Instruction manual for packaging, transport, handling, installation, storage and maintenance of three-phase power transformers immersed in insulating liquid > 500 kVA

Content

1. Safety and risks

Please read this instruction manual carefully before servicing the product, disregarding the instructions may result in property damage, serious injury, or death.

The product covered in this manual must be operated only by qualified personnel.

This manual contains important information for the safety of personnel and the product.

If any problem not covered in this manual occurs, contact MAGNETRON SAS

When working with transformers, operators are exposed to a series of risks and dangers, it is very important to know them in order to eliminate or minimize situations or conditions that may cause damage.

1.1 Personal security

- Stop any activity if working conditions are unsafe.
- All team members must know the instructions in this manual, the safety practices established in the workplace and the applicable legislation.
- Use clothing and personal protection elements according to the work to be carried out.

  - ✓ Long-sleeved cotton shirt.
  - ✓ Dielectric safety boots.
  - ✓ Bait or dielectric gloves.
  - ✓ Latex gloves (taking samples of the insulating liquid).
  - ✓ Latex gloves (handling tools).
  - ✓ Safety glasses.
  - ✓ Dark glasses for sun protection (field activities).
  - ✓ Helmet.
  - ✓ Avoid wearing loose clothing.
  - ✓ Do not wear rings, watches, chains, earrings or any personal item that could cause harm.
  - ✓ Do not wear tennis shoes, shorts, short-sleeved shirts, and headphones.

1.2 Types of risks

➢ Physical risks

It refers to all environmental factors that depend on the physical properties of the bodies and that act on the tissues and organs of the worker's body, can produce

harmful effects according to their intensity and exposure time.

They are related to the imminent probability of suffering bodily harm with or without direct contact, they can be classified as labor or environmental.

They are the most common and dangerous conditions at work:

- ✓ Noises,
- ✓ Lightning,
- ✓ Temperature,
- ✓ Humidity,
- ✓ Radiations,
- ✓ Vibrations,
- ✓ Electricity.

Listed below are some activities that must be carried out:

- Install localized lighting in those jobs that require it, when general lighting is moderate and may be insufficient.
- Avoid dead flow areas (where air does not circulate).
- Use work equipment that generates low noise levels.
- Locate noisy equipment or sources out of the way, if possible.
- Reduce the exposure time.
- Establish a shift site rotation system.
- Use screens or protective shielding, for radioactive sources.
- Apply the 5 golden rules when working with energy.

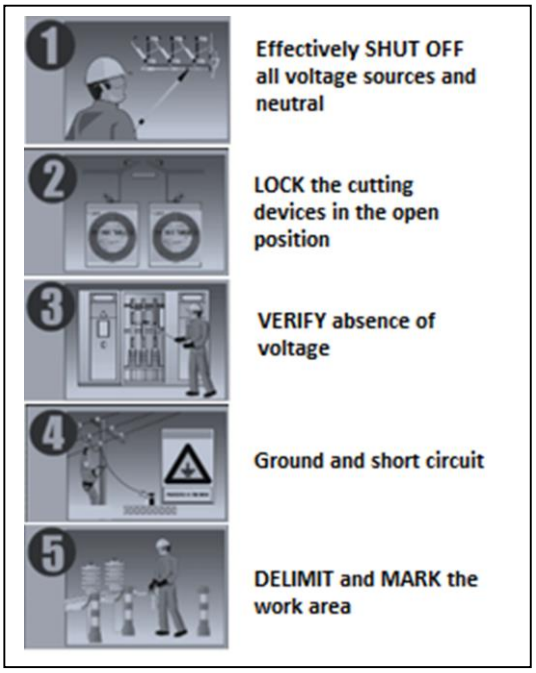


Figure 1: 5 golden rules

➢ Mechanical risks

They are associated with the set of physical factors that can give rise to an injury due to the mechanical action of machine elements, tools, work pieces or projected, solid or fluid materials.

The mechanical risk can occur in any operation that involves manipulation of hand tools, machinery, handling of vehicles, use of lifting devices.

- ✓ collision with moving or stationary objects,
- ✓ Hits,

- ✓ Cuts,
- ✓ Entrapments due to overturning of machines or vehicles,
- ✓ Entrapments by or between objects,
- ✓ Projection of fragments or particles,
- ✓ Falling objects being handled.

Listed below are some activities that must be carried out:

- Train workers in preventive matters, both in theoretically and practically related to the work equipment necessary for their job.

- Guarantee the conditions and correct way of using machinery, based on the manufacturer's instructions.

- Promote the consultation and participation of workers in aspects related to mechanical risks.

- Guarantee periodic monitoring of the health status of workers.

- In the event of accidents or occupational diseases due to mechanical risks, the necessary corrective measures must be investigated and applied so that it does not happen again.

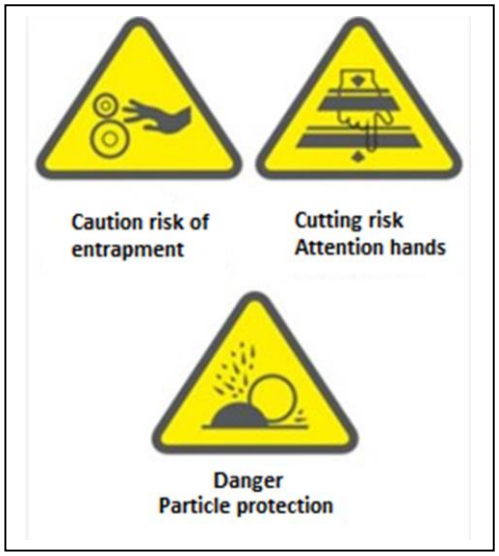


Figure 2: Signs of mechanical risk

2. Introduction

Read carefully and comply with the indications given in this manual before any intervention on the product, failure to comply with them invalidates the guarantee

The IEEE C57.12.80 standard defines a transformer as a static electrical device consisting of one winding, or two or more coupled windings, with or without a magnetic core, to introduce mutual coupling between electrical circuits. Transformers are widely used in electric power systems to transfer energy by electromagnetic induction between circuits at the same frequency, usually with modified voltage and current values.

Likewise, it defines the power transformer as a transformer that transfers electrical energy in any part of the circuit between the generation source and the primary distribution circuits.

At present, the use of the transformer plays a very important role in the electrical supply. A failure in its operation can generate enormous inconveniences for companies, the industry or the population, since everyone uses the electrical service equally in their daily activities.

The small and medium power transformers manufactured by MAGNETRON SAS are mainly used in substations, industrial service loads, shopping centers, educational institutions, residential units and substations of electric companies.

The useful life of the transformer depends, among other reasons, on the following:

- Manufacturing design,
- The voltage and insulation levels,
- The connected load,
- Heating regime (core and windings),
- The protections used,
- The level of the insulating liquid,
- The maintenance received.

Transformers are normally made up of an active part with a core (magnetic circuit), a coil (electric circuit), flange and the tank, which are defined depending of the type of transformer and gives particular characteristics to the equipment.

The information, recommendations, descriptions and safety notes compiled in this document are based on guides, standards and the experience of MAGNETRON SAS

This information does not include or cover all contingencies, therefore, if you require more information, contact MAGNETRON SAS

3. Definitions

3.1 Transformer

Electrical device without moving parts that transforms electrical energy into its two main factors: Voltage and Current.

3.2 Power transformer

Device that transfers electrical energy in any part of the circuit between the generation source and the primary distribution circuits

3.3 Primary winding

Winding that is connected to a power source.

3.4 Secondary winding

Winding to which a load is connected.

3.5 Medium voltage winding

Winding with the highest voltage.

3.6 Low voltage winding

Winding with the lowest voltage.

3.7 Packaging

Cover normally made of wood in which transformers are packed during storage and transport.

3.8 Packing basis

Flat and strong structure manufactured usually in wood that serves to protect and support the weight of the transformer.

3.9 Iso-tank

Container for the bulk storage and transport of hazardous and non-hazardous fluids, gases and dusts.

3.10 Bushing

Device that allows one or several drivers to pass through an obstacle, for example, a wall or a tank, insulating the conductors of it.

3.11 Flanche

Cover made of resistant material and easy to install.

3.12 Purge

Process to remove the air contained inside an element.

3.13 Danger

Inherent situation with the capacity to cause injury or damage to people's health.

3.14 Risk

Combination of the probability that a dangerous event will occur with the seriousness of the injuries or damage to health that such an event can cause.

4. Abbreviations

A	Amps
DGA	Dissolved gas analysis (DGA)
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
MV	Medium voltage
LV	Low voltage
DPS	Device for surges (lightning rod), source arresters
IEEE	Institute of electrical and electronic engineers
kg	Kilogram
kV	Kilovolt
kVA	kilo volt amps
lbf.ft	pound-force foot
m	Meter
max	Maximum
min	Minimum
mΩ	milliohms
MΩ	megohms
ms	milliseconds
NTC	Colombian technical standard
PCB's	PCBs
Pn	Neutral point
PSI	Pounds per square inch
PTS	Grounding system
Grd	Grounding
TTR	Transformer turns ratio
VSP	Overpressure valve

5. Handling

Caution: The transformer must be handled in a vertical position.

Keep the product on the base (wood or metal) on which it is dispatched to the place where it will be installed, since it provides greater protection.

Also, it can be kept on the casters or in the crate (if it has one).

