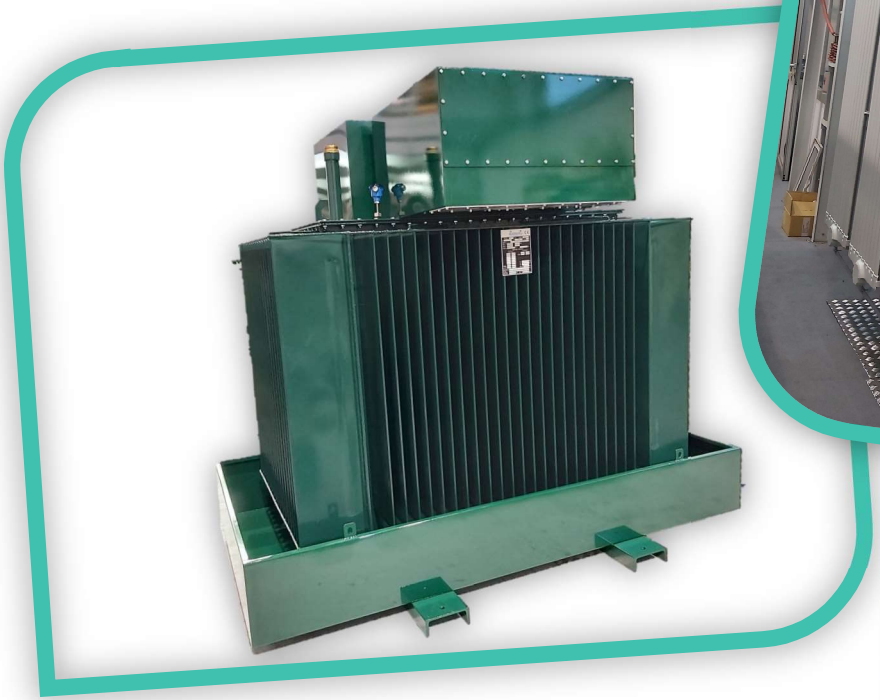
Three-phase HV/LV transformers

oil filled

Summary



ELETRAFO SRL

TRASFORMATORI ELETTRICI

Sistema di management certificato SQS ISO 9001 / ISO 14001

IQNET CERTIFIED MANAGEMENT SYSTEM

Installation, commissioning and maintenance manual

1. INTRODUCTION

The instructions in this manual apply to oil-immersed transformers of the following type :
- **Breather with conservator - Hermetically sealed,** with the following types:
• Maximum insulation class 36 kV
• Rated power from 25 to 8000 kVA

2. MAINTENANCE AND STORAGE

WARNING MAINTENANCE, INSTALLATION, AND CONNECTION OPERATIONS OF TRANSFORMERS MUST BE PERFORMED BY PERSONNEL QUALIFIED FOR SUCH OPERATIONS

2.01 Transport and reception

Transformers are shipped from the factory ready for installation. To reduce the risk of damage during transportation, transformers must be secured with cables using the special hooks provided on the machine. The cables must be positioned so as not to damage the radiators. However, it is mandatory for the customer to inspect the condition of the transformer upon arrival at its destination to verify that it has not suffered any damage
However, it is mandatory for the customer to check the condition of the transformer upon arrival at the destination to ensure that it has not sustained any damage.
If any anomalies are found, contact *ELETRAFO* immediately and place a RESERVE on the CMR.
If no reports of anomalies or defects are received within 3 days, it will be considered that the transformer was delivered in perfect condition.
Therefore, the manufacturer cannot be held responsible for anything that may happen to the transformer during operation or for any resulting consequences.

2.02 Lifting

The lifting must be carried out using all the Lifting lugs located on the transformer cover. The chains used must be long enough so that they do not form an angle greater than 60° (fig. 1). Small movements can be made with forklift by applying suitable support plates under the case.

Transport (fig. 2)

The transport of the transformer must be carried out on the frame. For this purpose, except for small powers or particular specifications, there are 30 mm diameter holes at the ends of the frame. The transport must be carried out only in two directions: along the axis of the frame and perpendicular to it

Maintenance with forklift(fig. 2)

The load-bearing area of the forks must be the frame, inside the U-shaped bars. The sliding rollers are removed to prevent the forks from getting stuck or damaged during transport.

2.03 Movement

To move the transformer, use the traction hooks on the wheels or push it by supporting it on the bottom of the case (avoid forcing it on the radiators or insulators).

