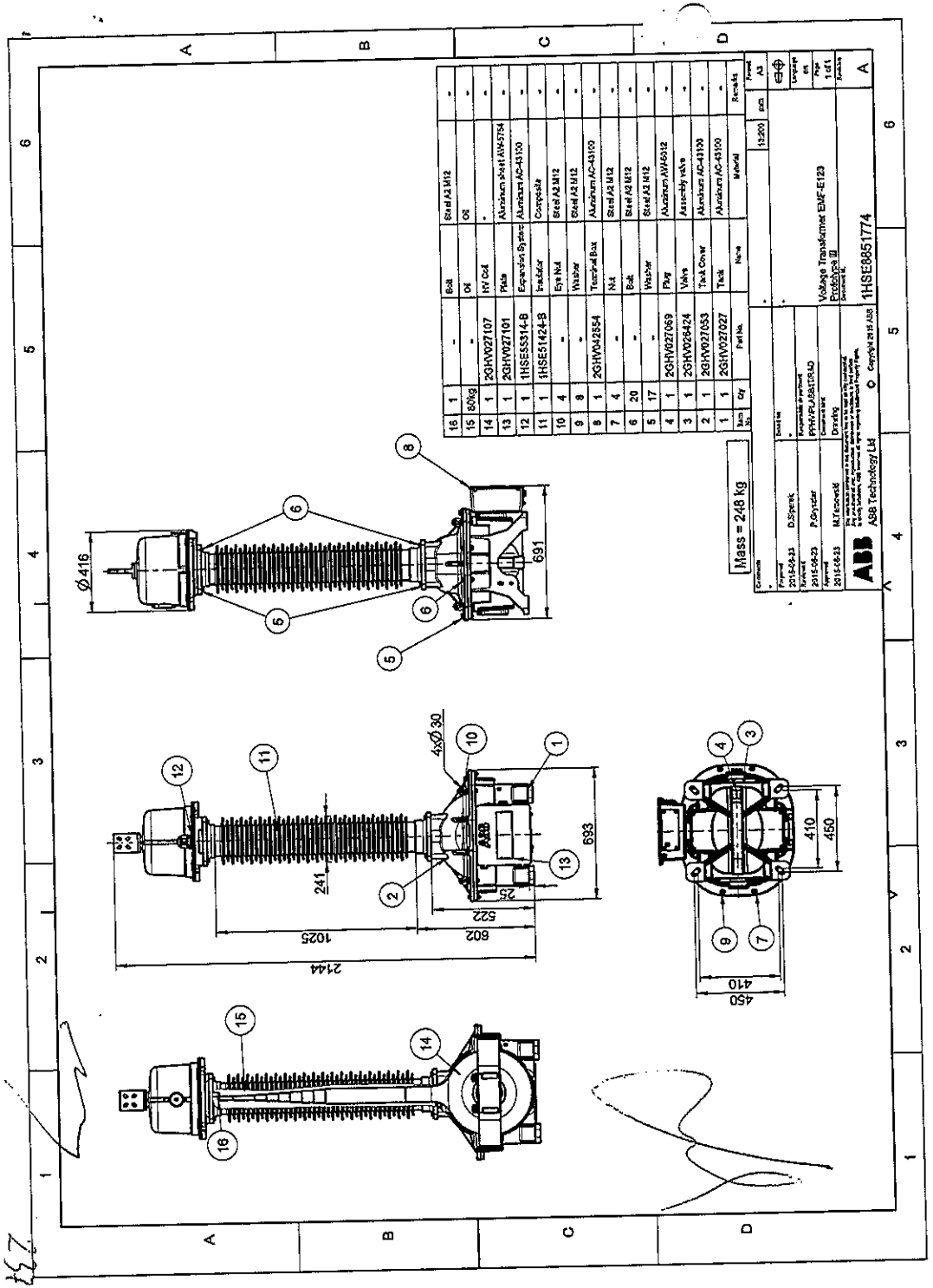


Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA	
A-N	115000/√3					
1a-1n	115/√3	0.1	25	100	1000+0	
1a-1n	115/√3	1.0	25	575	1000+0	
2a-2n	115/√3	0.2	25	100	1000+0	
2a-2n	115/√3	1.0	25	575	1000+0	
3a-3n	115/√3	0.2/3P	25	100	1000+0	
3a-3n	115/√3	3.0/3P	500	575	1000+0	
4a-4n	115/√3	0.2/3P	25	100	1000+0	
4a-4n	115/√3	3.0/3P	25	575	1000+0	
da-dn	115	1.0	100	675	450+0	
da-dn	115	3P	300	875	450+0	

Serial number 1HSE nnnnnnn = 1HSE 8851774

Production year yyyy = Actual year for production

Prepared		Responsible department	Title	
Gustaf Högberg	2015-06-18	PPHC/IM	Rating plate	
Approved		Take over department		Language
Björn Sjöström	2015-06-18			en
Revision			Order No.	Sheet
B Data changed. 2015-10-07			E90000012-30	1
ABB AB			Document No.	Last
			1HSE 22040-PCC	1



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

ANNEX 2 for test report EWN/109/E/15-1

(8 pages)

Reports of routine test and determination of errors:

- Routine test report of voltage instrument transformer EMF-123 (1HSE8851774),
- Routine test report of voltage instrument transformer EMF-123 (1HSE8851774) after lightning impulse,

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine test report of voltage instrument transformer	TYPE: EMF-E123 Serial no: 1HSE8851774	
A-N 115:√3 kV	126/230/550 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1000
1a - 1n	0,115:√3	25	1,0	1000
2a - 2n	0,115:√3	25	0,2	1000
2a - 2n	0,115:√3	25	1,0	1000
3a - 3n	0,115:√3	25	0,2/3P	1000
3a - 3n	0,115:√3	500	3,0/3P	1000
4a - 4n	0,115:√3	25	0,2/3P	1000
4a - 4n	0,115:√3	25	3,0/3P	1000
da - dn	0,115	100	1,0	450
da - dn	0,115	300	3P	450

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings – A: Up = 230kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings ☑
7. Determination of errors – Up = 3 kV/60s ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC 60247

  Tg δ = 0.1653 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156

  Mean breakdown voltage = 81.75 kV, Relative standard deviation = 3.82 %;

  f = 50Hz, oil temp. = 25 °C, measurement without the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	82.5
2	80.2
3	81.3
4	87.5
5	78.4
6	80.6

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

Date of measurement: 2015-10-01

Ambient temperature: 24 +/-

Relative air humidity: 28 +/-

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.094	-0.092	-0.092
Δφ U	2.2	2.2	2.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.052	-0.050	-0.050
Δφ U	1.8	1.8	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.109	-0.108	-0.107
Δφ U	2.0	2.0	2.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.068	-0.067	-0.066
Δφ U	1.6	1.6	1.7

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.249	-0.176	-0.092	-0.090	-0.090	-0.181
Δφ U	2.6	1.7	1.7	1.7	1.7	0.1

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.213	-0.144	-0.059	-0.057	-0.057	-0.149
Δφ U	2.3	1.6	1.5	1.5	1.6	-0.0

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.282	-0.206	-0.118	-0.116	-0.116	-0.211
Δφ U	2.7	1.9	2.0	2.0	2.0	0.3

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.233	-0.161	-0.072	-0.071	-0.070	-0.165
Δφ U	2.2	1.5	1.5	1.6	1.6	-0.1

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.019	-0.017	-0.017
Δφ U	2.3	2.4	2.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.041	-0.039	-0.039
Δφ U	3.3	3.3	3.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.002	0.003	0.003
Δφ U	2.9	2.9	2.9

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.052	-0.050	-0.050
Δφ U	3.2	3.2	3.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.010	-0.009	-0.008
Δφ U	2.8	2.8	2.9

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.193	-0.120	-0.037	-0.035	-0.035	-0.124
Δφ U	3.8	3.0	2.8	2.8	2.9	1.4

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.156	-0.089	-0.004	-0.002	-0.002	-0.092
Δφ U	3.7	2.9	2.7	2.7	2.7	1.3

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.227	-0.151	-0.063	-0.061	-0.061	-0.155
Δφ U	3.9	3.2	3.1	3.2	3.2	1.6

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.185	-0.106	-0.017	-0.015	-0.015	-0.110
Δφ U	3.6	2.8	2.7	2.7	2.8	1.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.218	0.220	0.220
Δφ U	3.0	3.0	3.0

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

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

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

Date of measurement: 2015-10-01
Ambient temperature: 24 +/-
Relative air humidity: 28 +/-

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.427	-0.425	-0.426
Δφ U	-4.68	-4.62	-4.60

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.385	-0.383	-0.384
Δφ U	-5.09	-5.04	-5.03

2a-2n: 25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.444	-0.442	-0.442
Δφ U	-5.19	-5.13	-5.12

2a-2n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.402	-0.401	-0.401
Δφ U	-5.57	-5.53	-5.51

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-1.076	-0.999	-0.913	-0.913	-0.913	-0.16
Δφ U	5.61	4.81	5.03	5.14	5.19	0.18

3a-3n: 125 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.426	-0.352	-0.268	-0.266	-0.266	-0.513
Δφ U	3.01	2.26	2.44	2.47	2.49	-2.44

4a-4n: 25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.648	-0.570	-0.478	-0.477	-0.476	-0.731
Δφ U	-5.88	-6.60	-6.18	-6.10	-6.09	-11.49

4a-4n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.602	-0.522	-0.432	-0.429	-0.428	-0.685
Δφ U	-6.18	-6.88	-6.60	-6.54	-6.51	-11.91

da-dn: 300 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA; 4a-4n: p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.970	-0.892	-0.802	-0.822
Δφ U	-2.67	-3.4	-3.01	-2.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.041	-0.039	-0.039
Δφ U	3.3	3.3	3.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.002	0.003	0.003
Δφ U	2.9	2.9	2.9

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.052	-0.050	-0.050
Δφ U	3.2	3.2	3.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.010	-0.009	-0.008
Δφ U	2.8	2.8	2.9

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-1.02	-0.943	-0.856	-0.854	-0.854	-1.10
Δφ U	6.9	6.02	6.15	6.24	6.29	1.42

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.370	-0.296	-0.212	-0.210	-0.210	-0.454
Δφ U	4.39	3.54	3.60	3.63	3.67	-1.26

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.227	-0.151	-0.063	-0.061	-0.061	-0.155
Δφ U	3.9	3.2	3.1	3.2	3.2	1.6

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.185	-0.106	-0.017	-0.015	-0.015	-0.110
Δφ U	3.6	2.8	2.7	2.7	2.8	1.2

da-dn: 75 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.0549	0.0222	0.112	0.0969
Δφ U	4.41	3.50	3.69	3.96

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

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

Partial discharge measurement

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

Stress voltage: 230 kV / 60 s
Frequency: 120 Hz

Test voltage	1,2 Um = 151.2 kV	1,2 Um / √3 = 87.2 kV
Level of partial discharge	0.6 pC	0.6 pC

Remarks: background noise level: 0.6 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating charge).

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 25 °C, Frequency: 50

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.2	217	0.735
66.4 kV	0.2	217	4.567
72.7 kV	0.2	217	4.97

Measurement of windings' resistance

	R (26 °C)	Rct (75 °C)
A-N	13.50 kΩ	16.100 kΩ
1a-1n	79.600 mΩ	94.929 mΩ
2a-2n	78.100 mΩ	93.140 mΩ
3a-3n	51.600 mΩ	61.537 mΩ
4a-4n	50.500 mΩ	60.225 mΩ
da-dn	148.900 mΩ	177.574 mΩ

Checked by: I. Krawczyk

Przasnysz, 2015-10-01

OG-4 KJ-58

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

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59	Routine test report of voltage instrument transformer after lighting impulse		TYPE: EMF-E123 Serial no: 1HSE8851774	
A-N 115:√3 kV	126/230/550 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,115:√3	25	0,1	1000
1a - 1n	0,115:√3	25	1,0	1000
2a - 2n	0,115:√3	25	0,2	1000
2a - 2n	0,115:√3	25	1,0	1000
3a - 3n	0,115:√3	25	0,2/3P	1000
3a - 3n	0,115:√3	500	3,0/3P	1000
4a - 4n	0,115:√3	25	0,2/3P	1000
4a - 4n	0,115:√3	25	3,0/3P	1000
da - dn	0,115	100	1,0	450
da - dn	0,115	300	3P	450

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings - A: Up = 184kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC 60247
  Tg δ = 0.1653 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.
- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 81.75 kV, Relative standard deviation = 3.82 %;
  f = 50Hz, oil temp. = 25 °C, measurement without the stirrer, type of electrodes used: partially spherical

Sample	Breakdown voltage [kV]
1	82.5
2	80.2
3	81.3
4	87.5
5	78.4
6	80.6

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

Date of measurement: 2015-11-10
Ambient temperature: 24 +/- 2°C
Relative air humidity: 28 +/- 10%

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.098	-0.098	-0.096
Δφ U	2.1	2.1	2.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.056	-0.054	-0.054
Δφ U	1.7	1.7	1.7

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.108	-0.107	-0.106
Δφ U	2.0	2.0	2.0

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.067	-0.066	-0.065
Δφ U	1.6	1.6	1.6

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.253	-0.180	-0.095	-0.094	-0.094	-0.186
Δφ U	2.2	1.5	1.5	1.6	1.6	0.0

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.222	-0.149	-0.063	-0.061	-0.061	-0.153
Δφ U	2.0	1.4	1.4	1.4	1.5	-0.1

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.282	-0.203	-0.117	-0.116	-0.115	-0.208
Δφ U	2.0	1.5	1.7	1.8	1.8	-0.0

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.245	-0.163	-0.074	-0.072	-0.072	-0.169
Δφ U	1.8	1.3	1.4	1.4	1.4	-0.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.040	0.042	0.042
Δφ U	2.4	2.4	2.4

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.044	-0.043	-0.042
Δφ U	3.2	3.2	3.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.002	-0.001	-0.000
Δφ U	2.8	2.8	2.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.054	-0.053	-0.052
Δφ U	3.1	3.1	3.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.013	-0.011	-0.011
Δφ U	2.7	2.7	2.8

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.199	-0.126	-0.040	-0.039	-0.038	-0.131
Δφ U	3.5	2.8	2.7	2.8	2.8	1.3

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.164	-0.093	-0.007	-0.006	-0.005	-0.097
Δφ U	3.4	2.7	2.6	2.6	2.7	1.1

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.232	-0.152	-0.062	-0.060	-0.060	-0.151
Δφ U	3.5	2.9	2.9	3.0	3.0	1.2

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.195	-0.111	-0.021	-0.019	-0.019	-0.114
Δφ U	3.2	2.6	2.6	2.7	2.7	1.0

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.219	0.221	0.221
Δφ U	2.7	2.8	2.8

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

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

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

Date of measurement: 2015-11-10
Ambient temperature: 24 +/- 2°C
Relative air humidity: 28 +/- 10%

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.432	-0.431	-0.430
Δφ U	-4.9	-4.9	-4.9

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.390	-0.389	-0.389
Δφ U	-5.3	-5.3	-5.3

2a-2n: 25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.450	-0.449	-0.448
Δφ U	-5.4	-5.4	-5.4

2a-2n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.409	-0.408	-0.408
Δφ U	-5.8	-5.8	-5.8

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-1.088	-1.015	-0.926	-0.925	-0.926	-1.169
Δφ U	5.5	4.9	4.9	4.9	5.0	0.0

3a-3n: 125 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.436	-0.359	-0.273	-0.272	-0.272	-0.514
Δφ U	3.0	2.3	2.3	2.3	2.4	-2.7

4a-4n: 25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.641	-0.568	-0.475	-0.474	-0.474	-0.729
Δφ U	-6.1	-6.8	-6.6	-6.5	-6.5	-12.0

4a-4n: 6.25 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.604	-0.526	-0.434	-0.433	-0.433	-0.687
Δφ U	-6.4	-7.0	-6.9	-6.8	-6.8	-12.3

da-dn: 300 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 25VA; 3a-3n: 500VA; 4a-4n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.907	-0.822	-0.727	-0.737
Δφ U	-5.1	-5.7	-5.4	-5.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.044	-0.043	-0.042
Δφ U	3.2	3.2	3.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.002	-0.001	-0.000
Δφ U	2.8	2.8	2.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.054	-0.053	-0.052
Δφ U	3.1	3.1	3.2

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.013	-0.011	-0.011
Δφ U	2.7	2.7	2.8

3a-3n: 500 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-1.038	-0.957	-0.868	-0.866	-0.866	-1.104
Δφ U	7.1	6.2	6.1	6.1	6.2	1.1

3a-3n: 125 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 4a-4n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.378	-0.304	-0.218	-0.216	-0.216	-0.458
Δφ U	4.4	3.7	3.5	3.5	3.6	-1.5

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.232	-0.152	-0.062	-0.060	-0.060	-0.311
Δφ U	3.5	2.9	2.9	3.0	3.0	-2.5

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

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.195	-0.111	-0.021	-0.019	-0.019	-0.274
Δφ U	3.2	2.6	2.6	2.7	2.7	-2.8

da-dn: 75 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA; 3a-3n: 0 VA; 4a-4n: 0 VA

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.050	0.035	0.128	0.113
Δφ U	3.7	3.0	3.1	3.3

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

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

Partial discharge measurement

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

Stress voltage: 184 kV / 60 s
Frequency: 120 Hz

Test voltage	1,2 Um = 151.2 kV	1,2 Um / √3 = 87.2 kV
Level of partial discharge	0.6 pC	0.6 pC

Remarks: background noise level: 0.6 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 25 °C, Frequency: 50

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.2	217	0.71
66.4 kV	0.2	217	4.634
72.7 kV	0.21	217	4.844

Measurement of windings' resistance

	R (23 °C)	Rct (75 °C)
A-N	13.30 kΩ	16.018 kΩ
1a-1n	77.900 mΩ	93.820 mΩ
2a-2n	76.100 mΩ	91.652 mΩ
3a-3n	50.200 mΩ	60.459 mΩ
4a-4n	49.530 mΩ	59.652 mΩ
da-dn	146.100 mΩ	175.957 mΩ

Checked by: J. Krawczyk

OG-4 KJ-58

Przasnysz, 2015-11-10

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

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HIGH VOLTAGE LABORATORY
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ANNEX 3 for test report EWN/109/E/15-1

(8 pages)

Lightning impulse test protocol:

- ewn109e15-1a

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Próba udarem uciętym 1,2/50us

project : ewn109e15-1a test date 05-10-2015

Test - object - data

WNR	EWN/109/E/15-1a	TR-No. 1HSE8851774	O.-No. 4500678253	
test object	EMF-E123		vector group	-
output	-	kVA	BIL	550
voltage	123	kV	frequency	50 Hz
customer	ABB Sp. z o. o. ul. Zeganska 1, 04-713 Warszawa			

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Próba udarem uciętym 1,2/50us

project : ewn109e15-1a

LI lightning-impulse no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
1	-276.3	1.15	44.8		-264.6	LI: A - RW(50.0%)
2	-550.7	1.16	45		-212.1	LI: A - FW(100.0%)
3	-317.9	1.16		3.59	682.2	LI: A - CRW(57.5%)
4	-632.6	1.17		3.45	-1460	LI: A - CFW(115.0%)
5	-632.2	1.17		3.58	-1450	LI: A - CFW(115.0%)
6	-550	1.17	45.1		-216.1	LI: A - FW(100.0%)
7	-549.8	1.17	45.1		-188.6	LI: A - FW(100.0%)
8	-550	1.16	45.1		-216.6	LI: A - FW(100.0%)
9	-550.3	1.17	45.1		-207.8	LI: A - FW(100.0%)
10	-550.3	1.17	45.1		-213.7	LI: A - FW(100.0%)
11	-550.6	1.16	45.1		-235	LI: A - FW(100.0%)
12	-550.3	1.17	45.1		-195.6	LI: A - FW(100.0%)
13	-550	1.17	45.1		-197.2	LI: A - FW(100.0%)
14	-550.2	1.17	45.1		-204	LI: A - FW(100.0%)
15	-550.3	1.16	45.1		-220.5	LI: A - FW(100.0%)
16	-550.4	1.17	45.1		-198.6	LI: A - FW(100.0%)
17	-550.5	1.17	45.2		-185.1	LI: A - FW(100.0%)
18	-550.5	1.16	45.2		-205.7	LI: A - FW(100.0%)
19	-550.2	1.16	45.2		-205	LI: A - FW(100.0%)
20	277.2	1.16	45		257	LI: A - RW(50.0%)
21	553	1.16	45.1		271.5	LI: A - FW(100.0%)
22	553	1.16	45.1		303.3	LI: A - FW(100.0%)
23	552.9	1.16	45.1		319.5	LI: A - FW(100.0%)
24	552.8	1.16	45.1		322.7	LI: A - FW(100.0%)
25	552.8	1.16	45.2		341.5	LI: A - FW(100.0%)
26	552.6	1.16	45.2		310.1	LI: A - FW(100.0%)
27	552.6	1.16	45.2		298.8	LI: A - FW(100.0%)
28	552.6	1.16	45.2		347.1	LI: A - FW(100.0%)
29	552.6	1.16	45.2		266.8	LI: A - FW(100.0%)
30	552.5	1.16	45.2		351.4	LI: A - FW(100.0%)
31	552.5	1.16	45.2		279.2	LI: A - FW(100.0%)
32	552.3	1.16	45.2		268.9	LI: A - FW(100.0%)
33	552.5	1.16	45.2		329.4	LI: A - FW(100.0%)
34	552.3	1.16	45.2		365.3	LI: A - FW(100.0%)
35	552.3	1.16	45.2		361.7	LI: A - FW(100.0%)