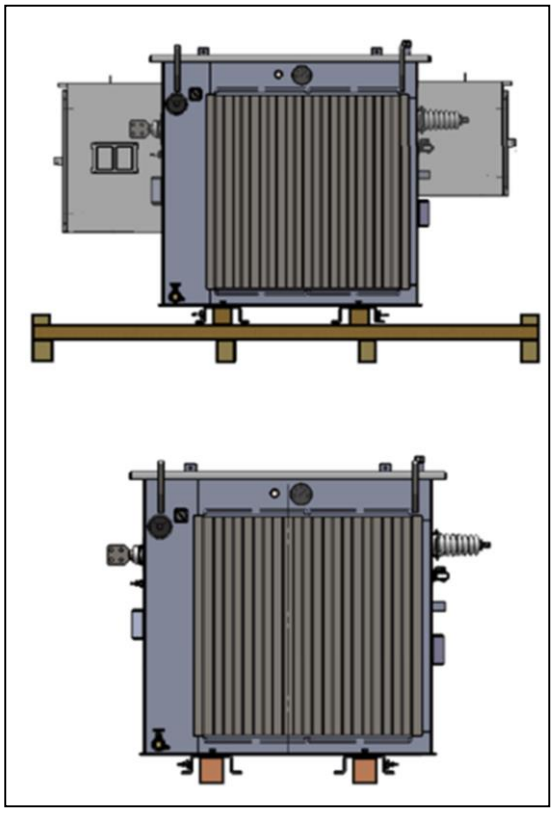


Figure 3: Transformers on wooden bases

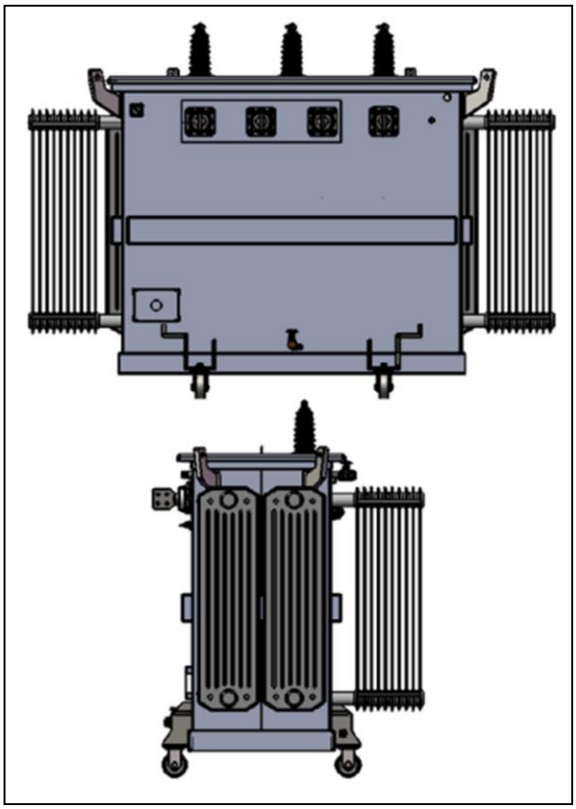


Figure 4: Transformer on the casters

Do not for any reason allow the product If it is dragged directly on the floor, the tank or cabinet may be deformed or the paint may deteriorate, resulting in the oxidation of the sheet metal.

The product must only be lifted using the lifting lugs. To transport it, use forklift or crane.

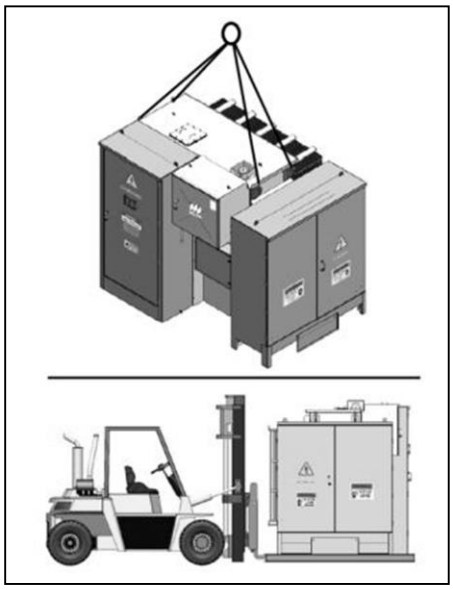


Figure 5: Handling transformers

Do not lift or move the transformer by placing crowbars or jacks under accessories, radiators or other devices, these elements are not designed to be subjected to this type of stress and may introduce ruptures or deformations causing leaks of the insulating liquid.

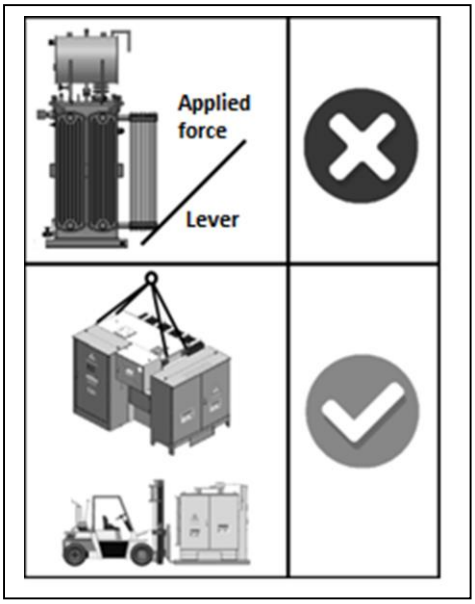


Figure 6: Transformer handling

If it is not possible to use a crane, differential, forklift or stowage carrier, you can slide the transformer on rollers or skids. For this purpose, use the base of the transformer since it is designed to slide it in both directions, parallel to its axes.

Use rollers or skids according to the weight of the transformer and in sufficient quantity to distribute its weight.

Don't let it tip over (it may tip over); besides, be careful not to damage the base and put pressure on the cabinet.

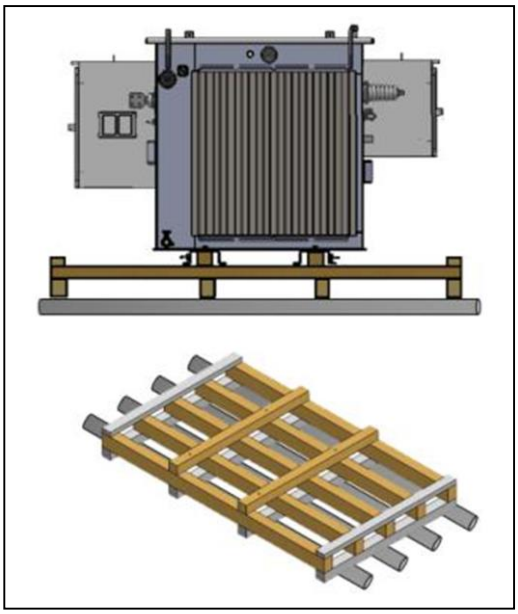


Figure 7: Use of rollers or skids for transportation

The transformers are provided with hoisting devices or lifting lugs that are used to handle it with a crane, fiber sling should be used to protect the paint

If you use strings or metal slings, be sure to cover the parts in contact to avoid paint detachment.

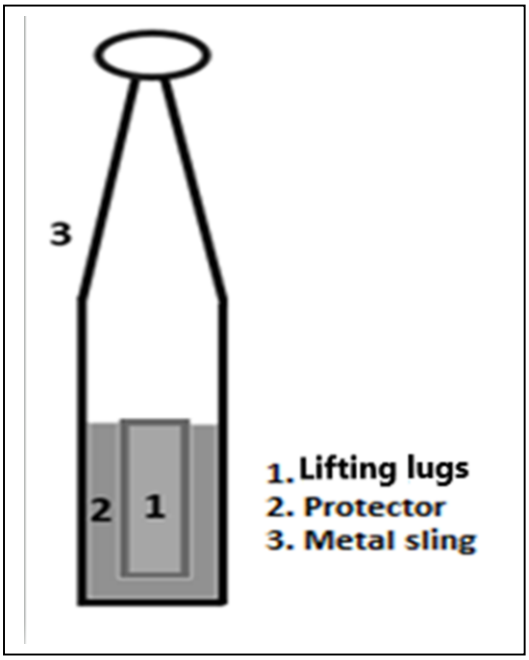


Figure 8: Paint protection on the lifting lugs

Do not use the lift lugs to carry the product, these devices are only designed to lift

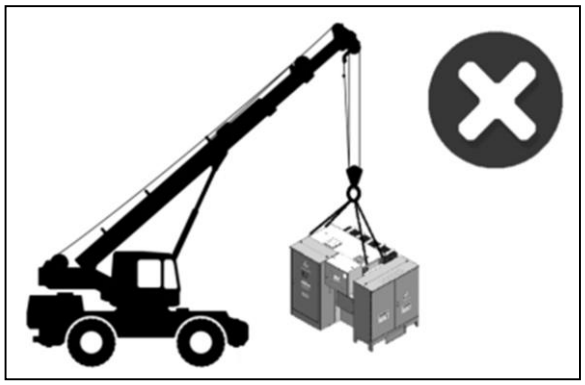
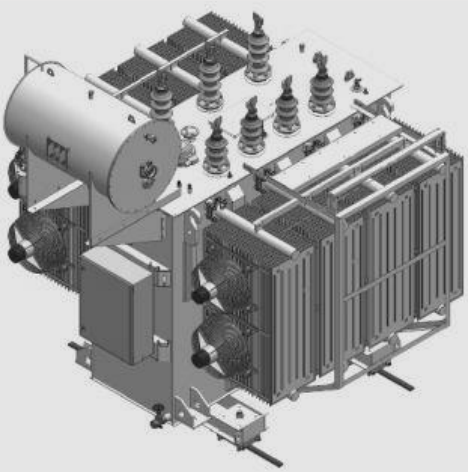


Figure 9: Prohibited from transporting the transformer from the lifting lugs

Caution: For no reason stand or lean on the transformer: cabinets, LV terminals, MV insulators, drain and recirculation valves or any control or protection element, these elements are very fragile and can be easily damaged.



6. Packaging

The transformer packaging must allow handling in such a way that, when any movement is required for its storage or transport, it can be easily lifted by the base of the packaging.

The base of the packaging must have a minimum height of 10 cm to allow the entry of a forklift or a pallet rack.

The wooden bases are designed to be manipulated from the front, the back or the sides.

