APPENDIX 3 for test report EWN/70/E/11-1

Report of performed tests in Distribution Equipment Laboratory of Institute of Power Engineering in Warsaw.

- Test Report No. EUR/33/E/11-1E of 25.07.2011
- Test Report No. EUR/33/E/11-2E of 10.08.2011
  (Short-time current tests, short-circuit withstand capability test and mechanical.)
TEST REPORT No. EUR/33/E/11-2E

TEST OBJECT: Combined transformer type PVA 123 Serial No. 84500

MANUFACTURER: ABB Sp. z o.o. ul. Żegańska 1, 04-713 Warszawa

TESTS ORDERED BY: Internal order No. EWN/70/E/11 dated 19.07.2011

TYPE OF TESTS: Short-time current tests, short-circuit withstand capability tests and mechanical tests


DATE OF TESTS: 05.07, 19/20.07 and 08/09.08.2011

TESTS RESULT: Positive for
- $I_{th} = 10$ kA, $I_{dyn} = 25$ kA for 50 A terminal
- $I_{th} = 20$ kA, $I_{dyn} = 50$ kA for 100 A terminal
- $I_{th} = 40$ kA, $I_{dyn} = 100$ kA for 200 A terminal
- 63.5 kV at short-circuit in secondary circuits of VT
- $F_R = 3600$ N and resulting dynamic load

Tests result refers only to the test object


Test engineer

Stanisław Maziarz

HEAD OF LABORATORY

Lidia Gruza

Warsaw, 10.08.2011

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<td>3</td>
</tr>
<tr>
<td>photographs</td>
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</tr>
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1. TEST OBJECT

1.1 Description

Combined transformer type PVA 123 is used for supplying of measuring and protection circuits in the network of nominal voltage 110 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common porcelain enclosure immersed with transformer oil.

1.2 Technical data

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>110/√3 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Rated continuous thermal current</td>
<td>50 A, 100 A, 200 A</td>
</tr>
<tr>
<td>Rated short-time current</td>
<td>10 kA, 20 kA, 40 kA</td>
</tr>
<tr>
<td>Rated dynamic current</td>
<td>25 kA, 50 kA, 100 kA</td>
</tr>
<tr>
<td>Rated static load</td>
<td>3600 N</td>
</tr>
</tbody>
</table>

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- dimension drawing of combined transformer PVA 123, No.2GKK 610211, ABB Sp. z o.o., 12.07.2011 (Annex 3),

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

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of EN 60044-3:2003 (idt IEC 60044-3:2002):
- short-time current tests of current transformer windings acc. to item 6.2 a) of above standards at the following parameters:
  for 50 A: \( I_{\text{dyn}} \geq 25 \text{ kA}, I_{\text{th}} = 10 \text{ kA} t_{\text{th}} = 1 \text{ s}, I_{\text{th}}^2 \times t_{\text{th}} \geq 100 \text{ kA}^2 \times \text{s}, \)
  for 100 A: \( I_{\text{dyn}} \geq 50 \text{ kA}, I_{\text{th}} = 20 \text{ kA} t_{\text{th}} = 1 \text{ s}, I_{\text{th}}^2 \times t_{\text{th}} \geq 400 \text{ kA}^2 \times \text{s}, \)
  for 200 A: \( I_{\text{dyn}} \geq 100 \text{ kA}, I_{\text{th}} = 40 \text{ kA} t_{\text{th}} = 1 \text{ s}, I_{\text{th}}^2 \times t_{\text{th}} \geq 1600 \text{ kA}^2 \times \text{s}, \)
- short-circuit withstand capability test of voltage transformer acc. to item 6.2 f) of above standards at parameters: \( U_p \geq 63.5 \text{ kV}, t_p = 1 \text{ s}, \)
- mechanical tests acc. to item 6.4 d) of above standards for \( F_R = 3600 \text{ N} \) and resulting dynamic load of terminals P1 and P2/A 200 A.
3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests were made in one phase circuit presented on fig. 1 and 2. Short-circuit withstand capability tests were made in test circuit presented on fig. 3.

Mechanical tests were performed applying the load consecutively to the transformer’s terminals as shown on photographs 5 to 10 in Annex 2.

