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 on 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 subject of this manual are type PA 123 and PA 145 overhead current transformers. These transformers are used for feeding measurement and protection systems in power networks with maximum system voltage of 123 kV and 145 kV 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.
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 may be transported in either vertical or horizontal position.
In the case of horizontal transportation, transformers should be transported on a special bed in accordance with the method as shown in Figure 1. Additionally, before laying the transformer, restrain its compensation bellows by inserting a flexible disc made of, for example, polyurethane foam, under the bellows cover. During horizontal transportation, the compensation bellows cannot have any freedom of movement due to their flexibility and possibility of damage.
In vertical transportation, due to the high position of the centre of gravity, the transformer should be transported on arms or platforms expanding spacing of the base. Those elements shall be removed before setting the transformer on the support structure (in the working location).
Transformers should be lifted with a crane with appropriate load capacity using two slings of the same length (min. 1.5 m). Hooks should be attached to the openings designed for that purpose located in the transformer head enclosure (see Fig. 1).
4. Storage
Transformers should be stored 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 energising.

5.1. Earthing terminals
Two earthing terminals are found on the base 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 terminals
Primary terminals of the transformer, marked as P1 and P2, are placed on the opposite sides of the head. In the case of reconectable transformer, up to 3 P2 terminals can be found on the primary side, marked with respective values of the rated primary current.
Reconnection of the primary winding to the required current range is performed by placing a detachable terminal (bolt or flat) in the location marked with the respective current value. These terminals should be fastened to the transformer with four supplied M12 bolts. Contact surfaces should be cleaned beforehand.
All contact surfaces of the primary terminals should be even and cleaned from the oxide layer before connecting. In the case of copper terminals, use of extraction naphtha is usually sufficient. Conducting grease can be applied in order to improve contact.
The line cable terminals should be tightened with M12 bolts (stainless bolts are recommended) to such prepared terminals. An incorrectly performed primary connection will lead to excessive heating of the transformer, which can cause its damaging. Primary connections should be made in such a way so as to minimise mechanical static loads of the transformer terminals. It is recommended to use flexible elements as rigid connections may cause damage of the transformer. The maximum allowable static load of each transformer terminal is equal to 3,600 N in any direction. At the same time, only one terminal can be loaded with such force. Also, it is recommended to maintain the sum of the loads acting on the primary terminals 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 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.
Optionally, the connectors to which metering windings are led may be adapted for sealing with use of a transparent cover.
The current coil screen is led out with a pin through the resin bushing (tg δ terminal).
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 M40 glands with the choking range of ø19 mm – ø28 mm.
An example of a terminal box for secondary windings of the transformer is shown in Figure 2.
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 current coil screen terminal (tg δ) should be earthed with a jumper 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.

- Transformer with taps on the secondary side:
  In the case of a transformer with reconnection on the secondary side, unused taps should remain unearthed, and only one of the terminals, to which circuits are connected for a given secondary winding, should be earthed.

- Unused windings:
  Utmost terminals (with reconnection on the secondary site, these are terminals corresponding to the highest ratio) of the unused secondary winding should be shorted with each other (with a cable of minimum cross section of 6 mm²) and earthed with a crosswise bridge. Each unused winding should be earthed in only one point.

**NOTE:**
Opening of the secondary circuit of the transformer during normal operation causes appearance of high voltage on terminals of this circuit, which is dangerous for personnel and may cause damage of the transformer insulation.

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**6. Bolt tightening torques**

- Primary terminal bolts M12: 60 Nm
- Bolts fastening the transformer to the support structure: 280 Nm

**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:
- the 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 terminals.

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 lid covering the head stainless steel expansion bellows (1) are 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 3.

<table>
<thead>
<tr>
<th>Position of the oil level indicator</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator in the green area</td>
<td>Correct transformer operation</td>
</tr>
<tr>
<td>Indicator on the upper red field</td>
<td>Oil pressure too high</td>
</tr>
<tr>
<td></td>
<td>Transformer over heating</td>
</tr>
<tr>
<td></td>
<td>Oil gasification</td>
</tr>
<tr>
<td></td>
<td>(insulation failure)</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>
<tr>
<td></td>
<td>Suspicion of oil leakage (moisture may penetrate inside)</td>
</tr>
<tr>
<td></td>
<td>Further inspection necessary</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 the $\tan \delta$ symbol. 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 terminals 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
PA 123 or PA 145 type current transformer comprises a current coil in a tight enclosure filled with transformer oil. This is a “top core” type structure where the magnetic toroidal cores are located in the transformer head. The cores with secondary windings are additionally encapsulated in a metal can connected via a tube to terminal box $tg\delta$ terminal. Both the metal can as well as the tube are insulated with oil impregnated electrical grade paper. The distribution of electric stresses in the paper insulation is capacitor controlled. An exterior screen is located external to the coil, connected to the primary terminal inside the head.

Such a coil structure provides the following advantages: protection of devices connected to the terminal in the event of primary insulation perforation, equalisation of electrical stresses in primary insulation and a facility for measuring the $tg\delta$ coefficient on the primary insulation only.

Fig. 4. PA 123 and PA 145 current transformers structure
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>20</td>
</tr>
<tr>
<td>2</td>
<td>Aluminium alloy AC-Al Si10Mg (Cu)</td>
<td>80</td>
</tr>
<tr>
<td>3</td>
<td>Steel</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Transformer plate</td>
<td>50 – 150</td>
</tr>
<tr>
<td>5</td>
<td>Permalloy (iron-nickel alloy)</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Mineral transformer oil</td>
<td>120</td>
</tr>
<tr>
<td>7</td>
<td>Electrical grade paper</td>
<td>25</td>
</tr>
<tr>
<td>8</td>
<td>Solid insulation materials (epoxy resin, bakelite paper)</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Porcelain</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>Composite insulator</td>
<td>20</td>
</tr>
</tbody>
</table>

Items 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. Before first energising

<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. After first energising

<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</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

<table>
<thead>
<tr>
<th>When</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>After arrival of the transformer to the final location</td>
</tr>
<tr>
<td>B</td>
<td>After unpacking</td>
</tr>
<tr>
<td>C</td>
<td>Directly before applying voltage</td>
</tr>
<tr>
<td>D</td>
<td>During routine inspection in accordance with the schedule determined for the station</td>
</tr>
<tr>
<td>E</td>
<td>After 15–20 years or inspection of efficiency after the non-conformity state if there are suspicions as to transformer efficiency</td>
</tr>
</tbody>
</table>

11. End

For additional information concerning the operation and maintenance of type PA 123 and PA 145 transformers, please contact the transformer manufacturer.