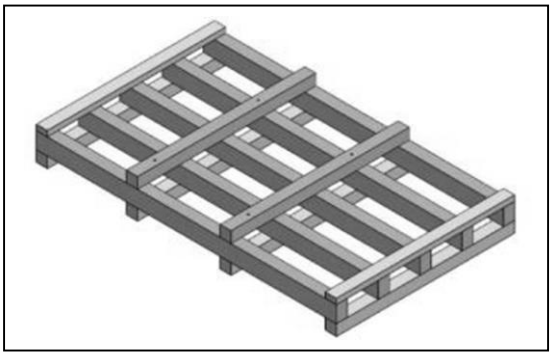


Figure 10: Wooden base for power transformers

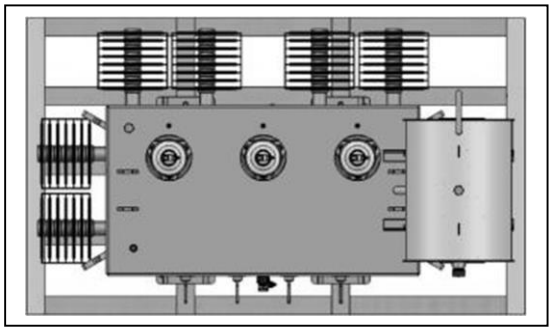


Figure 11: Wood Base Transformer – Top View

The metal bases are designed in two models:

- For handling from the front or rear, when the base does not exceed 2200 mm in length.
- Other for handling from the sides, when the base exceeds 2200 mm in length.

Note: The metallic bases are used in transformers with weight ≥ 4000 kg.

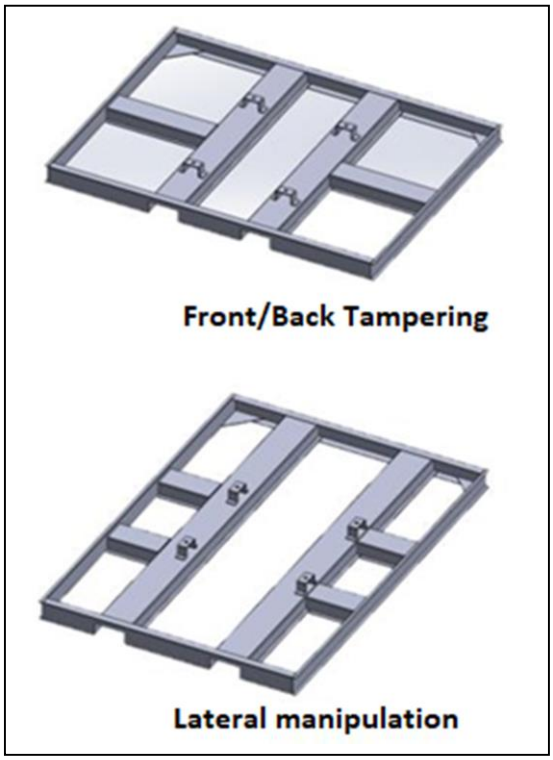


Figure 12: Metal base for power transformers

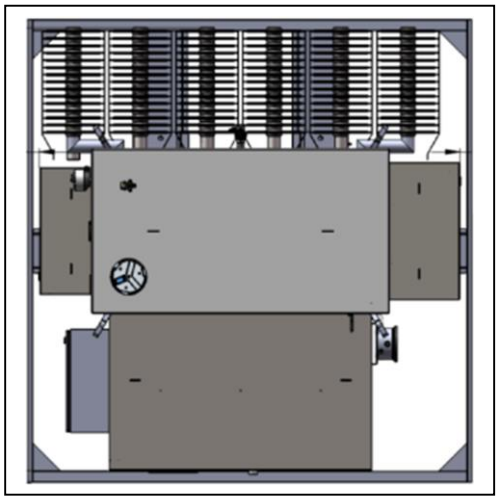


Figure 13: Metal Base Transformer – Top View

For transformers that must be lifted or transported by crane and that are boxed, it must be ensured that the lifting lugs are free and easily accessible for the location of the slings or slings.

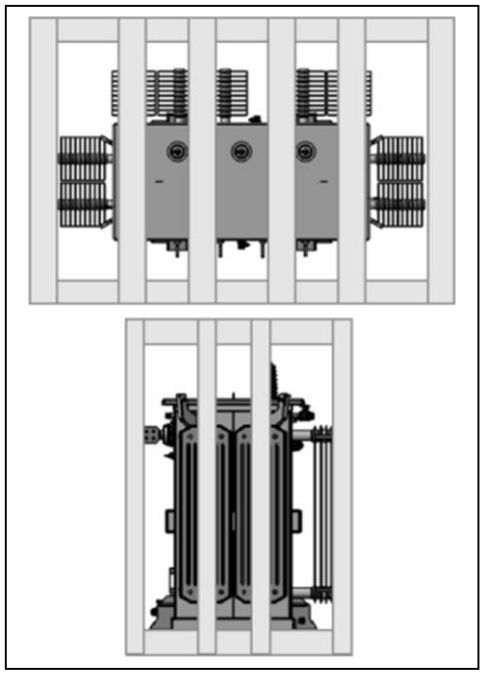


Figure 14: Lifting lugs for easy access when the transformer is crated

The transformer must be attached to the base of the packaging to prevent it from suffering deterioration caused by sudden movements. In power transformers, the coupling is done through of screws.

Figure 15: Anchoring the transformer to the base with screws

When the transformer is shipped crated, the nameplate must remain visible to validate the characteristics of the transformer.

If the transformer consists of one or more cabinets and the nameplate is inside one of them, for identification, locate the serial number attached to the cabinet cover in the upper right part of the front, you can also check the kVA (if applicable) on the same front.

The location of the sticker with the serial number may vary depending on the configuration of the transformer.

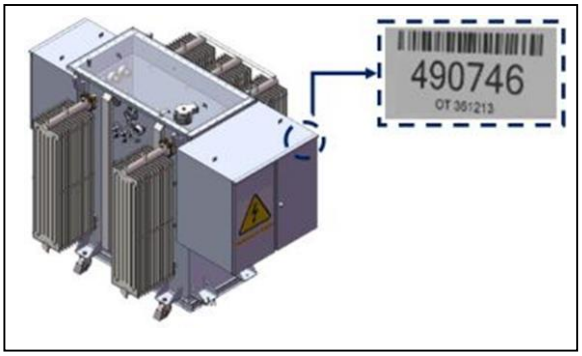
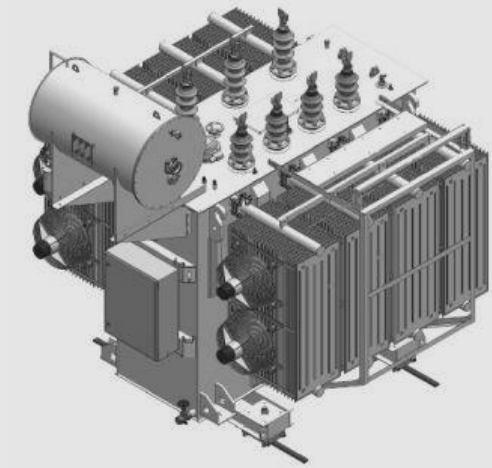


Figure 16: Serial Number Sticker

Caution: For no reason stand or lean on the transformer cabinets, LV terminals, MV insulators, drain and recirculation valves or any control or protection element, these elements are very fragile and can be easily damaged.



7. Transport

Power transformers come in a wide variety of sizes, weights, and configurations; therefore, it is very important to pay attention to the established requirements when scheduling your transportation.

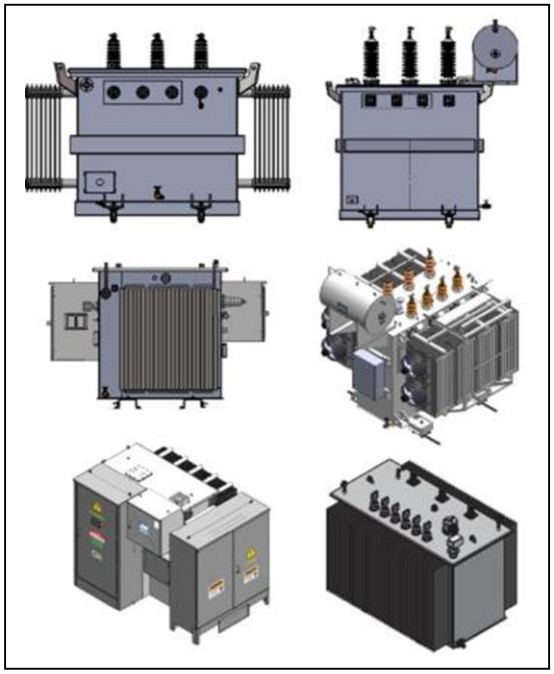


Figure 17: Types of power transformers

The following should be taken into account:

- The commercial conditions,
- road conditions,
- The final place of delivery,
- The height of the load,
- The weight of the load,
- The final dimensions.

Power transformers can be transported in two ways:

- Fully assembled.
- By parts, this procedure is used to reduce weight or dimensions to the load when they exceed the capacity of the means of transport or the restrictions of the routes.

Take into account the weight of the transformer to determine the appropriate lifting and/or transport elements, this information appears on the nameplate, in the test certificate or in the documents required for its transport.

Lift the transformer using the lifting lugs or the base of the packaging.

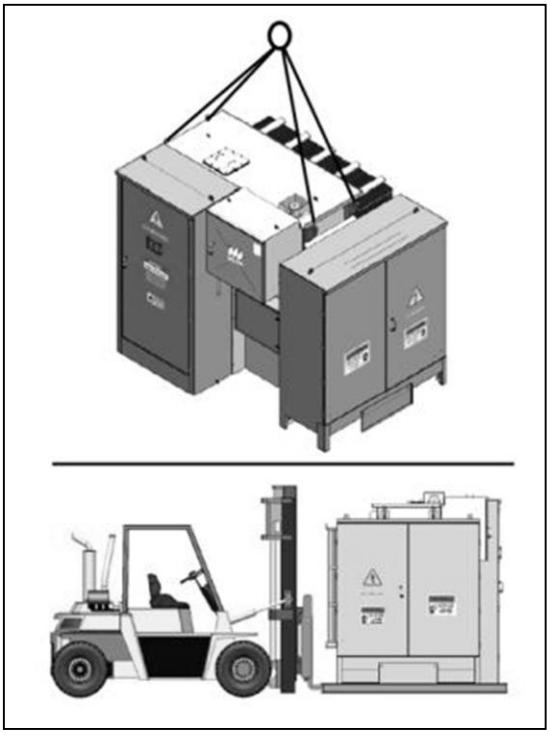


Figure 18: Parts to lift the transformer.