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Próba udarem uciętym 1,2/50us

project : ewn109e15-1a

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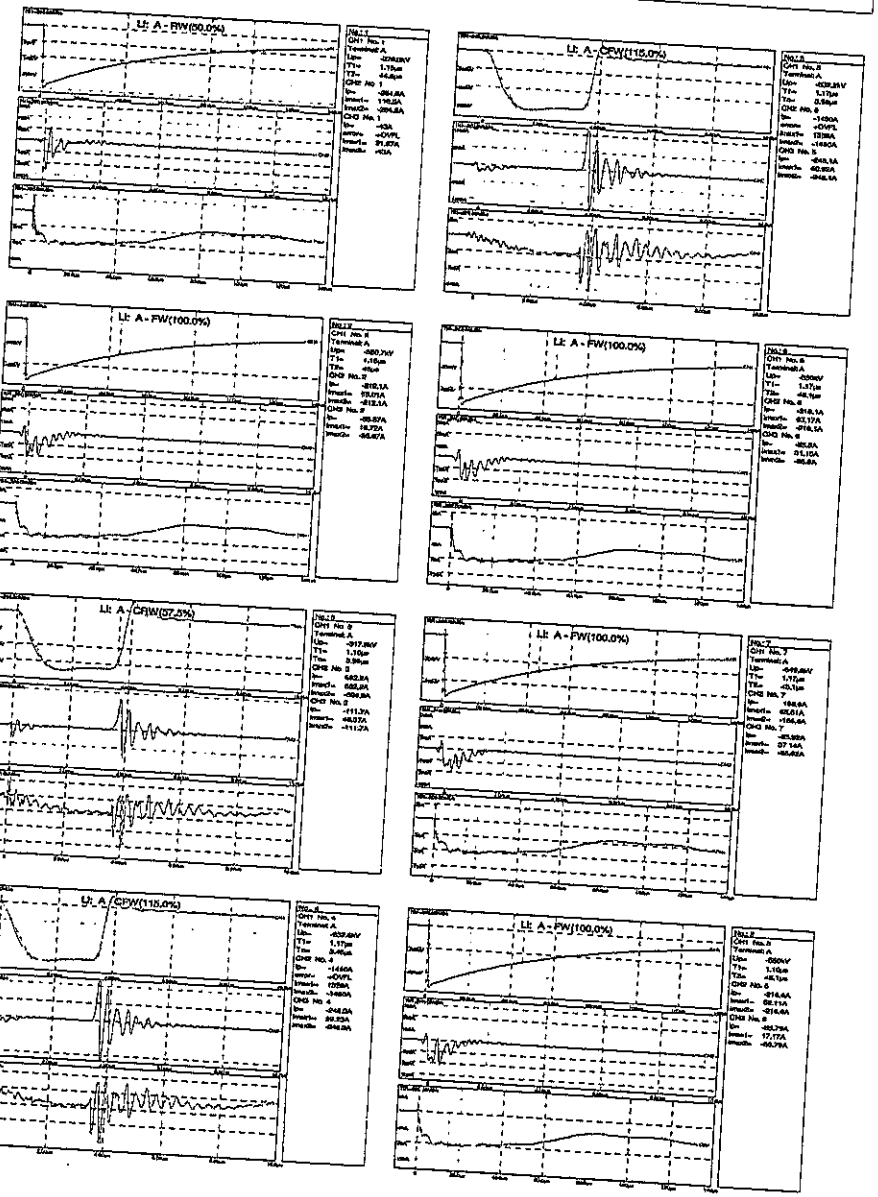
Próba udarem uciętym 1,2/50us

project : ewn109e15-1a



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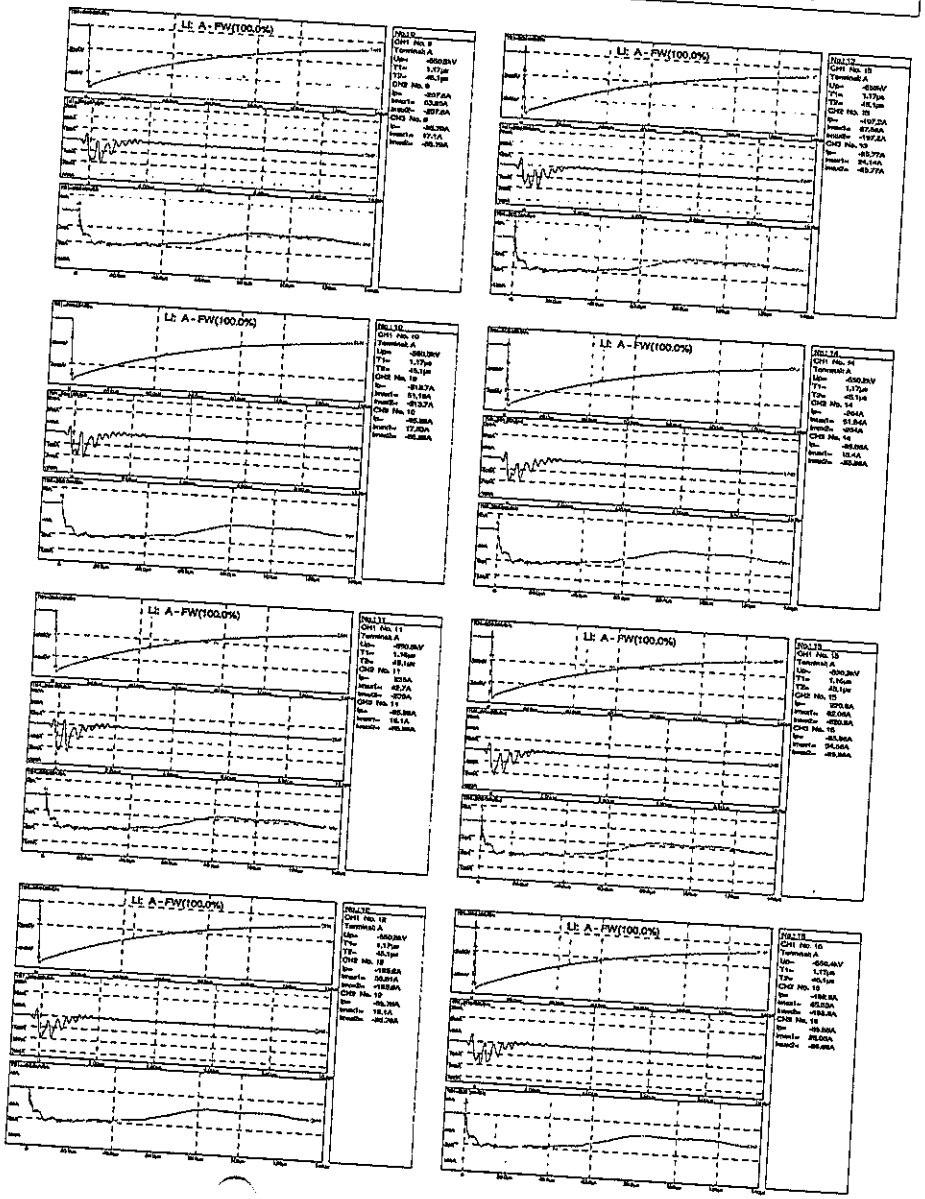

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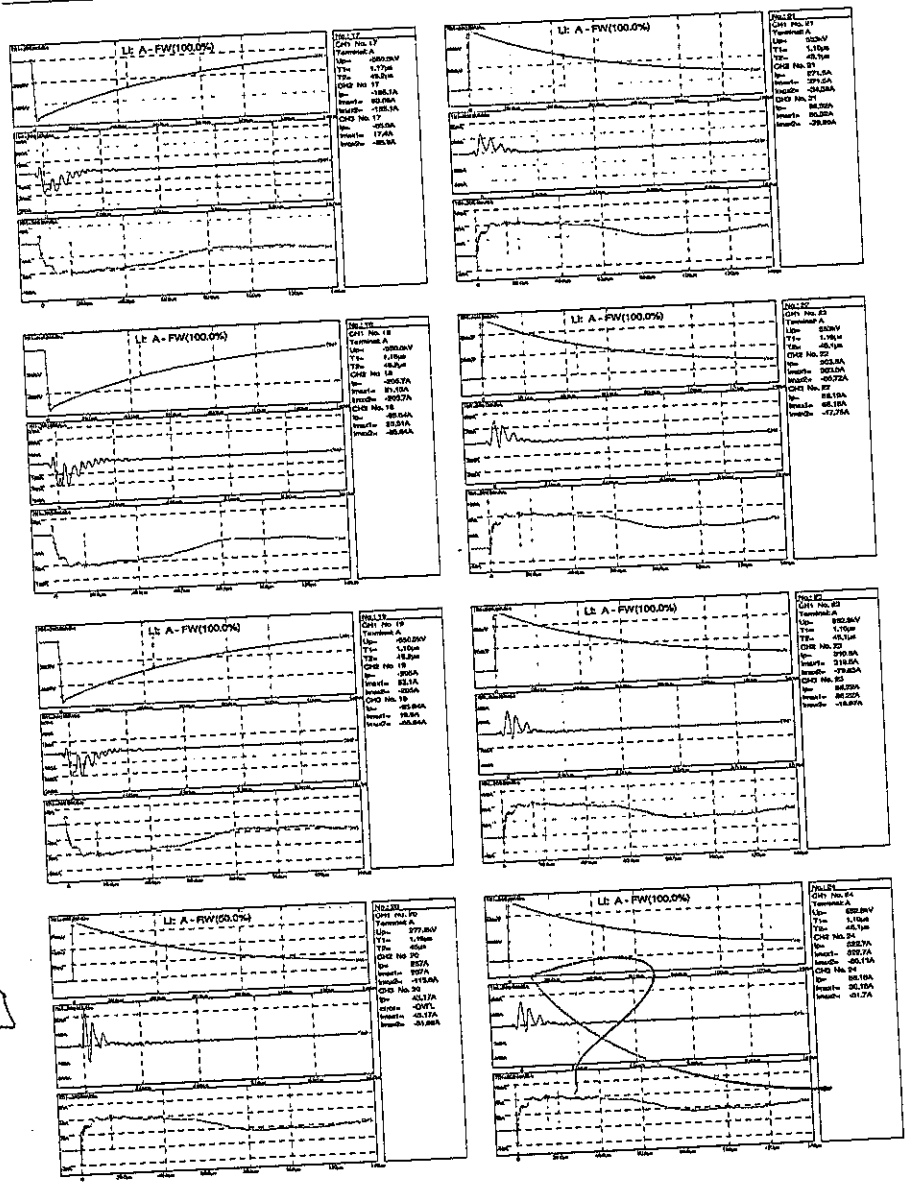

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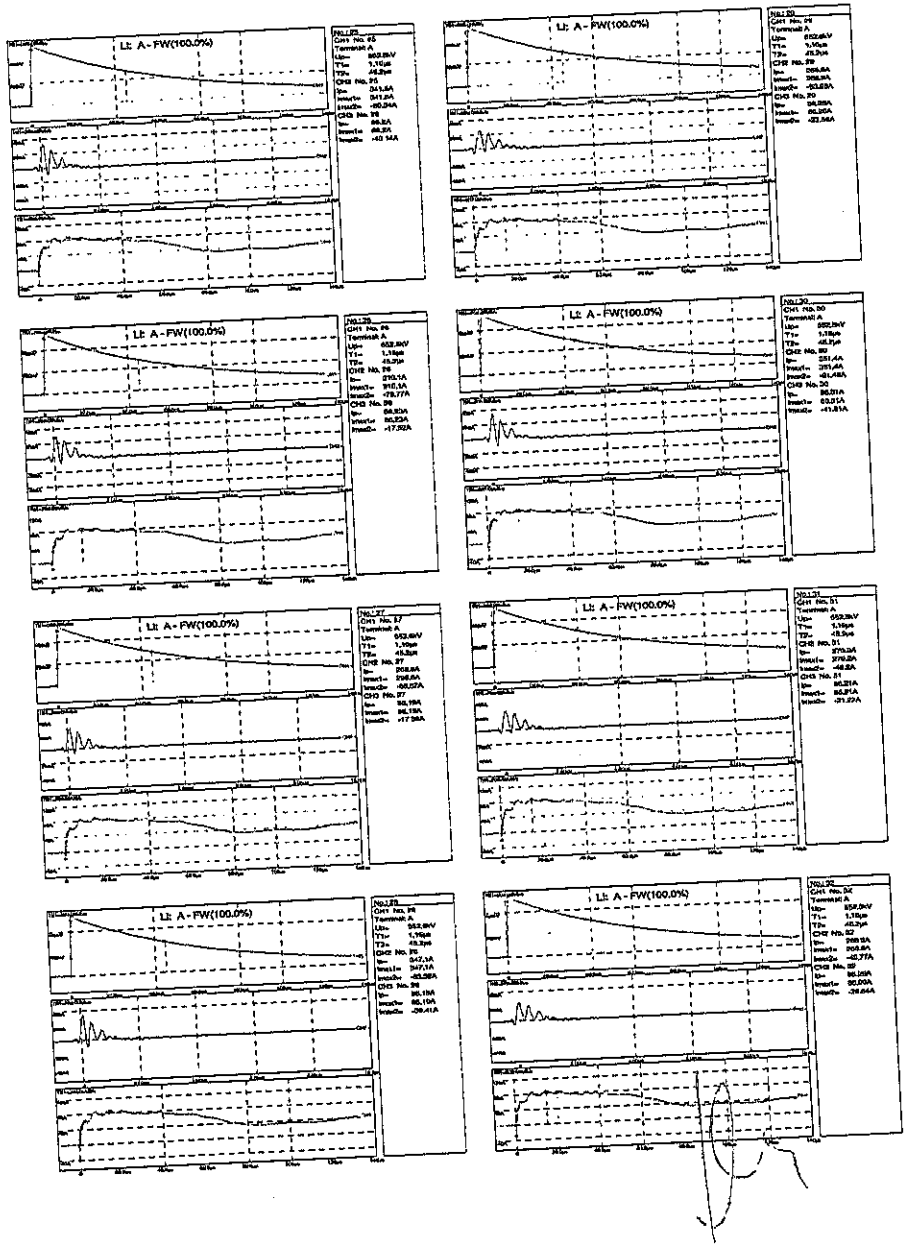

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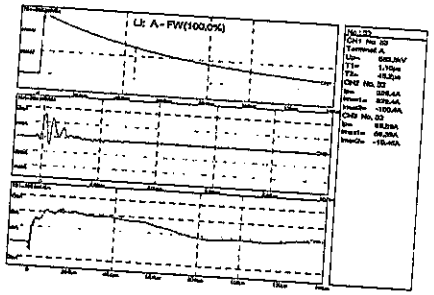
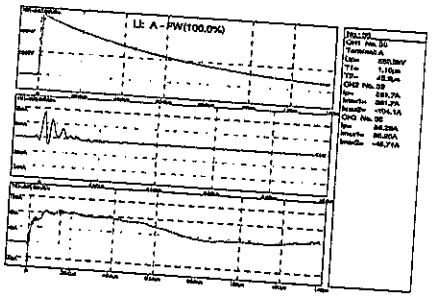
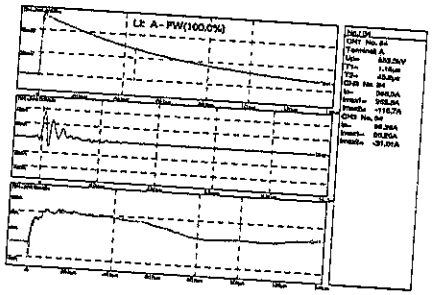
Próba udarem uciętym 1,2/50us

project : ewn109e15-1a







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

ANNEX 4 for test report EWN/109/E/15-1

(8 pages)

Transmitted overvoltage test protocol:

- ewn109e15-1b

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

Test - object - data

test date	07-10-2015
factory ser.-no.	1HSE8851774
test object	EMF-E123
order-no.	4500678253
specification	
test-field	

Climate - Data

temperature	9.1 °C	humidity	49 %
		air-pressure	1007 hPa

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LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Up [V]	remark
1	16.29	0.48	72.6		-129.6	1a - 1n
2	16.29	0.48	72.6		-129.6	1a - 1n zoom
3	16.27	0.48	72.5		-135.7	2a - 2n
4	16.27	0.48	72.5		-135.7	2a - 2n zoom
5	16.25	0.48	72.7		-133.6	3a - 3n
6	16.25	0.48	72.7		-133.6	3a - 3n zoom
7	16.32	0.48	72.2		-111.3	4a - 4n
8	16.32	0.48	72.2		-111.3	4a - 4n zoom
9	16.27	0.48	72.6		-88.33	da - dn
10	16.27	0.48	72.6		-88.33	da - dn zoom

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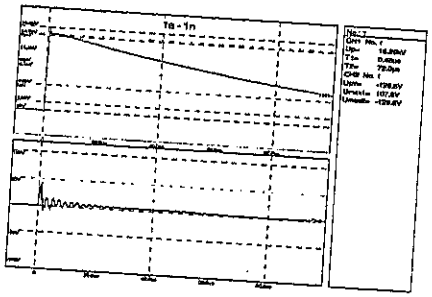
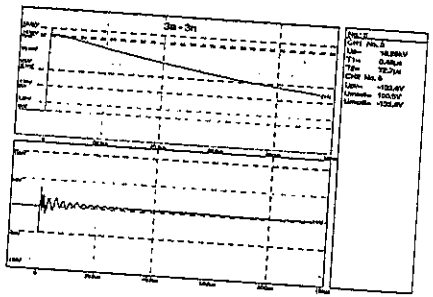
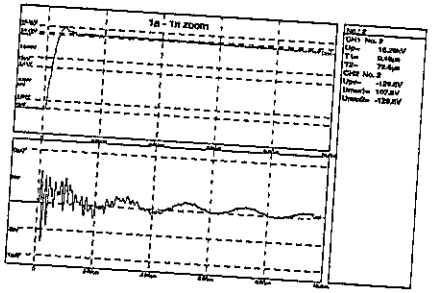
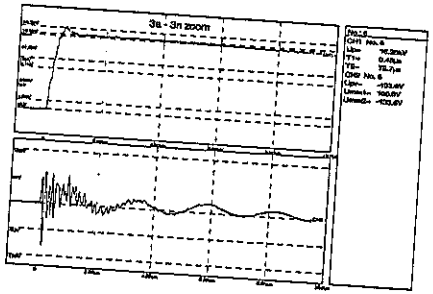
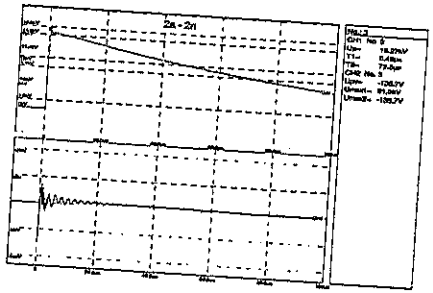
project : ewn109e15-1b

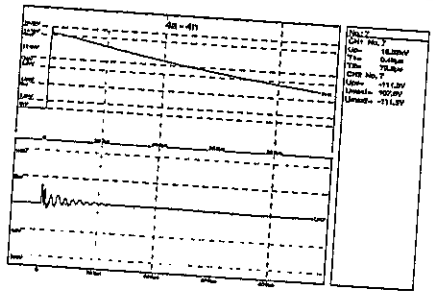


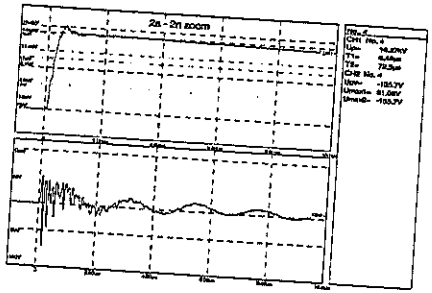


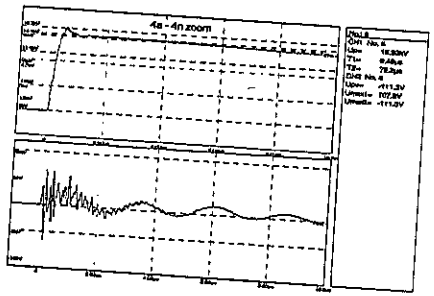












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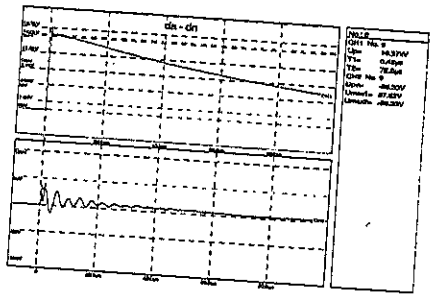
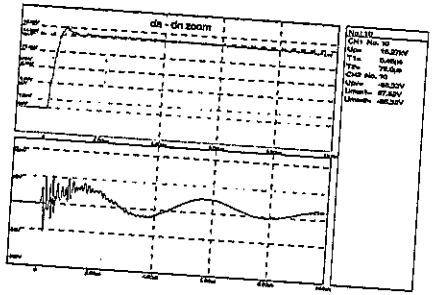
project : ewn109e15-1b





HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/109/E/15-2

Impulse voltage withstand test on primary terminal,
chopped impulse voltage withstand test on primary terminal,
transmitted overvoltage test,
of voltage instrument transformer type EMF-E072

Warsaw, October 2015

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

TEST REPORT EWN/109/E/15-2

TEST OBJECT:	**Voltage instrument transformer type EMF-E072**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500678253 (15.09.2015)**
TEST TYPE:	**Impulse voltage withstand test on primary terminal,** **Chopped impulse voltage withstand test on primary terminal,** **Transmitted overvoltage test**
TEST PROCEDURE:	**According to:** **PN-EN/IEC 61869-1** **PN/EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**05.10.2015 – 14.10.2015**
TEST RESULT:	**POSITIVE - details are presented in following parts of report**

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

Warsaw, October 2015.

CONTENTS

Test report includes:

- 10 numbered pages;
- 4 figures;
- 1 photograph;
- 7 tables.

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

Annex 2: Reports of routine test and determination of errors (6 pages);

Annex 3: Lightning impulse test protocol (8 pages);

Annex 4: Transmitted overvoltage test protocol (3 pages);

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1 COMPETENCE OF THE LABORATORY

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

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

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

Note

Tests described in sub-clause 5.2 of this Report don't comply with the scope of Laboratory accreditation.

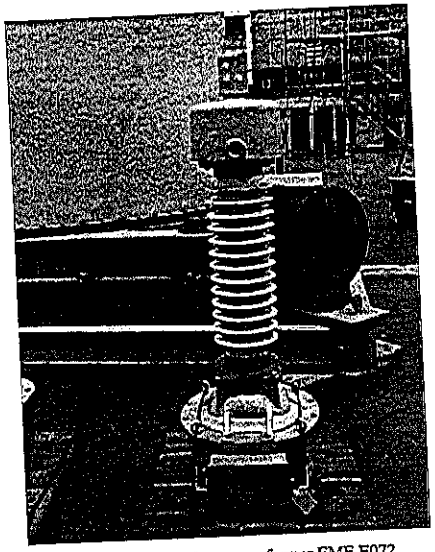
2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer EMF-E072 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 4 – EMF-E072

Serial number: 1HSE8851776

- Highest voltage for equipment 72.5 kV
- Rated primary voltage 66000 / √3 V
- Insulation level 140 / 325 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 160 kg



Phot. 1: Tested voltage transformer EMF-E072

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E072 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Impulse voltage withstand test on primary terminal	PN-EN/IEC 61869-1, p.7.2.3
SPECIAL TESTS		
2	Chopped impulse voltage test on primary terminal	PN-EN/IEC 61869-1, p.7.4.1
3	Transmitted overvoltage test	PN-EN/IEC 61869-1, p.7.4.4

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o. in the presence of a representative of the High Voltage Department of Institute of Power Engineering. Detailed results are presented in Annex 2.

Tests were carried out according to:

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

4 TYPE TEST

4.1 Impulse voltage withstand test on primary terminal

4.1.1 Method of testing and acceptance criteria

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

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

4.1.2 Test arrangement

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

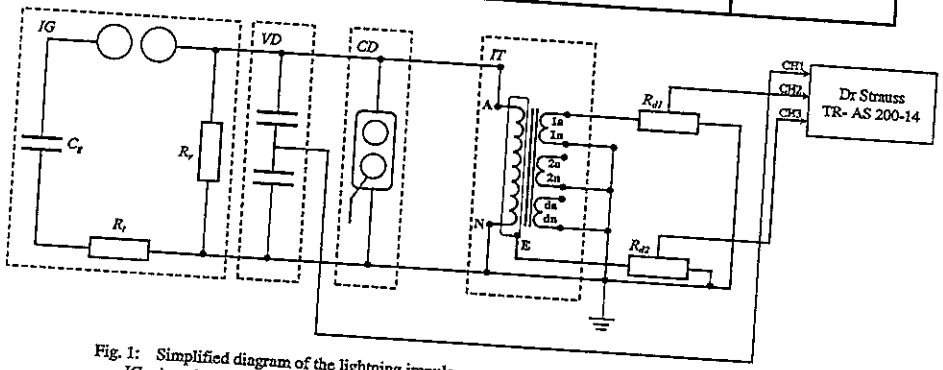


Fig. 1: Simplified diagram of the lightning impulse measurement system (for one step of the generator): *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; *CD* – chopping device; *IT* - instrument transformer (general schematic representation); R_{d1}, R_{d2} – detection resistance

4.1.3 Test conditions

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

Tab. 2: Parameters of the lightning impulse measurement system

IMPULSE GENERATOR			
Number of steps	n	-	4
General capacitance	C_g	µF	0,187
Discharge resistance	R_r	Ω	356
Damping resistance	R_t	Ω	128
VOLTAGE DIVIDER			
HV unit capacitance	C_u'	pF	~2400
LV unit capacitance	C_u''	µF	1,103
Scale factor	ϑ_V	-	460,7
DETECTION RESISTORS			
Detection resistance	R_{dt}	Ω	0,707
	R_{dz}	Ω	2,970

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

Full impulse test voltage	RW = 162,5 kV FW = 325,0 kV	
Chopped impulse test voltage	CRW = 186,87 kV CFW = 373,75 kV	
Sequence of impulses	Positive polarity 1 reduced full impulse (RW), 15 full impulses (FW).	Negative polarity 1 reduced full impulse (RW), 1 full impulse (FW), 1 reduced chopped impulse (CRW), 2 chopped impulses (CFW), 14 full impulses (FW).
Registration	Transients of test voltage (channel 1) Current flowing through secondary winding 1a-1n (channel 2) Current flowing through primary winding screen E (channel 3)	

4.1.4 Test results

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

TEST RESULT: POSITIVE

5 SPECIAL TESTS

5.1 Chopped impulse voltage withstand test on primary terminal

Chopped impulse test on the primary winding was combined with the negative polarity lightning impulse test. Detailed results of this test are presented in Section 4.1 and Annex 3 of this report.

TEST RESULT: POSITIVE

5.2 Transmitted overvoltage test

5.2.1 Method of testing and acceptance criteria

Transmitted overvoltage test was performed according to IEC 61869-3, IEC 61869-1 clause 7.4.4 and 6.11.4. During the test type „A" impulse (U_1) was applied between the primary terminal A and earth. Measurements of transmitted voltage (U_2) were carried out for all the secondary windings of the voltage instrument transformer.

It is considered that the instrument voltage transformer passed the test with a positive result if the value of the transmitted voltage (U_S) does not exceed 1,6 kV (IEC 61869-3 clause 6.11.4 Table 9).