The following quantities were recorded during the tests using digital recorder type HIOKI 8842:

- primary current of current transformer (with short-circuited all secondary terminals) during short-time current tests using laboratory current transformer type CdC class 0,5 with a ratio 50.000/2 A/A,
- primary voltage and current, secondary current in short-circuited windings: 1a-1n (next da-dn) during short-circuit withstand capability tests of voltage transformer using:
  - inductive voltage transformer type U110a class 0,5 with a ratio $110/\sqrt{3}/0,1/\sqrt{3}$ kV/kV for primary voltage measurement,
  - laboratory current transformer type GE 4461 class 0,2 with a ratio 5/5 A/A for primary current measurement,
  - laboratory current transformer type IL 20a class 0,5 with a ratio 2.000/5 A/A for secondary currents measurements.

![Fig. 1. Configuration of test circuit during short-time current tests](image-url)
110 kV

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

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

Recorder
HIOKI 8842
Fig. 3. Test and measuring circuits during short-circuit withstand capability tests

WB110 - back-up circuit-breaker
PN - voltage transformer
PP1, PP2 - current transformers
4. TESTS AND THEIRS DETAILED RESULTS

Mechanical tests were performed 05.07.2011 and short-circuit tests - in the nights 19/20.07, 08/09.08.2011. Tests results present tables 1, 2 and 3.

During the tests the following records were made:
- No. 30696 – calibration of measuring circuit,
- Nos. 30697, 30698 – short-circuit withstand capability tests,
- Nos. 30725, 30727, 30729 – calibration of test circuit,
- Nos. 30726, 30728, 30730 – short-time current tests,
  (Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory’s archives),
- phot. 1 to 4 – combined transformer on short-circuit tests stand,
- phot. 5 to 10 - combined transformer during mechanical tests
  (Annex 2 presents the photographs).

Table 1. Results of static load withstand tests at F = 3620 N and dynamic *)

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Terminal</th>
<th>Load direction</th>
<th>Test time</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>s</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>P1</td>
<td>transverse</td>
<td>60 s</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>2</td>
<td>P1</td>
<td>transverse</td>
<td>60 dyn. *)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>3</td>
<td>P1</td>
<td>vertical</td>
<td>60 s</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>4</td>
<td>P1</td>
<td>vertical</td>
<td>60 dyn. *)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>5</td>
<td>P1</td>
<td>longitudinal</td>
<td>60 s</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>6</td>
<td>P1</td>
<td>longitudinal</td>
<td>60 dyn. *)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>7</td>
<td>P2/A</td>
<td>transverse</td>
<td>60 s</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>8</td>
<td>P2/A</td>
<td>transverse</td>
<td>60 dyn. *)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>9</td>
<td>P2/A</td>
<td>vertical</td>
<td>60 s</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>10</td>
<td>P2/A</td>
<td>vertical</td>
<td>60 dyn. *)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>11</td>
<td>P2/A</td>
<td>longitudinal</td>
<td>60 s</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>12</td>
<td>P2/A</td>
<td>longitudinal</td>
<td>60 dyn. *)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
</tbody>
</table>

Remark:
*) Dynamic tests were performed by sudden loading the terminal by the weight 3620 N.
Table 2. Results of short-circuit withstand capability tests (t_{amb} = 20 °C)

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Terminals</th>
<th>U_z</th>
<th>I_{PS}</th>
<th>I_{SS}</th>
<th>t_z</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>30697</td>
<td>1a – 1n</td>
<td>65,4(^1)</td>
<td>0,6</td>
<td>633</td>
<td>1,0</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>30698</td>
<td>da - dn</td>
<td>65,5(^1)</td>
<td>0,4</td>
<td>716</td>
<td>1,0</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
</tbody>
</table>

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

Table 3. Results of short-time current tests (t_{amb} = 16 °C)

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Term.</th>
<th>i_{peak}</th>
<th>I_z</th>
<th>t_z</th>
<th>I_z^2 \times t_z</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>30726</td>
<td>50 A</td>
<td>27,0(^1)</td>
<td>10,4</td>
<td>1,0</td>
<td>108(^2)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>30728</td>
<td>100 A</td>
<td>54,4(^3)</td>
<td>20,8</td>
<td>1,0</td>
<td>432(^4)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>30730</td>
<td>200 A</td>
<td>102,7(^5)</td>
<td>40,5</td>
<td>1,0</td>
<td>1640(^6)</td>
<td>After tests no damage nor oil leak was stated.</td>
</tr>
</tbody>
</table>

Legend:
- i_{peak} - peak value of test current
- I_z - r.m.s. value of test current
- t_z - test duration
- \(^1\) - i_{peak} \geq 25 kA, \(^2\) - I_z^2 \times t_z \geq 100 (kA)^2 \times s
- \(^3\) - i_{peak} \geq 50 kA, \(^4\) - I_z^2 \times t_z \geq 400 (kA)^2 \times s
- \(^5\) - i_{peak} \geq 100 kA, \(^6\) - I_z^2 \times t_z \geq 1600 (kA)^2 \times s