When lifting the transformer from the lifting lugs, check that the slings do not come into contact with any component of the equipment such as insulators, cabinets, accessories, etc.

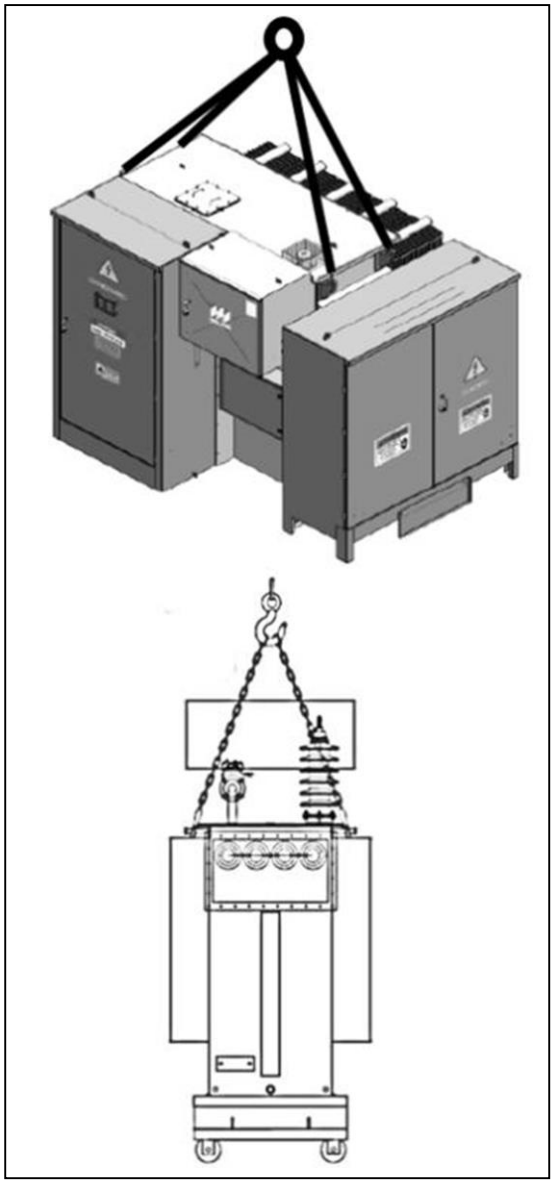


Figure 19: Elevation of the transformer from the lifting lugs

7.1 Fully Assembled Loaded Transformers

7.1.1 Transformers with and without crate

Due to their size and weight, these transformers can only be transported on a single level (they cannot be stacked), therefore, the load must be located centered on the platform of the means of transport (truck, open truck, container, etc.).

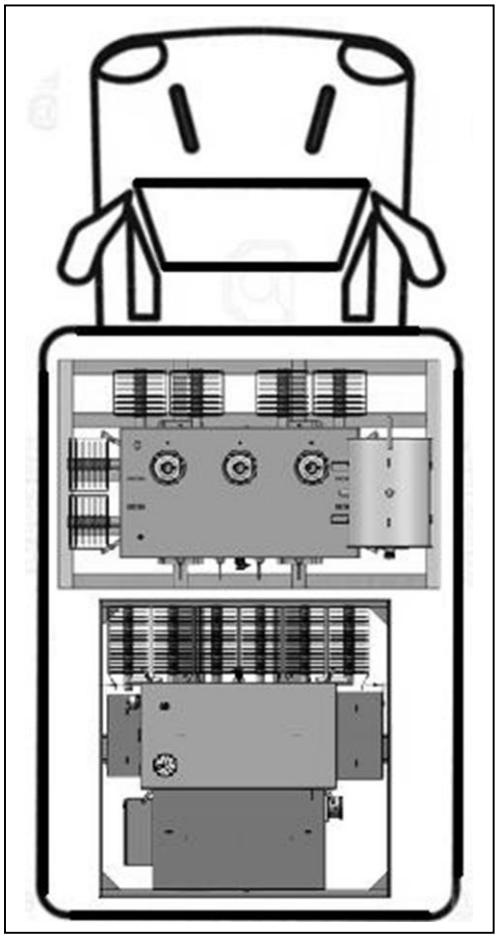


Figure 20: Loading and distribution of transformers without crate.

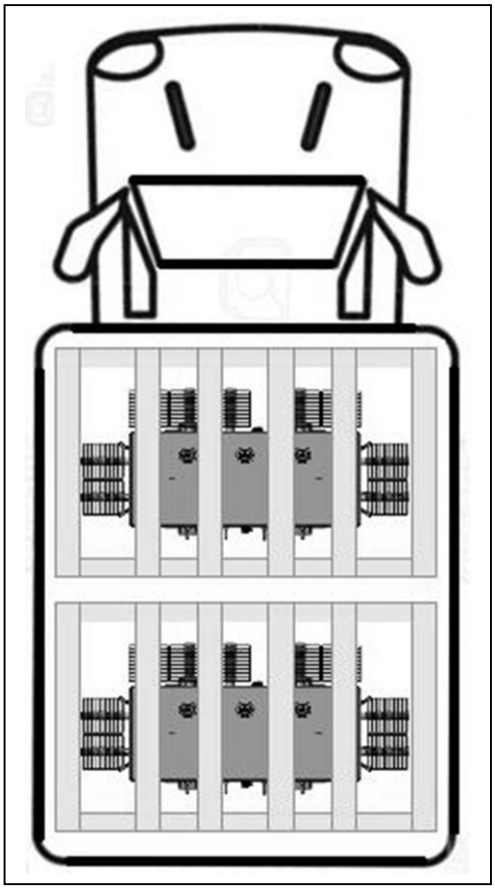


Figure 21: Loading and distribution of boxed transformers

Once the transformers are located and aligned, secure each one to the walls or vehicle body noting the following:

- Use the four (4) lifting lugs to secure the transformer to the vehicle.
- Use metal slings or straps for small power transformers (in size and weight).
- In large and heavy transformers, use properly tensioned steel cables or chains, for no reason use handles or any other material that allows elongation.

Figure 22: Some ways to secure cargo

7.1.2 Special considerations

- If the product has radiators, load them interspersed in the truck or container, this ensures the good balancing of the load.

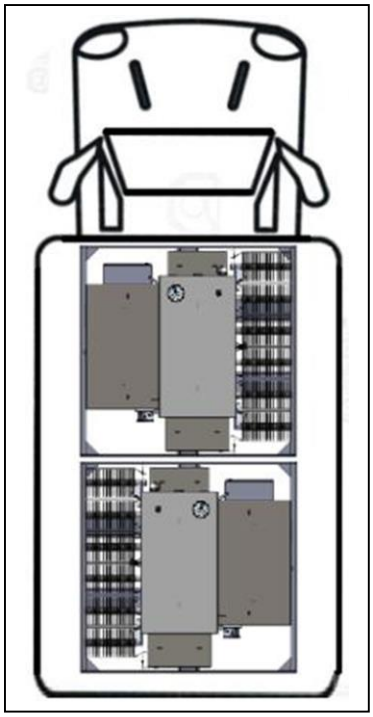


Figure 23: Intercalated radiators to balance the load

- If only one transformer is loaded, the part with the radiators should be next to the cabin.

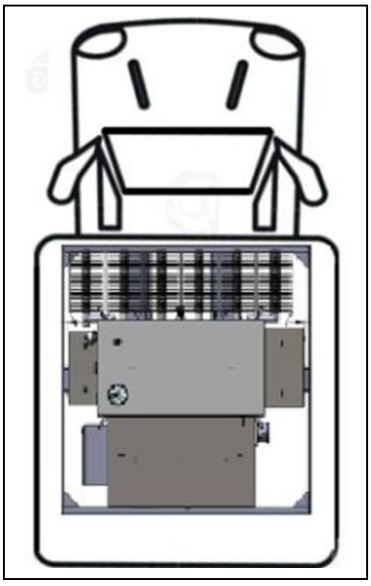


Figure 24: Radiator next to cab

- If it has a conservative (expansion) tank, it must be next to the cabin.

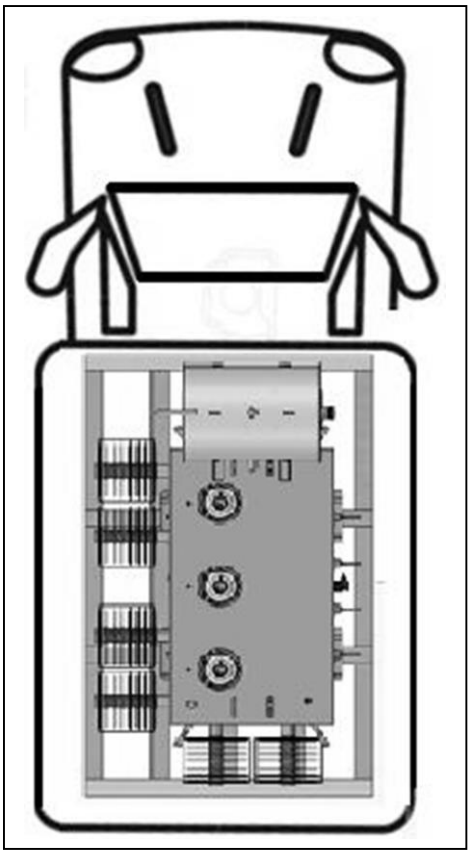


Figure 25: Conservative (expansion) tank next to the cabin

- When the base of the transformer and the vehicle floor are metallic, wooden boards must be located between them to prevent displacement.

  In addition, the base of the transformer must also be tied to the truck body.

Figure 26: Wooden boards between the metal base of the transformer and the metal floor of the truck

- In small power transformers, the base of the transformers acts as a separator, when there are spaces between them, wooden wedges must be fixed between them and the floor.

  The function of the wooden wedges is to prevent displacement of the transformers when the transport is in motion.

