Your safety first!
This is the reason why our instruction begins with the following guidelines:
– Use the transformer for its intended purpose.
– Observe the technical data given in the rating plate and in the specification.
– To facilitate and ensure high quality standards, the installation should be carried out by trained personnel or supervised by the service department of ABB.
– Operations have to be carried out by specially trained electricians who are familiar with the following instructions.
– It is recommended to observe the standards (DIN VDE/IEC) and local H&S regulations as well as the requirements of the local electric authority.
– Transformer work should be changed over in accordance with the instructions in the manual.
– All documentation should be available to all persons involved in installation, maintenance and operation.
– Operating personnel shall bear all responsibility for all aspects related to the operational safety as stated in EN 50110 (VDE 0105) and national regulations.
– Observe the safety rules, which are compliant with EN 50110 (VDE 0105) standard. It pertains to ensuring a dead state at the site of works carried out on a transformer.

If you have any questions regarding the information contained in this manual, our organisation will provide the necessary information.
Important information
This manual is intended to explain the mode of operation and installation of the product.

NOTE:
All descriptions contained in this document are for general information only and do not include specific design requirements. Please refer to the exact design documentation while connecting the device.

Operating the device without reading the manual may entail property damage, serious injury or death. The person responsible for the installation of the device should read the following instructions and follow the recommendations contained herein.

For your own safety:
– Make sure that all installation, service and maintenance works are performed by professionals.
– Make sure that during all the phases (installation, service, up-keeping) all applicable regulations will be preserved.
– Ensure that the guidelines contained in this manual are followed.

Basic guidelines for this manual.
Read the relevant chapters of this manual to provide adequate operation. Chapters are marked according to their significance.

For the purposes of this manual, failure to follow the instructions concerning the dangers could result in death or serious injury.
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1. Introduction
The manual covers PV 123 overhead inductive voltage transformers. Those instrument transformers are used for feeding measurement and protection systems in power networks of 123 kV highest system voltage or lower (the greatest effective value of phase-to-phase voltage) and 50 Hz frequency. They are designed either to operate in grids with effectively earthed or insulated neutral points or in compensated networks.

2. Transformer delivery
Typically the transformers are delivered in bulk packaging (3 pcs) where they are stacked vertically. The packaging is in the form of a complete crate or just the base. The delivered transformers are fully assembled, tested and ready for direct use. Product testing protocols are delivered together with the transformers. Immediately after delivery, check whether the transformer has not been damaged during transportation. Check the transport packaging. Damaged packing may point out to careless handling of the transformer. Next, check the transformer itself. Special attention should be paid to possible damage of sheds and binder at insulator flanges, to the tightness of the transformer and the correct oil level indication in the device.

One should ensure that technical parameters of the transformer given in the rating plate are in accordance with the parameters given when submitting the order and in accordance with the design documentation parameters. Any damage found or other error should be immediately notified to the manufacturer, and if appropriate, the carrier. Sending photos of damage will be helpful in its assessment.

3. Transportation, unpacking, lifting
Transformers should be transported in a vertical position. Horizontal transport is not possible. Transformers should be lifted with a crane with appropriate load capacity using four slings of the same length (min. 3 m). Hooks should be placed in designated holders in the bottom tank cover.

4. Storage
Transformers should be stored in the vertical position on a levelled and hardened surface, preferably in the original packaging. In the case of long-term storage, it is recommended to protect contact surfaces against corrosion. Transformers can be stored in the open air for up to two years. If this period is exceeded, it is recommended to place transformers in a well-ventilated room or under a roof, and to insert silica gel or another moisture absorbent into terminal boxes.

5. Installation
The support structure should be flat and horizontal. Levelling correction can be performed using distance washers, placing them between the transformer and the structure. Observe the notes given in item 3 while shifting the transformer. It should be fastened to the structure with screw elements of an adequate size. The support structure and fastening elements are not included in the delivery. The transformer should be placed in the vertical position at least 24 h before energizing (if it was tilted for any reason).

5.1. Earthing terminals
Two earthing terminals are found on the bottom tank of the transformer across its diagonal. Prior to connection, the contact surface of the terminals should be thoroughly cleaned from oxide layers so it becomes uniform and smooth. Additionally, a thin layer of conducting grease can be applied in order to improve contact. The earthing should be connected with stainless bolts.