5. TESTS RESULTS EVALUATION

According to criteria given in EN 60044-3:2003 (idt IEC 60044-3:2002) p. 6.2 a), 6.2 f) i 6.4 d) the results of tests of tested combined transformer is positive for:

- \(I_{th} = 10\) kA, \(I_{dyn} = 25\) kA for 50 A terminal,
- \(I_{th} = 20\) kA, \(I_{dyn} = 50\) kA for 100 A terminal,
- \(I_{th} = 40\) kA, \(I_{dyn} = 100\) kA for 200 A terminal,
- 63,5 kV at short-circuit in secondary circuits of voltage transformer,
- \(F_R = 3600\) N and resulting dynamic load.

ş ş ş
ANNEX 1  Test records

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

30697, 30698 – voltage transformer tests
30726, 30728, 30730 – current transformer tests

Denotations:

$u_{110}$ – test voltage during voltage transformer tests

$i_N$ – test current on primary side of VT

$i_{1a-ln}, i_{da-dn}$ – test current on secondary side of VT

$i$ – test current during current transformer tests
ANNEX 2  Photographs taken during the tests

Phot. 1. PVA 123 after short-time current tests of VT

Phot. 2. PVA 123 after short-circuit withstand capability tests of CT 50 A
Phot. 3. PVA 123 after short-circuit withstand capability tests of CT 100 A

Phot. 4. PVA 123 after short-circuit withstand capability tests of CT 200 A
Phot. 5. Transverse load of terminal P1

Phot. 6. Transverse load of terminal P2/A 200 A
Phot. 7. Vertical load of terminal P1

Phot. 8. Vertical load of terminal P2/A 200 A
Phot. 9. Longitudinal load of terminal P1

Phot. 10. Longitudinal load of terminal P2/A 200 A
ANNEX 3   Documentations delivered by orderer
TEST REPORT No. EUR/33/E/11-1E

TEST OBJECT: Combined transformer type PVA 123 Serial No. 84502

MANUFACTURER: ABB Sp. z o.o. ul. Żegańska 1, 04-713 Warszawa

TESTS ORDERED BY: Internal order No. EWN/70/E/11 dated 19.07.2011

TYPE OF TESTS: Short-time current tests and mechanical tests


DATE OF TESTS: 29.06 and 19/20.07.2011

TESTS RESULT: Positive for
- $I_{th} = 63 \text{ kA}$, $I_{dyn} = 158 \text{ kA}$ for CT
- $F_R = 3600 \text{ N}$ and resulting dynamic load

Tests result refers only to the test object


Test engineer

[Signature]
Stanislaw Maziarz

HEAD OF LABORATORY

[Signature]
Lidia Gruza

Warsaw, 25.07.2011

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<td>tables</td>
<td>2</td>
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<tr>
<td>figures</td>
<td>2</td>
</tr>
<tr>
<td>photographs</td>
<td>7</td>
</tr>
</tbody>
</table>
1. TEST OBJECT

1.1 Description

Combined transformer type PVA 123 is used for supplying of measuring and protection circuits in the network of nominal voltage 110 kV and frequency 50 Hz. The transformer consists of current and voltage transformers mounted in common composite enclosure immersed with transformer oil.

1.2 Technical data

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

- Rated voltage: 110/√3 kV
- Rated frequency: 50 Hz
- Rated continuous thermal current: 3000 A
- Rated short-time current: 63 kA
- Rated dynamic current: 158 kA
- Rated static load: 3600 N

1.3 Technical documentation

For the purpose of tests the orderer delivered the following technical documentation:
- Dimension drawing of combined transformer PVA 123, No. 2GKK 610212, ABB Sp. z o.o., 12.07.2011 (Annex 3),
- Electrical diagram of combined transformer PVA 123, ABB Sp. z o.o., 25.07.2011 (Annex 3).

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

1.4 Preparation for tests

The test object was prepared for test by factory.

2. SCOPE OF TESTS

Test program, agreed with orderer, comprised the following tests according to requirements of EN 60044-3:2003 (idt IEC 60044-3:2002):
- Short-time current tests of current transformer acc. to item 6.2 a) of above standards at parameters: $I_{\text{dyn}} \geq 158 \text{ kA}$, $I_{\text{th}} = 63 \text{ kA}$ $t_{\text{th}} = 1 \text{ s}$, $I_{\text{th}}^2 \times t_{\text{th}} \geq 3969 \text{ kA}^2 \times \text{s}$,
- Mechanical tests acc. to item 6.4 d) of above standards for $F_R = 3600 \text{ N}$ and resulting dynamic load.