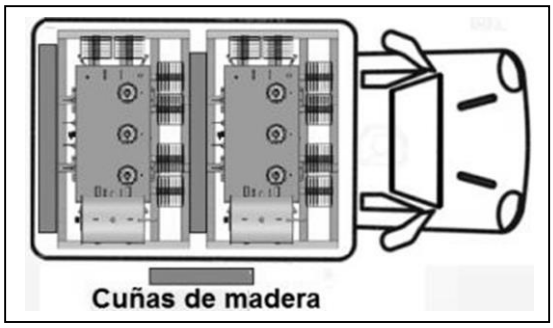


Figure 27: Use wooden wedges

- In open-top vehicles, the load can protrude up to 15 cm on each side.

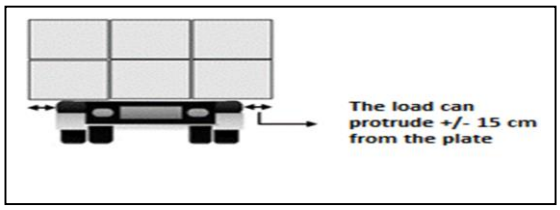


Figure 28: Load tolerance on the platform

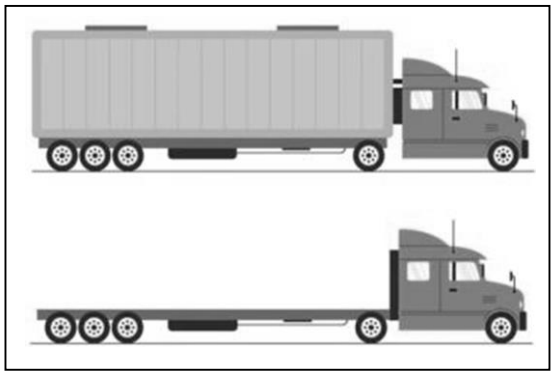


Figure 29: Normal and convertible truck

Caution: In Colombia, the total height of the load measured from the floor cannot exceed 4.3 m.

The total weight of the load cannot exceed the capacity of the truck.

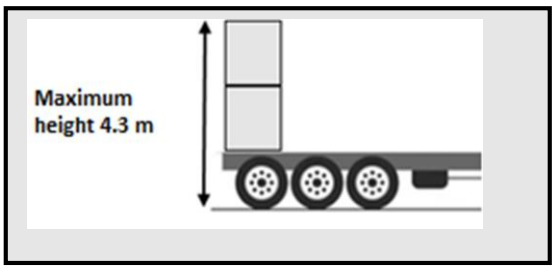
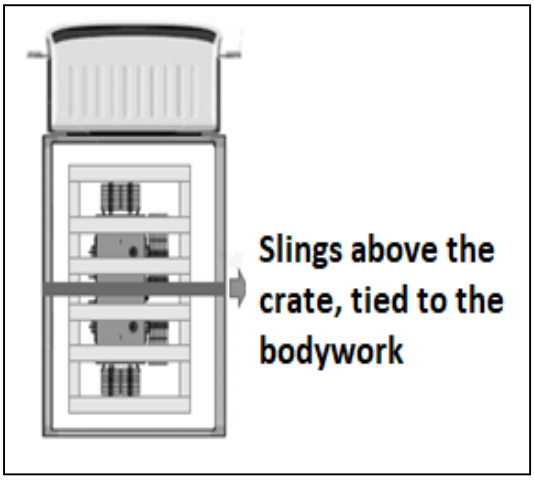


Figure 30: Maximum height of the load

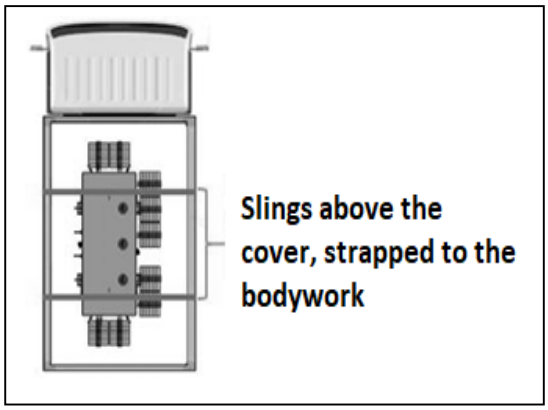
7.1.3 Other alternatives to improve the lashing of the cargo to the vehicle

- The lashing of the cargo to the body of the vehicle or container can be improved in several ways:

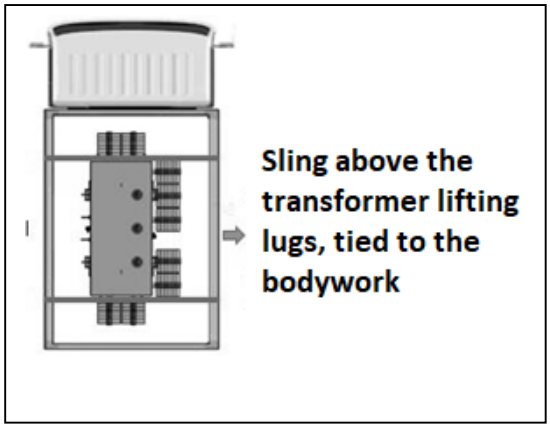
  - Passing one or more slings over the crate.



  - Passing one or more slings over the transformer cover, place a guard between the sling and the cover.



  - Passing the sling over the transformer lifting lugs.



7.1.4 Open top load

For loading this type of container, take into account the next:

- Use bridge crane (differential) or crane.
- When lifting the load, do so only until it exceeds the height of the container this to prevent accidents
- Make sure not to hit the charging unit.
- The cargo cannot stick to the container walls.
- Check the condition of the slings, straps or shackles, do not use them if they show damage or deterioration.

Figure 31: Load open top container

7.2 By Parts, Transformers load

7.2.1 With removable radiators

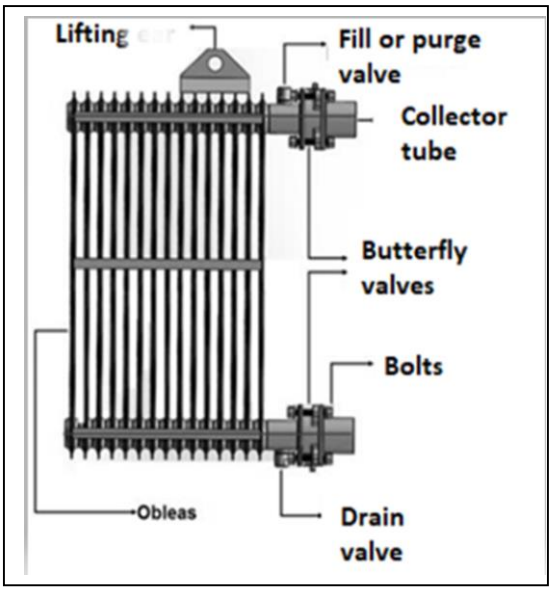


Figure 32: Parts that make up a radiator

- Disconnect and remove the accessories or components that are located on the radiators (fans, etc.).

Figure 33: Disassembled fans

- Protect accessories or component connections and tie them to the transformer tank.
- Close the butterfly valves (upper and lower).

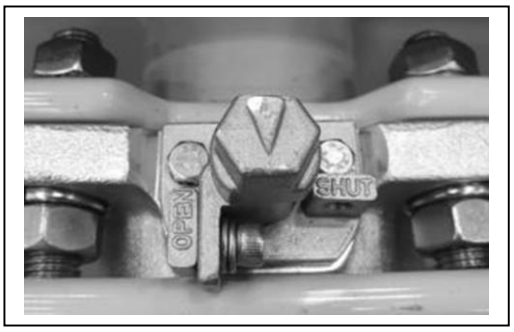


Figure 34: Butterfly valve (closed)

- Through the radiator drain valve, remove the insulating liquid from each radiator, as follow:

- Remove the cover.
- Place a clean container under the valve.
- Slowly turn the screw until the insulating liquid starts to flow.

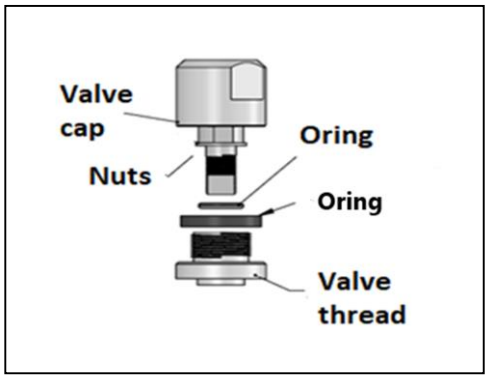


Figure 35: Parts of the radiator drain or fill valve

➢ Store the insulating liquid in a container.

Caution: Make sure that the insulating liquid is correctly store to carry out the filter-press process, with this, it is guaranteed that the insulating liquid is dispatched in optimal conditions.

➢ When the insulating liquid stops flowing, tighten the screw and put the drain valve plug back.

➢ Remove the supports that join the radiators (upper and lower).

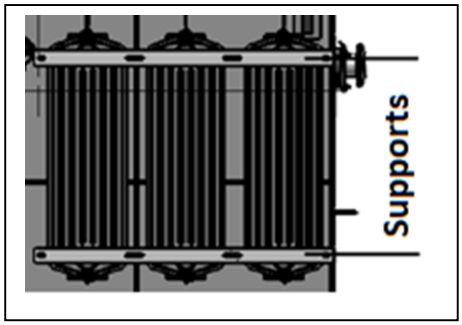


Figure 36: Brackets joining the radiators

➢ Remove the radiators, one by one, as follows:

- Start from 1 to 5 order, this makes it easier to maneuver.

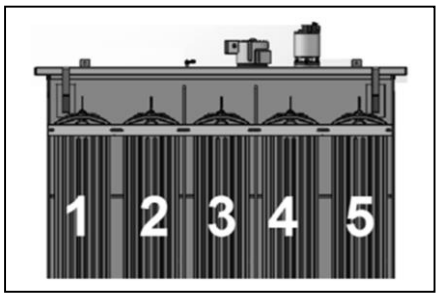


Figure 37: Remove radiators from 1 to 5.

- With the help of a differential or hoist, support the radiator on the lifting lug.