2.04 Storage

If the transformer is not installed immediately, it can be stored in covered and dry rooms. The temperatures where the transformer is stored must be between -30°C and +40 °C

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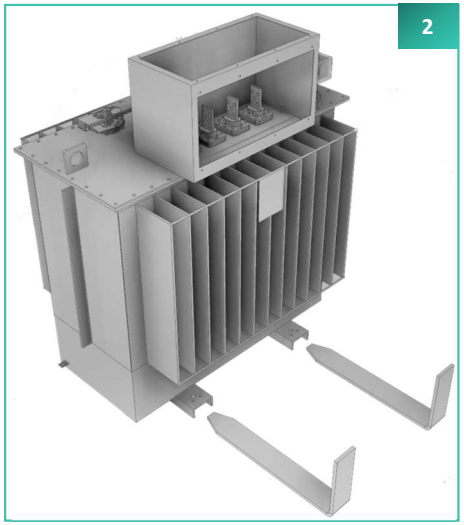


2.05 Long-term storage outside in wooden crates (for periods longer than 6 months)

Even though an oil transformer is protected by a wooden crate, for safe and effective outdoor storage over long periods before use, it is essential to adopt specific precautionary measures.Here are some key points to keep in mind:

Positioning and support:

Choose a flat and well-drained area: Avoid areas prone to flooding or stagnation of water, which could compromise the integrity of the enclosure and the transformer inside it.

Stable surface:

Place the wooden crate on a solid and flat base, preferably concrete or sturdy wooden planks. Distribute the weight evenly to prevent deformation or collapse.

Weather protection:

If possible, place the crate under a shelter to protect it from direct sunlight, heavy rain, snow, and strong winds. A waterproof tarpaulin can provide additional protection against the weather.

Accurate and meticulous control of packaging:

Carefully inspect the wooden crate for any damage, holes, or openings that could allow moisture, dust, or insects to enter inside, compromising the transformer

Keep the case dry:ù

Cover the top of the enclosure with a waterproof tarp or durable plastic sheet to prevent rainwater from getting inside and causing damage to the transformer.

Ensure adequate ventilation:

Make sure the case has enough air circulation to prevent condensation and mold from forming inside, which could deteriorate the transformer.

Regular monitoring:

Periodically check the case for signs of damage, deterioration, or water infiltration. Pay special attention to mold, mildew, or insects that could indicate the presence of moisture inside.

Pre-installation inspection:

Before installation, carefully inspect the transformer to ensure it has not sustained any damage during prolonged storage. Check the oil for leaks or contamination that could compromise its operation. Safe lifting and handling:Always use lifting methods appropriate for the size and weight of the transformer. Avoid lifting or moving the crate with ropes or chains wrapped around the wood, as this could cause structural damage.

By carefully following these guidelines and taking necessary precautions, it is possible to ensure that the oil transformer maintains its optimal condition during long-term outdoor storage and is ready for safe installation and flawless operation when needed.

Our packaging is made using fir wood.
The interior walls are covered with polyethylene tar paper.
The packaged material was wrapped in a moisture barrier bag.
A sheet of water-resistant polyethylene has been placed on top of the lid.
The packaging complies with the ISPM 15 FAO standard (HT treatment).

3. TRANSFORMER ACCESSORIES

3.01 Standard accessories

High and low voltage bushing(fig. 3) – They are normally located on the transformer cover. They allow connection to both copper and aluminum cables.

No load tap changer (fig. 4) – This switch allows you to adjust the primary voltage of the transformer in relation to the power grid. It should only be operated when the transformer is not connected to the power grid. The switch is numbered to indicate the position, has stops, and has a hole for a lock to prevent unauthorized operation.

Rating plate (fig. 5) – In accordance with CEI-IEC standards, electrical characteristics, weight and serial number are indicated..

Oil drain device(fig.6) of the transformer.

Earthing clamps (fig. 7) – They allow the transformer to be connected to the plant's ground network. The clamps are made of stainless steel.

Lifting lugs(fig. 8) of the transformer is only the part that can be lift

Carriage with wheels (fig. 9) that can slide and rotate in two perpendicular directions.

DGPT2 o DMCR3.0 (fig. 10) – It is mounted only on Hermetically sealed transformers and offers complete appliance protection.

