INSTRUCTION MANUAL

Vacuum cast coil transformers
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Information about the manual and the manufacturer

This operating manual is intended to illustrate the use of VCC dry-type transformers (referred to as transformer for short) correctly, safely and economically.

This manual is addressed to all personnel carrying out any of the following activities on the transformer:

• Transportation.
• Installation.
• Connection.
• Placing into operation.
• Operation.
• De-commissioning.
• Maintenance.
• Cleaning.
• Disposal.

In particular this operating manual is addressed to service engineers, qualified professional personnel and authorized operating personnel.

All personnel must be familiar with the contents of this operating manual and must have understood those contents. Following the instructions contained in this manual will help towards avoiding hazardous situations and increasing the reliability and service life of the transformer. In addition to observing the information and instructions contained in this operating manual, it is essential that all relevant personnel complies with all statutory regulations and other regulations applicable at the place of installation, i.e.:

• Accident prevention regulations.
• Regulations concerned with safe working practices.
Company register certificate
On 1995 ASEA BROWN BOVERI, S.A. was awarded the Company Register certificate guaranting that our Quality Management System satisfies standard UNE-EN-ISO 9001 and is applied throughout the process, from the design and development stages to after-sales service, establishes management criteria and procedures, as well as processes that ensure that all transformers are free of defects.

The applicable environmental certificate guarantees that the environmental management system satisfies standard UNE-EN-ISO 14001 and is applied to the design, production, after-sales service, and is developed as stated by Hitachi ABB Power Grids in its environmental policy.

Accreditation of the tests laboratory for the accomplishment of the routine and type tests defined in this manual are granted by ENAC with nº 262/LE591, which indicates that the tests laboratory meets UNE-EN-ISO/CEI 17025 Standard.

Keeping the operating manual available
This operating manual must be kept with the documentation for the transformer at all times and readily available to the user.

The operating manual is an integral part of the transformer. Should the transformer be sold or transferred to another party, this operating manual should be included.

Text formatting and symbols
The different elements in this operating manual are predefined text formats and symbols. This is to enable simple differentiation between the following elements:

Normal text.
• Bulleted list, first level.
  - Bulleted list, second level.
► Action.
Tips. These provide you with additional information, such as specific information about how to use the device economically.

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Safety

This chapter provides information on the following:

- Obligations of the owner/user.
- Personnel qualifications.
- Prohibition of unauthorized modifications or alterations.
- Personal protective measures.
- Intended use.
- Basic safety information.
- Safety devices.
- Warning symbols: damage to property and the environment.

**Obligations of the owner/user**
The owner/user of the transformer is required by law, or applicable regulations, to draw up instructions for ensuring the device is operated without danger.

The owner/user of the transformer must obtain an operating permit from the relevant authorities and comply with the associated laws and regulations, i.e.:

- Safety for personnel.
- Safety for material.

The owner/user of the transformer must ensure the following activities are carried out only by qualified and authorized personnel:

- Transportation.
- Installation.
- Connection.
- Commissioning.
- De-commissioning.
- Maintenance.
- Disposal.
The owner/user of the transformer must ensure the following documents are made available to operating and maintenance personnel:

- This operating manual.
- The transformer technical documentation, i.e. circuit diagrams, terminal layouts, test reports and operating manuals for installed accessories.
- Any relevant accident prevention regulations applicable at the workplace.
- Other applicable national regulations.

The owner/user of the transformer must ensure all safety information/instructions are observed.

Prior to the transformer being placed into operation, the owner/user or authorized personnel by the owner/user must check compliance with the following:

- The transformer will be operated in accordance with its intended use.
- Compliance with all safety regulations.

**Personnel qualification**

Qualified professional personnel must have knowledge and experience in the following fields, depending on the specific work to be carried out:

- Disconnection of electrical equipment.
- Securing prevention of accidental activation by unauthorized personnel.
- Verification of disconnection from the power supply.
- Earthing and short-circuiting of electrical equipment.
- Covering or safeguarding from adjacent live components.
- Transformer transport.
- Transformer installation.
- Transformer commissioning.
- Transformer operation.
- Transformer cleaning.
- Transformer maintenance.
- Transformer disposal.

**Prohibition of unauthorized modifications or alterations**

Modifications or alterations are only permitted following approval by the manufacturer. This applies in particular to any alteration and blocking of safety devices.
• Use of accessories not approved by Hitachi ABB Power Grids is strictly prohibited.
• Override or bypass of protective devices included in the transformer is strictly prohibited.

Personal Protection Equipment

• Use of protective footwear, according to ISO 20345, is mandatory.
• Use of safety gloves, according to ANSI/ISEA 105, is mandatory.
• Use of safety helmet, according to ANSI Z89.1, is mandatory.

Follow the instructions of the owner/user.

Intended use
The VCC dry-type transformer transforms voltage. Transformer must be operated strictly in accordance with the electrical data set out in the rating plate and the operating conditions agreed by contract.

The definition of intended use also encompasses observing and following all of the information and instructions contained in this operating manual. In particular this means observing and following the safety information/instructions and warnings, and observing the cleaning and maintenance intervals.

Any other use outside the intended use shall be regarded as improper use and may result in damage to property or personal injury.

The following practices in particular shall be regarded as improper use:

• Overriding and/or manipulation of monitoring devices settings.
• Alterations to attachment parts, i.e. fans, cooling systems, etc.
• Attachment of adhesive labels to the coil surface.
• Removal of information and warning signs.
• Connections, for which no provision is made in the relevant diagram.
• Application of a higher level of voltage to a tapping connection other than shown on the rating plate.
• Loading of a higher level of power than is shown on the rating plate.
• Use of a different supply voltage frequency to that shown on the rating plate.
• Mechanical loads on the consumer terminals and terminal lugs.
• Parallel connection with unsuitable transformers.
• Excessive loading with transient voltages; i.e. operation of vacuum type switchgear over short cable distances.
• Operation in networks with high voltage harmonics.

Any improper use of the transformer will render defects liability void.

Basic safety information

• Prevention of injury caused by electric shock.
  Only professional personnel with appropriate qualifications are permitted to carry out any work on or with the transformer. Designated personnel are only permitted to work on the transformer under the supervision of qualified professional personnel.
  - The following steps must be adhered to prior to commencing any work on the transformer:
    ► Disconnect.
    ► Secure it to prevent it being switched on by unauthorized personnel.
    ► Verify that it is disconnected from the power supply.
    ► Earthed and short-circuited.
    ► Cover or ensure clearances are kept with any adjacent live components.
  - Never place a transformer into operation if it is damaged.
  - The insulation on the outside of the windings is not touch-proof. The transformer must always be in a de-energized and earthed state when you carry out any work on it.
  - Transformers with enclosures must be energised only after the enclosure is duly secured and locked.
  - Wear the requisite protective equipment for all work.
  - In the event of a fire on the transformer, do not use water to extinguish the fire; use a suitable quenching agent instead, i.e. CO₂ quenching agent.

• Prevention of fatal injuries caused by magnetic fields.
  - Personnel with a cardiac pacemaker should not come any closer than three meters to the transformer when it is in operation.
  - Personnel with a metal implant should not come any closer than three meters to the transformer when it is in operation.

• Prevention of fatal injuries caused by improper transportation and installation.
  - Only qualified personnel with appropriate qualifications are permitted to undertake off-site and on-site transportation of the transformer.
  - Only qualified personnel with appropriate qualifications are permitted to install the transformer.
- Make sure that no one is standing beneath suspended loads.
- Make sure that the slinging and lashing arrangements are suitable for the weight of the transformer.
- Only lift the transformer by fork lift truck if the transformer is fixed on a suitable pallet.

• Prevention of injury caused by magnetic fields.
  - Personnel with jewelry/piercing should not come any closer to the transformer than three meters.

• Prevention of burns caused by hot surfaces.
  - The surface of the transformer becomes hot during operation. Wear the required personal protective equipment.
  - Always allow the transformer to cool down until it is only warm to the touch before commencing any work.
  - Check the temperature of the transformer, i.e. using an infrared thermometer.

• Prevention environmental hazard caused by improper disposal.
  - If you intend to dispose of the transformer, make sure you do so in accordance with the applicable regulations at the place of use.

• Prevention of damage to property or of malfunctions.
  - Never place a transformer into operation if it is damaged.
  - If the transformer is fitted with an enclosure, do not step on the top cover.
  - Ensure the transformer is always kept upright, either on its feet or on its rollers.