Figure 38: Lifting lug

- Loosen the nuts on the bolts that fix the radiator to the transformer tank.

- Remove the nuts.

Figure 39: Loosen and remove nuts

- Place the radiator on a base.

➢ Clean butterfly valves and radiator flanges.

➢ Protect butterfly valves and radiator header pipes with blank covers or flanges.

Figure 40: Valves protection

➢ Store the disassembled radiators and accessories for transport.
➢ Remove all traces of oil and dirt from the transformer.

7.2.2 With detachable conservator (expansion) tank

➢ Disconnect and disassemble the accessories that are located in the conservator tank (thermometer, level, silica gel breather, etc.).

➢ Protect accessory connections and tie them to the transformer tank.

➢ Close the valves of the buchholz relay.

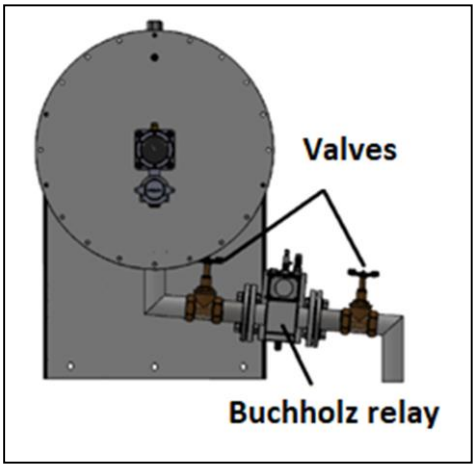


Figure 41: Buchholz relay valves

➢ Remove the insulating liquid from the buchholz relay, to do this:

- Place a clean container under the relay.

- Slowly turn the drain plug until the insulating liquid starts to flow.
- When the insulating liquid stops flowing, tighten the drain plug.

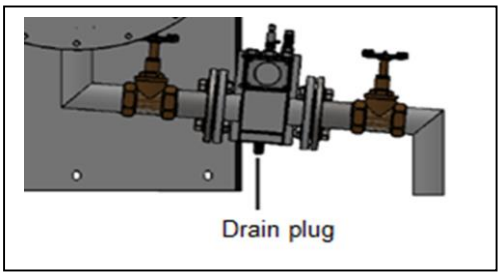


Figure 42: Buchholz relay drain plug

➢ Remove the insulating liquid from the conservator (expansion) tank, to do so:

- Place a clean container under the drain valve.
- Remove the plug and slowly open the valve until the insulating liquid starts to flow.
- When the insulating liquid stops flowing, close the valve and put the plug back on.

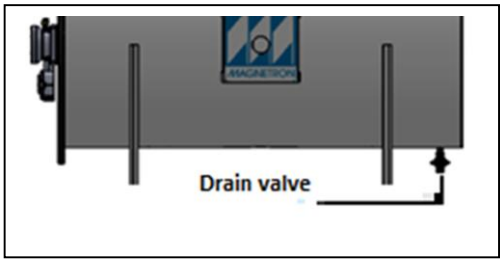


Figure 43: Conservative tank drain valve (expansion)

- Loosen the screws that hold the conservator (expansion) tank to the main tank, this action allows the buchholz relay to release pressure.
- Remove the buchholz relay.
- With the aid of a differential or hoist, support the conservator tank by the lifting lugs.
- Remove hardware and lower conservator tank.

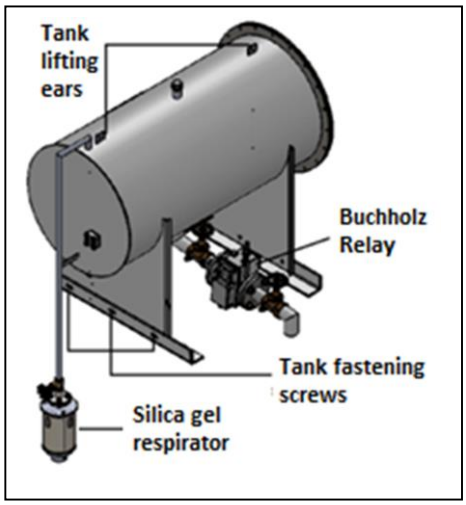
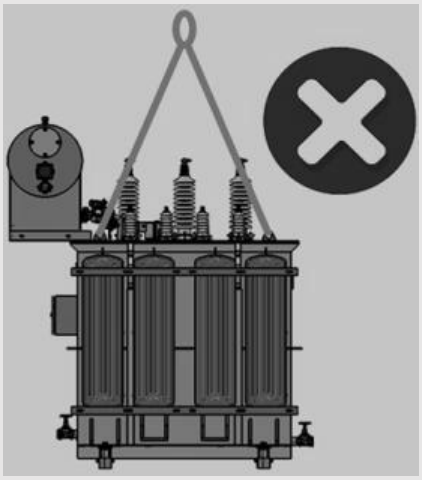


Figure 44: Conservative tank parts (expansion)

7.2.3 Download

Precautions: Some transformers have lid lifting lugs, NEVER use them to lift or hoist the transformer.



If you use strings or metal slings to lift the transformer, be sure to cover the parts in contact to avoid paint detachment.

The unloading of the transformers is the responsibility of the customer, unless otherwise specified in the contract. However, the following should be noted:

- Always use the appropriate mechanical means, forklift, crane, etc.
- The mechanical equipment used must have at least twice the capacity of the weight of the product.
- Lift the transformer only by the lifting lugs or the bottom of the packaging.
- Personnel involved in the unloading must remain away from the product when it is lifted.
- The product loaded in open-top trucks must be unloaded in opposite way to loading.
- In containers or trucks with close container, the products that are out of reach must be pulled until they are in the unloading position, to do so:
  - Attach a sling to the hoist or mechanical means used and pass it around the base of the transformer packaging.
  - Pull the product until it is within reach
  - Download the transformer.

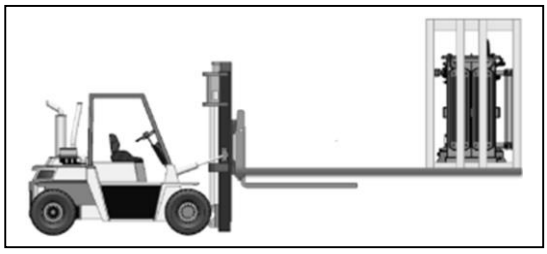


Figure 45: Proper way of pulling the product in the download.

8. Reception

Caution: Before discharging the transformer, should visually inspect the state of the same, any abnormality communicates it to the transporter and leave a record of it.

The transformers covered in this manual are factory tested according to standards, they are delivered completely assembled and ready for installation or divided into several parts, however, considering the difficulties encountered during transportation, the following should be noted:

- Check that the security seals located between the lid and the tank for the national product have not been removed or show evidence of having been tampered with.

Figure 46: Security Seal

- Check that the security seals located in places that have removable parts (junction boxes, hand holes, bolted covers, etc.) for the export-type product, have not been removed or show evidence of having been tampered with.

Figure 47: Security seal on removable parts

- When the transformers are shipped divided into several parts, such as the main tank, the conservator tank, the radiators and other parts; disassembled components are packed in crates or boxes and must be check against the supplied packing list.

- Check the state of the medium and low voltage bushings, they should not be loose or present damage.

- Check the state of the control instruments that are attached to the main tank.

- Check the state of the tank, it should not show bumps, cracks or damage to its paint.

- Check that caster wheels (if fitted) arrive with the transformer.

Figure 48: Casters wheels

- Check that there are no leaks of the insulating liquid.
- Check that the hardware is not loose.
- Inspect the base of the packaging, it should not show damage.
- Check that the characteristics of the transformer correspond to what was requested (power, phases, voltages, serial number, etc.).
- In case of finding damage to the transformer, if possible, leave a photographic record of the findings.
- Inform the transporter of the abnormalities found.
- Contact MAGNETRON S.A.S. and notify what happened, supplying the complete information of the transformer.
- Keep in mind what is established in numeral 7 "Transportation" before unloading the transformer.

9. Storage

Caution: Keep the transformer in the packaging (base or crate), this protects it from damage or deterioration during storage.

Caution: To prevent the ingress of moisture into the product, the overpressure valve MUST NOT be actuated for any reason

Once the transformer has been delivered to the customer, it is advisable to place it in its permanent location, even if it is not put into operation immediately. If this is not possible, locate it in a dry place; In addition, you must fill it with insulating liquid, if applicable.

Follow the next instructions to ensure its good condition:

- Store it indoors.

  Note: If storage is done outdoors, keep in mind that environmental conditions can deteriorate the base or crate, thereby causing damage or deterioration of the product

- Whenever possible, feed the control cabinets at their corresponding voltage to avoid water condensation inside.

- When storage is extended for more than six (6) months, has to periodically inspect the state of the wooden base or the crate.

- Do not store it in places where there is presence of moisture, sludge, corrosive gases or explosive atmospheres.

- Transformers received in multiple sections must be fully assembled, topping up the insulating liquid level, and pressurize the tank with dry nitrogen at 3 psi.

  Note: If it cannot be fully assembled, the parts and pieces must be kept sealed to prevent appearance of humidity.

10. Accessories

Caution: If any accessory is not covered in this manual or requires more information, contact MAGNETRON SAS

The accessories installed in power transformers can be classified into two (2) types:

10.1 Basic accessories

Minimum required elements, supplied by the manufacturer with the transformers, useful for their identification, handling, installation, proper functioning and protection.

- Low voltage bushings,
- Medium voltage bushings,
- Tank grounding device,
- Caster wheels,
- Devices for hydraulic jack,
- Devices for lifting or hoisting the complete transformer,
- Device for lifting or hoisting the active part and the cover,
- Valve for sampling the insulating liquid,
- Thermometer case,
- Valves for recirculation and drainage of the insulating liquid,
- Magnetic indicator of the level of the insulating liquid,
- Dial thermometer with contacts,
- One contact overpressure relief device,
- Labeling of the MV and LV Bushings,
- Name plate,
- Non-voltage tap changer,
- Terminal box for instrument signals,
- Removable radiators,
- Butterfly valve for radiators in transformers ≥ 5000 kVA.