5.2.2 Test arrangement

Arrangement for transmitted overvoltage measurement was based on one step of Marx impulse generator made by HAEFELY. Measurement of the voltage U_1 applied to the primary terminal of the instrument transformer was performed with impulse voltage measuring system Dr Strauss TR-AS 200-14, in connection with a resistive voltage divider Siemens SMR 10/770. The transmitted voltage U_2 measurement was also performed with impulse voltage measuring system Dr Strauss TR-AS 200-14. For both measured voltages U_1 and U_2 impulse peak value measuring uncertainty doesn't exceed 2% of the measured value for the confidence interval 95% and coverage factor k=2. Simplified diagram of the measurement system is shown in the Fig. 2.

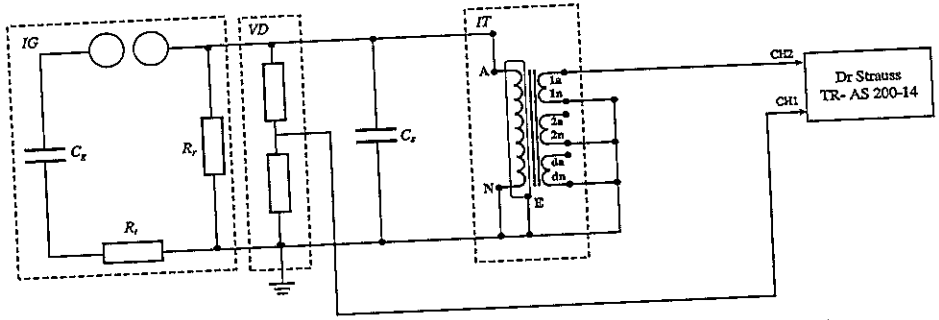


Fig. 2: Simplified diagram of the transmitted overvoltage measurement system *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; C_S – front shaping capacitor; *IT* - instrument transformer (general schematic representation);

5.2.3 Test conditions

Test conditions for transmitted overvoltage test (parameters of the measurement system and value of test voltage) are presented in Tab. 4. The influence of atmospheric condition on test voltage value was not taken into consideration.

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EWN/109/E/15-2

Tab. 4: Parameters of the transmitted overvoltage measurement system and parameters of the test voltage

IMPULSE GENERATOR			
Number of steps	n	-	1
General capacitance	C_g	μF	0,750
Discharge resistance	R_r	Ω	150
Damping resistance	R_t	Ω	89
VOLTAGE DIVIDER			
HV unit resistance	R_u'	Ω	10098,96
LV unit resistance	R_u''	Ω	10,06
Scale factor	ϑ_V	-	1005
FRONT SHAPING CAPACITOR			
Front shaping capacitor	C_S	pF	500
PARAMETERS OF THE TEST VOLTAGE			
Peak value of applied voltage	U_1	kV	18,8
Conventional front time	T_1	μs	0,50
Time to half-value	T_2	μs	73

5.2.4 Test results

Results of the transmitted overvoltage measurement are presented in Tab. 5. The oscillograms of all applied and registered impulses are present in Annex 4 of hereby Report.

Tab. 5: Transmitted overvoltage measurement results

terminal	U_1	U_2	U_s	$U_{s\%}$
	kV	V	V	%
1a - 1n	18,77	159	801,8	50,1
2a - 2n	18,78	195	981,4	61,3
da - dn	18,80	158	798,0	49,9

Note:
U_1 – peak value of applied voltage
U_2 – maximal value of transmitted voltage
U_S – maximal value of transmitted voltage for specified overvoltage U_p
U_p – specified overvoltage U_p=1,6·U_m·√2/√3
$U_{s\%}$ – percent of permissible overvoltage $U_{s\%}$=U_s/1600·100%

TEST RESULT: POSITIVE

ANNEX 1 for test report EWN/109/E/15-2

(3 pages)

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

- Declaration of conformity – No. 097/2015 (EN),
- Rating plate – Document No. 1HSE 22040-PCC,
- Technical drawing – Document id. 1HSE8851776.

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

DECLARATION OF CONFORMITY No. 097/2015 (EN)
(acc. to ISO/IEC 17050-1)

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E072

Above mentioned product comforms with the following standard :

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

Additional Information:
Serial numbers: **1HSE 8851776;**

Place and date of issue of declaration

Przasnysz 05.10.2015

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

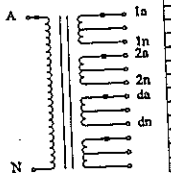
Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Lubecki

(Name) (Signature)

ABB	CE	ABB AB	Made in Sweden
Voltage transformer	1HSE nnnnnnn	Type EMF-E072 Production year	yyyy
Serial number	1407325 kV	Standard	IEC 61869-5
Insulation level	66000/√3 V	Frequency	50 Hz
Rated primary voltage	72.5 kV	Temperature range	-40 – +40 °C
Highest voltage for equipment		Total mass	160 kg

1HSE 68504-5

Serial number	1HSE nnnnnnn
Insulation oil	(IEC 61039: L-NTIO-296) 43 kg
Voltage factor	1.9 / 8h



Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA	
A-N	66000/√3				1000+0	
1a-1n	110/√3	0.2	20	40	1000+0	
1a-1n	110/√3	0.5	25	145	1000+0	
2a-2n	110/√3	0.2	20	40	1000+0	
2a-2n	110/√3	0.5/3P	120	145	150+0	
da-dn	110	1.0	50	90	150+0	
da-dn	110	3P	100	245	150+0	

1HSE 68504-6

Serial number 1HSE nnnnnnn = 1HSE 8851775 – 8851776

Production year yyyy = Actual year for production

Prepared	Responsible department	Title	
Gustaf Högberg 2015-06-18	PPHC/IM	Rating plate	Language en
Approved	Take over department		
Björn Sjöström 2015-06-18		Order No.	Sheet
Revision		E90000012-40	1
D Data changed. 2015-10-07		Document No.	Last
ABB AB		1HSE 22040-PCE	1

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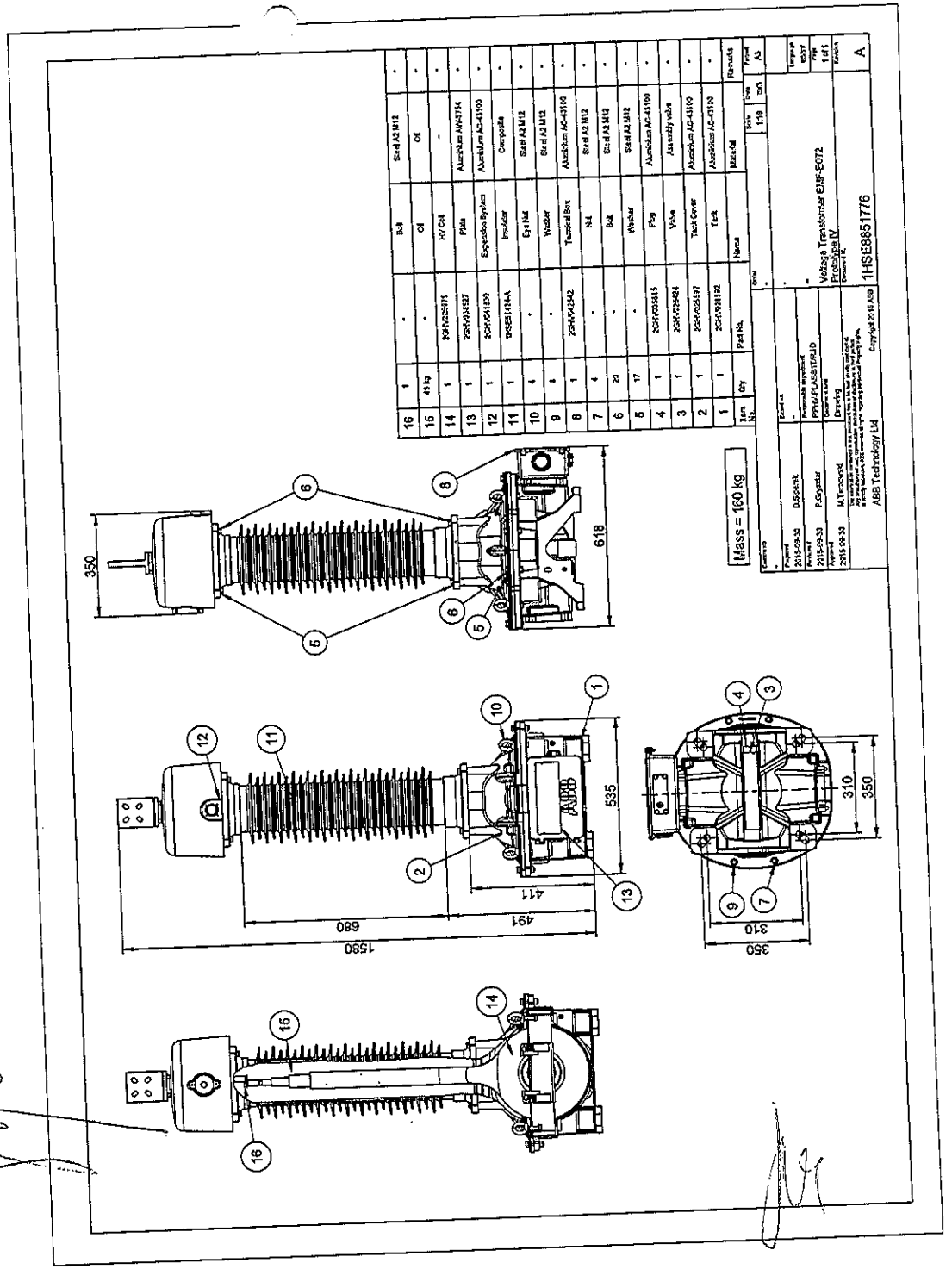

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EWN/109/E/15-2

Annex 2

ANNEX 2 for test report EWN/109/E/15-2

(6 pages)

Reports of routine test and determination of errors:

- Routine test report of voltage instrument transformer EMF-072 (1HSE8851776),
- Routine test report of voltage instrument transformer EMF-072 (1HSE8851776) after lightning impulse,

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine test report of voltage instrument transformer	TYPE: EMF-E072 Serial no: 1HSE8851776	
A-N 66:√3 kV	72,5/140/325 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,11:√3	20	0,2	1000
1a - 1n	0,11:√3	25	0,5	1000
2a - 2n	0,11:√3	20	0,2	1400
2a - 2n	0,11:√3	120	0,5/3P	1400
da - dn	0,11	50	1	1100
da - dn	0,11	100	3P	1100

1. Oil dielectric parameters check before filling (oil after treatment): ☑
   tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test
   on primary windings - A: Up = 140kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings ☑
7. Determination of errors - Up = 3 kV/60s ☑
8. Measurement of capacitance and dielectric dissipation factor - tgδ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.1653 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 81.75 kV, Relative standard deviation = 3.82
  f = 50Hz, oil temp. = 25 °C, measurement without the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	82.5
2	80.2
3	81.3
4	87.5
5.	78.4
6	80.6

Partial discharge measurement

- Measurement according to procedure A
(PD test voltages were reached while decreasing the voltage
after the power-freqency withstand test on primary winding)
Stress voltage: 140 kV / 60 s
Frequency: 120 Hz

Test voltage	1,2 Um = 87.0 kV	1,2 Um / √3 = 50.2 kV
Level of partial discharge	0.6 pC	0.6 pC

Remarks: background noise level: 0.6 (measured after voltage switch off),
measuring circuit was calibrated with 5 pC (calibrating charge).

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

Date of measurement: 2015-10-01
Ambient temperature: 23 +/-
Relative air humidity: 21 +/-

1a-1n: 20 VA p.f. = 0,8 lag.
2a-2n: 20VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.0068	-0.005	-0.004
Δφ U	2.28	2.34	2.39

1a-1n: 5 VA p.f. = 0,8 lag.
2a-2n: 20VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.027	-0.025	-0.024
Δφ U	2.38	2.43	2.49

2a-2n: 20 VA p.f. = 0,8 lag.
1a-1n: 20VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.0615	-0.059	-0.059
Δφ U	1.95	2.01	2.06

2a-2n: 5 VA p.f. = 0,8 lag.
1a-1n: 20VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.017	-0.016	-0.015
Δφ U	2.25	2.30	2.35

da-dn: 50 VA p.f. = 0,8 lag.
1a-1n: 20VA; 2a-2n: 20VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.125	-0.071	0.0052	-0.0006
Δφ U	2.84	2.01	1.59	1.92

1a-1n: 20 VA p.f. = 0,8 lag.
2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.052	-0.051	-0.05
Δφ U	3.42	3.47	3.53

1a-1n: 5 VA p.f. = 0,8 lag.
2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.012	0.014	0.015
Δφ U	3.2	3.26	3.32

2a-2n: 20 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.022	-0.020	-0.019
Δφ U	2.77	2.82	2.88

2a-2n: 5 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.022	0.0236	0.0245
Δφ U	3.07	3.12	3.18

da-dn: 12.5 VA p.f. = 0,8 lag.
1a-1n: 0 VA; 2a-2n: 0 VA

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.043	0.007	0.083	0.077
Δφ U	4.70	3.81	3.22	3.56

Measurements uncertainty: ε U = ± 0,044 %, Δφ U = ± 2,2 min

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

Date of measurement: 2015-10-01
Ambient temperature: 23 +/- 2°C
Relative air humidity: 21 +/- 10%

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 120VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.308	-0.306	-0.306
Δφ U	-1.41	-1.35	-1.30

1a-1n: 6,25 VA p.f. = 0,8 lag.
2a-2n: 120VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.228	-0.226	-0.225
Δφ U	-1.69	-1.64	-1.57

2a-2n: 120 VA p.f. = 0,8 lag.
1a-1n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.48	-0.431	-0.360	-0.358	-0.358	-0.562
Δφ U	1.11	0.23	-0.19	-0.14	-0.07	-3.81

2a-2n: 30 VA p.f. = 0,8 lag.
1a-1n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.210	-0.168	-0.099	-0.097	-0.097	-0.299
Δφ U	2.82	1.97	1.56	1.62	1.67	-2.12

da-dn: 100 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 120VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.51	-0.46	-0.383	-0.39
Δφ U	-1.46	-2.21	-2.49	-2.11

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.0748	-0.0725	-0.0716
Δφ U	3.51	3.57	3.63

1a-1n: 6,25 VA p.f. = 0,8 lag.
2a-2n: 0 VA

	0,8 Un	1,0 Un	1,2 Un
ε U	0.0067	0.0086	0.0094
Δφ U	3.24	3.29	3.36

2a-2n: 120 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.431	-0.385	-0.313	-0.311	-0.310	-0.514
Δφ U	2.22	1.42	0.83	0.88	0.94	-2.74

2a-2n: 30 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.167	-0.121	0.050	0.048	0.048	-0.250
Δφ U	3.95	3.12	2.60	2.66	2.71	-1.08

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.044	0.098	0.176	0.17
Δφ U	4.85	3.96	3.32	3.67

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

Measurements uncertainty: ε U = ± 0,044 %, Δφ U = ± 2,2 min

Measurement of capacitance and dielectric dissipation factor - tg δ
Temperature: 23 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.3	225	0,73
38.1 kV	0.3	225	2.685
41.8 kV	0.3	225	2.951

Measurement of windings' resistance

	R (23 °C)	Rct (75 °C)
A-N	12.20 kΩ	14.693 kΩ
1a-1n	116.200 mΩ	139.947 mΩ
2a-2n	47.880 mΩ	57.665 mΩ
da-dn	218.900 mΩ	263.634 mΩ

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

Checked by: T. Kawalczyk OG-4 KJ-58

Przasnysz, 2015-10-01

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59	Routine test report of voltage instrument transformer after lighting impulse		TYPE: EMF-E072 Serial no: 1HSE8851776	
A-N 66:√3 kV	72,5/140/325 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,11:√3	20	0,2	1000
1a - 1n	0,11:√3	25	0,5	1000
2a - 2n	0,11:√3	20	0,2	1400
2a - 2n	0,11:√3	120	0,5/3P	1400
da - dn	0,11	50	1	1100
da - dn	0,11	100	3P	1100

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Prossure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings - A: Up = 112 kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tgδ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.1653 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 81.75 kV, Relative standard deviation = 3.82
  f = 50Hz, oil temp. = 25 °C, measurement without the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	82.5
2	80.2
3	81.3
4	87.5
5	78.4
6	80.6

Partial discharge measurement

- Measurement according to procedure A
(PD test voltages were reached while decreasing the voltage after the power-freqency withstand test on primary winding)
Stress voltage: 112 kV / 60 s
Frequency: 120 Hz

Test voltage	1,2 Um = 87.0 kV	1,2 Um / √3 = 50.2 kV
Level of partial discharge	0.6 pC	0.6 pC

Remarks: background noise level: 0.6 (measured after voltage switch off), measuring circuit was calibrated with 5 pC (calibrating charge).

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

Date of measurement: 2015-11-10
Ambient temperature: 24 +/-
Relative air humidity: 33 +/-

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 120VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.097	-0.095	-0.094
Δφ U	2.6	2.6	2.7

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 120VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.037	-0.035	-0.035
Δφ U	2.4	2.4	2.5

2a-2n: 120 VA p.f. = 0,8 lag.
1a-1n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.182	-0.136	-0.063	-0.061	-0.060	-0.166
Δφ U	4.1	3.0	2.0	2.0	2.1	0.2

2a-2n: 30 VA p.f. = 0,8 lag.
1a-1n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.139	-0.094	-0.020	-0.018	-0.017	-0.123
Δφ U	4.4	3.3	2.3	2.3	2.4	0.5

da-dn: 100 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 120VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.138	-0.079	0.004	-0.002
Δφ U	3.5	2.3	1.5	1.8

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.079	-0.054	-0.053
Δφ U	3.5	3.5	3.5

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.022	0.011	0.012
Δφ U	3.1	3.3	3.3

2a-2n: 120 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.143	-0.095	-0.025	-0.023	-0.022	-0.128
Δφ U	5.0	3.7	2.8	2.8	2.9	1.0

2a-2n: 30 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.101	-0.055	0.019	0.021	0.022	-0.084
Δφ U	5.3	4.2	3.1	3.1	3.2	1.3

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.082	0.135	0.219	0.214
Δφ U	5.0	4.1	3.2	3.5

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

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

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

Date of measurement: 2015-10-01
Ambient temperature: 23 +/- 2°C
Relative air humidity: 21 +/- 10%

1a-1n: 25 VA p.f. = 0,8 lag.
2a-2n: 120VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.311	-0.310	-0.309
Δφ U	-1.4	-1.3	-1.3

1a-1n: 6.25 VA p.f. = 0,8 lag.
2a-2n: 120VA p.f. = 0,8 lag.

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.231	-0.229	-0.228
Δφ U	-1.7	-1.6	-1.6

2a-2n: 120 VA p.f. = 0,8 lag.
1a-1n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.493	-0.444	-0.367	-0.365	-0.364	-0.566
Δφ U	1.7	0.7	-0.2	-0.2	-0.1	-3.8

2a-2n: 30 VA p.f. = 0,8 lag.
1a-1n: 25VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.232	-0.183	-0.107	-0.105	-0.104	-0.304
Δφ U	3.5	2.4	1.6	1.6	1.6	-2.2

da-dn: 100 VA p.f. = 0,8 lag.
1a-1n: 25VA; 2a-2n: 120VA p.f. = 0,8 lag.

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	-0.531	-0.469	-0.383	-0.388
Δφ U	-1.1	-2.2	-2.7	-2.3

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

	0,8 Un	1,0 Un	1,2 Un
ε U	-0.080	-0.078	-0.077
Δφ U	3.5	3.6	3.6

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

	0,8 Un	1,0 Un	1,2 Un
ε U	0.001	0.003	0.004
Δφ U	3.2	3.3	3.3

2a-2n: 120 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.448	-0.394	-0.317	-0.316	-0.315	-0.516
Δφ U	2.8	1.8	0.8	0.9	0.9	-2.9

2a-2n: 30 VA p.f. = 0,8 lag.
1a-1n: 0 VA

	0,02 Un	0,05 Un	0,8 Un	1,0 Un	1,2 Un	1,9 Un*
ε U	-0.189	-0.137	-0.059	-0.057	-0.056	-0.256
Δφ U	4.6	3.6	2.6	2.6	2.7	-1.1

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

	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.024	0.084	0.169	0.164
Δφ U	5.0	4.0	3.2	3.5

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

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

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 23 °C, Frequency: 50 Hz

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.3	225	0.735
38.1 kV	0.3	225	2.715
41.8 kV	0.3	225	2.952

Measurement of windings' resistance

	R (23 °C)	Rct (75 °C)
A-N	12.00 kΩ	14.452 kΩ
1a-1n	111.700 mΩ	134.527 mΩ
2a-2n	47.220 mΩ	56.870 mΩ
da-dn	217.000 mΩ	261.346 mΩ

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

Checked by: T. Krawczyk

OG-4 KJ-58

Przasnysz, 2015-11-10

ANNEX 3 for test report EWN/109/E/15-2

(8 pages)

Lightning impulse test protocol:

- ewn109e15-2a

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Próba udarem uciętym 1,2/50us

project : ewn109e15-2a test date 05-10-2015 page 1

Test - object - data

WNR	EWN/109/E/15-2a	TR-No. 1HSE8851776		O.-No. 4500678253	
test object	EMF-E072				
output	-	kVA	vector group	-	
voltage	72.5	kV	BIL	325	
			frequency	50	Hz
customer	ABB Sp. z o. o. ul. Zeganska 1, 04-713 Warszawa				

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Próba udarem uciętym 1,2/50us

project : ewn109e15-2a

LI lightning-impulse page 2

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
1	-163.2	1.16	45.3		-215.6	LI: A - RW(50.0%)
2	-327.5	1.13	45.1		-315.5	LI: A - FW(100.0%)
3	-188.3	1.14		3.52	-248.5	LI: A - CRW(57.5%)
4	-376.8	1.13		3.48	467.8	LI: A - CFW(115.0%)
5	-374.4	1.13		3.47	365.5	LI: A - CFW(115.0%)
6	-327.6	1.13	45.2		-282.4	LI: A - FW(100.0%)
7	-327.7	1.13	45.2		-298.8	LI: A - FW(100.0%)
8	-327.5	1.13	45.2		-304.9	LI: A - FW(100.0%)
9	-327.9	1.13	45.2		-299	LI: A - FW(100.0%)
10	-327.4	1.13	45.2		-278.3	LI: A - FW(100.0%)
11	-327.8	1.13	45.2		-311.7	LI: A - FW(100.0%)
12	-327.9	1.13	45.1		-298.2	LI: A - FW(100.0%)
13	-327.6	1.13	45.2		-297.9	LI: A - FW(100.0%)
14	-327.5	1.13	45.2		-305.9	LI: A - FW(100.0%)
15	-327.4	1.13	45.2		-316.3	LI: A - FW(100.0%)
16	-327.7	1.13	45.2		-316.4	LI: A - FW(100.0%)
17	-327.4	1.13	45.2		-300.5	LI: A - FW(100.0%)
18	-327.5	1.13	45.3		-290.4	LI: A - FW(100.0%)
19	-327.6	1.13	45.3		-305.7	LI: A - FW(100.0%)
20	162.7	1.15	45.2		173.6	LI: A - RW(50.0%)
21	325.4	1.13	45.2		339.3	LI: A - FW(100.0%)
22	325.4	1.13	45.3		339.5	LI: A - FW(100.0%)
23	325.4	1.13	45.2		327.1	LI: A - FW(100.0%)
24	325.4	1.13	45.2		339.5	LI: A - FW(100.0%)
25	325.4	1.13	45.2		323.9	LI: A - FW(100.0%)
26	325.3	1.13	45.2		339.4	LI: A - FW(100.0%)
27	325.1	1.13	45.3		331.2	LI: A - FW(100.0%)
28	325.2	1.13	45.2		335.1	LI: A - FW(100.0%)
29	325.3	1.13	45.3		339.4	LI: A - FW(100.0%)
30	325.3	1.13	45.3		339.5	LI: A - FW(100.0%)
31	325.5	1.14	45.2		330.9	LI: A - FW(100.0%)
32	325.2	1.13	45.2		336.2	LI: A - FW(100.0%)
33	325.1	1.13	45.3		331.5	LI: A - FW(100.0%)
34	325.1	1.13	45.3		335.4	LI: A - FW(100.0%)
35	325.2	1.13	45.2		339.5	LI: A - FW(100.0%)