Safety devices

• Temperature sensors.
  - Each phase in the transformer has at least one temperature sensor fitted inside it. The temperature monitoring device must be connected by the owner/user, in proper working order, to the transformer circuit-breaker, or to the protection system. If the transformer is supplied without a temperature monitoring device, the owner/user must connect the sensors directly to their own peripheral equipment.
  - If the coil temperature reaches Trip temperature, the transformer load must be reduced. If the Trip remains at least 1 hour, the transformer must be de-energised.
  - Alarm and Trip temperatures are set in accordance to the thermal class of the insulation materials used on the transformer and rated hot spot temperatures defined in IEEE Std C57.96.
- Please see below table comprising recommended alarm trip values for insulation system temperatures of 150 °C and 180 °C.
- Should additional safety margins be required, alarm and trip values can be adjusted and reduced by 10 °C.

<table>
<thead>
<tr>
<th>Insulation System Temp.</th>
<th>Alarm temperature</th>
<th>Trip temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 °C</td>
<td>135 °C</td>
<td>155 °C</td>
</tr>
<tr>
<td>180 °C</td>
<td>160 °C</td>
<td>180 °C</td>
</tr>
</tbody>
</table>

- Preset values of supplied temperature monitoring devices may differ from those in the table.

• Warning signs and information signs:
  ► Observe and follow the warning and information signs affixed to the transformer.
  ► Make sure the warning and information signs affixed to the transformer are always visible and are always easily readable.
  ► Replace any damaged warning and information signs.

The following warning signs and information signs are affixed to the transformer:

<table>
<thead>
<tr>
<th>Sign</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>![No Touch Symbol]</td>
<td>Do not touch, surface area is live</td>
</tr>
<tr>
<td>![Danger Symbol]</td>
<td>Danger - High voltage</td>
</tr>
<tr>
<td>![Earth Symbol]</td>
<td>Earth symbol</td>
</tr>
</tbody>
</table>
The line and neutral terminals are marked in accordance with the corresponding connection diagram:

- Phase marking for high voltage in accordance with IEEE Std. C57.12.70, i.e. h0, h1, h2, h3.
- Phase marking for low voltage in accordance with IEEE Std. C57.12.70, i.e. X0, X1, X2, X3.
- Marking of the tapping connections with number, i.e. 3, 4, 5, 6, 7, 8.
- Other signs:
  - Rating plate with connection diagram.
  - Trailer diagram for transport.

Warning symbols

- **DANGER**: Information or instructions accompanied by the word DANGER provide a warning about a hazardous situation that will lead to fatal or serious injuries.
- **CAUTION**: Information or instructions accompanied by the word CAUTION provide a warning about a situation that can lead to minor or moderate injuries.
- **WARNING**: Information or instructions accompanied by the word WARNING provide a warning about a hazardous situation that may possibly lead to fatal or serious injuries.

Warning symbols: damage to property

**ATTENTION!**

Information and instructions of this kind provide a warning about a situation that will lead to damage to property.
Description

Vacuum Cast Coil (VCC) transformers fall within the category known as dry-type transformers. The materials used are flame-retardant and have only a low fire load. This means that the risk of a fire has been reduced to a minimum.

**Design features**

The key features of the transformers are as follows:

- No danger of contamination for humans and the environment.
- Non-explosive.
- Flame-retardant.
- Resistant to loading caused by harmonics, if they are specified with the order.
- Minimal maintenance requirements.

Unless otherwise specified, the transformers are compliant with the following requirements in accordance with IEC 60076-11:

- Environment class E2.
- Climatic class C1 or C2.
- Fire class F1.

**Differences in design features**

The transformers described in this operating manual are, by default, ventilated transformers with or without weather-resistant enclosures, and without optional accessories.

In order to be used as intended, the transformers without protection enclosures may only be installed in indoor areas.

Transformers intended for outdoor use should be fitted with a protection enclosure that complies with the requirements contained in ANSI C57.12.55 for outdoor enclosures.
Depending on purpose and operating conditions, the transformers can be fitted with optional accessories. Please refer to the documents included in delivery if you require details about accessories.

Every transformer is routine tested and inspected at the factory. The results of the tests are documented in a test report. The test reports are part of the supplied documentation.

**Function and assembly**
The transformer transmits alternating voltage and alternating current of the same frequency between two or more windings of generally different voltage and current values.

Temperature sensors for measuring the coil temperature are included as standard.

Depending on customer specification, the transformer is fitted with four wheels to ease transport at the installation location. All of the wheels must be fitted and aligned in the same desired running direction before installation.

- Low-voltage and high-voltage windings.
  Aluminium or copper conductors are used for the low-voltage and high-voltage windings, along with interturn insulation to thermal class F or H, according to the insulation system temperature indicated on the rating plate. The high-voltage winding is encapsulated with epoxy resin under vacuum.

  The transformer comprises an individual encapsulated high-voltage winding installed over the low-voltage windings on a coaxial basis.

  The epoxy resin contains a mineral filler. This improves the following characteristics:
  - Thermal conductivity.
  - Mechanical load capacity.
  - Arc resistance.
  - Adhesion of the pure epoxy resin to the conductor.

  The windings encapsulated under vacuum are reinforced with glass fiber materials.

- Core assembly.
  The material used for the core is grain-oriented transformer magnetic sheet steel.
Core legs and yoke are formed with steel laminations. High-precision production ensures that noise and losses are reduced to a minimum.

In order to achieve optimum alignment of the flux distribution with the preferred direction of magnetization, the joints between the leg and yoke plates are in 45° steps and are laminated on an overlapped basis.

The core has an epoxy-resin coating to protect it against corrosion. The high-voltage and low-voltage windings are supported at top and bottom against the core yokes by blocks.

**Transformer overview**

- 01 Lifting eyes
- 02 Upper press clamps
- 03 Lashing eye
- 04 Coils
- 05 Lower press clamps
- 06 Earthing terminals
- 07 Pulling eyes
- 08 Wheels beam
- 09 Wheels (optional)
- 10 High-voltage tapping connections
- 11 High-voltage terminal
- 12 Rating plate and connection diagram
- 13 Temperature monitoring device, terminal strip
- 14 Neutral point terminal
- 15 Low-voltage terminal
Transformer enclosure overview

**Rating plate**

Every transformer or transformer enclosure has a rating plate affixed to it. The rating plate will contain at least the following information according to IEEE Std. C57.12.01:

- Serial number.
- Month and year of manufacturing.
- Class (AA, AA/AF, etc).
- Number of phases.
- Frequency.
- Power ratings.
- Voltage ratings.
• Tap voltages.
• Temperature rise in °C, by individual winding if different.
• Polarity (single-phase transformers).
• Phasor diagram (polyphase transformers).
• Percent impedance.
• Basic lightning impulse insulation levels (BILs).
• Approximate weight in pounds and kilograms.
• Connection diagram.
• Name of manufacturer.
• Installation and operating instruction reference.
• The words “dry-type transformer”.
• Conductor material.
• Step-up transformer suitability.
Transportation and storage of the transformer

Personnel qualification
The personnel assigned to carry out transportation must be trained in the following:

• Safety precautions during transportation.
• Safe handling of heavy loads.
• Securing of loads on the transport vehicle.
• Protection of the load against the weather.

Loading and unloading
Prior to any loading/unloading operations, ensure that any packaging and/or pallets has been removed. To do so, only use the lifting rings provided on the transformer.

Off-site transportation
The following requirements must be observed during off-site transportation:

• The transformer wheels must be removed.
• The transformer must be in an upright position at all times during transportation.
• The transformer must be protected against the weather.
• The ambient temperature on the transformer must be kept between –30 °C and +50 °C, unless agreed otherwise by contract.
• The ambient temperature on any accessories provided, i.e. temperature monitoring device, thermometers, fans, must be kept between –30 °C and +50 °C.
• Take precautions to prevent the impacts on the coils or any parts attached to them.
• Ensure the fastening equipment and mode of transport you select will not cause any damage to the transformer.
• Take precautions to prevent the transformer from being exposed to vibrations and oscillations.
• Comply with valid applicable regulations relating to work with transport vehicles.
• Secure the transformer to prevent it from slipping.
To secure a transformer effectively to prevent it from slipping during transportation, lashing eyes are provided on each upper press clamp and also eyes in wheels beam.

Must be used just one sling with hook for each lashing eye.

It’s recommended to follow instructions indicated in NSC Cargo Securement Standard, and related documents about load restraining on road vehicles.

To secure a transformer with enclosure effectively to prevent it from slipping during transportation, lashing eyes are provided on the sides of enclosure.
Make sure that a crane with sufficient load capacity is provided for unloading and loading.

① The total weight is shown on the rating plate.

ATTENTION!
Damage to property or malfunctions on the transformer caused by lifting by a fork lift truck.
► Lift the transformer by crane. You only may use a fork lift truck to lift a transformer that has been delivered and packed by Hitachi ABB Power Grids on a suitable pallet.