Basic accessories when you have a conservative tank (expansion):

- Filling device,
- Drain valve,
- Buchholz relay with two contacts,
- Air dehumidifier system with silica gel.

10.2 Optional accessories

Other additional elements are supplied by the manufacturer with the transformers, at the client's request.

- Thermal image thermometer for simulation of the temperature in the windings and/or control of forced ventilation,

- Fans and their fixing means for forced ventilation,
- Swivel castors with rail flanges and brake device,
- Ski or skate type base to drag the transformer on the floor,
- Supports for lightning rods,
- Valves for the buchholz relay
- Butterfly valve for radiators in transformers ≤ 5000 kVA,
- Sudden Pressure Relay,
- Current transformers for measurement and/or protection,
- LV and MV hub protection boxes,
- Remote indication of transformer temperature signal.

Optional accessories when it has a conservator tank (expansion):

- Vacuum or pressure relief device,
- Contactless pressure gauge.

10.3 Accessories illustration

Some of the accessories used in the transformers that are the subject of this manual are detailed below.

10.3.1 MV bushing

Accessory, normally made of porcelain, designed to mechanically hold the conductors that are part of the power line, keeping them isolated from earth and other conductors.

Its main function is to make the bridge between the medium voltage terminals of the active part and the power supply.

Its characteristics vary according to the voltage level of the transformer, the basic level of insulation and the creepage and arc distances.

Figure 49: MV Bushings

10.3.2 LV bushing

Accessory, normally made of porcelain, designed to mechanically hold the conductors that are part of the power line,

keeping them isolated from earth and other conductors.

Its main function is to make the bridge between the low voltage terminals of the active part and the external load.

Its characteristics vary according to the voltage level of the transformer, the basic level of insulation and the creepage and arc distances.

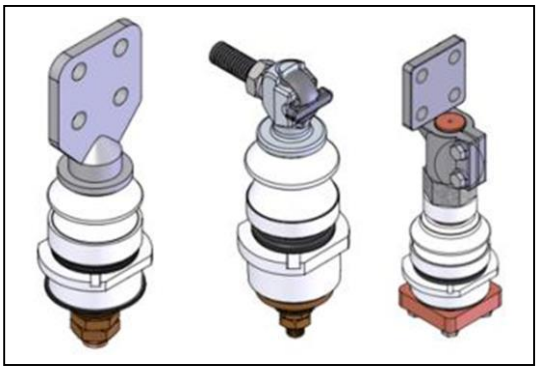


Figure 50: LV bushings with their respective terminals

10.3.3 Pressure relief device

Its main function is to limit the internal pressure of the transformer when it is affected by its operating temperatures, directly associated with the installed load. The pressure relief valve is a means to relieve abnormal pressures that occur inside the transformer.

The relief valve must have a suitable gas evacuation capacity for the volume of the transformer.

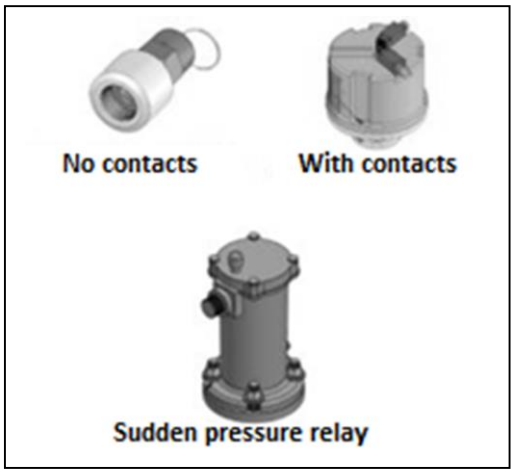


Figure 51: VSP types

10.3.4 Tap changer switch

Caution: The switch has an external handle, which must be operated only with the transformer de-energized.

The switches carry out voltage regulation, which consists of compensating for voltage variations that are detected at the receiving points of a power transmission or distribution system, varying the ratio of turns in the primary winding until the required voltage is obtained in the secondary.

There is a wide variety of switches used in small and medium power transformers, two types are the most common:

- Circulars (3 bodies)
- Linear

10.3.4.1 Steps to operate the CIRCULAR switch

- Disconnect the transformer from the power source.
- Verify the absence of voltage on the transformer by measuring the LV winding with a voltmeter.
- Ground the MV and LV terminals.
- Using a screwdriver, loosen the handle anchor screw until it protrudes from the disc.
- Rotate the handle and bring it to the desired position.
- Re-secure the handle anchor screw, until it enters the disc.
- Remove the ground connections from the MV and LV terminals.
- Measure continuity at the MV terminals to ensure that the switch is properly engaged.
- Re-energize the transformer.
- Measure the voltage on LV, confirm that it is the desired voltage.

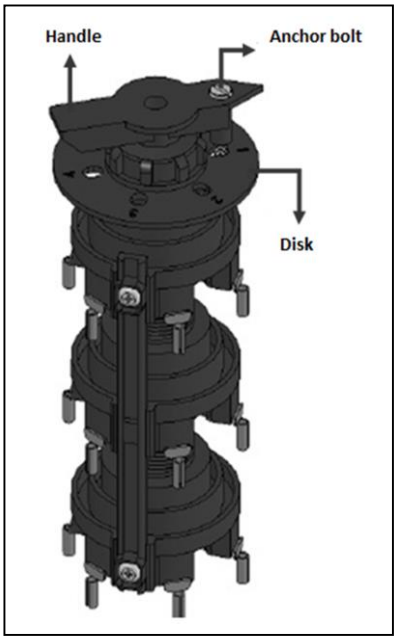


Figure 52: Circular switch

10.3.4.2 Steps to maneuver the LINEAR switch

- Disconnect the transformer from the power source.
- Verify the absence of voltage on the transformer by measuring the LV winding with a voltmeter.
- Ground the MV and LV terminals.
- Pull the knob until it is released from the disc anchor.
- Turn the knob and bring it to the desired position.
- Make sure the knob anchors properly on the disc.

- Remove the grounding connections from the MV and LV terminals,
- Measure continuity at the MV terminals to ensure that the switch is properly engaged.
- Re-energize the transformer.
- Measure the voltage on LV, confirm that it is the needed voltage.

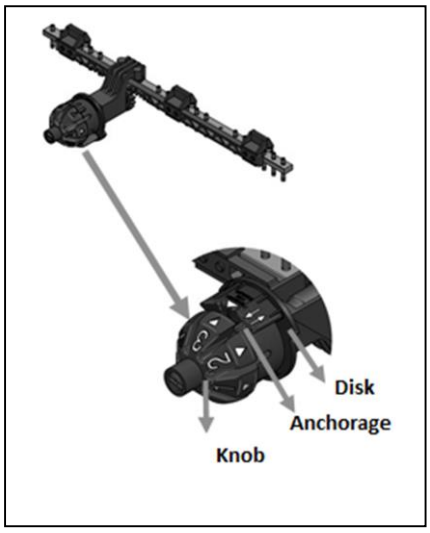


Figure 53: LINEAR switch

10.3.5 Name plate

It is an accessory made of a material resistant to corrosion (aluminum, stainless steel, etc.) where the most relevant information on the transformer is recorded.

The plate must be fixed in a visible place and its inscriptions must be legible and indelible.

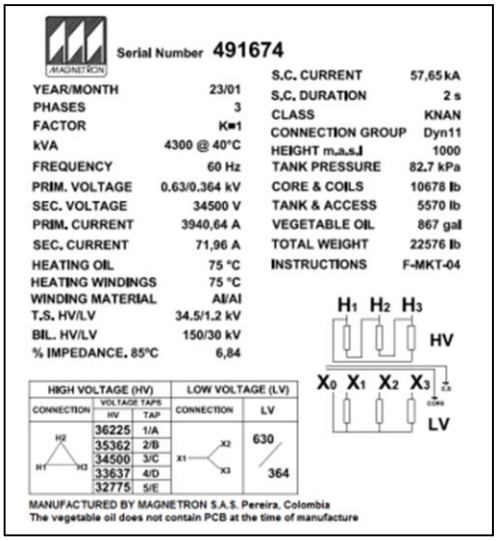


Figure 54: Example nameplate

10.3.6 Grounding system

The transformer is provided with screws (studs) or plates with their respective accessories to allow:

- The low voltage neutral point grounding to the tank is shipped connected from the factory.
- The grounding of the tank to the grounding system where the transformer will be installed.

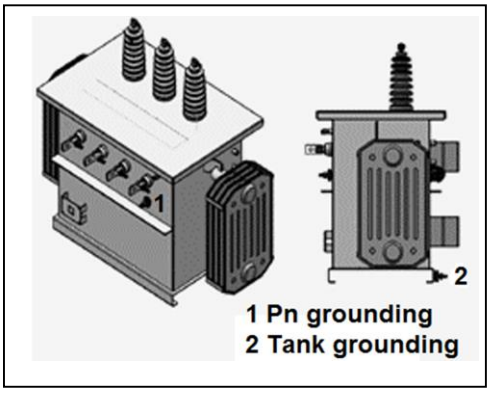


Figure 55: Grounding points

10.3.7 Lifting lugs

Devices for lifting or hoisting the fully assembled transformer and filled with insulating liquid, are located in such a way that when hooking the straps or slings they do not press against other accessories, nor against the bushings, nor do they damage the cover.

They are only used for hoisting or lifting, they are not for transporting.

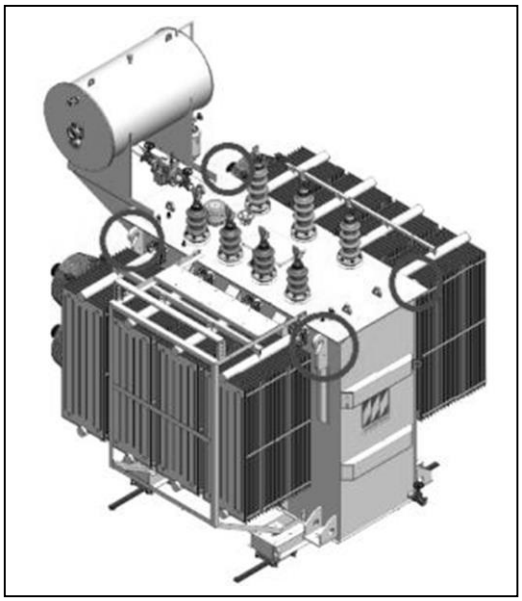


Figure 56: lugs to lift or hoist

10.3.8 External indication of the insulating liquid level

It is a device or meter that indicates the level of dielectric fluid in the transformer tank.