3.02 Accessories on request

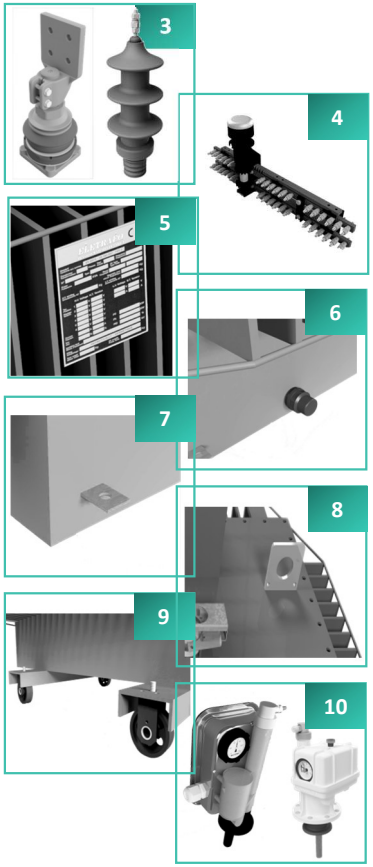
Relè Buchholz (fig. 11) – It is mounted only on the conservator version and serves to indicate any gas formation due to electrical discharges inside the transformer. It is supplied with NA – NA electrical contacts

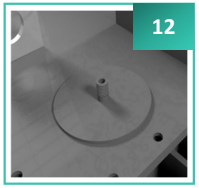
Thermometer pocket (fig. 12) – Allows mounting of a thermometer for measuring oil temperature in the highest part of the case

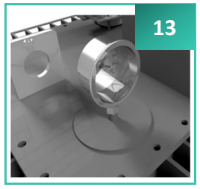
Dial thermometer (fig. 13) – Used to measure the oil temperature in the highest part of the case. It is supplied with NA – NA electrical contacts.

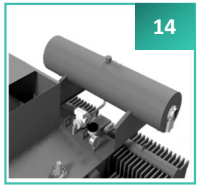
Conservator (fig. 14) – It allows to absorb the variations of the oil volume due to the operating conditions. The conservator is equipped with a level indicator, a filling and aeration device and a drain plug

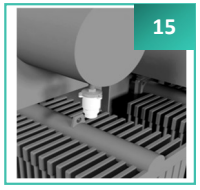
Silica gel (fig. 15) – It is mounted only on the conservator version and its function is to dry the moisture from the oil into the transformer. It is shipped not mounted on the device





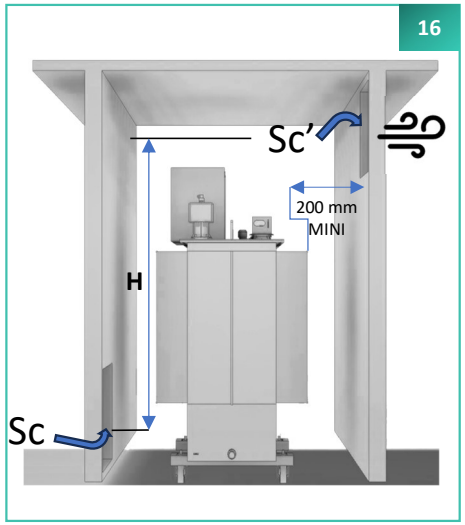






4. INSTALLATION

The transformer must be installed at an altitude of no more than 1000 meters, unless a specific request is made at the time of order, as the rarefaction of the air compromises the good cooling of the coils.
In standard construction, unless a specific request is made at the time of order, the transformers are dimensioned according to IEC EN60076 for an ambient temperature: -**Maximum: 40°C** -**Average daily: 30°C** -**Average annual: 20°C**
The ambient temperature inside the room, when the transformer is under voltage, must comply with these temperatures, with a minimum temperature of -25°C, unless a special request is made that requires a special calculation of the transformer.



4.01 Room size (Fig.16)

To ensure proper cooling of the transformer, it must be installed at a minimum distance of 200 mm from the walls, allowing for sufficient working space around it, and at least 1m away from other transformers. The room must have ventilation that provides an air exchange rate of at least 5-6 m^3/min for every kW of equipment loss. To calculate the area Sc (in m^2), use the following formula:

$$Sc = \frac{0{,}18p}{\sqrt{H}} \quad \text{et} \quad Sc' = 1{,}10 \times \text{Sc}$$

P = Sum of no-load losses and load losses of the transformer expressed in kW at 75°C, as well as losses emitted by any equipment present in the room.
Sc = Surface area of the fresh air inlet opening (minus any potential grille) expressed inm^2.
Sc' = Surface area of the air outlet opening (minus any potential grille) expressed inm^2.
H = Height between the two openings expressed in meters
This formula is valid for an average annual ambient temperature of 20°C and a maximum altitude of 1000 meters

4.02 Forced ventilation of the room

This is required in the case of a small or poorly ventilated room, or if the ambient temperature of the room is much higher than the external temperature, taking into account the temperatures that have been used to define the transformer. In the event of frequent overloads of the transformer, it can be used to evacuate the heat generated by the device, without, however, reducing the effects of such overloads on material degradation.