If the transformer is to be delivered to a building site, proceed as follows:
► Check the situation on site a few days before delivery.
► Inform all those concerned about the delivery.

If the transformer is to be installed indoors, proceed as follows:
► Make sure that an area is available in front of the room which is suitable for the transformer's protection degree designation and its weight.
► Set the transformer down in designated area.
► Fit the wheels.
► Move the transformer into the closed room from this area.
► In the case of transformers with a protective enclosure, remove the lashing eyes (1) fitted to the side.
► Remove the plate (2) underneath the lashing eyes (dependent on model).
► Use the plate to close the opening in the enclosure for the lashing eyes (dependent on model).
Checking the transformer on delivery

⚠️ DANGER
Risk of fatal injury caused by a transformer that is visibly damaged.
- Never place a transformer into operation if it is visibly damaged.
- Contact the manufacturer.

Check the transformer and components for and damage with reference to the following list upon arrival:

- Is the transformer specification in accordance with the test report and the name plate?
- Are all parts specified on the delivery note present?
- Are the fastenings and/or packaging damaged or damp?
- Are the fastenings for the transformer damaged?
- Are there any indications that the load was reloaded or slipped while in transit?
- Have all the items indicated on the drawing included with the documentation been removed?
- Are the connection elements or insulated supports on the coils twisted or broken?
- Are the marked bolted connections properly tight?
- In case of marked blocks, have the coil support blocks moved?
- Is there any damage to the coils, i.e. scratches?
- Is there any damage to the coating?

If you should discover any non-conformities, proceed as follows:
- Enter the type of damage on the consignment note.
- Send the consignment note to the manufacturer.
- Send a damage report to the haulage firm.
- Do not place the transformer into operation.

If you should discover that any parts are missing, proceed as follows:
- Notify the haulage firm.
- Do not place the transformer into operation.

If the information on the packaging does not correspond with the information on the delivery note, proceed as follows:
- Contact the manufacturer without delay.
On-site transportation
Make sure that the following conditions are observed during on-site transportation:

• Transport the transformer in an upright position only.
• The transformer must be protected against the elements.
• Take precautions to prevent the impact of force on the coils or any parts attached to them.
• The ambient temperature on the transformer must be kept between −30 °C and +50 °C, unless agreed otherwise by contract.
• The ambient temperature on any accessories which may be provided, i.e. temperature monitoring device, thermometers, fans, must be kept between −30 °C and +50 °C.
• Make sure that the fastening equipment and mode of transport you select will not cause any damage to the transformer.
• Take precautions to prevent the transformer being exposed to vibrations or oscillations.
• Secure the transformer to prevent it from slipping.
• Before transporting the transformer, make sure that it has cooled down enough so as not to cause any burns if touched.

Using a crane to transport a transformer without a protective enclosure.

1 The total weight is shown on the rating plate.

To use a crane to lift the transformer, proceed as follows:
► Make sure that the transformer will not get wet, i.e. from rain.
► Secure the slings to the four slinging points provided on the upper press frame.
► Make sure that the slinging angle does not exceed 60°.
► Lift the transformer by the crane.
► Fasten the bidirectional wheels or feet in accordance with the instructions.
► Set the transformer down in the designated area.
► Remove the slings from the transformer.

DANGER
Risk of fatal injury caused by falling loads.
► Cordon off the transportation route for the duration of transportation.
► Only use load suspension equipment and slings suitable for the load free from damage.
► Make sure no one is standing beneath suspended loads.
Using a crane to transport a transformer with a protective enclosure.

1 The total weight is shown on the rating plate.

To use a crane to lift a transformer with a protective enclosure, proceed as follows:

- Make sure that the transformer and enclosure will not get wet, i.e. from rain.
- Remove the top cover from the protective enclosure.
- Secure the slings to the four slinging points provided on the upper press clamps.
- Make sure that the slinging angle does not exceed 60°.
- Lift the transformer using the crane.
- Fasten the bidirectional wheels or feet in accordance with the instructions.
- Set the transformer down in the designated area.
- Remove the slings from the transformer.
- Replace the top cover on the protective enclosure.
**DANGER**
Risk of fatal injury caused by falling loads.
- Cordon off the transportation route for the duration of transportation.
- Only use load suspension equipment and slings suitable for the load free from damage.
- Make sure no one is standing beneath suspended loads.

**CAUTION**
Fall hazard: top cover is not a load bearing structure.
- Do not step onto the top cover of the enclosure.
ATTENTION!
Risk of damage to property caused by stepping on the top cover on the enclosure.
▶ Do not step onto the top cover of the enclosure.

ATTENTION!
Risk of damage to property caused by the use of incorrect slinging points.
▶ Make sure that the slings are only secured to the four slinging points provided for the purpose on the upper press frame.
▶ Never secure the slings to the lashing eyelets on the enclosure for lifting.

Fitting the bidirectional wheels (optional). The bidirectional wheels are fitted in the same way for transformers with and without a protective enclosure.

For on-site transportation you can fit bidirectional wheels to the wheels beam of the transformer. For off-site transportation the bidirectional wheels are fastened on the wheels beam or supplied separately.
To fit the bidirectional wheels, proceed as follows:
► Remove the bidirectional wheels from the wheels beam or separate wheels packaging.
► Lift the transformer by crane.
► Set the transformer down on a structure with sufficient load bearing capacity that is higher than the bidirectional wheels, and will permit the bidirectional wheels to be fitted. Fasten the bidirectional wheels to the wheel beam and ensure they are all aligned in the desired running direction.
► Check that the bidirectional wheels are all aligned in the same running direction once you have fitted them.
► Lift the transformer off the structure.
► Set the transformer down on the fitted bidirectional wheels.

Using a fork lift truck. You can tow the transformer on its bidirectional wheels using a fork lift truck through lower clamps.
► Check that the wheels on the transformer are fitted aligned in the intended direction.

**ATTENTION!**
Damage to property or malfunctions on the transformer caused by lifting by a fork lift truck.
► Lift the transformer by crane. Use a fork lift truck to lift the transformer only in the event that Hitachi ABB Power Grids has performed packaging of the transformer on top a suitable pallet.

► Secure load suspension equipment and slings, suitable for the load to the lashing eyes on the transformer.
► Secure the other end of the load suspension equipment and slings to the lashing eyes on the fork lift truck.
► Tow the transformer with care to the desired location.
Storage of the transformer. For temporary or longer term storage, the following conditions must be observed:

► Store the transformer in a room that is dry, clean and well ventilated.
► Store the transformer at an ambient temperature between –30 °C and +50 °C. If the transformer has to be stored at lower temperatures, please ask the supplier.
► Cover the transformer with heavy plastic to protect it from dirt.
► If the transformer is to be stored for a longer period (more than one month), provide the packed transformer with a suitable drying agent, i.e. silicagel.
► Check the drying agent at regular intervals for moisture.
► Replace the drying agent in accordance with the manufacturer’s instructions, if it accumulates too much moisture.
Transformer installation

⚠️ DANGER
Risk of fatal injury caused by an unsuitable installation location.
► Ensure all transformers without enclosure are only used indoors.
► Make sure that access to the transformer is only possible when it is in a de-energized state.

⚠️ ATTENTION!
Risk of damage to property caused by improper storage before installation.
► Protect the transformer from dirt and damp while in storage.

⚠️ ATTENTION!
Risk of inadequate cooling caused by incorrect installation.
► In case of transformer supplied with wheels, the distance between wheels beam and floor must be at least the distance taking into account wheels height to allow sufficient air flow for cooling of the inner part of the transformer.
► Install the transformer only on the wheels or on the wheels beam provided by the manufacturer.

You can install the transformer with or without a protective enclosure in the following ways:

• On the bidirectional wheels.
• On the wheels beam.

If you wish to install the transformer on the bidirectional wheels, proceed as follows:
► Make sure that the transformer has a sufficient supply of cooling air.
► Make sure that the distance between the floor and bidirectional wheels beam corresponds to that shown in the applicable dimension diagram.
► Secure the bidirectional wheels with wedges to prevent the transformer rolling away.
Installation location conditions

ATTENTION!
Risk of damage to property caused by an excessively low ambient temperature on provided accessories, i.e. temperature monitoring device, thermometers, fans.
► Do not expose any such accessories to temperatures lower than –30 °C.
► Contact the manufacturer if you expect lower temperatures.