5.2. Primary terminal (A)
Primary terminal (A) is located on the plate located on the transformer isolator. The contact surface of the primary terminal should be even and cleaned from the oxide layer before connecting. To a terminal prepared in such a way the line cable terminals should be tightened with M12 bolts (stainless bolts are recommended).
Primary connections should be made in such a way so as to minimise mechanical static loads of the transformer terminal. It is recommended to use flexible elements as rigid connections may cause damage of the transformer. The maximum allowable static load on a transformer terminal is equal to 3,600 N in any direction. Also, it is recommended to maintain the sum of the loads acting on the primary terminal during normal operation of the transformer below 50% of such a value.

5.3. Secondary terminals
Secondary windings are connected to terminal blocks placed in the terminal box on the bottom tank of the transformer. These are typically Phoenix ST spring connectors with terminals adapted to connection of cables of cross-section up to 10 mm² or up to 6 mm². Each terminal is described in accordance with winding markings given on the rating and schematic diagram plates. Yellow-green terminals (with the earthing mark) are intended for earthing secondary windings with the use of pushed crosswise bridges. The crosswise bridge can be removed with a screwdriver, by inserting it in the slit and levering. Apart from secondary terminals, there are two additional terminals in the terminal box: voltage coil screen terminal (E), primary winding terminal (N).

Optionally, the connectors to which metering windings are led may be adapted for sealing with use of a transparent cover. A rating plate is placed on the external side of the door, while the schematic diagram plate is placed inside. In the bottom wall of the terminal box, there is a plate with openings for glands for secondary circuits’ connection cables. In the typical execution, they are two M32 glands with the choking range of Ф11 mm – Ф21 mm. An example of a terminal box for secondary windings of the transformer is shown in Figure 1.

![Figure 1. Example of a terminal box](image-url)
Connect external circuits to secondary terminals of the voltage module of the transformer pursuant to the design documents and wiring shown on the schematic diagram plate. The screen terminal (E) and the primary winding (N) terminal of the voltage coil shall be earthed with crosswise bridges with the neighbouring earthing connector during normal transformer operation.

Connectors inside the terminal box are arranged so that, when using crosswise bridges, earthing is possible for any secondary terminal of a given winding. The unused secondary windings shall remain open and its “end” marked as “...n” should be earthed with a crosswise bridge.

In PV 123 type transformers, the chokes on all secondary windings are constructed of copper wire Cu-ETP of the diameter of 1.2 mm and length of 50 mm. The chokes are installed in the conductors running out of the resin bushing downstream the terminal block located in the transformer box.

The chokes protect the transformer against damage in the case of shorting of the transformer secondary terminals. This type of protection is sufficient to protect the transformer at a short section to the nearest point in which proper protections are installed. Additional fuses in the transformer terminal box are not necessary. If a short circuit has occurred and this type of protection has been activated, the choke must be replaced.

**NOTE:**
Secondary terminals of the transformer shall never be shorted.
Residual voltage windings marked as “da-dn”, used to connect three transformers in an open delta to adjacent phases, should be grounded in one point only (in one of three transformers). Earthing of “da-dn” windings connected in such a way in more than one point will cause shorting and may lead to damage of the transformer.

5.4. Ferroresonance phenomenon
The PV 123 transformers are resistant to ferroresonance in a wide range of capacitance to earth and of control capacitors used in circuit breakers. However, in the case of networks for which these phenomena occurred before or network configurations being particularly sensitive to such phenomena (e.g. with long cable lines), it is recommended to use an additional damping resistor with a value of 50–60 ohms and power of 200 W, connected in the open delta circuit of three da-dn transformer windings.