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Próba udarem uciętym 1,2/50us

project : ewn109e15-2a

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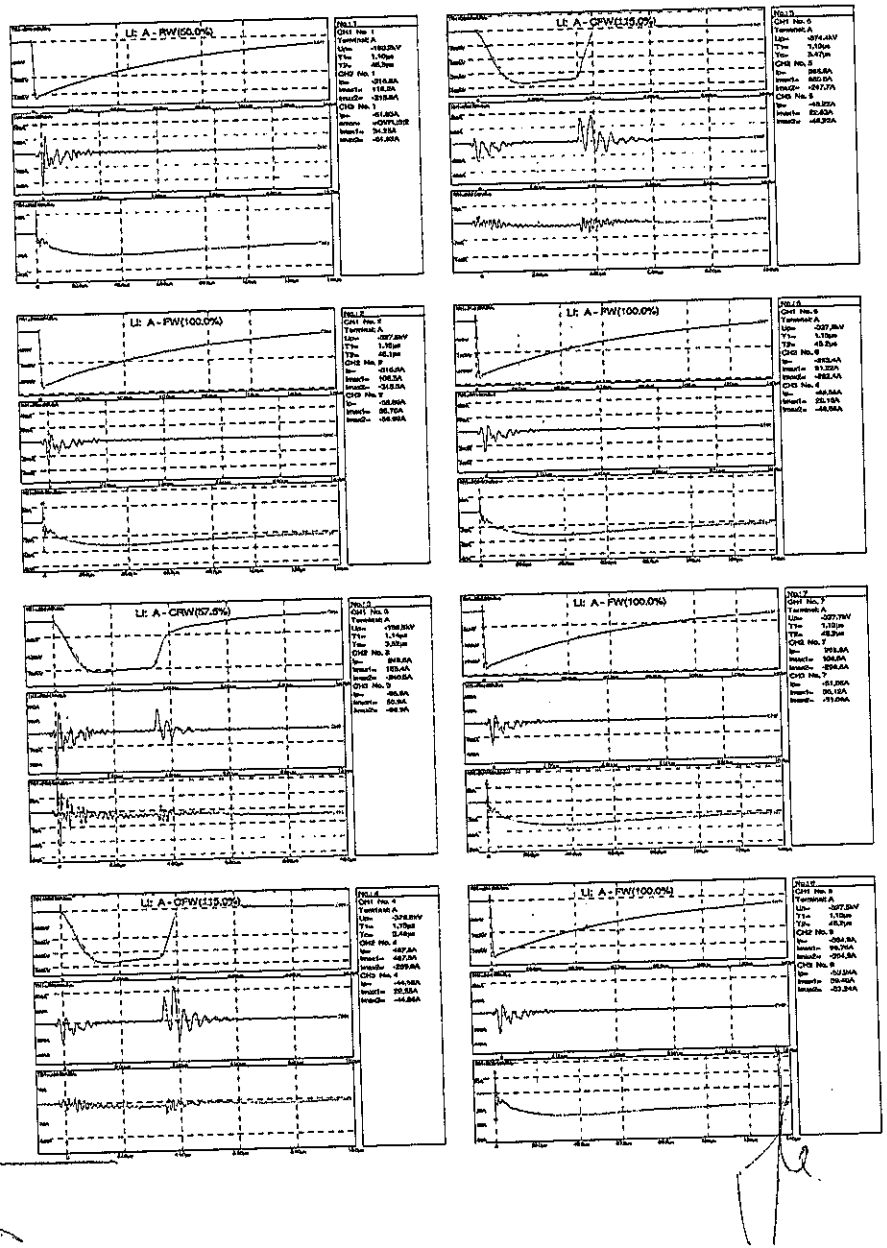
Próba udarem uciętym 1,2/50us

project : ewn109e15-2a



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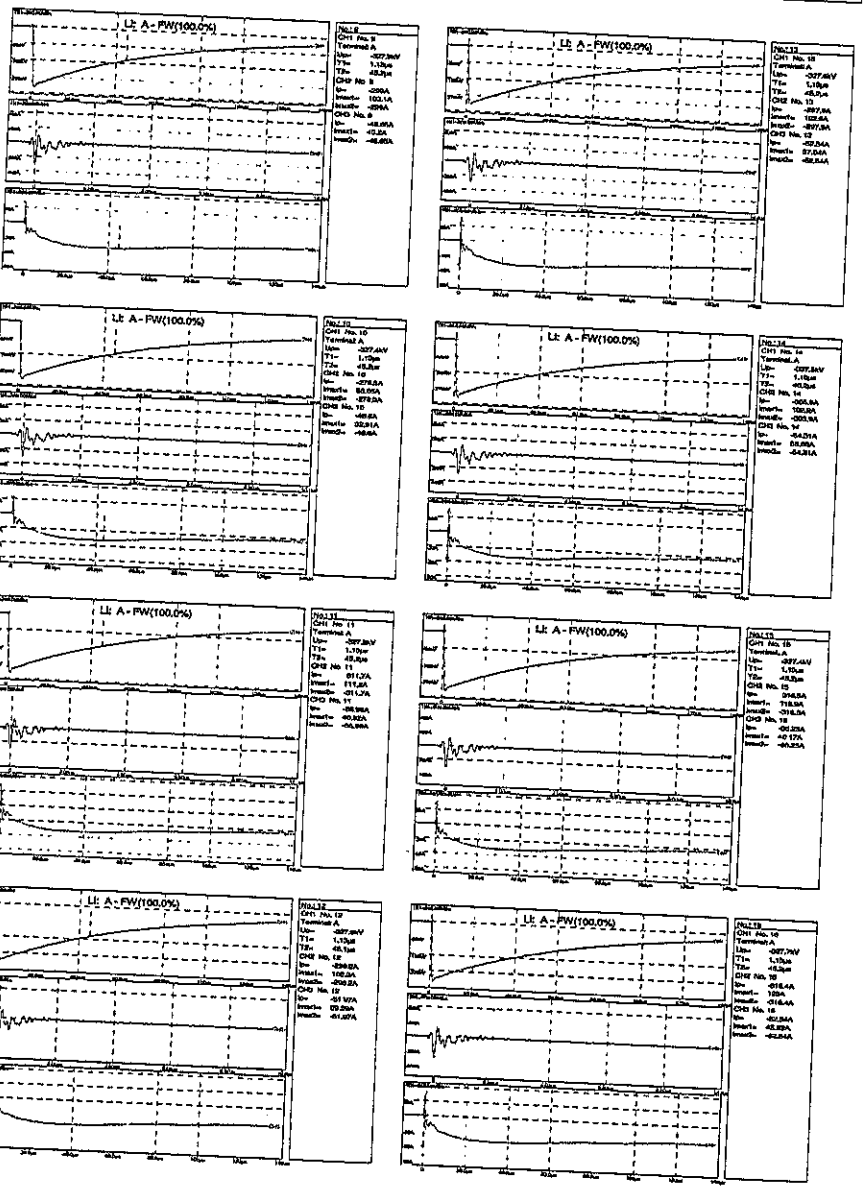
Próba udarem uciętym 1,2/50us

project : ewn109e15-2a



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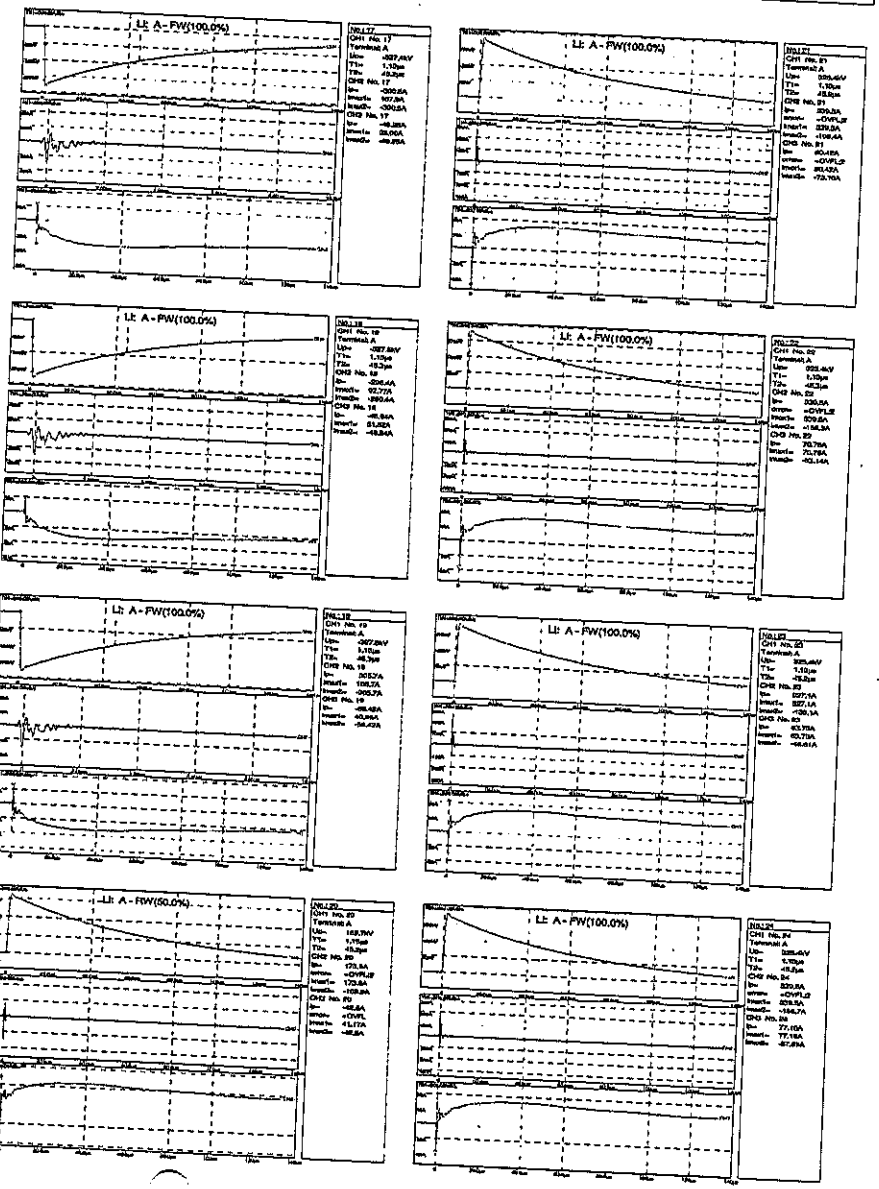
fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

Próba udarem uciętym 1,2/50us

project : ewn109e15-2a



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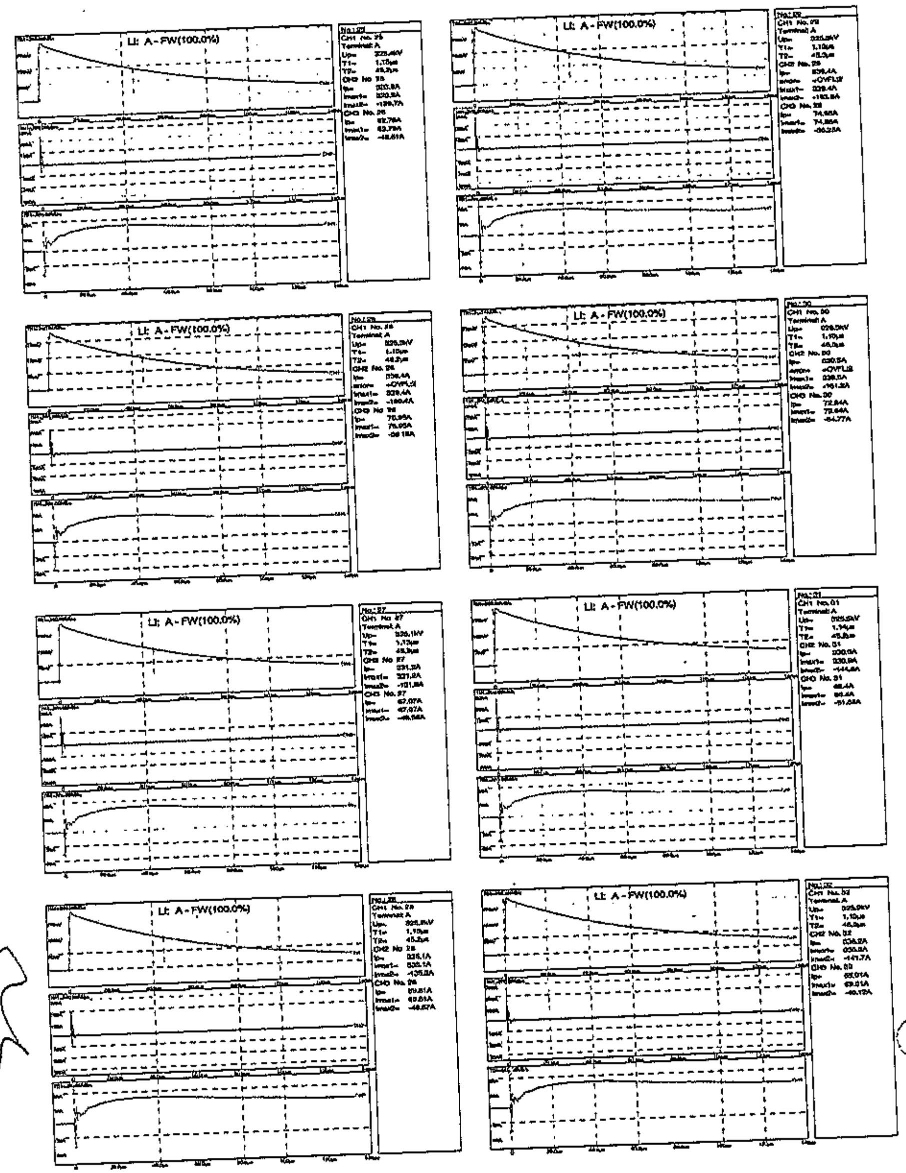
fax (+4822) 836-80-48, mail: ewn@ien.com.pl

Próba udarem uciętym 1,2/50us

project : ewn109e15-2a



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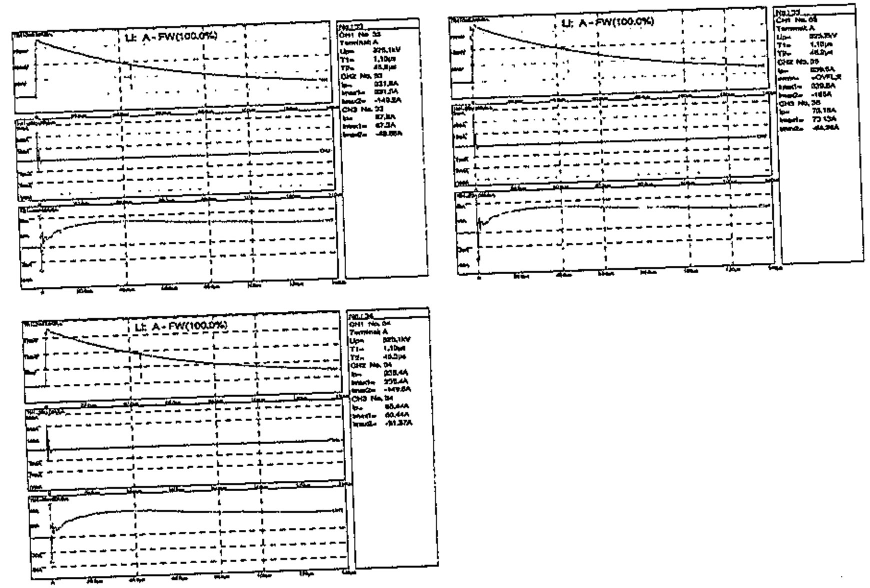
fax (+4822) 836-80-48, mail: ewn@ien.com.pl

Próba udarem uciętym 1,2/50us

project : ewn109e15-2a



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

ANNEX 4 for test report EWN/109/E/15-2

(3 pages)

Transmitted overvoltage test protocol:

- ewn109e15-2b

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

Test - object - data

test date	06-10-2015
factory ser.-no.	1HSE8851776
test object	EMF-E072
order-no.	4500678253
specification	
test-field	

Climate - Data

temperature	14 °C	humidity	78 %
		air-pressure	1004 hPa

HIGH VOLTAGE LABORATORY
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fax: (+4822) 836-80-48, mail: ewn@len.com.pl

U lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Up [V]	remark
1	18.77	0.5	73.5		158.9	1a - 1n
2	18.77	0.5	73.5		158.9	1a - 1n zoom
3	18.78	0.51	73.6		194.6	2a - 2n
4	18.78	0.51	73.6		194.6	2a - 2n zoom
5	18.8	0.5	73.6		158.4	da - dn
6	18.8	0.5	73.6		158.4	da - dn zoom

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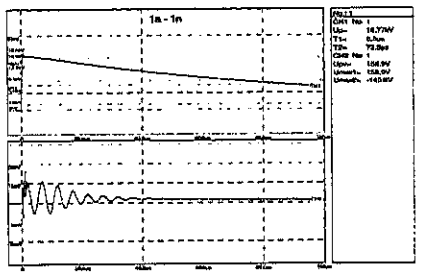
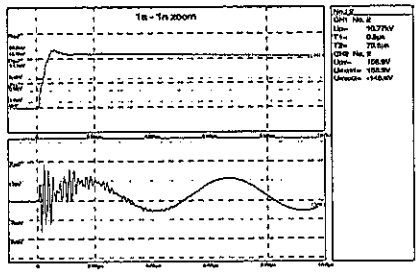
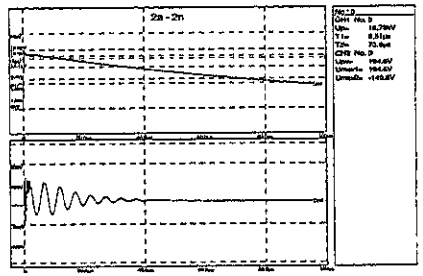
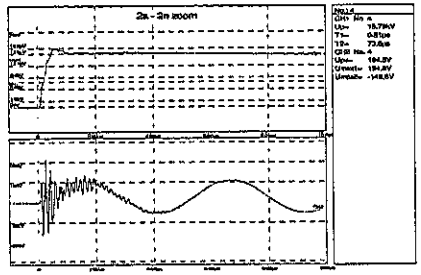
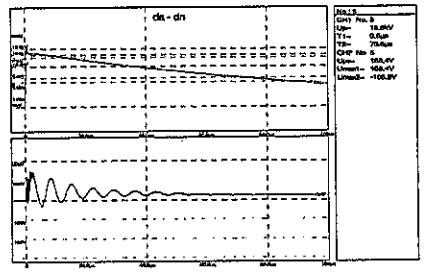
fax: (+4822) 836-80-48, mail: ewn@len.com.pl

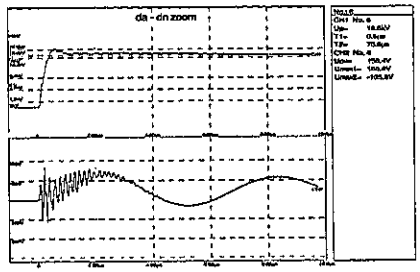












HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/109/E/15-3

Impulse voltage withstand test on primary terminal,
chopped impulse voltage withstand test on primary terminal,
transmitted overvoltage test,
of voltage instrument transformer type EMF-E084

Warsaw, October 2015

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

TEST REPORT EWN/109/E/15-3

TEST OBJECT:	**Voltage instrument transformer type EMF-E084**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500678253 (15.09.2015)**
TEST TYPE:	**Impulse voltage withstand test on primary terminal,** **Chopped impulse voltage withstand test on primary terminal,** **Transmitted overvoltage test**
TEST PROCEDURE:	**According to:** **PN-EN/IEC 61869-1** **PN/EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**05.10.2015 – 14.10.2015**
TEST RESULT:	**POSITIVE - details are presented in following parts of report**

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

Warsaw, October 2015.

CONTENTS

Test report includes:

10 numbered pages;
4 figures;
1 photograph;
7 tables.

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

Annex 2: Reports of routine test and determination of errors (4 pages);

Annex 3: Lightning impulse test protocol (8 pages);

Annex 4: Transmitted overvoltage test protocol (3 pages);

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

1 COMPETENCE OF THE LABORATORY

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

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

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

Note

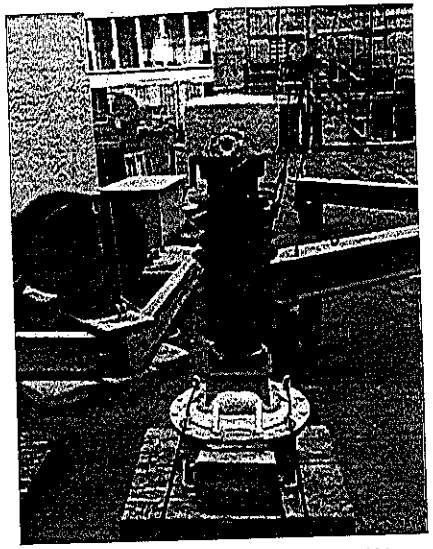
Tests described in sub-clause 5.2 of this Report don't comply with the scope of Laboratory accreditation.

2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer EMF-E084 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 5 – EMF-E084
Serial number: 1HSE8851777

- Highest voltage for equipment 84 kV
- Rated primary voltage 77000 / √3 V
- Insulation level 150 / 380 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 190 kg



Phot. 1: Tested voltage transformer EMF-E084

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E084 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Impulse voltage withstand test on primary terminal	PN-EN/IEC 61869-1, p.7.2.3
SPECIAL TESTS		
2	Chopped impulse voltage test on primary terminal	PN-EN/IEC 61869-1, p.7.4.1
3	Transmitted overvoltage test	PN-EN/IEC 61869-1, p.7.4.4

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o. in the presence of a representative of the High Voltage Department of Institute of Power Engineering. Detailed results are presented in Annex 2.
Tests were carried out according to:

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

4 TYPE TEST

4.1 Impulse voltage withstand test on primary terminal

4.1.1 Method of testing and acceptance criteria

According to IEC 61869-1 clause 7.4.1 lightning impulse test (for negative polarity) can be combined with chopped impulse voltage test. For positive polarity lightning impulse test was performed according to IEC 61869-1 clause 7.2.3 (15 impulse method).
It is considered that the instrument transformer passed the test with a positive result if analysis of the waveforms recorded during the test does not indicate failure of internal insulation of instrument transformer.

4.1.2 Test arrangement

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

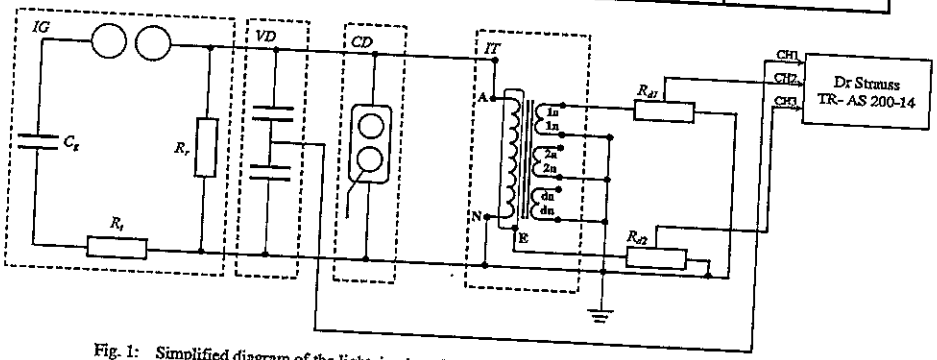


Fig. 1: Simplified diagram of the lightning impulse measurement system (for one step of the generator): *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; *CD* – chopping device; *IT* - instrument transformer (general schematic representation); R_{d1}, R_{d2} – detection resistance

4.1.3 Test conditions

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

Tab. 2: Parameters of the lightning impulse measurement system

IMPULSE GENERATOR			
Number of steps	n	-	4
General capacitance	C_g	µF	0,187
Discharge resistance	R_r	Ω	356
Damping resistance	R_t	Ω	128
VOLTAGE DIVIDER			
HV unit capacitance	C_n'	pF	~2400
LV unit capacitance	C_n''	µF	1,103
Scale factor	ϑ_V	-	460,7
DETECTION RESISTORS			
Detection resistance	R_{d1}	Ω	2,970
	R_{d2}	Ω	0,707

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

Full impulse test voltage	RW = 190 kV FW = 380 kV	
Chopped impulse test voltage	CRW = 218,5 kV CFW = 437,0 kV	
Sequence of impulses	Positive polarity 1 reduced full impulse (RW), 15 full impulses (FW).	Negative polarity 1 reduced full impulse (RW), 1 full impulse (FW), 1 reduced chopped impulse (CRW), 2 chopped impulses (CFW), 14 full impulses (FW).
Registration	Transients of test voltage (channel 1) Current flowing through secondary winding 1n-1n (channel 2) Current flowing through primary winding screen E (channel 3)	

4.1.4 Test results

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

TEST RESULT: POSITIVE

5 SPECIAL TESTS

5.1 Chopped impulse voltage withstand test on primary terminal

Chopped impulse test on the primary winding was combined with the negative polarity lightning impulse test. Detailed results of this test are presented in Section 4.1 and Annex 3 of this report.