To avoid disrupting the natural circulation in the room, an air extractor to the outside will be installed in the upper part of the outlet opening; it can be controlled by a thermostat. Recommended flow rate (m^3/s) at 20°C = 0.20 P, where P = total power losses to be removed, in kW, emitted by all installed equipment.

4.03 Fixing the transformer

Secure the transformer equipped with wheels using chocks to prevent the wheels from slipping. If the transformer is fixed rigidly to the floor, use rubber anti-vibration mounts to absorb dynamic stresses.

4.04 Grounding

Securely connect the ground terminals to the ground network of the plant, in accordance with current regulations.

4.05 Network connections

To make connections to the High Voltage and Low Voltage cables, follow the phase indications marked on the bushings and ensure that the weight of the connection does not overload them.
N.B.: THE CONNECTION TO THE NETWORK MUST BE CARRIED OUT ONLY BY QUALIFIED PERSONNEL

4.06 Auxiliary connections

If the transformer is equipped with the DGPT2 - DMCR protection device, Buchholz relay, and/or thermometer, connect it to the terminals of the central unit, or in its absence, directly to the protection devices. To verify the effectiveness of the device, follow the instructions provided with the device

4.07

Installation of the silica gel

In case the silica gel has been shipped not mounted on the transformer, it is necessary to screw it instead of the female threaded cap located under the conservator.

4.08 Checks before commissioning

Pre-energization procedures.

N.B.: THE TRANSFORMER MUST BE ENERGIZED ONLY BY QUALIFIED PERSONNEL.

- No foreign objects on the equipment (filings, bolts, etc.)
- If the device is equipped with a DGPT2 or DMCR protection block, ensure that the large float is in the upper position and that the vent is tightly closed (close by turning clockwise).
  Open the small vent valve to purge any air that may be present until a few drops of oil come out.
  Proper maintenance of cables and conductors. No force on the transformer connection areas.
- Wiring for protection or ventilation aids
  - Insulation distances and cable maintenance,
  - Operation.
- Checking the tightening of connections
- Continuity of grounding. For maintenance personnel safety, the transformer's grounding must be connected.
- Ensure correct positioning of the switch handle to the selected position and its locking..
- Ventilation grilles not obstructed.
- In the case of parallel operation, check short-circuit voltage, phase concordance, and voltage ratio.

If all these checks are satisfactory, you can proceed to energize the transformer.

5. COMMISSIONING

5.01 Cleanliness

If the transformer has been stored for an extended period (more than six months) before being put into service, conduct a general cleaning of the equipment, particularly the insulators. Verify the dielectric strength of the oil inside the transformer by taking approximately half a liter of insulating oil through the drain valve and sending the sample to a specialized laboratory for testing.Check for any oil leaks.

5.02 Oil level

Any additions of oil must be carried out exclusively with oil having the same characteristics as the one used inside the transformer.

- **Hermetically sealed transformers**: In this type of machine, oil is not subject to evaporation, so usually no top-ups are required.
  These transformers are not equipped with an oil level indicator. The oil level can only be seen if the DGPT2 - DMCR device is installed.
  If oil top-up becomes necessary due to an anomaly, please refer to the transformer manufacturer's instructions.
- **Transformers with conservator** : The level indicator must display the ambient temperature. If it shows a lower value, it's necessary to add oil. To perform the top-up, the transformer needs to be at ambient temperature. Once confirmed, simply remove the top-up plug located on the conservator and pour oil up to the indicated level corresponding to the ambient temperature. If a Buchholz relay is installed on the machine, proceed with air discharge from it. Then, close the top-up plug
  Note: Due to the difficulty of finding suitable oil for top-ups on-site, and therefore the need to always ship it from Italy, *ELETRAFO* has decided to ship transformers with the minimum level set at 60°C. To adjust the oil level to the correct position, in case the reading is higher than the ambient temperature, proceed with discharging excess oil. The drainage procedure involves removing the drain valve plug located at the bottom of the enclosure and turning the handle until the oil flows out. Allow the oil to drain to the level corresponding to the ambient temperature.
  Once the desired level is reached, close the valve and reattach the closure plug using Teflon.
- **Transformers with radiators equipped with valves**: Check the opening of the upper and lower valves, drain each radiator via the vent valve at the top.

5.03 Connections

Check that connections to high and low voltage cables, ground connections and auxiliary connections are made correctly.