Make sure that the following conditions are observed at the installation location:

• Altitude must not exceed 1,000 m above sea level, unless a different value is given on the rating plate.
• Keep away from direct sunlight unless otherwise agreed.
• The surface on which it stands must be flat, dry and suitable to accommodate the weight of the transformer.
• Comply with local building regulations.
• Unless otherwise agreed with the manufacturer, observe the following ambient temperatures:
  - Maximum daily average +30 °C.
  - Maximum temperature +40 °C.
  - Minimum temperature –30 °C

① Check and document the ambient temperatures at regular intervals.

Ventilation
All transformers, regardless of their power levels, are always designed for a certain type of ventilation.

It makes no difference whether the transformers are operated on a self-cooling (AA cooling) basis, or with fitted fans for enhanced performance (FA cooling). The ventilation system is designed to allow for the maximum possible heat loss.
• Electrical operating room for transformers with AA/FA cooling.
The design of the electrical operating room for the transformer, in particular, the ventilation aspects of the room need to be taken into consideration at the outset in the planning phase.

The ventilation of transformer rooms needs to fulfill the temperature requirements previously defined and needs to be designed to allow for all of the expected sources of heat in the room; including the heat loss for all of the transformers and any other heat sources, i.e. electrical equipment such as fans, lighting, etc. It is important that possible increases in transformer power at a later date are also taken into account.

The supply and exhaust air openings must lead directly to the open air. The rooms need to be ventilated effectively enough for the waste heat generated when the transformers are in operation to be completely dissipated at all times.

• Supply air and exhaust air.
The supply air for the rooms must be drawn in from the open air either directly or through special ventilation ducts, while the exhaust air must be conveyed separately out to the open air either directly or through special ventilation ducts.

Ventilation ducts which run through other rooms have to be installed in such a way that there is no risk of fire and smoke being transferred to other rooms. The openings of ventilation ducts to the open air must be provided with protective grates. If the supply air is contaminated, it has to be filtered before it enters the room.

Air inlet and outlet openings must be arranged in such a way that ensures that the transformers are ventilated with fresh air. The air inlet openings need to be low down in the transformer room, while the air outlet openings need to be high up.

Do not install any facilities in the air supply and outlet ducts for transformer rooms which would obstruct the free flow of the air. Ventilation ducts for natural ventilation should lead directly to the inlet and outlet openings.

Particularly effective cooling can be achieved if the cooling air flows into the room low down on one side of the room and out again just beneath the ceiling on the opposite side. It’s recommended to follow inlet and outlet heights.
Other supply air and exhaust air alternatives. The exhaust air alternative shown bottom right requires special consideration.
Observe the rules set out in the applicable technical literature when designing the installation room.

Make sure the air cooling rate is more than 4 m³/min per kW of total power loss of the transformer.

Refer to the precise details included in the supplied test reports.

Make sure the temperature of the supplied cooling air does not exceed the aforementioned ambient temperatures.

The air inlet and outlet cross-sections must be dimensioned in such way that the flow rate of the cooling air within the installation room does not exceed 1.5 m/s.

**Basic requirements to be met for adequate interior ventilation for transformer operation.**

For an efficient supply of sufficient cooling air to the transformer, the following limits must be complied with:

- Air volume: >4 m³ per minute and kW of power loss.
- Air speed: <1.5 m/s.
- Air temperature:
  - Maximum average daily temperature 30 °C.
  - Maximum temperature 40 °C.
  - Installation altitude <1,000 m above sea level.

The size of the air inlets and outlets recommended for the above can be determined using the following rules of thumb for an initial approximation.

\[ A_1 = \frac{0.18 \times P_v}{\sqrt{H}} \]

\[ A_2 = 1.1 \times A_1 \]

- \( A_1 \): Cross-sectional area for supply air in m²
- \( A_2 \): Cross-sectional area for exhaust air in m²
- \( P_v \): Total power loss in kW
- \( H \): Difference in height between the center of the inlet and the center of the outlet in meters

If blinds, filters or similar are to be installed in the intake for the supply air, the area of the inlet/outlet must be enlarged accordingly.

**Special conditions.**

Under certain circumstances it may not be possible to provide an electrical operating area with the requisite dimensioning (i.e. if existing rooms are used). In room cases, it can still be possible to provide sufficient cooling for the
transformer if the room is provided with active cooling (ACCS = Assisted Cooling Convection System).

In this case the use of suitably dimensioned fans in the exhaust air duct and suitable air ducting provides the transformer coils with a forced air flow. This solution generally allows operating areas to be used where only the requirements in terms of electrical conditions (clearances, etc.) have to be met.

- Using filter elements.
If the cooling air contains harmful substances that form a conductive layer in a dry or damp state, they must be filtered out. Examples of such harmful substances include the following:
- Cement dust.
- Salt deposits.
- Dust containing metal.
- Carbon dust, etc.

**ATTENTION!**
Risk of an inadequate supply of cooling air and excessive temperature rise caused by the installation of filters.
► Ensure there is an adequate supply of cooling air if filters are used.
► Enlarge the cross-section of the ventilation openings if the supply of cooling air is inadequate.
► Make sure that the air flow is sufficient for both, the air inlet and the air outlet openings.

► Clean the filter elements at suitable intervals.
► Replace used or damaged filter elements with new ones.

- Ventilation for transformers with a protective enclosure.
For transformers with protective enclosures, the following information and instructions must also be observed.
- In order to ensure adequate air circulation is provided, the protective enclosure must be installed at a sufficient distance from the floor and the walls.
  - For the minimum distance between the floor and the bottom edge of the enclosure, please refer to the up-to-date drawings included in the supplied documentation.
  - If you remove the bidirectional wheels, you must take appropriate measures on site to ensure the minimum distance between the floor and the bottom edge of the enclosure is not less than the specified limit.
• Ensure the minimum distance between the transformer and the walls on all sides is 0.35 m. Also, make provisions in your plans for sufficient space for installation and maintenance work.
• Ensure the minimum distance between any two transformers is not less than 0.5 m. In addition, you must also comply with the minimum distances for electrical components (see the table in the following section).

- The required minimum distance between the floor and the bottom edge of the enclosure does not have to be met if the floor immediately below the transformer is provided with ventilation openings with cross-sections of sufficient size.
- Ventilation gratings or louvres in the air inlet and outlet openings must be designed in such a way as to not impede the flow of air.

Space requirements, planning and minimum clearances
► Please refer to the dimension diagram in the documents included in delivery for the dimensions of the transformer.
► Install the transformer in the intended room in such a way that the following conditions are met:

• You must be able to read the rating plate without having to enter the installation room.
• You must be able to read the provided measuring instruments without having to enter the installation room.

⚠️ The insulation of the coils is not safe in the event of accidental contact during operation.

► Do not install the transformer in easily accessible places.
► Place clearly visible warning and danger signs on the surface of the coils.

Comply with the minimum clearances between live parts and between live parts and earth as set out in the following table according with IEC 61936-1 standard.

The minimum distances must be observed for steel-reinforced concrete walls as well.
<table>
<thead>
<tr>
<th>Maximum system(^c) voltage phase-to-phase (kV, rms)</th>
<th>Basic BIL(^c) (kV, crest)</th>
<th>Minimum phase to-ground(^d,i) clearances</th>
<th>Minimum phase to-phase(^d,i) clearances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>(in)</td>
<td>mm</td>
</tr>
<tr>
<td>1.2</td>
<td>30</td>
<td>57</td>
<td>(2.3)</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>86</td>
<td>(3.3)</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>115</td>
<td>(4.5)</td>
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<tr>
<td></td>
<td>75</td>
<td>145</td>
<td>(5.6)</td>
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<tr>
<td>15</td>
<td>95</td>
<td>180</td>
<td>(7)</td>
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<td></td>
<td>110</td>
<td>210</td>
<td>(8)</td>
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<tr>
<td>26.2</td>
<td>150</td>
<td>285</td>
<td>(11)</td>
</tr>
<tr>
<td>36.2</td>
<td>200</td>
<td>380</td>
<td>(15)</td>
</tr>
<tr>
<td>48.3</td>
<td>250</td>
<td>475</td>
<td>(19)</td>
</tr>
<tr>
<td>72.5</td>
<td>250</td>
<td>475</td>
<td>(19)</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>665</td>
<td>(26)</td>
</tr>
</tbody>
</table>
Lifting operations

► Remove central cover:

- Ensure all personnel comply with local HSE regulations for working at height.
- Unscrew by means of spanner M8 tool the panel (x8 screws with contact washers NFE25511).