TEST RESULT: POSITIVE

5.2 Transmitted overvoltage test

5.2.1 Method of testing and acceptance criteria

Transmitted overvoltage test was performed according to IEC 61869-3, IEC 61869-1 clause 7.4.4 and 6.11.4. During the test type „A" impulse (U_1) was applied between the primary terminal A and earth. Measurements of transmitted voltage (U_2) were carried out for all the secondary windings of the voltage instrument transformer.

It is considered that the instrument voltage transformer passed the test with a positive result if the value of the transmitted voltage (U_S) does not exceed 1,6 kV (IEC 61869-3 clause 6.11.4 Table 9).

5.2.2 Test arrangement

Arrangement for transmitted overvoltage measurement was based on one step of Marx impulse generator made by HAEFELY. Measurement of the voltage U_1 applied to the primary terminal of the instrument transformer was performed with impulse voltage measuring system Dr Strauss TR-AS 200-14, in connection with a resistive voltage divider Siemens SMR 10/770. The transmitted voltage U_2 measurement was also performed with impulse voltage measuring system Dr Strauss TR-AS 200-14. For both measured voltages U_1 and U_2 impulse peak value measuring uncertainty doesn't exceed 2% of the measured value for the confidence interval 95% and coverage factor k=2. Simplified diagram of the measurement system is shown in the Fig. 2.

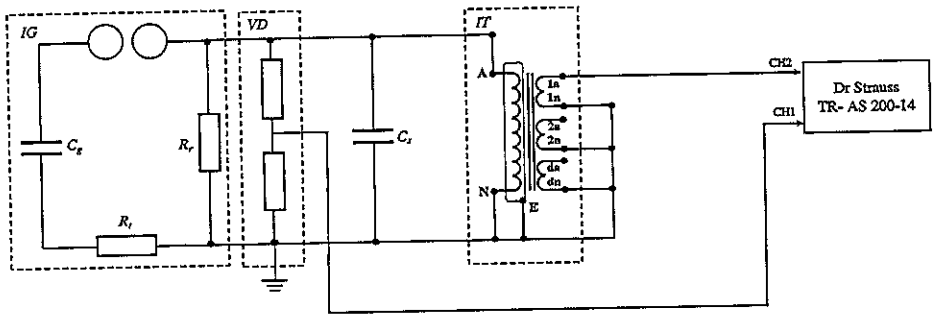


Fig. 2: Simplified diagram of the transmitted overvoltage measurement system *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; C_S – front shaping capacitor; *IT* - instrument transformer (general schematic representation);

5.2.3 Test conditions

Test conditions for transmitted overvoltage test (parameters of the measurement system and value of test voltage) are presented in Tab. 4. The influence of atmospheric condition on test voltage value was not taken into consideration.

Tab. 4: Parameters of the transmitted overvoltage measurement system and parameters of the test voltage

IMPULSE GENERATOR			
Number of steps	n	-	1
General capacitance	C_g	μF	0,750
Discharge resistance	R_r	Ω	150
Damping resistance	R_t	Ω	89
VOLTAGE DIVIDER			
HV unit resistance	R_u'	Ω	10098,96
LV unit resistance	R_u''	Ω	10,06
Scale factor	ϑ_V	-	1005
FRONT SHAPING CAPACITOR			
Front shaping capacitor	C_S	pF	500
PARAMETERS OF THE TEST VOLTAGE			
Peak value of applied voltage	U_1	kV	23,6
Conventional front time	T_1	μs	0,50
Time to half-value	T_2	μs	74

5.2.4 Test results

Results of the transmitted overvoltage measurement are presented in Tab. 5. The oscillograms of all applied and registered impulses are present in Annex 4 of hereby Report.

Tab. 5: Transmitted overvoltage measurement results

terminal	U_1	U_2	U_s	$U_{r\%}$
	kV	V	V	%
1a - 1n	23,52	175	816,5	51,0
2a - 2n	23,69	208	964,9	60,3
da - dn	23,59	136	632,7	39,5

Note:
U_1 – peak value of applied voltage
U_2 – maximal value of transmitted voltage
U_S – maximal value of transmitted voltage for specified overvoltage U_p
U_p – specified overvoltage U_p=1,6·U_m·√2/√3
$U_{r\%}$ – percent of permissible overvoltage $U_{r\%}$=U_s/1600·100%

TEST RESULT: POSITIVE

ANNEX 1 for test report EWN/109/E/15-3

(3 pages)

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

- Declaration of conformity – No. 098/2015 (EN),
- Rating plate – Document No. 1HSE 22040-PCF,
- Technical drawing – Document id. 1HSE8851777.

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

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

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E084

Above mentioned product comforms with the following standard :

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

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

Place and date of issue of declaration

Przasnysz 05.10.2015

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

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

(Name) (Signature)

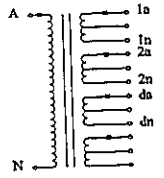
ABB CE

ABB AB — Made in Sweden

Voltage transformer		Type EMF-E084 Production year	yyyy
Serial number	1HSE nnnnnnn	Standard	IEC 61869-3
Insulation level	150 / 380 kV	Frequency	50 Hz
Rated primary voltage	77000/√3 V	Temperature range	-40 – +40 °C
Highest voltage for equipment	84 kV	Total mass	190 kg

1HSE 68504-5

Serial number	1HSE nnnnnnn
Insulation oil	(IEC 61039: L-NTIO-296) 41 kg
Voltage factor	1.9 / 8h



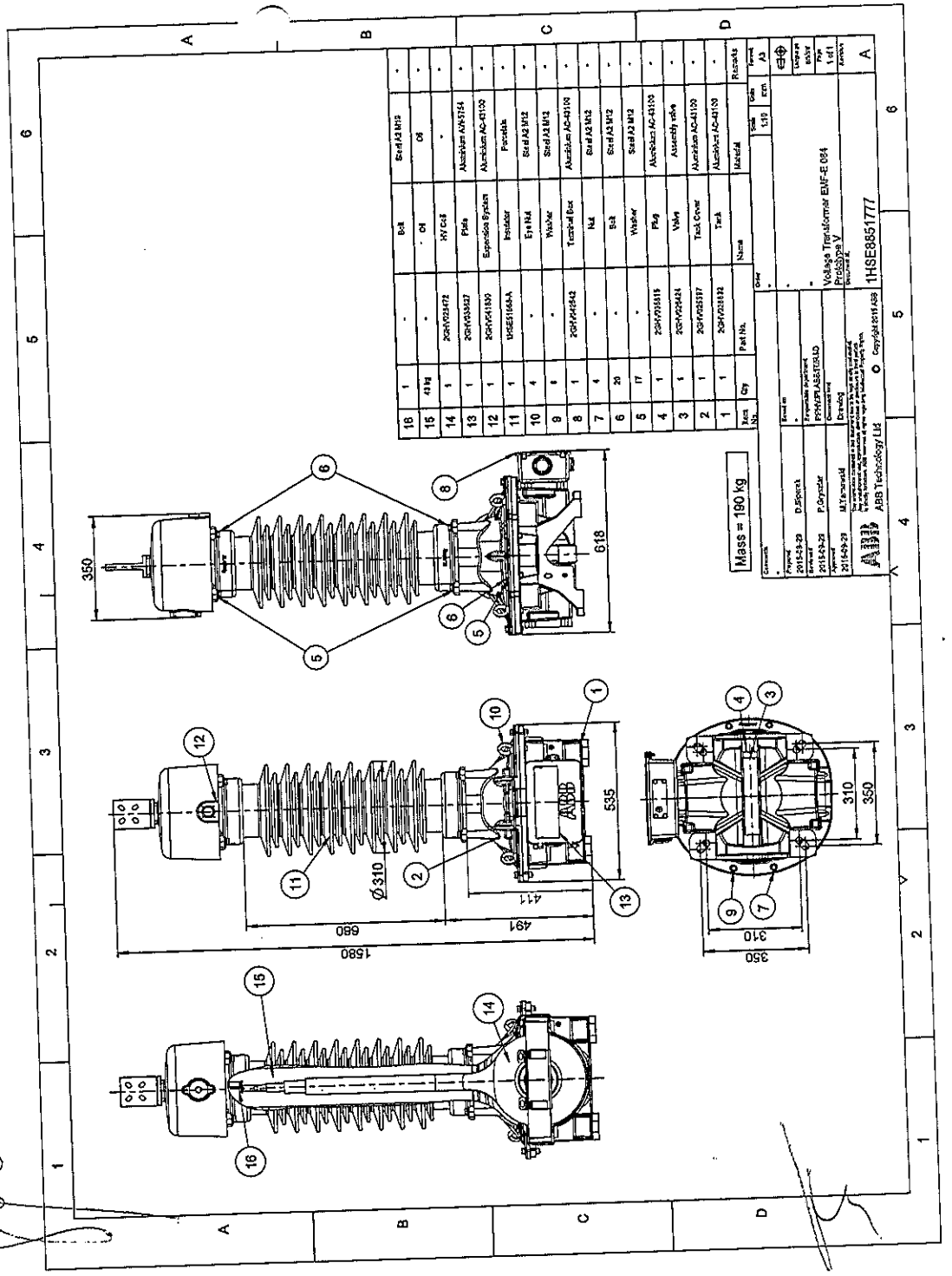
Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA
A-N	77000/√3				
1a-1n	110/√3	0.2	25	50	1000+0
2a-2n	110/√3	0.2	25	50	1000+0
da-dn	110/3	3P	50	100	150+0

1HSE 68504-6

Serial number 1HSE nnnnnnn = 1HSE 8851777

Production year yyyy = Actual year for production

Prepared Gustaf Högberg 2015-06-18	Responsible department PPHC/TM	Title Rating plate	Language en
Approved Björn Sjöström 2015-06-18	Take over department		Sheet 1
Revision C Class 1.0 removed. 2015-09-21		Order No. E90000012-50	Last 1
ABB AB		Document No. 1HSE 22040-PCF	



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EWN/109/E/15-3

Annex 2

ANNEX 2 for test report EWN/109/E/15-3

(4 pages)

Reports of routine test and determination of errors:

- Routine test report of voltage instrument transformer EMF-084 (1HSE8851777),
- Routine test report of voltage instrument transformer EMF-084 (1HSE8851777) after lighting impulse,

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59		Routine test report of voltage instrument transformer	TYPE: EMF-084 Serial no: 1HSE8851777	
A-N 77:√3 kV	84/150/380 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,11:√3	25	0,2	1000
2a - 2n	0,11:√3	25	0,2	1000
da - dn	0,11:3	50	3P	150

1. Oil dielectric parameters check before filling (oil after treatment): tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage ☑
4. Power-frequency withstand test on primary windings - A: Up = 150kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings - Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance ☑

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.2098 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 83.22 kV, Relative standard deviation = 2.59
  f = 50Hz, oil temp. = 24.3 °C, measurement without the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	79.8
2	84
3	85.7
4	84.9
5	83.1
6	81.8

Partial discharge measurement

- Measurement according to procedure A
  (PD test voltages were reached while decreasing the voltage after the power-frequency withstand test on primary winding)
  Stress voltage: 150 kV / 60 s
  Frequency: 120 Hz

Test voltage	1,2 Um = 100.8 kV	1,2 Um / √3 = 58.2 kV
Level of partial discharge	0.5 pC	0.5 pC

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

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

Date of measurement: 2015-10-01

1a-1n: 25 VA 2a-2n: 25VA			p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	-0.047	-0.0446	-0.0432
Δφ U	1.63	1.68	1.73

1a-1n: 6.25 VA 2a-2n: 25VA			p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	0.0274	0.0297	0.0310
Δφ U	1.42	1.47	1.52

2a-2n: 25 VA 1a-1n: 25VA			p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	0.0507	0.053	0.0543
Δφ U	1.32	1.38	1.43

2a-2n: 6.25 VA 1a-1n: 25VA			p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	0.0508	0.053	0.0545
Δφ U	1.335	1.37	1.425

da-dn: 50 VA 1a-1n: 25VA; 2a-2n: 25VA				p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.802	0.905	1.028	1.027
Δφ U	0.34	-0.23	0.295	0.553

1a-1n: 25 VA 2a-2n: 0 VA			p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	-0.003	-0.006	0.008
Δφ U	2.66	2.72	2.77

1a-1n: 6.25 VA 2a-2n: 0 VA			p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	0.0714	0.0739	0.0753
Δφ U	2.45	2.50	2.55

2a-2n: 25 VA 1a-1n: 0 VA			p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	0.095	0.0975	0.0988
Δφ U	2.37	2.42	2.46

2a-2n: 6.25 VA 1a-1n: 0 VA			p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un
ε U	0.095	0.0974	0.0988
Δφ U	2.36	2.41	2.46

da-dn: 12.5 VA 1a-1n: 0 VA; 2a-2n: 0 VA				p.f. = 0,8 lag.
	0,02 Un	0,05 Un	1,0 Un	1,9 Un
ε U	0.892	1.001	1.122	1.121
Δφ U	2.95	2.23	2.50	2.78

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

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 23 °C, Frequency: 50

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.25	228	0.742
45.5 kV	0.26	228	3.2
48.5 kV	0.26	228	3.48

Measurement of windings' resistance

	R (24 °C)	Rct (75 °C)
A-N	14.10 kΩ	16.926 kΩ
1a-1n	112.100 mΩ	134.568 mΩ
2a-2n	104.900 mΩ	125.925 mΩ
da-dn	40.620 mΩ	48.761 mΩ

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Certification Department
Witnessed ☐ Reviewed ☑
Data / Sign. M. Sc. Eng. Jerzy Mikołajczyk

Checked by: J. Krawczyk

OG-4
KJ-58

Przasnysz, 2015-10-01

ABB Sp. z o.o. 06-300 Przasnysz ul. Leszno 59	Routine test report of voltage instrument transformer After lighting impulse		TYPE: EMF-084 Serial no: 1HSE8851777	
A-N 77:√3 kV	84/150/380 kV	Voltage factor: 1.9/8h	IEC 61869-3	50 Hz

Winding	Usn [kV]	Sn [VA]	Class	Sth [VA]
1a - 1n	0,11:√3	25	0,2	1000
2a - 2n	0,11:√3	25	0,2	1000
da - dn	0,11:3	50	3P	150

1. Oil dielectric parameters check before filling (oil after treatment): ☑
   tg δ acc. IEC 60247, breakdown voltage acc. IEC 60156 ☑
2. Verification of terminal markings ☑
3. Pressure and tightness test: oil overpressure: 0,8 bar / 24h – no traces of oil leakage
4. Power-frequency withstand test on primary windings – A: Up = 120kV / 60s, f = 120Hz; N: Up = 3kV / 60s, f = 50Hz ☑
5. Partial discharge measurement ☑
6. Power-frequency withstand test on secondary windings – Up = 3 kV/60s ☑
7. Determination of errors ☑
8. Measurement of capacitance and dielectric dissipation factor - tg δ ☑
9. Measurement of windings' resistance

Oil dielectric parameters check before filling (oil after treatment)

- Measurement of oil tg δ according to IEC
  Tg δ = 0.2098 %; electrical stress = 1kV/mm, f = 50Hz, oil temp. = 90C ±1C.

- Measurement of breakdown voltage according to IEC 60156
  Mean breakdown voltage = 83.22 kV, Relative standard deviation = 2.59
  f = 50Hz, oil temp. = 24.3 °C, measurement without the stirrer, type of electrodes used: partially spherical.

Sample	Breakdown voltage [kV]
1	79.8
2	84
3	85.7
4	84.9
5	83.1
6	81.8

Partial discharge measurement

- Measurement according to procedure A
  (PD test voltages were reached while decreasing the voltage
  after the power-frequency withstand test on primary winding)
- Stress voltage: 120 kV / 60 s
- Frequency: 120 Hz

Test voltage	1,2 Um = 100.8 kV	1,2 Um / √3 = 58.2 kV
Level of partial discharge	0.5 pC	0.5 pC

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

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

Date of measurement: 2015-11-10

1a-1n: 25 VA 2a-2n: 26VA				p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	-0.057	-0.054	-0.053	
Δφ U	1.9	1.9	1.9	

1a-1n: 6.25 VA 2a-2n: 25VA				p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	0.018	0.021	0.023	
Δφ U	1.6	1.6	1.7	

2a-2n: 25 VA 1a-1n: 25VA				p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	-0.052	-0.049	-0.047	
Δφ U	1.8	1.8	1.8	

2a-2n: 6.25 VA 1a-1n: 25VA				p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	0.021	0.024	0.026	
Δφ U	1.6	1.6	1.7	

da-dn: 50 VA 1a-1n: 25VA; 2a-2n: 25VA					p.f. = 0,8 lag. p.f. = 0,8 lag.
	0,02 Un	0,05 Un	1,0 Un	1,9 Un	
ε U	0.484	0.590	0.719	0.716	
Δφ U	3.4	2.7	2.7	2.9	

1a-1n: 25 VA 2a-2n: 0 VA				p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	-0.013	-0.009	-0.009	
Δφ U	2.9	3.0	3.0	

1a-1n: 6.25 VA 2a-2n: 0 VA				p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	0.063	0.066	0.067	
Δφ U	2.7	2.7	2.7	

2a-2n: 25 VA 1a-1n: 0 VA				p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	-0.007	-0.004	-0.002	
Δφ U	2.8	2.8	2.8	

2a-2n: 6.25 VA 1a-1n: 0 VA				p.f. = 0,8 lag.
	0,8 Un	1,0 Un	1,2 Un	
ε U	0.066	0.069	0.071	
Δφ U	2. 6	2.6	2.7	

da-dn: 12.5 VA 1a-1n: 0 VA; 2a-2n: 0 VA					p.f. = 0,8 lag.
	0,02 Un	0,05 Un	1,0 Un	1,9 Un	
ε U	0.802	0.917	1.042	1.041	
Δφ U	4.1	3.3	3.2	3.3	

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

Measurement of capacitance and dielectric dissipation factor - tg δ

Temperature: 23 °C, Frequency: 50

Primary voltage	Tg δ [%]	Capacity [pF]	Leak.current [mA]
10 kV	0.33	224	0.703
45.5 kV	0.33	224	3.132
48.5 kV	0.33	224	3.412

Measurement of windings' resistance

	R (24 °C)	Rct (75 °C)
A-N	14.00 kΩ	16.861 kΩ
1a-1n	108.70 mΩ	130.914 mΩ
2a-2n	102.70 mΩ	123.688 mΩ
da-dn	42.53 mΩ	51.221 mΩ

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

Checked by: J. Krawczyk

OG-4
KJ-58

Przasnysz, 2015-11-10

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EWN/109/E/15-3

Annex 3

ANNEX 3 for test report EWN/109/E/15-3

(8 pages)

Lightning impulse test protocol:

- ewn109e15-3a

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

Próba udarem uciętym 1,2/50us

project : ewn109e15-3a test date 07-10-2015

Test - object - data

WNR	EWN/109/E/15-3a	TR-No. 1HSE8851777		O.-No. 4500678253	
test object	EMF-E084		vector group	-	
output	-	kVA	BIL	380	
voltage	84	kV	frequency	50	Hz
customer	ABB Sp. z o. o. ul. Zeganska 1, 04-713 Warszawa				

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Próba udarem uciętym 1,2/50us

project : ewn109e15-3a

LI lightning-impulse

no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Ip [A]	remark
1	-190.1	1.12	45.5		-57.73	LI: A - RW(50.0%)
2	-381.4	1.12	45.1		-65.13	LI: A - FW(100.0%)
3	-219.6	1.14		3.51	-66.33	LI: A - CRW(57.5%)
4	-438.6	1.12		3.91	-79.62	LI: A - CFW(115.0%)
5	-438.4	1.13		3.62	-74.01	LI: A - CFW(115.0%)
6	-380.9	1.12	45.2		-56.15	LI: A - FW(100.0%)
7	-381.1	1.12	45.2		-56.08	LI: A - FW(100.0%)
8	-381.1	1.12	45.2		-56.17	LI: A - FW(100.0%)
9	-381.3	1.12	45.2		-56.19	LI: A - FW(100.0%)
10	-381.2	1.13	45.2		-56.08	LI: A - FW(100.0%)
11	-381.2	1.12	45.2		-56.21	LI: A - FW(100.0%)
12	-381.3	1.12	45.2		-59.65	LI: A - FW(100.0%)
13	-381.1	1.12	45.3		-56.12	LI: A - FW(100.0%)
14	-381	1.12	45.3		-56.03	LI: A - FW(100.0%)
15	-381.1	1.12	45.2		-56.15	LI: A - FW(100.0%)
16	-381.3	1.12	45.2		-56.11	LI: A - FW(100.0%)
17	-381.3	1.12	45.3		-56.14	LI: A - FW(100.0%)
18	-381.1	1.12	45.2		-56.13	LI: A - FW(100.0%)
19	-381	1.12	45.3		-56.27	LI: A - FW(100.0%)
20	191.7	1.15	45.4		57.91	LI: A - RW(50.0%)
21	380.5	1.13	45.3		56.69	LI: A - FW(100.0%)
22	380.4	1.12	45.3		56.09	LI: A - FW(100.0%)
23	380.3	1.12	45.3		59.51	LI: A - FW(100.0%)
24	380.3	1.12	45.3		56.48	LI: A - FW(100.0%)
25	380.1	1.12	45.3		56.52	LI: A - FW(100.0%)
26	380.1	1.12	45.3		56.57	LI: A - FW(100.0%)
27	380.4	1.12	45.3		56.56	LI: A - FW(100.0%)
28	380	1.12	45.3		56.67	LI: A - FW(100.0%)
29	380.4	1.12	45.3		56.69	LI: A - FW(100.0%)
30	379.8	1.12	45.3		56.23	LI: A - FW(100.0%)
31	379.9	1.12	45.4		56.53	LI: A - FW(100.0%)
32	380.2	1.12	45.4		62.05	LI: A - FW(100.0%)
33	379.9	1.12	45.3		56.42	LI: A - FW(100.0%)
34	379.9	1.12	45.4		66.38	LI: A - FW(100.0%)
35	379.8	1.12	45.4		56.55	LI: A - FW(100.0%)