5.04 No load tap changer (fig. 17-18)

Verify that the No load tap changer is in the position corresponding to the voltage closest to that of the grid

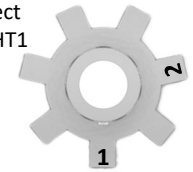
Adjustment socket 17

Adjust the No load tap changer switch to the desired position:

Pos. 1 : Higher primary voltage
Pos. 2 : Upper average primary voltage
Pos. 3 : Rated primary voltage
Pos. 4 : Lower average primary voltage
Pos. 5 : Lower primary voltage

Double primary voltage 18

For devices with two primary voltages, select the desired position HT1 or HT2:



Pos. 1 : HT1
Pos. 2 : HT2

5.05 DGPT2 – DMCR (fig.19)

This device is a comprehensive transformer protection and has several functions:

- The main role of DGPT2 - DCMR is to detect gas formation due to internal fault.
  The operation is divided into two phases:
- The red float appears in the case of a slight decrease in level.
- Electrical operation (disconnection) in the case of a significant level loss.

- DGPT2 - DMCR also detects a decrease in dielectric level through an independent float.
- DGPT2 - DMCR allows the visualization of oil temperature through a dial with a scale of 0/120°C, located on the front of the device.
  Additionally, two thermometers with switching contacts serve as alarm and disconnection functions.
  They can be adjusted from 30°C to 120°C.
  The maximum tripping temperature values, it is advisable to maintain 95°C for the alarm and 100°Cfor disconnection.
- DGPT2 - DMCR indicates excessive pressure that has occurred inside the transformer. The pressure switch responsible for this function is factory-set (0.3 bar can be adjusted up to 0.45 bar).
- DGPT2 - DMCR is equipped at the top with a test socket and a special plug with a valve through which oil top-ups can be performed.

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5.06 Relais Buchholz (fig.20) on request

To prevent unwarranted interventions, perform the following operations: - Drain the relay by operating the equipped valves.-Remove the wooden or plastic pin inside the push-button cap for mechanical testing.
If the relay indicates gas formation during the initial hours of operation, before considering an anomaly, repeat the drainage operation.

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5.07 Thermometer (fig.21) on request

Check that the programmed temperature threshold for intervention is suitable for the desired operating conditions. **The maximum set values should be 95°C for the alarm and 100°C for disconnection**.

5.08 Silicagel on request

Regarding the silica gel, ensure that the air passage holes are not obstructed and check that the crystals are orange in color. If they appear white, it indicates saturation with moisture. In such a case, remove the silica gel and regenerate the crystals in an oven at 150°C until they return to an orange color.

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5.09 Parallel operation

Ensure that the transformers have the following identical characteristics:

- Voltage ratio
- Short-circuit voltage
- Vector group.

Also, verify that the corresponding high and low voltage terminals of the transformer are connected to the same phase of the installation and that the switches are in the same position, corresponding to the same transformation ratio.

5.10 Insulation resistance control

- Before commissioning, it's necessary to perform an insulation test using a Megger to ensure that there are no winding points connected to ground.
- Insulation Check on HV side: Connect HV side to the Megger at 2500 V and LV side to ground.
- Insulation resistance value > 200 Mohm.
- Insulation Check on LV side:Connect LV side to the Megger at 1000 V and HV side to ground.
- Insulation resistance value > 200 kΩ.

5.11 Dielectric strength test of the oil.

Verify the dielectric strength of the transformer oil using a surge arrester, UNEL SAP 80, and the measured value must be above 40 kV.

5.12 Energization.

Following a comprehensive inspection of the installation, the HV (High Voltage) supply switch can be closed.
It is advisable to maintain the transformer at full rated voltage, but without a load (LV, or Low Voltage, switch open) for approximately 2 hours to facilitate the dissipation of any potential air bubbles within the protective devices.
After this duration and upon confirming the absence of air bubble indications in both the DGPT2 - DMCR and the Buchholz devices, load can be introduced by closing the LV switch.

6. VOLTAGE CHANGE

6.01 High voltage side

If the transformer is equipped with a no load tap changer, simply move the handle to the notch corresponding to the new voltage. **(WITHOUT VOLTAGE)**

6.02 Low voltage side

If the transformer has multiple voltages taps on the low-voltage side, modify the connections according to the diagram accompanying the transformer at the time of shipment

7. MAINTENANCE

The transformer is a machine that does not require specific care for monitoring and maintenance. However, to ensure smooth and safe operation, it is advisable to periodically perform a series of checks, the frequency of which will depend on the environmental and operating conditions.
In a clean and dry environment with regular operating conditions, monitoring can be limited, and checks can be conducted at larger intervals. In a dusty and humid environment or when significant temperature variations occur, checks must be more frequent, and continuous monitoring is recommended.
Below is a table with an example of a program under average operating conditions:

	Insulating liquid level*	Silicagel *	Cleaning of insulators	Checking DGPT2 - DMCR or Buchholz Relay	Location of surge arresters	Dielectric strength	Control of screw and accessory tightening	Filtration of the insulating liquid
Every week								
Every month								
Every three months	X	X	X					
Every year				X	X	X	X	
Every two years								
If the dielectric strength is low								X

*** Control required only for transformers with conservator**

7.01 Oil level (unit with conservator)

If the indicator shows a significant decrease in level, add oil as indicated in section 5.02. It is important to note that during the initial operating period, the oil volume may experience a slight reduction. If the indicator does not show oil replenishments, check that the float is not obstructed or punctured.

7.02 Silicagel (units with conservator)

Proceed as indicated in paragraph 5.05.

7.03 Verification di DGPT2 - DMCR

To check the effectiveness of the device, proceed according to the instructions attached to the device.

7.04 Verification of the Buchholz relay (unit with conservator)

To check the effectiveness of the device, proceed according to the instructions attached to the device.

7.05 Dielectric strength (unit with conservator)

Have the dielectric strength checked by an equipped laboratory.

7.06 Oil filtration (unit with conservator)

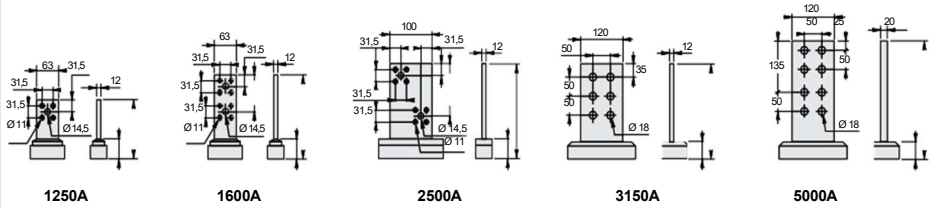
It is recommended to carry out oil treatment to eliminate any deposits, even if the dielectric strength is low.

8. MV AND LV CONNECTIONS

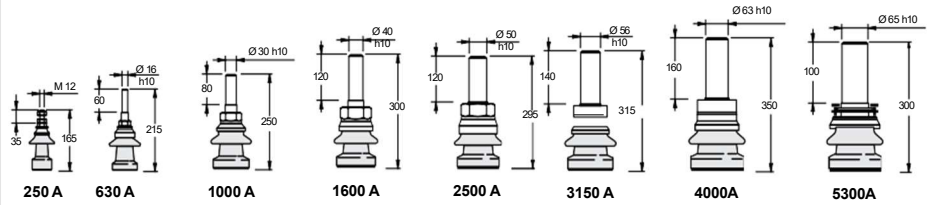
8.01 Type of bushing

Transformers can be equipped with the following connections:

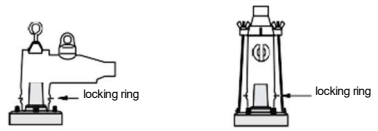
LV connections on busbar bushing (only for those above 250 kVA)