• Lift and remove ONLY the central panel. There are two different methodologies to lift central panel:
  - Lifting with crane: By means of 2 vertical hoisting points. It’s important to abide by the minimum angle defined between rope slings or chains (in the picture below), ensuring a minimum angle between slings of 45°, always with two different hoisting points (avoid only one hoisting point).
  - Lifting the panel by means of roof handles: Two workers at the same time and working according to your local HSE regulations.
Two important safety considerations at this stage: (See stickers attached to the enclosure):

- Lifting the entire transformer using panel lifting lugs is NOT ALLOWED.

- Lifting the entire transformer using removable transportation eyebolts is NOT ALLOWED.

► Hook the lifting lugs with chains or rope slings.
Enclosure is not designed to bear loads. Personnel should operate in “A” zone in the picture below: core and clamps; cleaning during operation.

Abide by maximum lifting angles described in this document.

Lift and handle the transformer carefully. At this point the transformer can be lifted. Remember that it’s not allowed to lift the transformer directly from the roof panel lugs. First remove the panel and then hook to the beam lifting lugs as shown in the picture below.
Other especial lifting system can be defined in general arrangement inside the enclosure but the steps are the same, the system will be clearly defined in the drawings.

► Remove the rope slings or chains with the methodology defined previously.

1. **Attention to the “A” zone defined and respect HSE procedures.**

► Cover and close the enclosure with central panel as per methodology defined previously.

► Screw with torque wrench at 5Nm (low torque due to encaged nuts M8).
Transformer connection

The transformer is always connected in the same way regardless of whether it comes with or without a protective enclosure.

**Personnel qualification**
The personnel assigned to carry out the job of connection must be trained in the following:

- Disconnection of electrical equipment.
- Securing to prevent accidental activation by unauthorized persons.
- Verification of disconnection from the power supply.
- Earthing and short-circuiting of electrical equipment.
- Covering or safeguarding of adjacent live components.
- Making electrical connections.
- Connection of transformers.

**Electrical and mechanical connections**
Ensure the following conditions are met before you start to connect the transformer:

- All the provided cables and the earthing system must be suitably prepared in accordance with requirements.
- All cables must have cross-sections suitable for the power to be transmitted.
- The electrical data for the transformer (see the rating plate) must be the same as the electrical data for the low-voltage and high-voltage mains.
- Clean the contact surfaces and remove any rust surfaces in order to ensure low contact resistance.
- Comply with the minimum distances between live and earthed parts. This applies particularly to the distances between cables and the high-voltage windings.
- Secure the transformers to prevent them moving at the installation location, i.e. with wedges.
- Ensure all the connections fit tightly and are mechanically secure when you connect them, proceed as follows:
• Use high tensile steel bolts and nuts for the electrical connections (A2-70, 8.8).
• Use a suitable torque wrench to tighten the screws or bolts on electrical connections.
• Please refer to the tables below for the torques.

The torque for electrical connections only apply to the tightening of screws or bolts without the use of lubricant. If lubricants are used, the quoted torques can be reduced slightly.

The torque for tensile 8.8 mechanical connections apply to the tightening of screws or bolts without the use of lubricant. If lubricants are used, the quoted torques can be reduced slightly.

The torque for tensile A2-70 mechanical connections apply to the tightening of screws or bolts with the use of lubricant Krafft Luberkraft® W Paste or similar.

### Mechanical connections (N/m)

<table>
<thead>
<tr>
<th>Size</th>
<th>Steel 4.6</th>
<th>Steel 5.6</th>
<th>Steel 8.8</th>
<th>Stainless steel A2-70</th>
<th>Stainless steel A4-80</th>
<th>Metallic bolt to insulator</th>
<th>No metallic bolt to insulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>M6</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>6</td>
<td>8</td>
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<td>-</td>
</tr>
<tr>
<td>M8</td>
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<td>10</td>
<td>20 (**)</td>
<td>15 (**)</td>
<td>20 (**)</td>
<td>-</td>
<td>4</td>
</tr>
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<td>120</td>
<td>120</td>
<td>70</td>
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<td>-</td>
<td>420</td>
<td>420</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lubricant</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>(*)</td>
<td>(*)</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

### Electrical connections (Nm)

<table>
<thead>
<tr>
<th>Size</th>
<th>To leadouts (***))</th>
<th>To brass terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>M16</td>
<td>120</td>
<td>-</td>
</tr>
<tr>
<td>M20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>M24</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lubricant</td>
<td>(***)</td>
<td>no</td>
</tr>
</tbody>
</table>

(*) = can be reduced slightly if lubricants are used.
(**) = Apply to the tightening of screws or bolts without the use of lubricant.
(*** and ****) = Apply to the tightening of screws or bolts without the use of lubricant.
(*) In order to avoid incidences in stainless steel joints, it is necessary to Kraft luberkraft® W paste or similar to the connection.

(**) The tightening torque for bolted connections M8 in enclosure panels will be 5 Nm for both Q8.8 and stainless steel bolts due to the small thickness of the panels.

(***) The tightening torques apply to bolted connections between leadouts with flat washer DIN7349 and conical washer DIN6796.

****) The contact surfaces of the terminals and, if applicable, the bimetallic plates in bolted connections between leadouts are lubricated with electric contact grease UPREXAL or similar. The hardware will not be greased.

① The quote torques do not apply for the tightening of screw connections which have flexible material, i.e. rubber, in between.

- Setting the voltage ratio on transformers with vacuum cast coil windings. Changing over the tapping connections is carried out by changing the connections of the taps on all high voltage windings while the transformer is de-energised.

⚠️ DANGER
Risk of fatal injury caused by a transformer that has not been disconnected from the power supply and is not earthed.
- Disconnect the transformer from the power supply.
- Secure the transformer to prevent incidental activation by unauthorized persons (lock-out/tag-out).
- Check that the transformer has been disconnected from the power supply.
- Earth the transformer.
- Short the transformer.
- Cover or safeguard adjacent live components.

ATTENTION!
Damage to the transformer.
- Make sure that all of the windings are set to the same tapping connection.
- Please refer to the connection diagram on the transformer for the assignment of the tapping connections.

To adjust the voltage ratio between the input voltage and output voltage, you must move the tapping connection on each winding into the corresponding position. Consult the connection diagram on the transformer and rating plate for details of the position.
- Tighten the connections with the required torque as described in this manual.
• Making connections.

Make the connections in accordance with IEEE Std. 80 or your national standard.

Carry out the following, prior to connecting the high-voltage side:
► On the low-voltage side, place an electrical connection between the zero conductor on the low-voltage side and the zero conductor of the mains.

This is to prevent excessive potential being transmitted to the low-voltage winding due to capacitive couplings in the event of an earth fault in the mains.

To connect the transformer, proceed as follows:
► Earth the transformer with the earth screws on the lower press clamps.
► For reconnectable transformers, check the voltage ratio with reference to the connection diagram on the transformer.
► If necessary, set the voltage ratio with reference to the connection diagram and the transformer rating plate

ATTENTION!
Risk of damage to the transformer caused by incorrect insulating resistance.
► Check that the insulating resistance is at least 1000 Ohm per volt of operating voltage for HV case and 2 MegaOhm for LV case (less or equal to 1.2 kV).

To check the insulating resistance, proceed as follows:
► Use an insulation tester to check the electrically isolated windings against each other.
► Use a test voltage of 5 kV between primary and secondary winding.
► Use an insulation tester to check each of the electrically isolated windings against earth.
► Use a test voltage of 5 kV between primary winding and earth.
► Use a test voltage of 2 kV between secondary winding and earth.

Should the transformer become damp, this will reduce the insulating resistance. In this case, the transformer must be dried. The manufacturer can advise you about suitable drying methods.
► Check the voltage and phasing of the mains.
► Clean all connection points on the insulated supports and terminal lugs and make them bright.
To connect aluminum with copper parts, proceed as follows:
► Insert the Cupal sheets (copper-clad aluminum sheets) in such a way that the same materials always come into contact with each other.
► In the case of aluminum connections, apply MoS2 corrosion protection between the aluminum and the Cupal sheets, or between aluminum connections.
► Connect the monitoring device(s).
► Check that the monitoring device(s) is/are in proper working order.

When installing the cables, follow the instructions below:
► Ensure there are no severe bends in the cables.
► Ensure they are not subjected to mechanical strain.
► Ensure the cables are not twisted.
► For currents in excess of 1000 A, is recommended to use flexible connectors between the busbars and the connecting terminals on the transformer.
► Comply with the minimum clearances described in this manual.
► Use suitable cable holders to fasten the cables.
► Fit strain relief devices to the cables.
► Ensure the required contact pressure is maintained.
► Please refer to the connection diagram on the transformer for the assignment of the high-voltage connections.
► Make the required electric connections.
► In order to restore the type of protection, seal off any unused cable entries on transformers with enclosures by inserting suitable plugs in them.