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Próba udarem uciętym 1,2/50us

project : ewn109e15-3a

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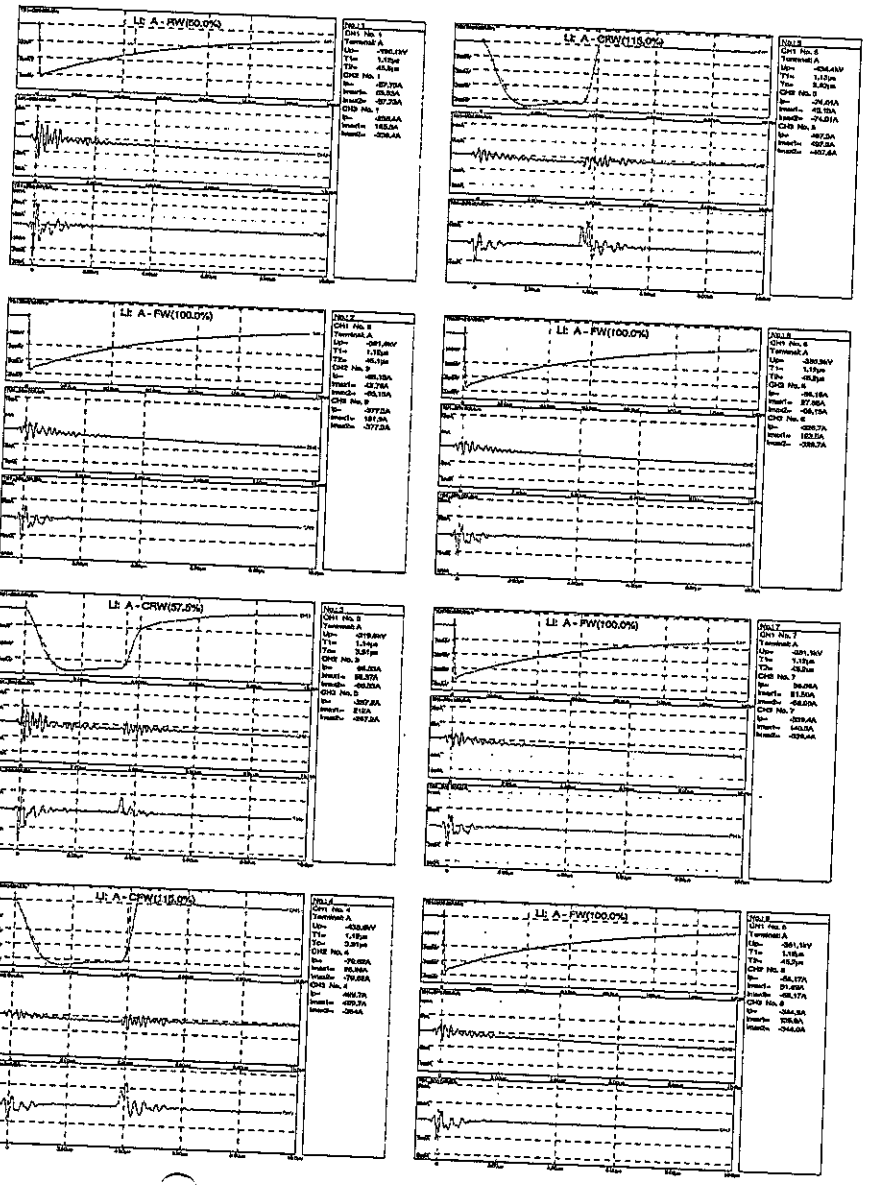
Próba udarem uciętym 1,2/50us

project : ewn109e15-3a



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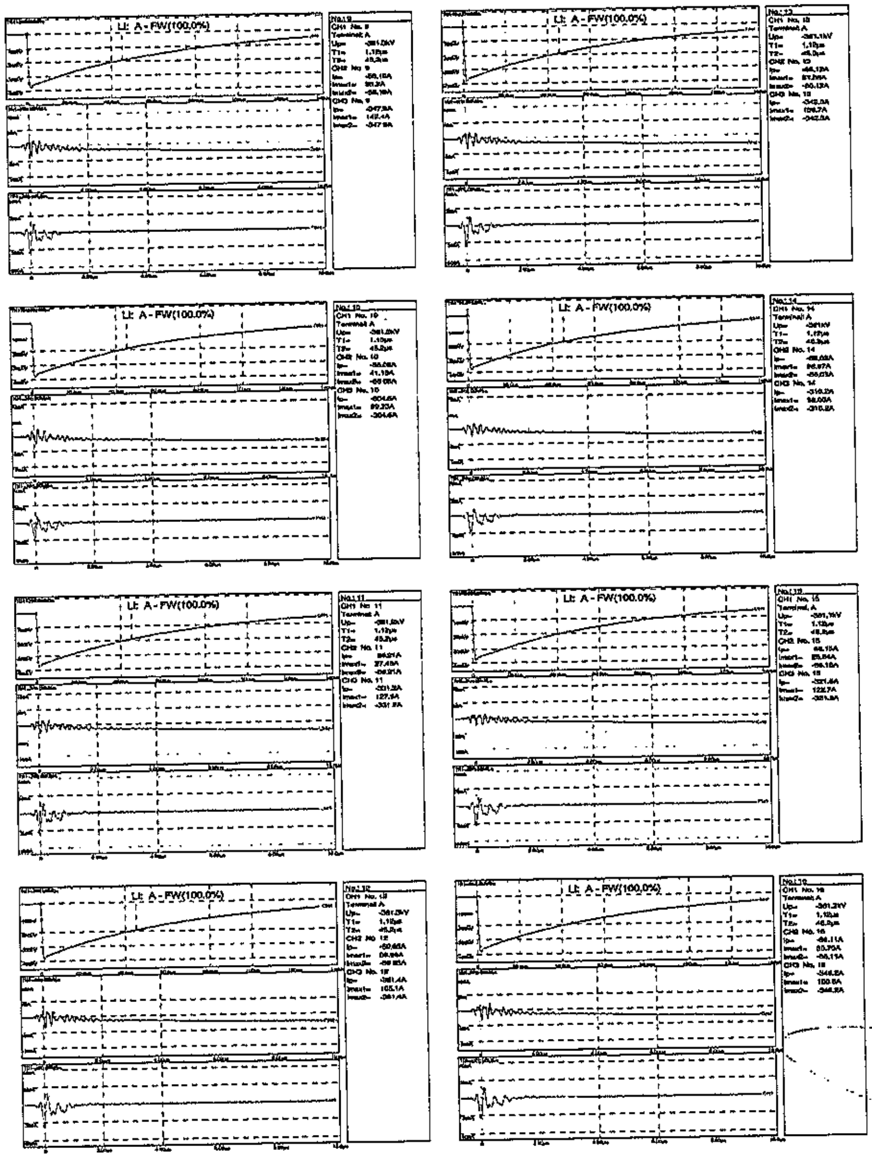

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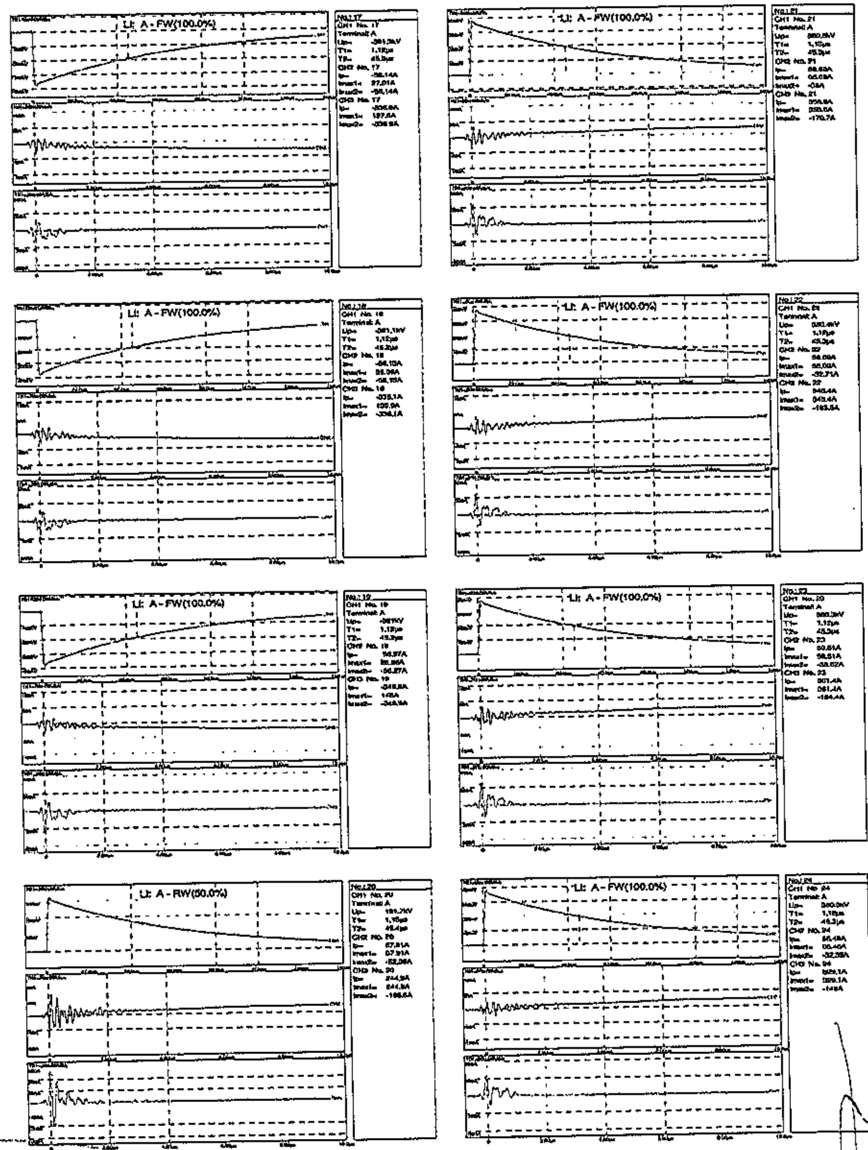

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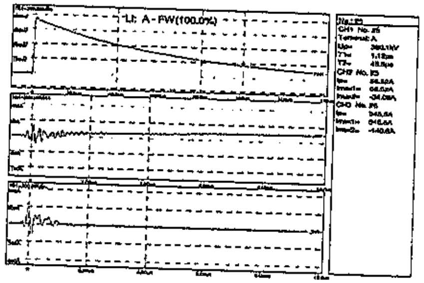
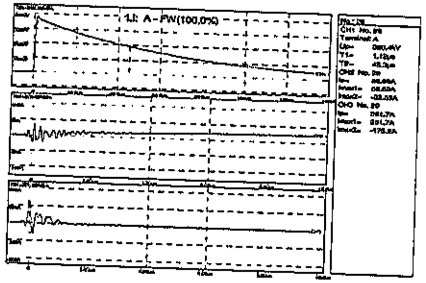
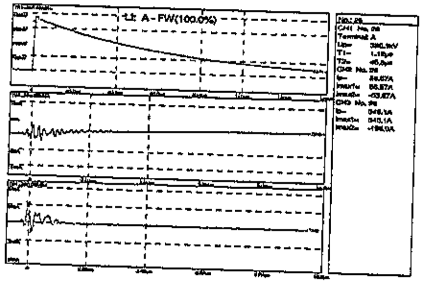
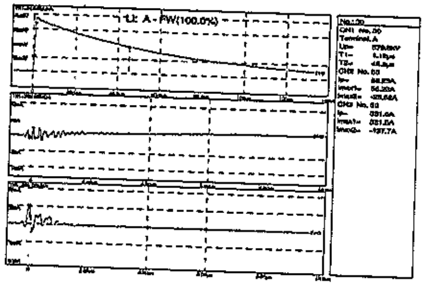
Próba udarem uciętym 1,2/50us

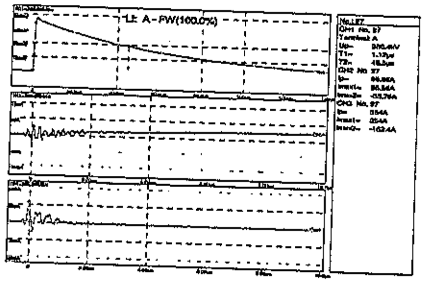
project : ewn109e15-3a

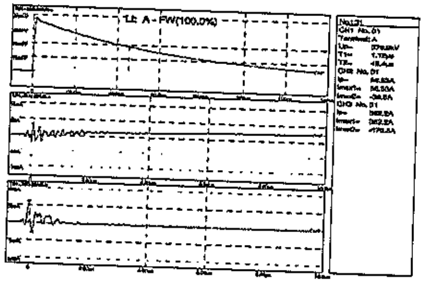


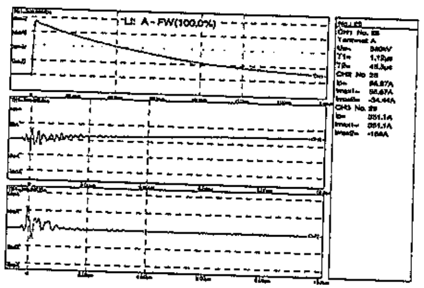


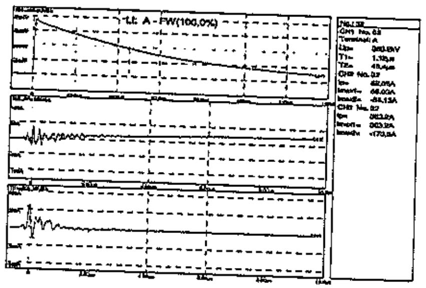












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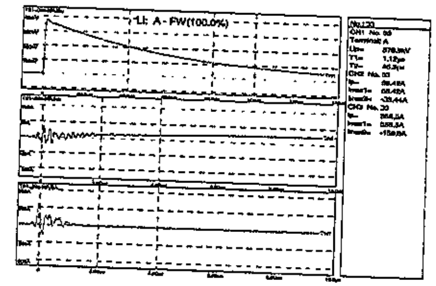
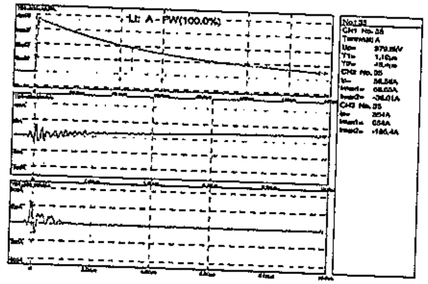
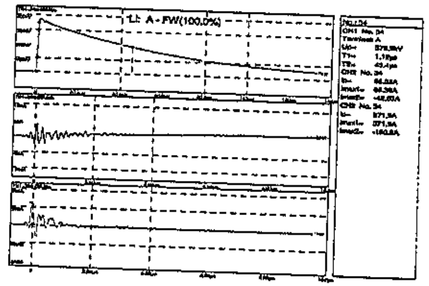
Próba udarem uciętym 1,2/50us

project : ewn109e15-3a







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ANNEX 4 for test report EWN/109/E/15-3

(3 pages)

Transmitted overvoltage test protocol:

- ewn109e15-3b

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

Test - object - data

test date	14-10-2015
factory ser.-no.	1HSE8851777
test object	EMF-E084
order-no.	4500678253
specification	
test-field	

Climate - Data

temperature	5 °C	humidity	48 %
		air-pressure	1013 hPa

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

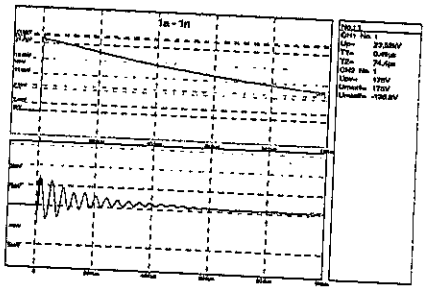
project : ewn109e15-3b

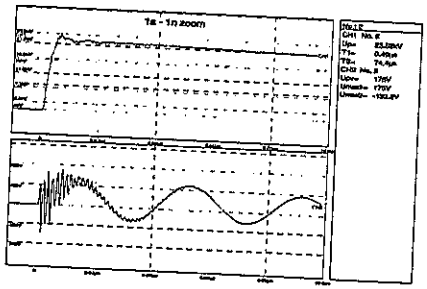
LI lightning-impulse

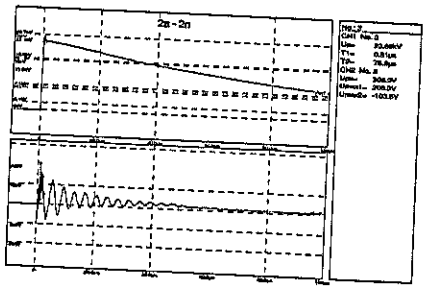
no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Up [V]	remark
1	23.52	0.49	74.4		175	1a - 1n
2	23.52	0.49	74.4		175	1a - 1n zoom
3	23.69	0.51	73.8		208.3	2a - 2n
4	23.69	0.51	73.8		208.3	2a - 2n zoom
5	23.59	0.5	74.1		136	da - dn
6	23.59	0.5	74.1		136	da - dn zoom

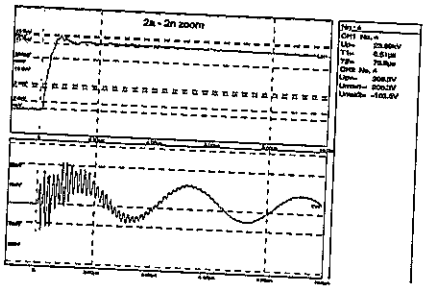
HIGH VOLTAGE LABORATORY
POLAND 01-330 WARSZAWA, ul. Mory 8
fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

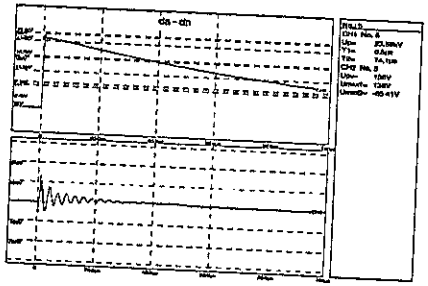
project : ewn109e15-3b

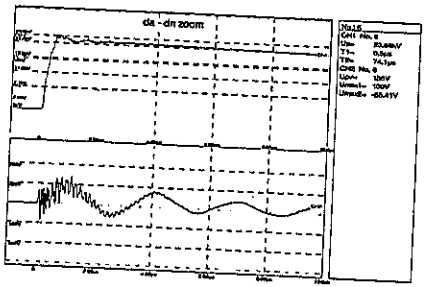












HIGH VOLTAGE LABORATORY

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LABORATORY ACCREDITED
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Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/109/E/15-4

Transmitted overvoltage test,
Electromagnetic Compatibility (EMC) tests – RIV test
of voltage instrument transformer type EMF-E145

Warsaw, November 2015

TEST REPORT EWN/109/E/15-4

TEST OBJECT:	**Voltage instrument transformer type EMF-E145**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500678253 (15.09.2015)**
TEST TYPE:	**Transmitted overvoltage test**
TEST PROCEDURE:	**Electromagnetic Compatibility (EMC) tests – RIV test** **According to:** **PN-EN/IEC 61869-1** **PN/EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**29.10.2015; 03.11.2015**
TEST RESULT:	**POSITIVE- details are presented in following parts of report**

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

Warsaw, November 2015.

CONTENTS

Test report includes:

- 11 numbered pages;
- 3 figures;
- 1 photograph;
- 5 tables.

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

Annex 2: Transmitted overvoltage test protocol (3 pages);

1 COMPETENCE OF THE LABORATORY

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

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

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

Note

Tests described in sub-clause 5.1 of this Report don't comply with the scope of Laboratory accreditation.

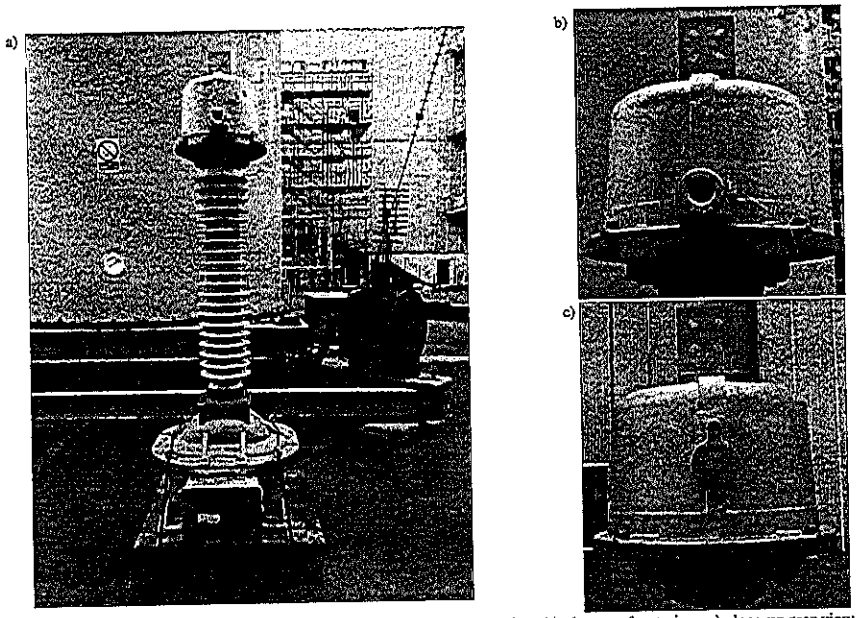
2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer EMF-E145 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 1 – EMF-E145

Serial number: 1HSE8851772

- Highest voltage for equipment 145 kV
- Rated primary voltage 145000 / √3 V
- Insulation level 275 / 650 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 248 kg



Phot. 1: Tested voltage transformer EMF-E145: a) general view, b) close-up front view, c) close-up rear view

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E145 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Electromagnetic Compatibility (EMC) tests - RIV test	PN-EN/IEC 61869-1, p.7.2.5
SPECIAL TESTS		
2	Transmitted overvoltage test	PN-EN/IEC 61869-1, p.7.4.4

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o. in the presence of a representative of the High Voltage Department of Institute of Power Engineering. Detailed results are presented in Annex 2.

Tests were carried out according to:

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

4 TYPE TEST

4.1 Electromagnetic compatibility (EMC) tests - RIV test

4.1.1 Method of testing and acceptance criteria

Measurement of the radio interference voltage was performed according to IEC 61869-1 clause 7.2.5.1. Before taking the measurement a pre-stress voltage was applied and maintained for 30 s (voltage value $U_{RIVpre}=1.5 \cdot U_m/\sqrt{3}$). Then, within 10 seconds, the voltage was decreased to test voltage value equal to $U_p=1.1 \cdot U_m/\sqrt{3}$ and maintained at this level for another 30 s. After that time RIV value was measured.

It is considered that the instrument voltage transformer passed the test with a positive result if the value of the RIV, measured at a voltage equal to U_p, does not exceed 2500 µV (IEC 61869-1 clause 6.11.2).

Besides measuring the maximal level of the RIV at a voltage equal to U_p, the RIV characteristics of the tested instrument transformer were prepared in scope of voltages equal to $0,3 \cdot U_m/\sqrt{3}$ - $1.1 \cdot U_m/\sqrt{3}$.

4.1.2 Test arrangement

Measurement was carried out in a measuring system shown in the Fig. 1, measuring interference voltage drop on a resistance 300Ω at frequency 0,5 MHz with a RIV voltmeter LMZ-4 of a logarithmic scale (0 dB = 1 μV on 300Ω). Before actual measurements the calibration of the measuring system was performed using a stable signal generator resulting in correction factor estimation. Moreover, the „background level" was checked within the test voltages scope 0-300 kV.

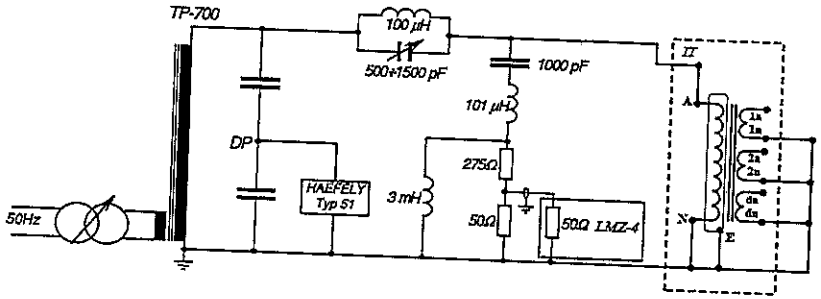


Fig. 1: Diagram of the RIV level measuring system

4.1.3 Test conditions

Test conditions for measurement of the radio interference voltage are presented in Tab. 2. No correction factors for atmospheric conditions are applicable for this test.

Tab. 2: Test conditions for measurement of the radio interference voltage

ATMOSPHERIC CONDITIONS			
Temperature	t	°C	10,6
Pressure	p	hPa	1009,9
Relative humidity	R	%	57,2
VOLTAGES			
Pre-stress voltage	U_{RIVps}	kV	125,6
Test voltage	U_p	kV	92
Estimated correction factor	RIV_{CF}	dB	24

4.1.4 Test results

Maximal measured RIV level at a voltage equal to U_p = 92 kV : (39 +/- 0,5) dB = 89,1 μV

Tab. 3: RIV measurement results

U [kV]		92	84	75	67	59	50	42	33	25
x $U_m/\sqrt{3}$		1,1	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3
[dB]	→	15	13	10	5	0	-	-	-	-
	←	-	14	12	7	1	-6	-	-	-
	→	15	13	10	6	2	-5	-	-	-
RIV	[dB]	39	37	34	30	26	16	-	-	-
	[μV]	89,1	70,8	50,1	31,6	20,0	8,9	-	-	-

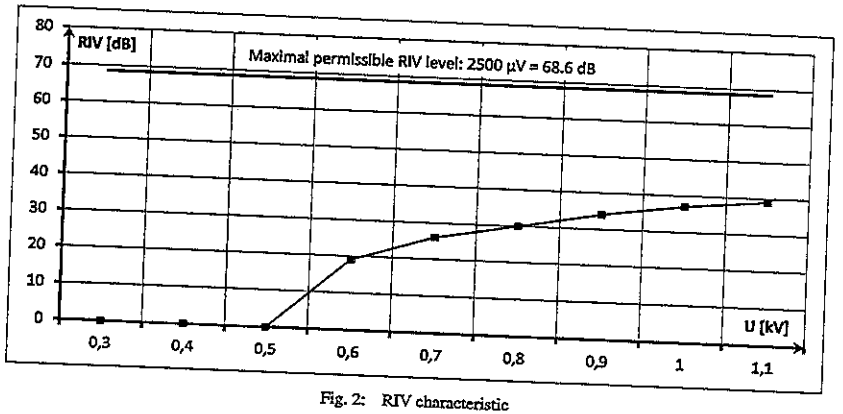


Fig. 2: RIV characteristic

TEST RESULT: POSITIVE

5 SPECIAL TESTS

5.1 Transmitted overvoltage test

5.1.1 Method of testing and acceptance criteria

Transmitted overvoltage test was performed according to IEC 61869-3, IEC 61869-1 clause 7.4.4 and 6.11.4. During the test type „A" impulse (U_i) was applied between the primary terminal A and earth. Measurements of transmitted voltage (U_2) were carried out for all the secondary windings of the voltage instrument transformer.