LV connections on Porcelain bushing



HV connections
On plug grafts



Terminated vertical

With Termination square

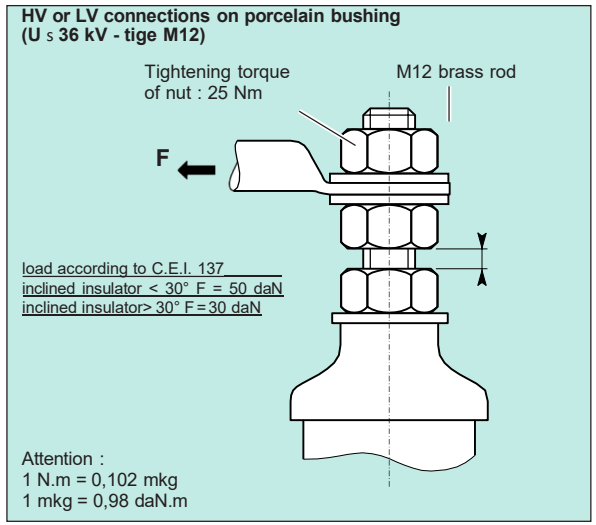
HV connections on porcelain bushing

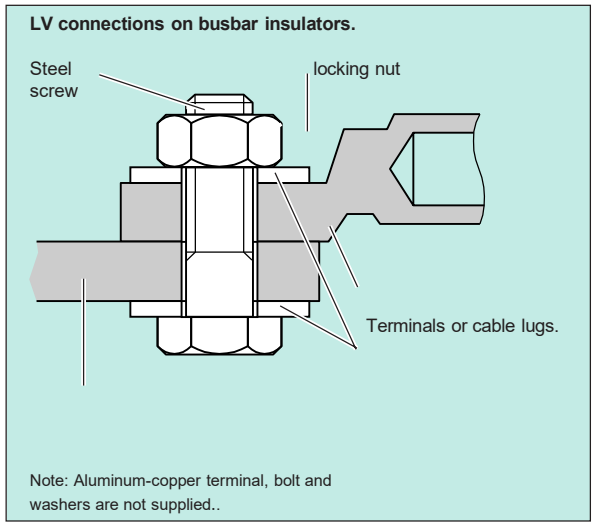
kVA	100	160	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150
HV Busbar bushing	—	—	1250A	1250A	1250A	1250A	1250A	1250A	1600A	2500A	2500A	3150A	4000A	5000A
LV Porcelain bushing	250A	250A	630A	630A	630A	1250A	1250A	1250A	2000A	2000A	3150A	3150A	4000A	5000A

8.02 Assembly and tightening torque.

It is necessary to ensure that the penetrations are not subjected to forces due to cable or busbar connections; these efforts can lead to leaks in various seals

The following assemblies and tightening torques will be respected:





8.03 Table of screw tightening torques

Screws	Steel class 6.8	Inox class A2-70 e A4-70	Inox class A2-80 e A4-80	Brass
M8	15,2	15,5	17,7	7,6
M10	30	30	35	15,1
M12	52	53	60	25
M14	83	85	97	41
M16	130	133	152	55

Tightening torque in N.m.
Tightening tolerance± 20%.
These values refer to assemblies made with flat washers; furthermore, the use of contact washers on the plates is recommended: these torques must then be increased by 35%. The steel and stainless steel screws are mounted lubricated.

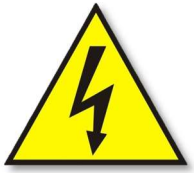
8.04 Bushing crossbar

Screws	Tightening torque(Nm)	Bushing
M12	20	250A
M20	25	630A
M30	30	1000A
M42	55	2000A
M48	60	3150A
M55	75	4500A

SURGE PROTECTORS

It is important to take appropriate measures to protect each transformer from surges, which can be caused by the power grid, switching operations, or direct or indirect lightning strikes.

The correct sizing of surge protections must be based on the reference value of the impulse withstand voltage, specified in the transformer's insulation class, which is indicated both in the test certificate and on the nameplate.



NOTE (IEC 60076-11:2008 Annex A par. A.2.4):

Fast voltage transients can occur when the tap changer interrupts the magnetizing current before it reaches zero.
These transients are often repeated several times with increasing peak values during the operation of the tap changer.

NOTE (IEC 60076-1:2011 par. 1.3):

The switching of transformers with light loads or low power factor (inductive loads) using vacuum circuit breakers and SF_6 can expose the transformer to potentially harmful voltage transients with frequencies up to MHz and voltages exceeding the transformer's impulse withstand voltage.

IMPROPER USE

They are considered, among other things, improper uses:

- Movements different from those specified
- Changes to the components of the transformer and/or its accessories.
- Application of adhesive labels on the wraps not provided by the manufacturer.
- Connections not provided by the manufacturer
- Tightening the bolts with torque values significantly different from those shown on page 11-12.
- Installation in unsuitable environments or with insufficient air exchange for cooling.

END OF LIFE TRANSFORMER

The "end of life" of an oil-filled transformer refers to the point when the transformer is no longer capable of operating efficiently and safely. This can be due to various factors, including the deterioration of insulating materials, mechanical wear, electrical failures, or oil contamination.

Some common indicators that an oil-filled transformer may be reaching the end of its useful life include:

1. **Insulation Degradation**: Internal insulation can degrade over time due to heat, moisture, and contaminants. Insulating paper and oil can lose their insulating properties, increasing the risk of electrical failures.
2. **Oil Leaks**: Oil leaks can indicate problems with seals and gaskets, leading to a reduction in insulating and cooling properties.
3. **Temperature Increase**: A consistent increase in the operating temperature of the transformer may indicate an overload, cooling issues, or insulation degradation.
4. **Oil Analysis Data**: Oil analysis can reveal the presence of dissolved gases, acids, moisture, and other contaminants that form due to overheating or electrical discharges.
5. **Unusual Noise**: Unusual noises like buzzing or clicking can be signs of mechanical or electrical problems inside the transformer.
6. **Insulation Resistance**: Testing insulation resistance can provide indications of the internal insulation condition. Low resistance can indicate significant degradation.
7. **Maintenance and Failure History**: The frequency and severity of necessary repairs can provide clues about the overall condition of the transformer.
8. **Transformer Age**: Although age is not the only factor, older transformers are more susceptible to degradation and may require more frequent assessment.