Parallel operation of transformers
If several transformers are to be operated in parallel mode, proceed as follows:
► Check that the requirements for the parallel operation of transformers are met. Relevant information can be found in the IEEE Std. C57.12.70 i.e.

Transformers that have terminals marked in accordance with this standard may be operated in parallel by connecting similarly marked terminals together, provided that their angular displacements are the same and also provided that their ratios, voltages, resistances, reactances, and ground connections are such as to permit parallel operation.
Placing the transformer into operation

The transformer must always be placed into operation in the same way regardless of whether it comes with or without a protective enclosure.

**Personnel qualification**
The personnel assigned to carry out the job of placing the transformer into operation must be trained in the following:

- Disconnection of electrical equipment.
- Securing to prevent incidental activation by unauthorized persons.
- Verification of disconnection from the power supply.
- Earthing and short-circuiting of electrical equipment.
- Covering or safeguarding of adjacent live components.
- Making electrical connections.
- Connection of transformers.
- Placing transformers into operation.

⚠️ **DANGER**
Risk of fatal injury caused by a transformer that has not been de-energised and is not earthed.

- Disconnect the transformer from the power supply.
- Secure the transformer to prevent incidental activation by unauthorized persons (lock-out/tag-out).
- Check that the transformer has been disconnected from the power supply.
- Earth the transformer.
- Short the transformer.
- Cover or safeguard adjacent live components.
Preparation
Make sure that the following conditions are met prior to placing the transformer into operation:

- The information on the delivery note must correspond with the information on the rating plate on the transformer. If this is not the case, contact the manufacturer. Let them know the serial number of the transformer.
- After being moved to the installation location the transformer must be given at least eight hours to adopt the prevailing ambient temperature.
- Comply with the valid applicable statutory regulations in the country of use when you place the transformer into operation.
- If the transformer is dirty, it must be cleaned before you place it into operation.
- Connect the temperature monitoring device(s). Comply with the minimum clearances between live parts and between live parts and earth as described in this manual.
- The owner/user must affix safety signs at all points where, in spite of the provision of protective measures, there is a danger to personal safety. The relevant mandatory action and prohibition signs in accordance with the regulations applicable at the place of use must be affixed in clearly visible locations in the installation room and at its entrance.

To prepare for placing the transformer into operation, proceed as follows:
► Make sure all packaging materials and any transport restraints have been cleared away.
► To prevent corrosion, touch up any damage to the paintwork.

ATTENTION!
Risk of damage to the transformer due to flashovers during operation caused by the wheels fitted to the lower press clamps.
► Ensure the wheels, if provided, are fitted to the wheel support during operation.
► Ensure wheels that are not used are removed from the press clamps.

► Fit provided bidirectional wheels.
► In order to check insulation resistance on individual cables they must be separated from the transformer first.
► Tighten all screw connections with the specified torque.
► Ensure all connections on the high-voltage and low-voltage sides are securely fitted and clean.
Ensure the earth has been connected correctly.

Check whether the flashover distances listed below in accordance with the table previously detailed have been adhered to:
- Between live parts.
- Between live parts and earthed parts.
- Between cables and windings.
- Between cables and the high-voltage relay.

• Checking the temperature monitoring device.
  To check the temperature monitoring device with Pt100 sensors, proceed as follows:
  ► Check that all of the connections are securely tightened.
  ► Tighten any loose connections.
  ► Measure the resistance at the ambient temperature and compare it with those given in ASTM E1137.
  ► Replace faulty components if any non-conformities are found.

  To check the temperature monitoring device with PTC thermistor sensors, proceed as follows:
  ► Check that all of the connections are securely tightened.
  ► Tighten any loose connections.
  ► Interrupt the sensor circuit. The temperature monitoring device must indicate a malfunction.
  ► If a malfunction is not indicated, check whether the components and the connection of the temperature monitoring device are in proper working order.
  ► Replace any faulty component.
  ► Connect all the sensors again in accordance with regulations.

① If a different temperature monitoring device (i.e. a dial thermometer) is used, the instruction manual of this device would be applicable.

• Checking the connections.
  ► Check the installation of the control circuit for damaged insulation and loose connections.
  ► Check that the connections correspond with those on the connection diagram on the transformer.
  ► Check that the rated voltage to be applied corresponds with the connected position of the windings.
Ventilation system check
Check whether the ventilation is effective enough.

For transformers with fans, check the following:
► Make sure that the fans are connected in accordance with the circuit diagram and air flow is oriented pointing to the section closest to exterior side of the inner coil.
► Check that the fans are in proper working order and that their direction of rotation is correct.
► In the case of air-to-water coolers and air-to-air coolers there is a direction of rotation arrow on the fan propeller.
► If the direction of rotation of the air-to-water cooler or air-to-air cooler is incorrect, change the electrical direction of rotation.

• Checking for cleanliness:
► Check that the transformer is clean and free of any foreign particles.
► Use a vacuum cleaner and/or dry, oil-free compressed air (max. 3 bar) to remove any small parts in the ventilation ducts of the windings.
► Ensure all tools and equipment have been removed from the transformer.

• Checking for protection devices:
► Make sure that settings of overcurrent and short-circuit current protection relays are adequately set.
► In case of operation with frequent transient voltage, install i.e. surge arresters.

Placing into operation

⚠️ DANGER
Risk of fatal injury caused by high voltage during operation.
► Operate transformers without protective enclosures in closed rooms only.
► Never enter the room during operation.

► Apply the power to the high-voltage side of the transformer.
► Run the transformer without load for about four hours.
► Monitor the secondary voltage. No irregularities should occur during this period.
► In order to check the output voltage in dependency on the voltage ratio, measure the voltage on the terminal lugs on the secondary winding.
► Apply load progressively and pay attention to the temperature rise.
Noise Level
In case the sound level of a transformer exceeds the specified value, check for the following:
► Check all connections and all supports for HV and LV cables. Vibrations from the cable trays can increase the noise level.
► Check the fixing of all accessories to the main body of the transformer. For instance a loose rating plate can be a source of noise.
► Check that the taps are correctly connected to the right position. If not the core can be saturated and create additional noise.
► Try to perform noise measurements on the transformer to verify the noise level.
► Analyze the transformer load component. Unexpected DC currents or harmonics can bring the core into saturation.
► Check that all four wheels or wheels beam of the transformer are stable and well support the transformer on the floor.
► Transmission of vibrations through the floor can be much reduced by using anti-vibration pads at the wheels.
► Flexible connections on the LV terminals can also help to reduce the noise level, but this is normally a final fine tuning step.
► Do not attach grids or guards to the metallic walls of the transformer. Check for sound wall reverberation.

The transformer itself is not always the only source of noise, also the environment or location of the transformer can have an effect.
The information on operation of the transformer is identical for transformers with and without a protective enclosure.

⚠️ DANGER
Risk of fatal injury caused by high voltage during operation.
► Operate transformers without protective enclosures in closed rooms only.
► Never enter the room during operation.

The ambient temperatures and regulations set out in IEEE Std. C57.12.01 were used on the design of the transformer, unless agreed with the manufacturer otherwise.

**Monitoring operating temperature**
You must monitor the operating temperature of the transformer. This means that the transformer must be fitted with a temperature monitoring device.

If the coil temperature reaches Trip temperature, the transformer load must be reduced. If the Trip remains at least 1 hour, the transformer must be shut down (the transformer has to be de-energised).

Attached recommended alarm and trip values for insulation system temperatures of 150 °C and 180 °C:

<table>
<thead>
<tr>
<th>Insulation System Temp.</th>
<th>Alarm temperature</th>
<th>Trip temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 °C</td>
<td>135 °C</td>
<td>155 °C</td>
</tr>
<tr>
<td>180 °C</td>
<td>160 °C</td>
<td>180 °C</td>
</tr>
</tbody>
</table>

**Standard operation**
Ensure the transformer's operating temperature is monitored on a permanent basis.
**Short-term overload**

The transformer can be operated above its power rating (overloaded) in accordance with the provisos set out in IEEE Std. C57.96.

This can be necessary when more power are required for a short period, i.e. when starting up motors.

Overload operation is only possible if the transformer was not operating at full load immediately prior to this, i.e. if the maximum permissible temperature was not reached.

As soon as it reaches Trip temperature, overload operation must be shut down automatically.

Attached recommended alarm and trip values for insulation system temperatures of 150 °C and 180 °C:

<table>
<thead>
<tr>
<th>Insulation System Temp.</th>
<th>Alarm temperature</th>
<th>Trip temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 °C</td>
<td>135 °C</td>
<td>155 °C</td>
</tr>
<tr>
<td>180 °C</td>
<td>160 °C</td>
<td>180 °C</td>
</tr>
</tbody>
</table>

① *Operating a transformer for longer periods at above alarm temperatures reduces its service life.*

The permissible duration of overload operation depends on the ambient temperature and the previous load (consistent loading before and after the peak load).