It is considered that the instrument voltage transformer passed the test with a positive result if the value of the transmitted voltage (U_S) does not exceed 1,6 kV (IEC 61869-1 clause 6.11.4 Table 9).

5.1.2 Test arrangement

Arrangement for transmitted overvoltage measurement was based on one step of Marx impulse generator made by HAEFELY. Measurement of the voltage U_1 applied to the primary terminal of the instrument transformer was performed with impulse voltage measuring system Dr Strauss TR-AS 200-14, in connection with a resistive voltage divider Siemens SMR 10/770. The transmitted voltage U_2 measurement was also performed with impulse voltage measuring system Dr Strauss TR-AS 200-14. For both measured voltages U_1 and U_2 impulse peak value measuring uncertainty doesn't exceed 2% of the measured value for the confidence interval 95% and coverage factor k=2. Simplified diagram of the measurement system is shown in the Fig. 3.

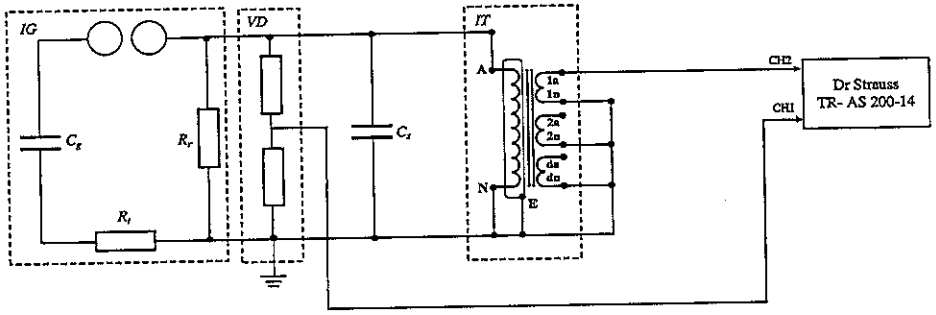


Fig. 3: Simplified diagram of the transmitted overvoltage measurement system *IG* – impulse generator; *VD* – voltage divider; C_g, R_s, R_r – generator elements; C_S – front shaping capacitor; *IT* - instrument transformer (general schematic representation);

5.1.3 Test conditions

Test conditions for transmitted overvoltage test (parameters of the measurement system and value of test voltage) are presented in Tab. 4. The influence of atmospheric condition on test voltage value was not taken into consideration.

Tab. 4: Parameters of the transmitted overvoltage measurement system and parameters of the test voltage

IMPULSE GENERATOR			
Number of steps	n	-	1
General capacitance	C_g	μF	0,750
Discharge resistance	R_r	Ω	150
Damping resistance	R_s	Ω	89
VOLTAGE DIVIDER			
HV unit resistance	R_u'	Ω	10098,96
LV unit resistance	R_u''	Ω	10,06
Scale factor	ϑ_V	-	1005
FRONT SHAPING CAPACITOR			
Front shaping capacitor	C_S	pF	500
PARAMETERS OF THE TEST VOLTAGE			
Peak value of applied voltage	U_i	kV	19,9
Conventional front time	T_1	μs	0,46
Time to half-value	T_2	μs	73

5.1.4 Test results

Results of the transmitted overvoltage measurement are presented in Tab. 5. The oscillograms of all applied and registered impulses are present in Annex 4 of hereby Report.

Tab. 5: Transmitted overvoltage measurement results

terminal	U_1	U_2	U_s	$U_{s\%}$
	kV	V	V	%
1a - 1n	19,9	146,8	1397,4	87,3
2a - 2n	19,9	122,5	1169,0	73,1
3a - 3n	19,9	127,9	1218,7	76,2
da - dn	19,9	102,0	970,9	60,7

Note:
U_1 – peak value of applied voltage
U_2 – maximal value of transmitted voltage
U_s – maximal value of transmitted voltage for specified overvoltage U_p
U_p – specified overvoltage $U_p = 1{,}6 \cdot U_m \cdot \sqrt{2}/\sqrt{3}$
$U_{s\%}$ – percent of permissible overvoltage $U_{s\%} = U_s/1600 \cdot 100\%$

TEST RESULT: POSITIVE

HIGH VOLTAGE LABORATORY
INSTYTUT ENERGETYKI
01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242
tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl
EWN/109/E/15-4
Annex 1

ANNEX 1 for test report EWN/109/E/15-4

(3 pages)

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

- Declaration of conformity – No. 101/2015 (EN),
- Rating plate – Document No. 1HSE 22040-PCA,
- Technical drawing – Document id. 1HSE8851772.

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

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

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product comforms with the following standard :

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

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

Place and date of issue of declaration

Przasnysz 29.10.2015

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

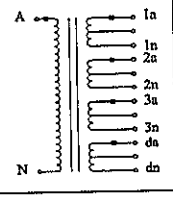
Kierownik ds. Zapewnienia Jakości
ABB Sp. z o.o.
Oddział w Przasnyszu
Krzysztof Lubecki

(Signature)

ABB	CE	ABB AB		Made in Sweden
Voltage transformer		Type EMF-E145	Production year	yyyy
Serial number	1HSE nnnnnnn	Standard		IEC 61869-3
Insulation level	275 / 650 kV	Frequency		50 Hz
Rated primary voltage	145000/√3 V	Temperature range		-40 – +40 °C
Highest voltage for equipment	145 kV	Total mass		248 kg

1HSE 68504-5

Serial number	1HSE nnnnnnn
Insulation oil	(IEC 61039: LNTIO-296) 80 kg
Voltage factor	1.9 / 8h



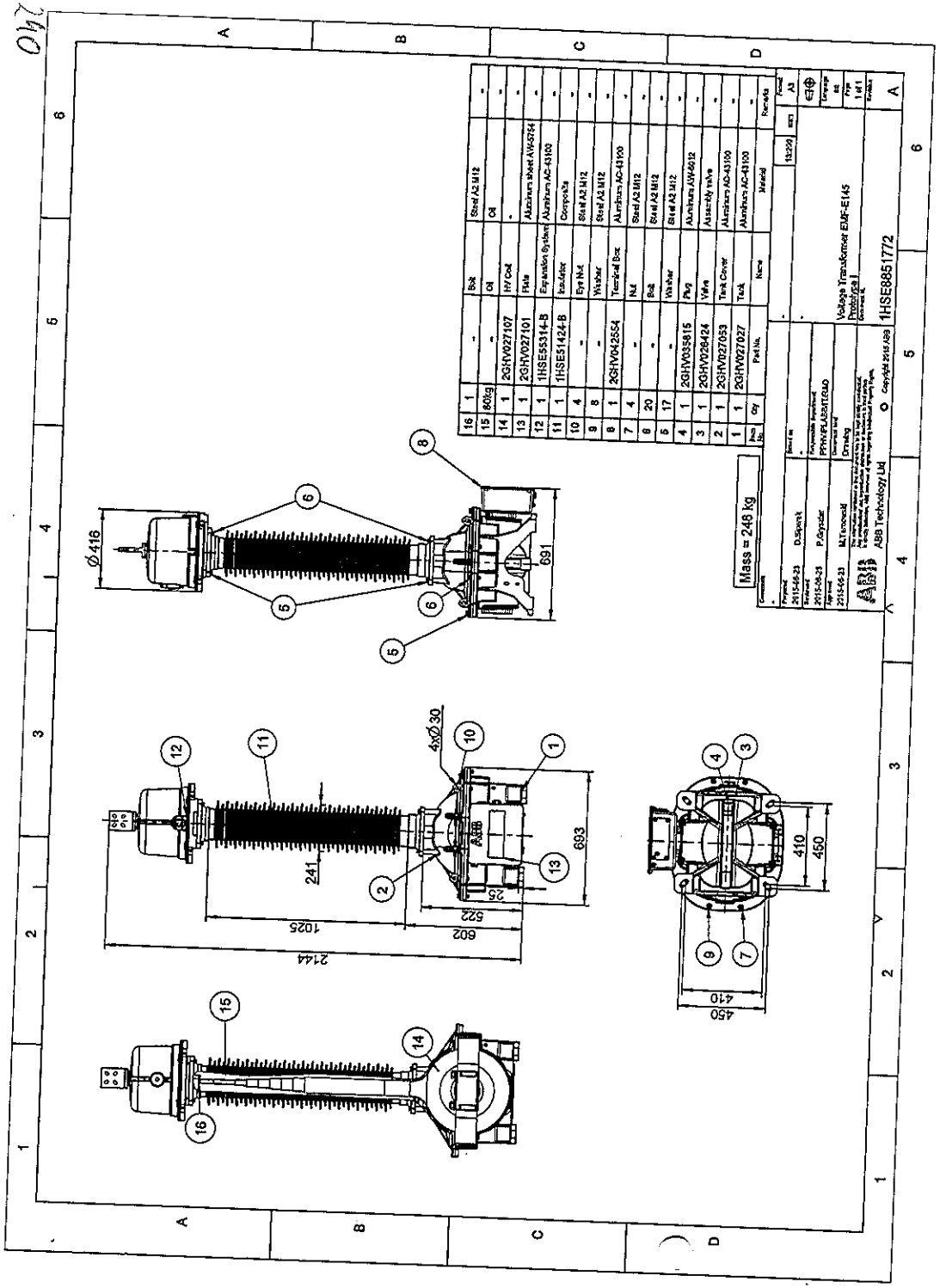
Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA	
A-N	145000/√3					
1a-1n	115/√3	0.1	25	75	1500+0	
1a-1n	115/√3	1.0	25	550	1500+0	
2a-2n	115/√3	0.1	25	75	1500+0	
2a-2n	115/√3	1.0	25	550	1500+0	
3a-3n	115/√3	0.1/3P	25	75	1500+0	
3a-3n	115/√3	3.0/3P	500	550	1500+0	
da-dn	115	1.0	100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

1HSE 68504-6

Serial number 1HSE nnnnnnn = 1HSE 8851772

Production year yyyy = Actual year for production

Prepared		Responsible department	Title	
Gustaf Högberg	2015-06-18	PPHC/IM	Rating plate	
Approved		Take over department		Language
Björn Sjöström	2015-06-18			en
Revision			Order No.	Sheet
A Data changed. 2015-07-01.			E90000012-10	1
ABB AB			Document No.	Last
			1HSE 22040-PCA	1



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

EWN/109/E/15-4

Annex 2

ANNEX 2 for test report EWN/109/E/15-4

(3 pages)

Transmitted overvoltage test protocol:

- ewn109e15-4b

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

project : ewn109e15-4b test date 29-10-2015 page 1

Test - object - data

test date	29-10-2015
factory ser.-no.	1HSE8851772
test object	EMF-E145
order-no.	4500678253
specification	
test-field	

Climate - Data

temperature	7.7 °C	humidity	73.9 %
		air-pressure	1007 hPa

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

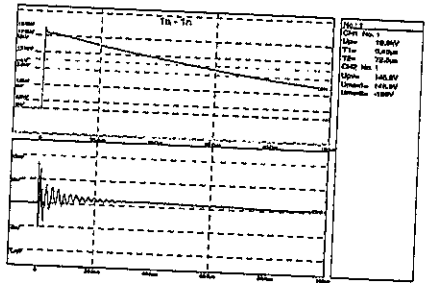
project : ewn109e15-4b page 2

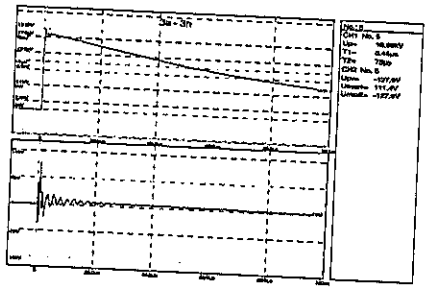
LI lightning-impulse

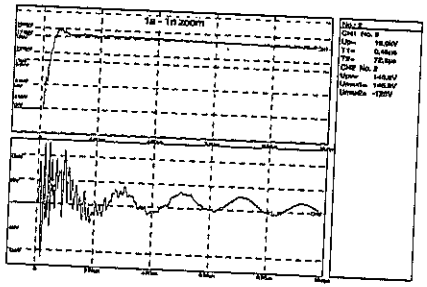
no.	Up [kV]	T1[µs]	T2[µs]	Tc[µs]	Up [V]	remark
1	19.9	0.46	72.8		146.8	1a - 1n
2	19.9	0.46	72.8		146.8	1a - 1n zoom
3	19.85	0.46	73		122.5	2a - 2n
4	19.85	0.46	73		122.5	2a - 2n zoom
5	19.88	0.46	73		-127.9	3a - 3n
6	19.88	0.46	73		-127.9	3a - 3n zoom
7	19.9	0.46	72.8		-102	da - dn
8	19.9	0.46	72.8		-102	da - dn zoom

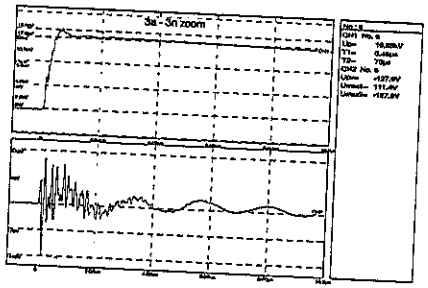
HIGH VOLTAGE LABORATORY
POLAND 01-330 WARSZAWA, ul. Mory 8
fax: (+4822) 836-80-48, mail: ewn@ien.com.pl

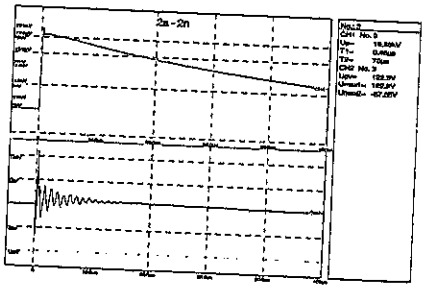
project : ewn109e15-4b

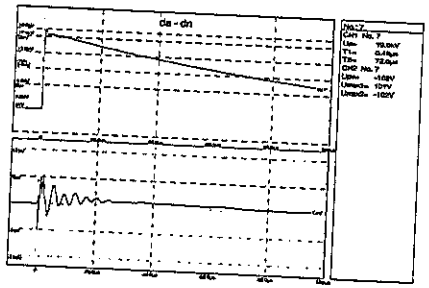


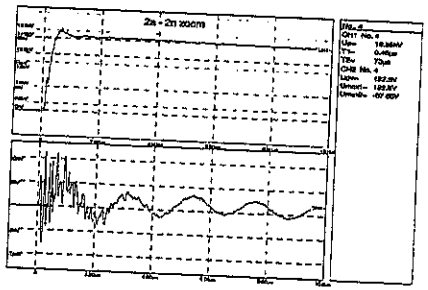


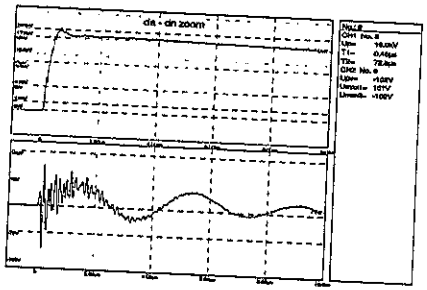












HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/109/E/15-5

Electromagnetic Compatibility (EMC) tests – RIV test
of voltage instrument transformer type EMF-E145

Warsaw, November 2015

TEST REPORT EWN/109/E/15-5

TEST OBJECT:	**Voltage instrument transformer type EMF-E145**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500678253 (15.09.2015)**
TEST TYPE:	**Electromagnetic Compatibility (EMC) tests – RIV test**
TEST PROCEDURE:	**According to:** **PN-EN/IEC 61869-1** **PN/EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**04.11.2015**
TEST RESULT:	**POSITIVE - details are presented in following parts of report**

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

Warsaw, November 2015.

CONTENTS

Test report includes:

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

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

1 COMPETENCE OF THE LABORATORY

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

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

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

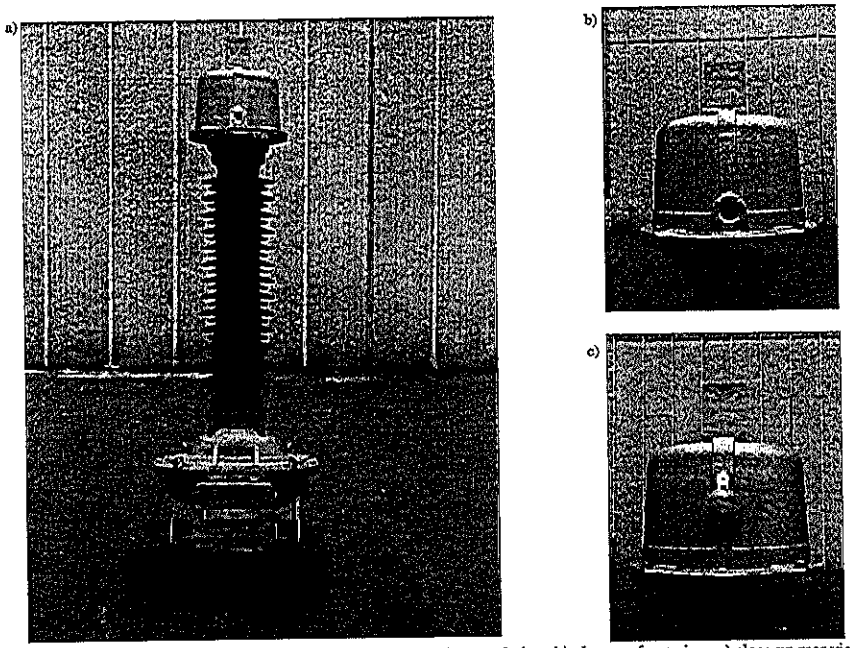
2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer EMF-E145 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 2 – EMF-E145

Serial number: 1HSE8851773

- Highest voltage for equipment 145 kV
- Rated primary voltage 145000 / √3 V
- Insulation level 275 / 650 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 295 kg



Phot. 1: Tested voltage transformer EMF-E145: a) general view, b) close-up front view, c) close-up rear view

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E145 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Electromagnetic Compatibility (EMC) tests - RIV test	PN-EN/IEC 61869-1, p.7.2.5

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o. in the presence of a representative of the High Voltage Department of Institute of Power Engineering. Detailed results are presented in Annex 2.

Tests were carried out according to:

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

4 TYPE TEST

4.1 Electromagnetic compatibility (EMC) tests - RIV test

4.1.1 Method of testing and acceptance criteria

Measurement of the radio interference voltage was performed according to IEC 61869-1 clause 7.2.5.1. Before taking the measurement a pre-stress voltage was applied and maintained for 30 s (voltage value $U_{RIVpre}=1.5 \cdot U_m/\sqrt{3}$). Then, within 10 seconds, the voltage was decreased to test voltage value equal to $U_p=1.1 \cdot U_m/\sqrt{3}$ and maintained at this level for another 30 s. After that time RIV value was measured.

It is considered that the instrument voltage transformer passed the test with a positive result if the value of the RIV, measured at a voltage equal to U_p, does not exceed 2500 µV (IEC 61869-1 clause 6.11.2).

Besides measuring the maximal level of the RIV at a voltage equal to U_p, the RIV characteristics of the tested instrument transformer were prepared in scope of voltages equal to $0,3 \cdot U_m/\sqrt{3}$ - $1.1 \cdot U_m/\sqrt{3}$.

4.1.2 Test arrangement

Measurement was carried out in a measuring system shown in the Fig. 1, measuring interference voltage drop on a resistance 300Ω at frequency 0,5 MHz with a RIV voltmeter LMZ-4 of a logarithmic scale (0 dB = 1 μV on 300Ω). Before actual measurements the calibration of the measuring system was performed using a stable signal generator resulting in correction factor estimation. Moreover, the „background level" was checked within the test voltages scope 0-300 kV.

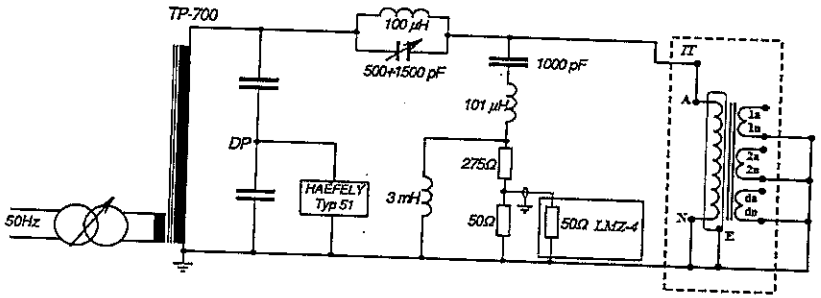


Fig. 1: Diagram of the RIV level measuring system

4.1.3 Test conditions

Test conditions for measurement of the radio interference voltage are presented in Tab. 2. No correction factors for atmospheric conditions are applicable for this test.

Tab. 2: Test conditions for measurement of the radio interference voltage

ATMOSPHERIC CONDITIONS			
Temperature	t	°C	10,5
Pressure	p	hPa	1010
Relative humidity	R	%	61
VOLTAGES			
Pre-stress voltage	U_{RIVps}	kV	125,6
Test voltage	U_p	kV	92
Estimated correction factor	RIV_{CF}	dB	24

4.1.4 Test results

Maximal measured RIV level at a voltage equal to $U_p = 92$ kV : (37 +/- 0,5) dB = 70,8 μV

Tab. 3: RIV measurement results

U [kV]		92	84	75	67	59	50	42	33	25
x $U_m/\sqrt{3}$		1,1	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3
[dB]	→	14	10	8	0	-	-	-	-	-
	←	-	11	9	1	-4	-	-	-	-
	→	13	10	8	1	-5	-	-	-	-
RIV	[dB]	37	34	32	25	19	-	-	-	-
	[μV]	70,8	50,1	39,8	17,8	8,9	-	-	-	-

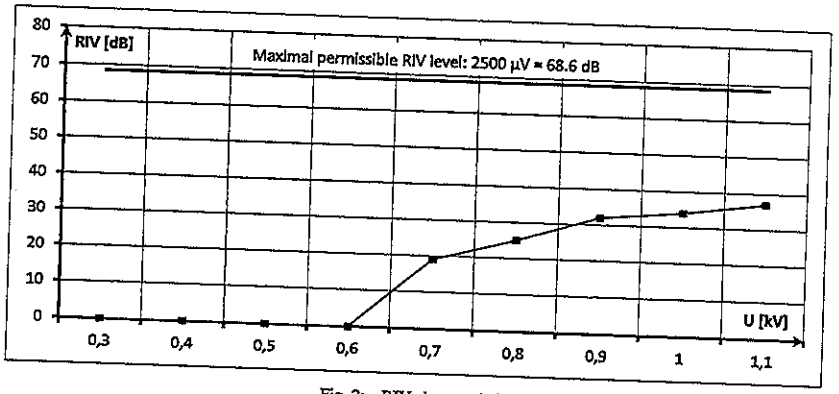


Fig. 2: RIV characteristic

TEST RESULT: POSITIVE

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

ANNEX 1 for test report EWN/109/E/15-5

(3 pages)

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

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

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

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

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product comforms with the following standard :

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

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

Place and date of issue of declaration

Przasnysz 29.10.2015

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

Kierownik Działalności DPHV
ABB Sp. z o.o.
Oddział w Przasnyszu
Paweł Nemerski

(Signature)

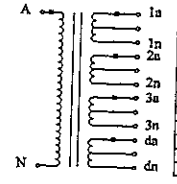
ABB CE

ABB AB

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

1HSE 68504-5

Serial number	1HSE nnnnnnn
Insulation oil	(IEC 61039: L-NTIO-296) 80 kg
Voltage factor	1.9 / 8h