![Fig. 2. Secondary winding](image)

![Fig. 3. Schematic diagram of a resistor in the open delta circuit](image)

6. Bolt tightening torques

<table>
<thead>
<tr>
<th>Bolt Type</th>
<th>Torque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary terminal bolts M12</td>
<td>60</td>
</tr>
<tr>
<td>Bolts fastening the transformer to the support structure</td>
<td>280</td>
</tr>
</tbody>
</table>

Choke constructed of copper wire Cu-ETP of the diameter of 1.2 mm and length of 50 mm.
7. Operation and maintenance

NOTE:
Combined transformers are HV equipment, hence appropriate safety precautions shall be observed during their operation.
The metrological range of the transformer is guaranteed exclusively in the field determined by the applicable standard on the basis of rated data. The standard is given on the rating plate of the transformer. The metrological range of the transformer is also shown in the record of the test of product, which is supplied with the transformer. Metrological values of the transformer are not guaranteed in any way beyond this field.

7.1. Operation
Transformers do not require special servicing. Visual inspection is usually sufficient. The check-list is placed at the end of this manual.

Visual inspection:
Visual inspection should be based on:
– position of the oil level indicator,
– tightness of the transformer,

– lack of mechanical damage,
– condition of the insulator and binder connecting the insulator with flanges.
Occasionally, check the tightening degree of the primary terminal.

The transformer tightness is a particularly important criterion as in the case of oil leaks moisture can penetrate the device. Small insulator damage may be repaired on site.

Oil level indicator:
Changes of the position of the oil level indicator depend on oil temperature in the transformer. The position of the indicator should be in the green field range. Shifting of the indicator to the upper or bottom red field points out to incorrect transformer operation. In such a case, the transformer should be put out of service, and the manufacturer should be contacted.

On the top of the transformer a stainless steel expansion bellow (1) is placed, used for compensation of oil volume thermal changes in the transformer. The oil level indicator (2) is placed on the upper surface of the bellows. The bellows are placed in a metal cover (3) equipped with a view-finder (4). Cover removal does not result in unsealing of the transformer. The whole compensation system is shown in Figure 4.

Fig. 4. Construction of the compensation system
### Position of the oil level indicator

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator in the green area</td>
<td>Correct transformer operation</td>
</tr>
<tr>
<td></td>
<td>Oil pressure too high</td>
</tr>
<tr>
<td></td>
<td>Transformer over heating</td>
</tr>
<tr>
<td></td>
<td>Oil gasification (insulation failure)</td>
</tr>
<tr>
<td></td>
<td>Further inspection necessary</td>
</tr>
<tr>
<td>Indicator on the upper red field</td>
<td>Oil level too low</td>
</tr>
<tr>
<td></td>
<td>Suspicion of oil leakage (moisture may penetrate inside)</td>
</tr>
<tr>
<td></td>
<td>Further inspection necessary</td>
</tr>
<tr>
<td>Indicator on the lower red field</td>
<td>Oil level too low</td>
</tr>
</tbody>
</table>

**NOTE:**

Oil level indication for all three transformers installed on adjacent phases should be almost equal.

### Measurement of the dielectric loss factor $\tan \delta$

During measurement of the dielectric loss factor $\tan \delta$, the measuring bridge should be connected to the correct terminal marked with an E.

One should remember to earth it after performing the measurement. Usually, the test voltage should equal 10 kV RMS, and it should be applied across transformer primary terminal A and earth.

### Oil sampling

Due to the fact that transformers are air-tight, they do not require periodical oil checking. Oil used in the transformer meets the requirements of the PN-EN 60296 (IEC 60296) standard. It is recommended to check the oil after 15–20 years of operation or after a non-conformity state if there are suspicions as to transformer efficiency.

Contact the manufacturer in order to obtain necessary instructions concerning oil sampling. If oil samples are taken during the guarantee period without the manufacturer's permission, the device loses its guarantee.

### 7.2. Corrosion protection

External elements of the transformer casing are made in the form of aluminium alloy casts, resistant to corrosion. Casts can be unpainted or painted. Typical colours in the case of painted casts include light-grey (RAL 7035) or grey-green (RAL 7033). While remaining metal elements, such as bolts, are made of stainless steel.

### 8. Transformer construction

PV 123 type voltage transformer comprises a voltage coil in a tight enclosure filled with transformer oil.

On the coiled, cut apron magnetic core, concentric secondary windings and the primary winding are located. Multilayered primary winding is insulated using transformer oil impregnated electrical grade paper. The distribution of stresses in the paper insulation is capacitor controlled. The core with windings is located in the lower tank.