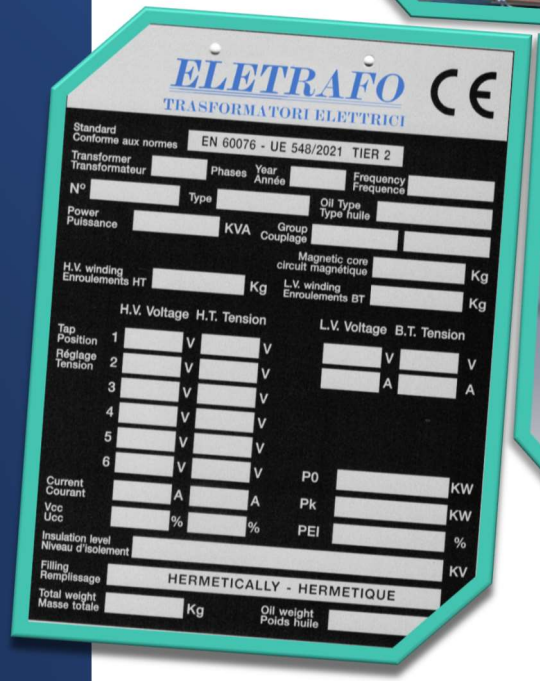
When one or more of these indicators suggest that a transformer is reaching the end of its useful life, it is important to plan for a replacement or major maintenance to prevent sudden and potentially costly or dangerous failures

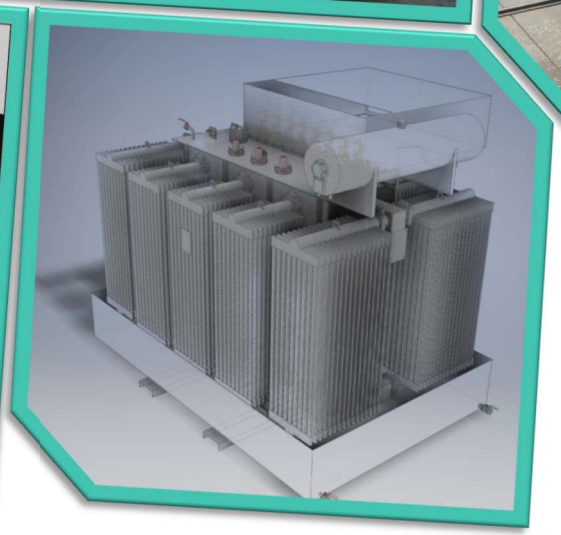
How to behave when a transformer reaches its end of life.

When an oil transformer reaches the end of its life, it is essential to act promptly to ensure safety and continuity of service.
Here is a series of recommended steps to follow:

1. **Evaluation of the transformer's condition**
   - **Visual Inspection:** Check the physical integrity of the transformer, including signs of oil leaks, corrosion, external damage, etc.
   - **Diagnostic Tests:** Perform detailed tests such as Dissolved Gas Analysis (DGA), insulation resistance measurements, oil analysis for contaminants, and load tests.
2. **Consultation with experts**
   - **Experts and Technicians:** Consult qualified experts and technicians for a comprehensive and accurate assessment of the transformer's condition.
   - **Maintenance Service Providers:** Collaborate with companies specialized in maintenance and replacement of transformers.
3. **Replacement or repair planning**
   - **Replacement:** If the transformer is irreparably damaged or no longer reliable, plan for replacement with a new transformer. Consider current and future loads, energy efficiency, and necessary technical specifications.
   - **Repair:** If possible, evaluate the option of repairing the transformer, which may include oil regeneration, seal replacement, or other specific repairs.
4. **Management of oil and contaminated materials**
   - **Oil Disposal:** Used oil must be disposed of correctly following local and international regulations on hazardous waste.
   - **Recycling:** When possible, recycle the oil and components in an environmentally responsible manner.
   - **Cleaning and Decontamination:** Ensure that the area around the transformer is clean and that any leaks have been properly managed to prevent contamination.

The disposal of end-of-life oil transformers must be carried out by specialized companies with ministerial authorization for disposal, or contact *ELETRAFO* for information on this matter, even for transformers not manufactured by us.





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