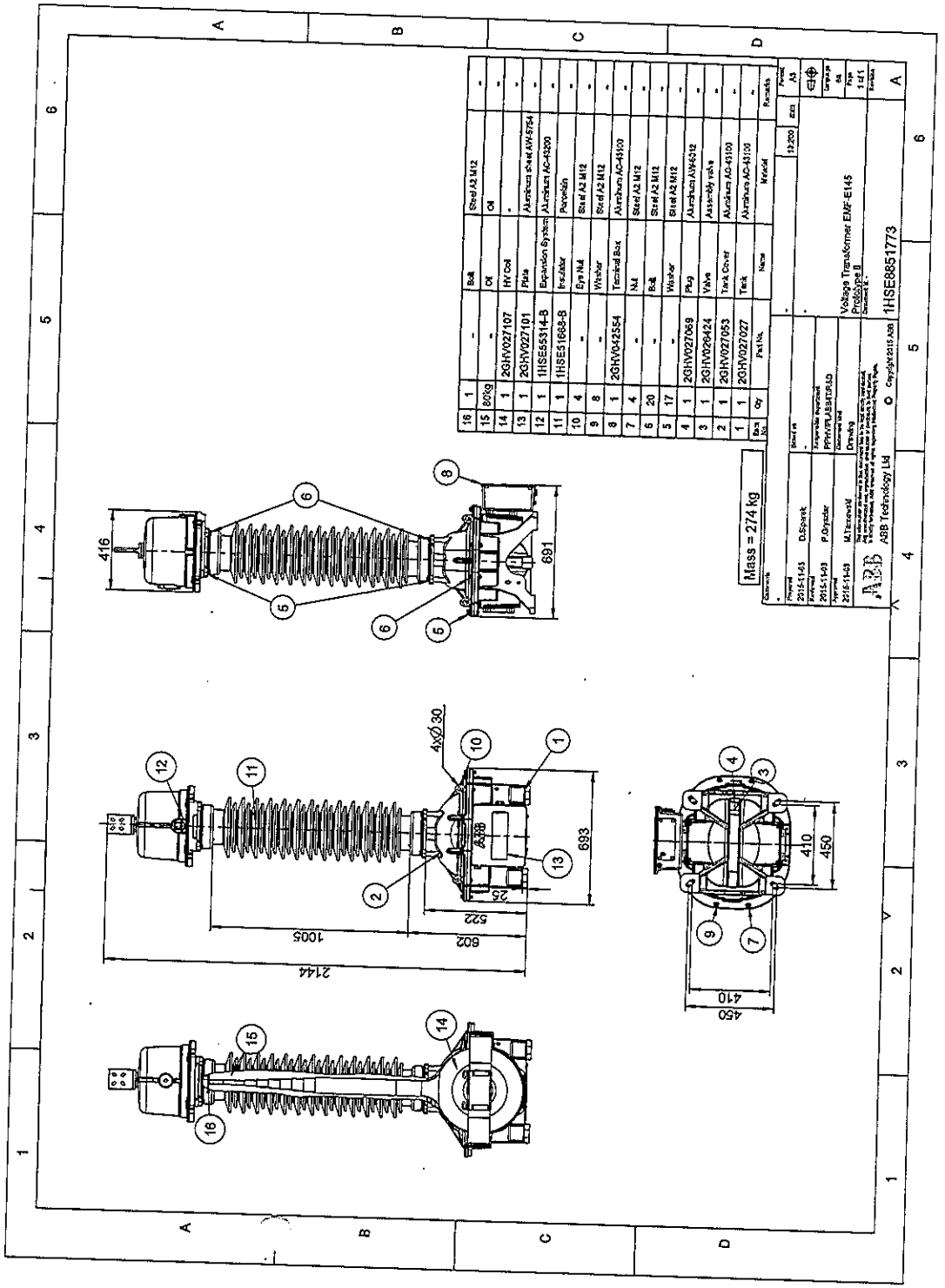
Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA
A-N	145000/√3				
1a-1n	115/√3	0.1	25	75	1500+0
1a-1n	115/√3	1.0	25	550	1500+0
2a-2n	115/√3	0.1	25	75	1500+0
2a-2n	115/√3	1.0	25	550	1500+0
3a-3n	115/√3	0.1/3P	25	75	1500+0
3a-3n	115/√3	3.0/3P	500	550	1500+0
da-dn	115	1.0	100	650	450+0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

1HSE 68504-6

Serial number 1HSE nnnnnnn = 1HSE 8851773

Production year yyyy = Actual year for production

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



HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/109/E/15-7

Electromagnetic Compatibility (EMC) tests – RIV test
of voltage instrument transformer type EMF-E145

Warsaw, December 2015

TEST REPORT EWN/109/E/15-7

TEST OBJECT:	**Voltage instrument transformer type EMF-E145**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500678253 (15.09.2015)**
TEST TYPE:	**Electromagnetic Compatibility (EMC) tests – RIV test**
TEST PROCEDURE:	**According to:** **PN-EN/IEC 61869-1** **PN-EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**21.12.2015**
TEST RESULT:	**POSITIVE - details are presented in following parts of report**

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

Warsaw, December 2015.

CONTENTS

Test report includes:

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

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

1 COMPETENCE OF THE LABORATORY

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

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

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

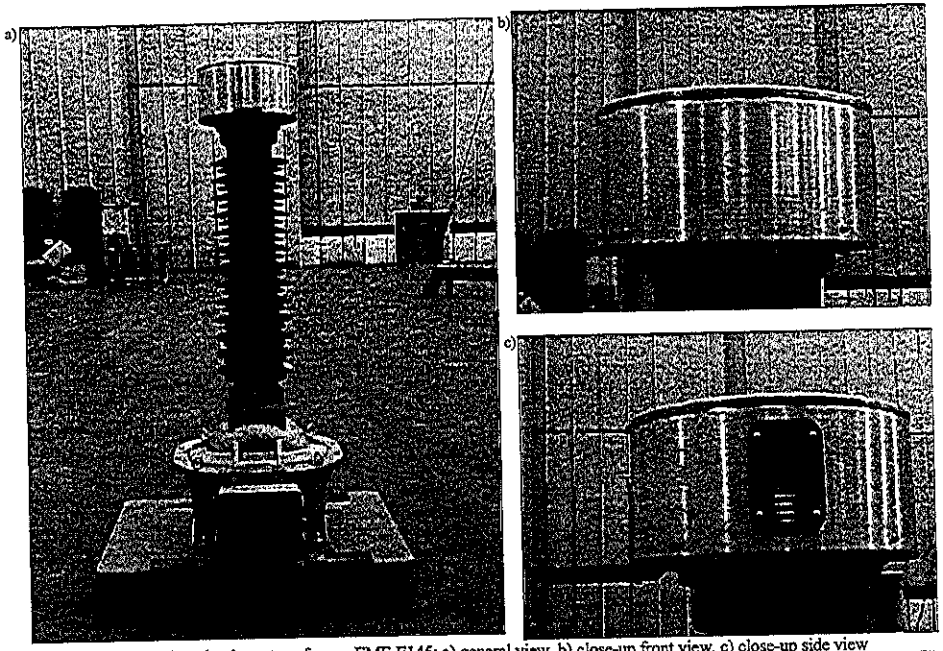
2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer EMF-E145 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 2 – EMF-E145

Serial number: 1HSE8851773

- Highest voltage for equipment 145 kV
- Rated primary voltage 145000 / √3 V
- Insulation level 275 / 650 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 295 kg



Phot. 1: Tested voltage transformer EMF-E145: a) general view, b) close-up front view, c) close-up side view

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E145 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Electromagnetic Compatibility (EMC) tests - RIV test	PN-EN/IEC 61869-1, p.7.2.5

Tests were carried out according to:

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

4 TYPE TEST

4.1 Electromagnetic compatibility (EMC) tests - RIV test

4.1.1 Method of testing and acceptance criteria

Measurement of the radio interference voltage was performed according to IEC 61869-1 clause 7.2.5.1. Before taking the measurement a pre-stress voltage was applied and maintained for 30 s (voltage value $U_{RIV_{pre}}=1.5 \cdot U_m/\sqrt{3}$). Then, within 10 seconds, the voltage was decreased to test voltage value equal to $U_p=1.1 \cdot U_m/\sqrt{3}$ and maintained at this level for another 30 s. After that time RIV value was measured.

It is considered that the instrument voltage transformer passed the test with a positive result if the value of the RIV, measured at a voltage equal to U_p, does not exceed 2500 μV = 68.6 dB (IEC 61869-1 clause 6.11.2).

Besides measuring the maximal level of the RIV at a voltage equal to U_p, the RIV characteristics of the tested instrument transformer were prepared in scope of voltages equal to $0{,}3 \cdot U_m/\sqrt{3}$ - $1.1 \cdot U_m/\sqrt{3}$.

4.1.2 Test arrangement

Measurement was carried out in a measuring system shown in the Fig. 1, measuring interference voltage drop on a resistance 300Ω at frequency 0,5 MHz with a RIV voltmeter LMZ-4 of a logarithmic scale (0 dB = 1 μV on 300Ω). Before actual measurements the calibration of the measuring system was performed using a stable signal generator resulting in correction factor estimation. Moreover, the „background level" was checked within the test voltages scope 0-300 kV.

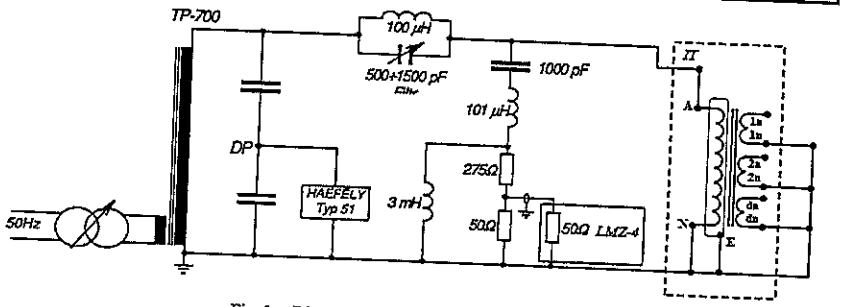


Fig. 1: Diagram of the RIV level measuring system

4.1.3 Test conditions

Test conditions for measurement of the radio interference voltage are presented in Tab. 2. No correction factors for atmospheric conditions are applicable for this test.

Tab. 2: Test conditions for measurement of the radio interference voltage

ATMOSPHERIC CONDITIONS			
Temperature	t	°C	10,1
Pressure	p	hPa	1007,4
Relative humidity	R	%	79,8
VOLTAGES			
Pre-stress voltage	U_{RIVps}	kV	125,6
Test voltage	U_p	kV	92
Estimated correction factor	RIV_{CF}	dB	23

4.1.4 Test results

Maximal measured RIV level at a voltage equal to U_p = 92 kV : 22 dB = 12,6 µV

Tab. 3: RIV measurement results

U [kV]		92	84	75	67	59	50	42	33	25
x $U_m/\sqrt{3}$		1,1	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3
[dB]	→	-1	-3	-	-	-	-	-	-	-
	←	-	-2	-5	-	-	-	-	-	-
	→	-1	-2	-4	-	-	-	-	-	-
RIV	[dB]	22	21	19	-	-	-	-	-	-
	[µV]	12,6	11,2	8,9	-	-	-	-	-	-

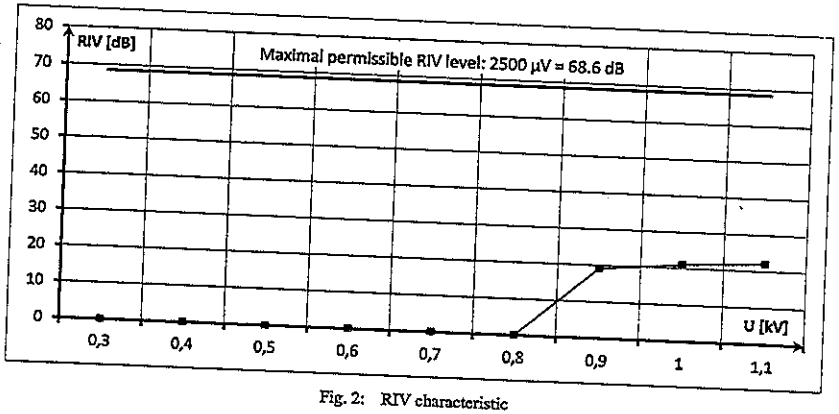


Fig. 2: RIV characteristic

TEST RESULT: POSITIVE

IEN	**HIGH VOLTAGE LABORATORY** **INSTYTUT ENERGETYKI** 01-330 WARSZAWA, ul. Mory 8, tel. (22) 3451242 tel. fax. (22) 8368048, e-mail: ewn@ien.com.pl	EWN/109/E/15-7 Annex 1

ANNEX 1 for test report EWN/109/E/15-7

(3 pages)

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

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

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

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

Manufacturer: ABB

Product: Voltage Instrument Transformer EMF-E145

Above mentioned product comforms with the following standard :

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

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

Place and date of issue of declaration

Przasnysz 29.10.2015

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

Kierownik Grupy BPNV
ABB Sp. z o.o.
Oddział w Przasnyszu
Paweł Nemeski

303

ABB CE

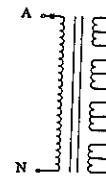
Voltage transformer		ABB AB		Made in Sweden
Serial number	1HSE nnnnnnn	Type EMF-E145	Production year	yyyy
Insulation level	275/650 kV	Standard		IEC 61869-3
Rated primary voltage	145000/√3 V	Frequency		50 Hz
Highest voltage for equipment	145 kV	Temperature range		-40 – +40 °C
		Total mass		295 kg

1HSE 68504-5

Serial number 1HSE nnnnnnn

Insulation oil (IEC 61039: L-NTIO-296) 80 kg

Voltage factor 1.9 / 8h



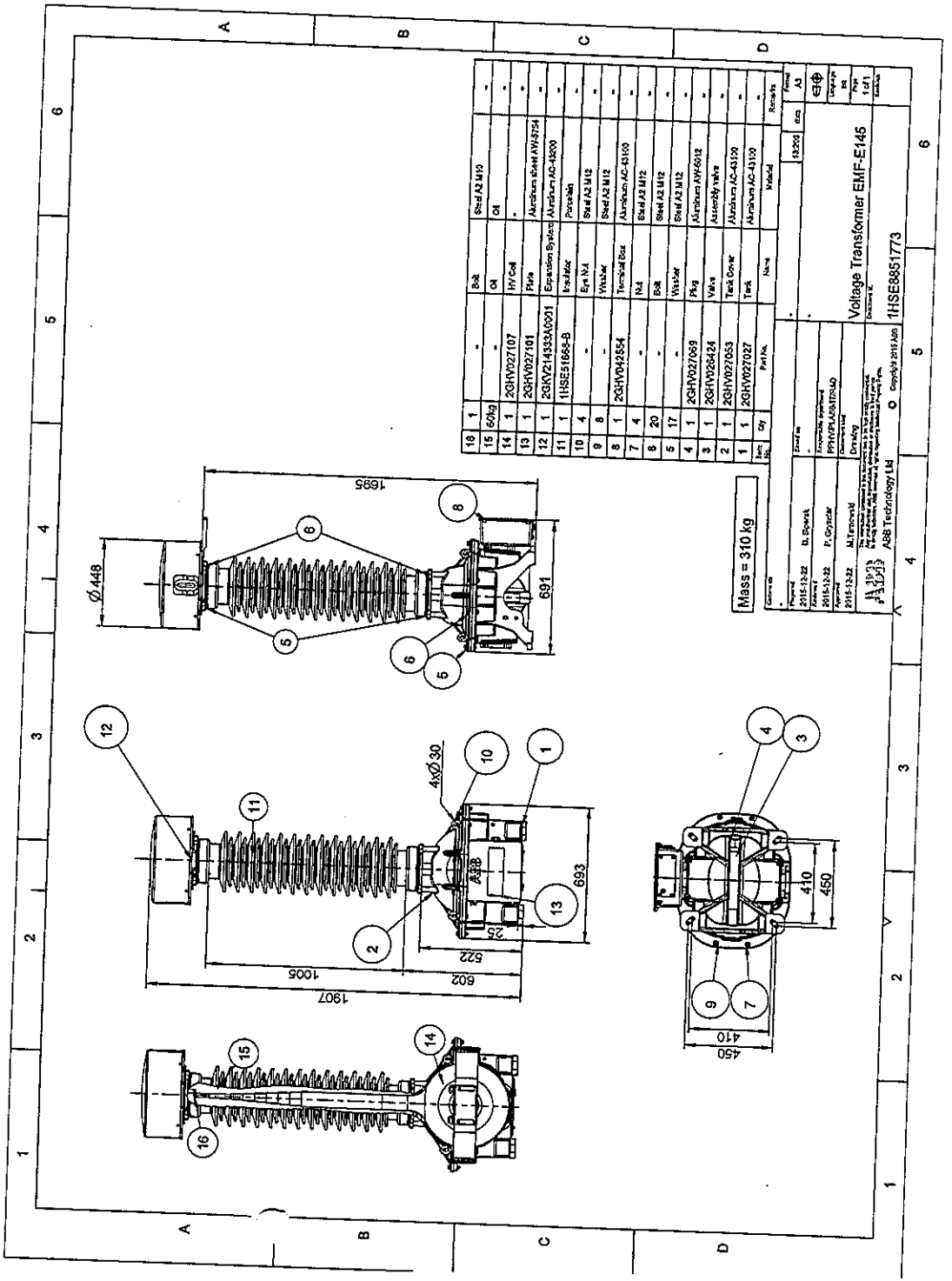
Terminal	Voltage V	Class	Burden VA	Total burden VA	Thermal limit VA
A-N	145000/√3				
1a-1n	115/√3	0.1	25	75	1500+0
1a-1n	115/√3	1.0	25	550	1500+0
2a-2n	115/√3	0.1	25	75	1500+0
2a-2n	115/√3	1.0	25	550	1500+0
3a-3n	115/√3	0.1/3P	25	75	1500+0
3a-3n	115/√3	3.0/3P	500	550	1500+0
da-dn	115	1.0	100	650	450+0
da-dn	115	3P	300	950	450+0

1HSE 68504-6

Serial number 1HSE nnnnnnn = 1HSE 8851773

Production year yyyy = Actual year for production

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



HIGH VOLTAGE LABORATORY

INSTYTUT ENERGETYKI

LABORATORY ACCREDITED
BY THE POLISH CENTRE FOR ACCREDITATION

Accreditation Certificate of Testing Laboratory
No AB 272

AB 272

TEST REPORT
No EWN/134/E/15

Impulse voltage withstand test on primary terminal,
chopped impulse voltage withstand test on primary terminal,
of voltage instrument transformer type EMF-E145

Warsaw, November 2015

TEST REPORT EWN/134/E/15

TEST OBJECT:	**Voltage instrument transformer type EMF-E145**
TEST CUSTOMER:	**ABB Sp. z o.o.** **04-713 Warszawa, ul. Żegańska 1**
MANUFACTURER:	**ABB**
ORDER NO:	**4500692511 (05.11.2015)**
TEST TYPE:	**Impulse voltage withstand test on primary terminal,** **Chopped impulse voltage withstand test on primary terminal**
TEST PROCEDURE:	**According to:** **PN-EN/IEC 61869-1** **PN/EN/IEC 61869-3** **Internal ABB specifications**
TEST DATE:	**06.11.2015**
TEST RESULT:	**POSITIVE - details are presented in following parts of report**

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

Warsaw, November 2015.

CONTENTS

Test report includes:

8 numbered pages;
1 figure;
1 photograph;
3 tables.

Attached to the test report:

Annex 1: Documents provided by ABB Sp. z o.o. used as base of identification of test object (3 pages);

Annex 2: Reports of routine test and determination of errors (8 pages);

Annex 3: Lightning impulse test protocol (7 pages);

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

1 COMPETENCE OF THE LABORATORY

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

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

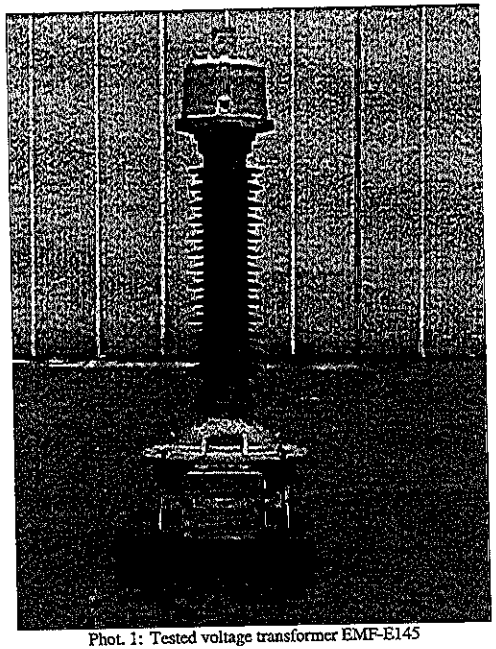
Full scope of accreditation of High Voltage Laboratory available on www.pca.gov.pl

2 TEST OBJECT DESCRIPTION

The tested object was instrument voltage transformer EMF-E145 manufactured by ABB sp. z o.o. 04-713 Warszawa, Żegańska 1 St. (Fabryka Aparatury Wysokich i Średnich Napięć, 06-300 Przasnysz, Leszno 59 St.), with the following parameters:

Prototype 2 – EMF-E145
Serial number: 1HSE8851773

- Highest voltage for equipment 145 kV
- Rated primary voltage 145000 / √3 V
- Insulation level 275 / 650 kV
- Frequency 50 Hz
- Temperature range -40 – +40 °C
- Total mass 295 kg



Phot. 1: Tested voltage transformer EMF-E145

3 SCOPE OF TESTS AGREED UPON

Test plan for voltage instrument transformer type EMF-E145 was consulted with the Customer. Tab. 1 includes the list of performed tests and requirements, which tested objects should comply with.

Tab. 1: Scope of tests of voltage instrument transformer

Item	Performed tests	Requirement
TYPE TESTS		
1	Impulse voltage withstand test on primary terminal	PN-EN/IEC 61869-3, p.7.2.3
SPECIAL TESTS		
2	Chopped impulse voltage test on primary terminal	PN-EN/IEC 61869-1, p.7.4.1

Determination of errors of transformer, performed to prove the positive results of consecutive tests, was carried out on the premises of Factory Laboratory of ABB Sp. z o.o. in the presence of a representative of the High Voltage Department of Institute of Power Engineering. Detailed results are presented in Annex 2.
Tests were carried out according to:

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

4 TYPE TEST

4.1 Impulse voltage withstand test on primary terminal

4.1.1 Method of testing and acceptance criteria

According to IEC 61869-1 clause 7.4.1 lightning impulse test (for negative polarity) can be combined with chopped impulse voltage test. For positive polarity lightning impulse test was performed according to IEC 61869-1 clause 7.2.3 (15 impulse method).
It is considered that the instrument transformer passed the test with a positive result if analysis of the waveforms recorded during the test does not indicate failure of internal insulation of instrument transformer.

4.1.2 Test arrangement

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

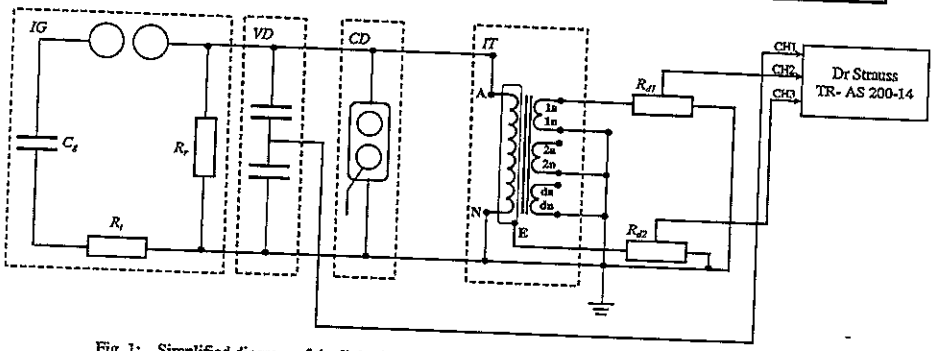


Fig. 1: Simplified diagram of the lightning impulse measurement system (for one step of the generator): *IG* – impulse generator; *VD* – voltage divider; C_g, R_t, R_r – generator elements; *CD* – chopping device; *IT* - instrument transformer (general schematic representation); R_{d1}, R_{d2} – detection resistance

4.1.3 Test conditions

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

Tab. 2: Parameters of the lightning impulse measurement system

IMPULSE GENERATOR			
Number of steps	n	-	6
General capacitance	C_g	μF	0,125
Discharge resistance	R_r	Ω	534
Damping resistance	R_t	Ω	157
VOLTAGE DIVIDER			
HV unit capacitance	C_u'	pF	~1200
LV unit capacitance	C_u''	μF	1,103
Scale factor	ϑ_V	-	927,0
DETECTION RESISTORS			
Detection resistance	R_{d1}	Ω	0,707
	R_{d2}	Ω	2,970

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

Full impulse test voltage	RW = 325 kV FW = 650 kV	
Chopped impulse test voltage	CRW = 373,7 kV CFW = 747,5 kV	
Sequence of impulses	Positive polarity 1 reduced full impulse (RW), 15 full impulses (FW).	Negative polarity 1 reduced full impulse (RW), 1 full impulse (FW), 1 reduced chopped impulse (CRW), 2 chopped impulses (CFW), 14 full impulses (FW).
Registration	Transients of test voltage (channel 1) Current flowing through secondary winding 1a-1n (channel 2) Current flowing through primary winding screen E (channel 3)	

4.1.4 Test results

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

TEST RESULT: POSITIVE

5 SPECIAL TESTS

5.1 Chopped impulse voltage withstand test on primary terminal

Chopped impulse test on the primary winding was combined with the negative polarity lightning impulse test. Detailed results of this test are presented in Section 4.1 and Annex 3 of this report.

TEST RESULT: POSITIVE