The permissible overload is directly dependent on the increase in temperature during the rated load and the thermal delay times of the windings. Loading periods can vary considerably between the different transformer versions and can be different for the high-voltage and low-voltage windings on a single transformer.

Based on this provisos, Hitachi ABB Power Grids is not in a position to provide definite load durations as part of this manual. Should you require overload operation, please contact the manufacturer. Quote the ambient temperature, the required overload cycle and the serial number of the transformer.

The manufacturer will then be able to calculate permissible overloads for your transformer and inform you accordingly.
Converter operation
The rating power of transformers designed for converter or rectifier operations take into account current harmonic contents.

Transformers, which are retroactively used for rectifier operation must not be operated at full load.

Operation at full load can in this scenario will lead to an inadmissible increase in the temperature due to the harmonics caused by the converter. Should you require a rectifier to be connected, please contact the manufacturer.

Overvoltages
The insulation values for the transformer are given on the connection diagram and in the test report. You must ensure the high-voltage connections are protected against abrupt increases in voltage.

If there is a risk of frequent transient overvoltages, adequate protection means like i.e. surge arresters or snubbers should be installed.

Intensive air cooling
For a higher rated load the transformer can be operated with forced air flow (AF) and be fitted with fans. Sensors and a relay for the control of the fans are installed. The fans switch on and off depending on the operating temperature.

Attached recommended fans switch on and shutdown values for insulation system temperatures of 150 °C and 180 °C:

<table>
<thead>
<tr>
<th>Insulation System Temp.</th>
<th>Switch-on temperature</th>
<th>Shutdown temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 °C</td>
<td>120 °C</td>
<td>110 °C</td>
</tr>
<tr>
<td>180 °C</td>
<td>140 °C</td>
<td>130 °C</td>
</tr>
</tbody>
</table>

The average service life of the fan motors is 30,000 operating hours. This means they cannot be used for continuous overloads for the total service life of the transformer.

To increase the performance of the transformer retroactively, it may be possible to install fans as retrofits. Please consult the manufacturer.
## Breakdowns and troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loud noises on transformer when switching on.</td>
<td>Transient reactions after switching on.</td>
<td>Allow one hour to see if there is a reduction in the noise level. If there is no reduction in the noise level, contact the manufacturer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smell coming from the transformer after just a short time in operation.</td>
<td>Finishing agents used in the production of the transformer.</td>
<td>Fumes are harmless and generally stops after a few hours of operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The measured temperature is between 100 °C and 120 °C in a no-load state (Pt100 sensors only).</td>
<td>The temperature sensors are positioned in the first cooling duct. They are influenced by the heated core when in a no-load state. The actual winding temperature is not displayed until the winding temperature exceeds the temperature indicated in the no-load state.</td>
<td>No action required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The temperature monitoring device issues a warning.</td>
<td>One or more of the fitted temperature sensors (PTC or Pt100) is faulty.</td>
<td>Replace faulty temperature sensors with another ones of the same type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The temperature monitoring device is faulty.</td>
<td>Replace the faulty temperature monitoring device with a another one of the same type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The actuation of optional fans is incorrectly set or faulty.</td>
<td>Set correct temperature values on the temperature monitoring device (see corresponding operating manual). Replace the faulty temperature monitoring device with a another one of the same type.</td>
</tr>
<tr>
<td>Problem</td>
<td>Possible cause</td>
<td>Action</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>One or more of the fans fitted as an option is faulty.</td>
<td></td>
<td>Replace the faulty fan with another one of the same type.</td>
</tr>
<tr>
<td>The transformer is loaded 100% and the ambient temperature is 5 °C higher than the maximum ambient temperature. Continued operation of the transformer will lead to a considerable reduction in its service life.</td>
<td>Reduce the load. Lower the ambient temperature, i.e. by improving the cooling of the installation location. Install fans on the transformer.</td>
<td></td>
</tr>
<tr>
<td>The transformer is operated with rectifiers at a load of less than 100%, but is not designed for operation with rectifiers.</td>
<td>Contact the manufacturer.</td>
<td>Contact the manufacturer.</td>
</tr>
<tr>
<td>The transformer load is higher than 100%.</td>
<td></td>
<td>Contact the manufacturer.</td>
</tr>
<tr>
<td>The temperature monitoring device causes the transformer to shutdown.</td>
<td>One or more of the fitted temperature sensors (PTC or Pt100) is faulty.</td>
<td>Replace faulty temperature sensors with another ones of the same type.</td>
</tr>
<tr>
<td>The temperature monitoring device is faulty.</td>
<td></td>
<td>Replace the faulty temperature monitoring device with another one of the same type.</td>
</tr>
<tr>
<td>The actuation of optional fans is incorrectly set or faulty.</td>
<td>Set correct temperature values on the temperature monitoring device (see corresponding operating manual). Replace the faulty temperature monitoring device with another one of the same type.</td>
<td></td>
</tr>
<tr>
<td>One or more of the fans fitted as an option is faulty.</td>
<td>Replace the faulty fan with another one of the same type.</td>
<td>Replace the faulty fan with another one of the same type.</td>
</tr>
<tr>
<td>Problem</td>
<td>Possible cause</td>
<td>Action</td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>The transformer is loaded 100% and the maximum permissible ambient temperature has been exceeded.</td>
<td>Reduce the load. Lower the ambient temperature, i.e. by improving the cooling of the installation location.</td>
<td></td>
</tr>
<tr>
<td>Continued operation of the transformer will lead to transformer failure.</td>
<td>Install fans on the transformer.</td>
<td></td>
</tr>
<tr>
<td>The transformer is operated with rectifiers at a load of less than 100%, but is not designed for operation with rectifiers.</td>
<td>Contact the manufacturer.</td>
<td></td>
</tr>
<tr>
<td>The transformer load exceeds 100%.</td>
<td>Reduce the load.</td>
<td></td>
</tr>
<tr>
<td>The transformer is not mounted on wheels or support feet and its inner part has insufficient cooling.</td>
<td>Install wheels or wheels beam.</td>
<td></td>
</tr>
<tr>
<td>The transformer has been shut down by the safety devices.</td>
<td>Faulty safety device.</td>
<td>Check the safety devices. Replace the faulty safety device with another one of the same type.</td>
</tr>
<tr>
<td>Damage to one or more of the transformer’s windings. The damage is not necessarily visible from the outside. Examples: Insufficient voltage distances due to twisted main leads. Short-circuits due to foreign bodies.</td>
<td>Do not place the transformer back into operation. Contact the manufacturer.</td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corona discharges at earthed metal parts of the transformer during switching operations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accumulation of dust on certain areas of the coil surface, i.e. in the center of the coil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of white deposits on certain areas of the coil surface, i.e. in the center of the coil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation of condensation water in the enclosures of air-to-water cooled transformers.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Possible cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one loose connection on metal parts of the transformer.</td>
</tr>
<tr>
<td>The coil surface can be subjected to electrostatic charging and this can lead to an accumulation of dust on certain areas of the coil.</td>
</tr>
<tr>
<td>Under certain unfavorable ambient conditions, corona discharges may occur on the surface of the coil. Water or salt water deposits on the coils surface and / or support blocks.</td>
</tr>
<tr>
<td>Condensation water can develop at below the dew point on the heat exchanger of the cooler.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check that the connections are securely tightened. Tighten the connections with the required torque.</td>
</tr>
<tr>
<td>Check that transformer is correctly earthed.</td>
</tr>
<tr>
<td>Clean the transformer at regular intervals.</td>
</tr>
<tr>
<td>Clean the transformer at regular intervals.</td>
</tr>
<tr>
<td>This is not a fault. Dry the inside of the enclosure.</td>
</tr>
</tbody>
</table>

Should any of the problems described persist, please contact manufacturer providing the following details:

- Serial number.
- Description of the problem.
- Installation location/ambient conditions.
De-commissioning

The information on de-commissioning is identical for transformers with and without a protective enclosure.

Personnel qualification
The personnel assigned to carry out the job of taking the transformer out of service must be trained in the following:

- Disconnection of electrical equipment.
- Securing to prevent incidental activation by unauthorized persons.
- Verification of disconnection from the power supply.
- Earthing and short-circuiting of electrical equipment.
- Covering or safeguarding of adjacent live components.
- Disconnection of electrical connections.
- Taking transformers out of service.