The transformer primary insulation constitutes electric grade paper dried at a high temperature and high vacuum impregnated with transformer oil. The free spaces inside the transformer are filled with transformer oil.

External insulation comprises a hollow insulator made out of electrical porcelain with brown enamel or a glass reinforced plastic (FRP) tube coated with grey silicon rubber.

The seals in the transformer are of the o-ring type, and they are made of NBR oil-resistant rubber.

If calibration of measuring windings has been performed, additional respective markings (designations) have been placed on the transformer and the rating plate (where required).
9. Disposal

During correct operation and when no mechanical damage occurs, the transformer should operate over 30 years. Once this period of time has expired or if operation is no longer required, it is recommended to dispose of the transformer.

### Primary materials used in the transformer:

<table>
<thead>
<tr>
<th>Item</th>
<th>Material</th>
<th>Quantity [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper (Cu – ETP)</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Aluminium alloy AC-Al Si10Mg (Cu)</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Steel</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Transformer plate</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>Mineral transformer oil</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Electrical grade paper</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Solid insulation materials (epoxy resin, bakelite paper)</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Porcelain</td>
<td>80</td>
</tr>
<tr>
<td>9</td>
<td>Composite insulator</td>
<td>10</td>
</tr>
</tbody>
</table>

Item 9 and 10 alternatively. Above values are approximate.

9.1. Recycling and disposal proceedings

Recycling and disposal should meet national (or local) regulations. On the territory of the Republic of Poland, the manner by which the transformer should be recycled and disposed is defined in the Waste Act of 14 December 2012, published in Journal of Laws, 2013, item 21, as amended.
10. Check list

10.1. Przed pierwszym zasilaniem

<table>
<thead>
<tr>
<th>What to check:</th>
<th>When</th>
<th>Check:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. External packing appearance</td>
<td>A</td>
<td>No signs of careless handling</td>
</tr>
<tr>
<td>2. Transformer tightness</td>
<td>A, B, C</td>
<td>No visible oil leaks or greasy stains (even if the packing is intact)</td>
</tr>
<tr>
<td>3. Transformer housing</td>
<td>B, C</td>
<td>Insulator, terminals and housing of the transformer show no signs of mechanical damage.</td>
</tr>
<tr>
<td>4. Oil level</td>
<td>B, C</td>
<td>Oil level indicator is in the proper position</td>
</tr>
<tr>
<td>5. Quality and correctness of performed connections</td>
<td>C</td>
<td>Performed connections are reliable and in accordance with the design</td>
</tr>
</tbody>
</table>

10.2. Po pierwszym zasilaniu

<table>
<thead>
<tr>
<th>What to check:</th>
<th>When</th>
<th>Check:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Transformer tightness</td>
<td>D, E</td>
<td>No visible oil leaks or greasy stains</td>
</tr>
<tr>
<td>7. Transformer housing</td>
<td>D, E</td>
<td>Insulator, terminals and housing of the transformer show no signs of mechanical damage.</td>
</tr>
<tr>
<td>8. Oil level</td>
<td>D, E</td>
<td>Oil level indicator is in the proper position</td>
</tr>
<tr>
<td>9. Secondary winding insulation test (measurement method depends on local practices)</td>
<td>E</td>
<td>Values dependent on age, voltage level, measurement method and temperature</td>
</tr>
<tr>
<td>10. Dielectric loss factor $\tan \delta$ (measurement method depends on local practices)</td>
<td>E</td>
<td>Values dependent on age, voltage level, measurement method and temperature Respective terminals are marked as: E/$\tan \delta$</td>
</tr>
<tr>
<td>11. Oil sampling: gas analysis (DGA), $\tan \delta$, water content</td>
<td>E</td>
<td>Measurements did not indicate exceeding of permissible limits</td>
</tr>
</tbody>
</table>

**When**

- **A** After arrival of the transformer to the final location
- **B** After unpacking
- **C** Directly before applying voltage
- **D** During routine inspection in accordance with the schedule determined for the station
- **E** After 15–20 years or inspection of efficiency after the non-conformity state if there are suspicions as to transformer efficiency

11. End

For additional information concerning the operation and maintenance of PV 123 transformers, please contact the transformer manufacturer.