3. TEST AND MEASURING CIRCUITS

For the tests the transformer was fixed to the rigid construction of the test stand. Short-time current tests were made in one phase circuit presented on fig. 1 and 2.

Mechanical tests were performed applying the load consecutively to the transformer’s terminals as shown on photographs 2 to 7 in Annex 2.

The following quantities were recorded during the tests using digital recorder type HIOKI 8842:
- Primary current of current transformer (with short-circuited all secondary terminals) during short-time current tests using laboratory current transformer type CdC class 0,5 with a ratio 100,000/2 A/A.
Fig. 1. Test and measuring circuits during short-time current tests


4. TESTS AND THEIRS DETAILED RESULTS

Short-circuit tests were performed in the night 19/20.07.2011 and mechanical tests - 29.06.2011. Tests results present tables 1 and 2.

During the tests the following records were made:
- No. 30688 – calibration of measuring circuit,
- Nos. 30689, 39690 – calibration of test circuit,
- No. 30691, 30692 – short-time current tests,

(Annex 1 presents the copies of short-circuit test records - all records are stored in laboratory’s archives),
- phot. 1 – combined transformer on short-circuit tests stand,
- phot. 2 to 7 - combined transformer during mechanical tests

(Annex 2 presents the photographs).

Table 1. Results of short-time current tests (\(t_{amb} = 20 \, ^\circ C\))

<table>
<thead>
<tr>
<th>Test No.</th>
<th>(i_{peak})</th>
<th>(I_z)</th>
<th>(t_z)</th>
<th>(I_z^2 \times t_z)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>kA</td>
<td>kA</td>
<td>s</td>
<td>(kA)^2\times s</td>
<td>-</td>
</tr>
<tr>
<td>30691</td>
<td>95,5</td>
<td>63,7</td>
<td>1,01</td>
<td>4098(^1)</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>30592</td>
<td>159,2(^2)</td>
<td>63,9</td>
<td>0,06</td>
<td>-</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
</tbody>
</table>

Legend:
- \(i_{peak}\) - peak value of test current
- \(I_z\) - r.m.s. value of test current
- \(t_z\) - test duration

Required:
\(^1\) - \(I_z^2 \times t_z \geq 3969 \, (kA)^2 \times s\)
\(^2\) - \(i_{peak} \geq 158 \, kA\)
### Table 2. Results of static load withstand tests at F = 3620 N and dynamic *)

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Terminal</th>
<th>Load direction</th>
<th>Test time</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>P1</td>
<td>transverse</td>
<td>60 s</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>3-4</td>
<td>P1</td>
<td>vertical</td>
<td>60 s</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>5-6</td>
<td>P1</td>
<td>longitudinal</td>
<td>60 s</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>7-8</td>
<td>P2/A</td>
<td>transverse</td>
<td>60 s</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>9-10</td>
<td>P2/A</td>
<td>vertical</td>
<td>60 s</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
<tr>
<td>11-12</td>
<td>P2/A</td>
<td>longitudinal</td>
<td>60 s</td>
<td>Behaviour of transformer during the tests was correct. After tests no damage nor oil leak was stated.</td>
</tr>
</tbody>
</table>

**Remark:**

*) Dynamic tests were performed by sudden loading the terminal by the weight 3620 N.

### 5. TESTS RESULTS EVALUATION

According to criteria given in EN 60044-3:2003 (idt IEC 60044-3:2002) p. 6.2 a), and 6.4 d) the results of tests of tested combined transformer is positive for:

- $I_{th} = 63$ kA, $I_{dyn} = 158$ kA for current transformer,
- $F_R = 3600$ N and resulting dynamic load..
ANNEX 1  Test records

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

30690, 30691 – current transformer tests

*Denotations:*

*i* – test current
Trigger: 2011-07-20 00:06:03  Interval: 100μs (55ms/DIV)  [IE nr rej. 30692]
ANNEX 2  Photographs taken during the tests

Phot. 1. PVA123 after short-time current tests of CT
Phot. 2. Transverse load of terminal P1

Phot. 3. Transverse load of terminal P2/A
Phot. 4. Vertical load of terminal P1

Phot. 5. Vertical load of terminal P2/A
Phot. 6. Longitudinal load of terminal P1

Phot. 7. Longitudinal load of terminal P2/A
ANNEX 3   Documentations delivered by orderer
Schemat elektryczny przekładnika PVA123