De-commissioning
The transformer must be taken out of service or must not be taken into operation whenever the following conditions apply:

- The transformer is visibly damaged.
- A safety device has tripped the transformer.
- The transformer has been stored for some time under unfavorable conditions, i.e. exposed to damp in combination with accumulation of dust.
- The transformer was subjected to severe mechanical strain during transportation, i.e. severe movements.

To take the transformer out of service, proceed as follows:
► Shut down the low-voltage.
► Shut down the high-voltage.
► Secure the transformer to prevent incidental activation by unauthorized persons.
► Allow the transformer to cool down.
⚠️ DANGER
Risk of fatal injury caused by a transformer that has not been disconnected from the power supply and is not earthed.
► Disconnect the transformer from the power supply.
► Secure the transformer to prevent incidental activation by unauthorized persons (lock-out/tag-out).
► Check that the transformer has been disconnected from the power supply.
► Earth the transformer.
► Short the transformer.
► Cover or safeguard adjacent live components.

► Earth the transformer terminals by using an insulating rod to ensure that it is disconnected and there is no remaining static charge.
► Earth and short-circuit the low-voltage and the high-voltage terminals.
► Disconnect the leads on the low-voltage side from the transformer.
► Disconnect the leads on the high-voltage side from the transformer.
► Disconnect the leads on any provided additional components from the transformer.
► Disconnect the earth terminal from the transformer.
Transformer maintenance

The transformer is a low-maintenance device. If the transformer is used in plants or on sites with high levels of dust, i.e. in steelworks and rolling mills, quarries or building sites, it requires regular cleaning. Otherwise, there is a risk of the insulation surfaces becoming extremely dirty and impairing effective cooling. This can reduce voltage clearances resulting in a danger of flashovers.

No longer than one month after the transformer has been placed into operation, the owner/user must carry out an assessment and implement suitable cleaning intervals.

To ensure the transformer provides trouble-free service, any fittings and accessories must be checked at regular intervals. Due to the uniqueness of each installation, the owner/user is responsible for specifying the intervals.

Quarterly checks are recommended on locations subjected to industrial fumes and dust or heavy vibrations (i.e. wind turbines).
► Check the temperature of the transformer using the relevant instrument at regular intervals.
► Check and document the ambient temperature at the installation location at regular intervals.
► If transformer is fitted with fans ensure they are in working order.
► Check any other fittings or accessories provided to make sure they are in working order.

Personnel qualification
The personnel assigned to carry out cleaning and checking duties must be trained in the following:

• Safety precautions in relation to the work to be carried out.
• Cleaning of transformers.
• Checking of transformers and any provided additional components.
• Documentation of work carried out.
Cleaning

⚠️ DANGER
Risk of fatal injury caused by a transformer that has not been de-energised and is not earthed.
► Disconnect the transformer from the power supply.
► Secure the transformer to prevent incidental activation by unauthorized persons (lock-out/tag-out).
► Check that the transformer has been disconnected from the power supply.
► Earth the transformer.
► Short the transformer.
► Cover or safeguard adjacent live components.

To prepare for cleaning, proceed as follows:
► De-energise the transformer.
► Cordon off the work area.
► Put up signs to provide warning of the work to be carried out.
► Earth the transformer terminals by using an insulating rod to ensure that it is disconnected and there is no remaining static charge.
► Permanently earth and short-circuit the low-voltage and the high-voltage terminals.

• Cleaning the transformer:
► Remove accumulations of dust with a vacuum cleaner.
► Clean hard to reach areas, such as the cooling ducts, using dry, oil-free compressed air (max. 3 bar).
► Remove any dislodged dirt using the vacuum cleaner again.
► Clean all electrically active surfaces, i.e. coil surfaces and the surfaces of insulators, with a clean, dry cloth.
► Thorough cleaning electrical terminals and area between tapping terminals.
► Remove coarse dirt with a cloth and methylated spirit.
► Any remaining dirt can be removed with the help of electric high-performance cleaners.
► Check that the transformer is completely dry before switching it on again.
• Cleaning the protective enclosure and fans.

If the transformer is provided with a protective enclosure or with fans, proceed as follows:
  ► Clean the fans with a vacuum cleaner.
  ► Check the fans to make sure they are in working order.
  ► Clean the protective enclosure in the same way as you would clean a control cabinet.
  ► Clean the air inlet and outlet openings with a vacuum cleaner.
  ► Check any air filters for dirt, if present.
  ► Replace dirty air filters with clean ones.

Checking the transformer

⚠️ DANGER
Risk of fatal injury caused by a transformer that has not been de-energised and is not earthed.
  ► Disconnect the transformer from the power supply.
  ► Secure the transformer to prevent incidental activation by unauthorized persons (lock-out/tag-out).
  ► Check that the transformer has been disconnected from the power supply.
  ► Earth the transformer.
  ► Short the transformer.
  ► Cover or safeguard adjacent live components.

Before starting to check the transformer, proceed as follows:
  ► De-energise the transformer.
  ► Cordon off the work area.
  ► Put up signs to provide warning of the work to be carried out.

• Visual examination:
  ► Check the following components for visible damage:
    • Coils.
    • All cables and lines.
    • Temperature monitoring device.
    • Any additional components if provided.

Should you discover any visible damage, proceed as follows:
  ► Document the damage.
  ► Report the damage to the person responsible.
• Mechanical check:
  Risk of high temperatures caused by inadequately secured connections.
  ► Tighten all screw connections with a torque wrench to the specified torque settings.
  ► Check the existing voltage distances.
  ► Ensure that the enclosure stainless steel bolts are always greased.

• Electrical check:
  ► Check the insulating resistances and the temperature monitoring device to make sure they are in working order.

ATTENTION!
Risk of damage to the transformer caused by incorrect insulating resistance.
  ► Check that the insulating resistance is at least 1000 Ohm per volt of operating voltage for HV case and 2 MegaOhm for LV case (less or equal to 1.1 kV).

To check the insulating resistance, proceed as follows:
  ► Use an insulation tester to check the electrically isolated windings against each other.
  ► Use an insulation tester to check each of the electrically isolated windings against earth.

To check the temperature monitoring device with Pt100 sensors, proceed as follows:
  ► Check that all of the connections are securely tightened.
  ► Tighten any loose connections.
  ► Measure the resistance at the ambient temperature and compare it with those given in ASTM E1137.
  ► Replace faulty components with ones if any non-conformities are found.

To check the temperature monitoring device with PTC thermistor sensors, proceed as follows:
  ► Check that all of the connections are securely tightened.
  ► Tighten any loose connections.
  ► Interrupt the sensor circuit.
The temperature monitoring device must indicate a malfunction.
► If a malfunction is not indicated, check whether the components and the connection of the temperature monitoring device are in working order.
► Replace any faulty component.
► Connect all the sensors again in accordance with regulations.

① If a different temperature monitoring device (i.e. a dial thermometer) is used, the instruction manual of that device is applicable.

► Document the work that has been carried out by recording it in writing in the forms provided.
Transformer disposal

If a transformer needs to be disposed due to faulty operation or changes on site requirements, please contact the manufacturer. The manufacturer can advise you of the components that must be removed from the transformer in accordance with environmental regulations so that those materials that can be recycled.

The transformer main components are as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast resin windings</td>
<td>Aluminium and/or copper, cast resin with</td>
</tr>
<tr>
<td></td>
<td>mineral filler or glass fiber</td>
</tr>
<tr>
<td>Impregnated winding</td>
<td>Aluminium and/or copper</td>
</tr>
<tr>
<td>Core sheet</td>
<td>Steel</td>
</tr>
<tr>
<td>Press beam, wheel support, screws, nuts</td>
<td>Steel</td>
</tr>
</tbody>
</table>
Accessories

Transformers can be ordered with a range of different accessories. Please refer to the relevant operating manuals for information about accessories.

If you wish to fit any accessories to your transformer retroactively, please contact the manufacturer.

Examples of available accessories:

• Devices for temperature monitoring.
• PTC or Pt100 temperature sensors.
• Dial thermometers.
• Fans.
• Skids.
• Earthing switches.
• Enclosures for different types of protection.
• Air-to-air or air-to-water cooling systems.
• Surge arresters.
• Cable plug-in bushings.
• On-load tap changer.
• Current or voltage transformers.
Technical data

Please refer to the rating plate and/or the documents included in delivery for the technical data for the transformer.

Additional information
We reserve the right to make technical changes or modify the contents of this document without prior notice. With regard to purchase orders, the agreed particulars shall prevail. Hitachi ABB Power Grids does not accept any responsibility whatsoever for potential errors or possible lack of information in this document.

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Approved by Opex & Quality Lean 6SS department, revised by Engineering department.