When the gauge is installed at the factory, the tank is filled to the level that corresponds to a liquid temperature of 25°C.

If the meter indicates a "LOW" liquid level, then the transformer should be de-energized and inspected to determine the cause of the low liquid level.

A low level of liquid can cause dielectric failure, overheating and reduction in the useful life of the product.

As an optional feature, the liquid level meter can be provided with one (1) or more contacts for remote signaling of levels (low or high) of dielectric fluid.

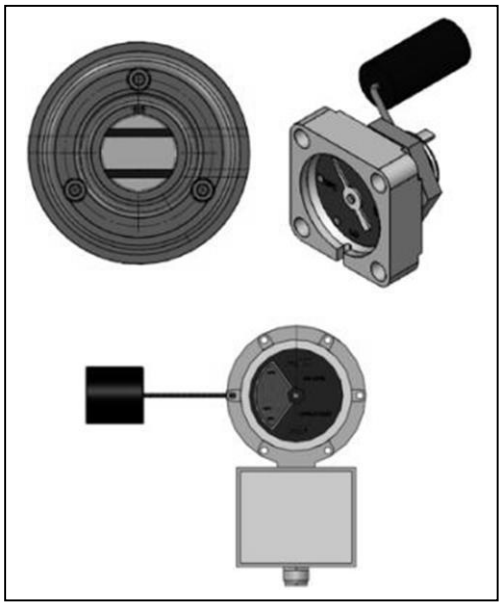


Figure 57: Insulating liquid level indicators

10.3.9 Temperature indicator (thermometer)

It is an instrument that measures the temperature of the liquid in degrees Celsius and includes are settable maximum temperature indicator.

The red maximum temperature indicator can be reset by turning the magnet in the center of the faceplate towards the white indicator pointer.

The temperature gauge is mounted in a liquid-tight drywell for easy replacement.

As an optional feature, liquid temperature indicators can be provided with one (1) or more contacts to allow remote signaling of unacceptable temperatures or to control cooling fans installed on the transformer.

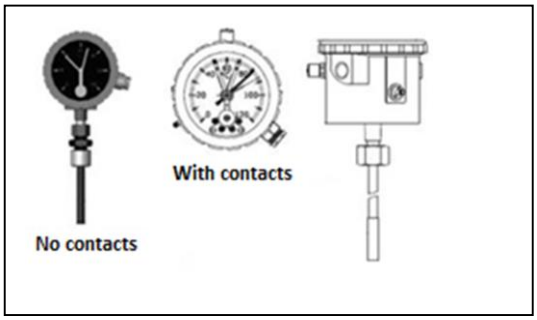


Figure 58: Temperature indicator

10.3.10 Drain valve

This device is located at the bottom of the tank, it is used for:

- Take samples of the insulating liquid in order to carry out tests.
- Drain the insulating liquid if necessary.
- Recirculate insulating liquid when performing field maintenance.

10.3.11 Recirculation valve

This device is located in the upper part of the tank above the level of the insulating liquid, it is used for:

- Fill the transformer with insulating liquid.
- Recirculate insulating liquid when performing field maintenance.
- Change the insulating liquid without taking the transformer out of service.

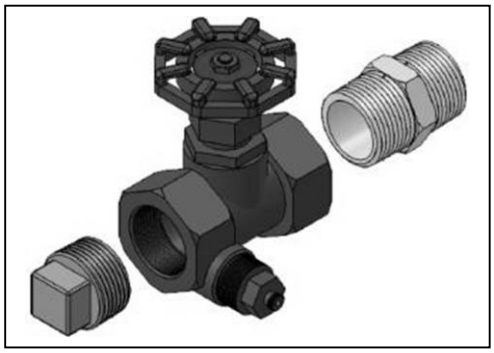


Figure 59: Drain valve

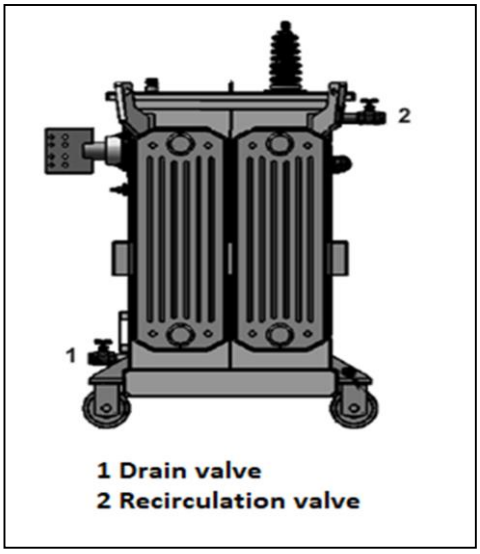


Figure 59-1 Drain valve

10.3.12 Lid lifting devices

Devices located on the cover that serve to lift or raise the cover, are not designed to lift the transformer. When the active part is attached to the lid, these devices are designed to lift the LID-ACTIVE PART assembly.

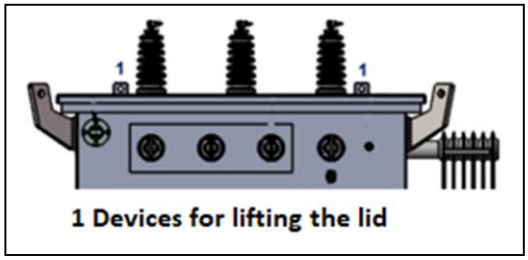


Figure 60: Devices for lifting the lid

10.3.13 Buchholz relay

This device makes possible to detect dielectric faults inside the transformer.

In the event of an overload (heating) the gas produced by the combustion internal buildup accumulates on top of the relay and forces the oil level to drop.

In case of a bow electrical, the accumulation of gas is sudden, and the insulating liquid flows rapidly into the expansion tank. In this case, an automatic interrupter circuit is activated that isolates the transformer before the fault causes more serious damage.

The relay also operates when the insulating liquid level is low, such as in the event of a leak.

The buchholz relay has a test port that allows accumulated gas to be withdrawn for testing.

If flammable gas is found in the relay, it is a sign that there were internal faults such as overload or internal arc production. In case there is air, it means that the insulating liquid level is low.

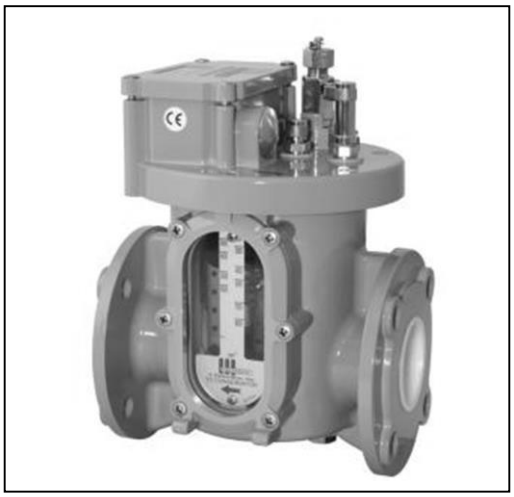


Figure 61: Buchholz relay

10.3.14 Flexible membrane

This membrane is used to avoid contamination of the insulating liquid of the transformer with humidity and/or air pollution.

When the transformer is under load, the insulating liquid is hot; under these conditions, if it comes into contact with oxygen, oxidation of the insulating liquid occurs.
When the oxidation of the insulating liquid occurs, sludge is generated inside the transformer. The sludge generated is not a conductor of electricity, but affects

the cooling of the coil by clogging the cooling ducts, causing transformer failure due to overheating.
It is important to specify that the membrane or elastic separator can be provided with an optical sensor, which is located inside it in order to detect the rupture of the membrane and the passage of the insulating liquid to it.

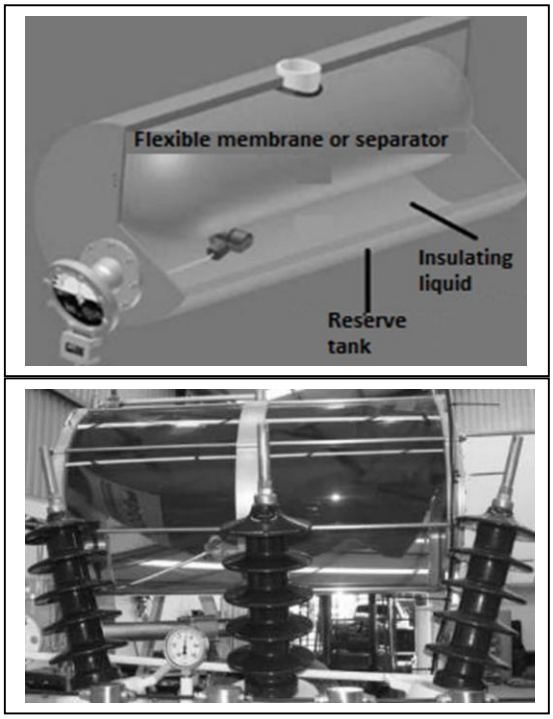


Figure 62: Nitrile membrane

10.3.15 Silica gel breather

It is an accessory that serves to keep the transformer in good condition. As the load on the transformer changes, so does the temperature as follows:

- If the temperature increases, the volume of the insulating liquid increases, expelling the air from the conservator tank.
- If the temperature decreases, the volume of the insulating liquid decreases and the air returns to the conservator tank through the silica gel breather.

The main function of the silica gel is to trap moisture and solid particles suspended in the air, in order to protect the insulation of the transformer

The breather has an oil trap located in the bottom part, it isolates the silica gel from the ambient air, so that it cannot flow freely, in this way, the silica gel does not constantly absorb moisture.

Note: When silica gel absorbs moisture, it starts to change its color (blue, purple, orange, etc.) to white or pink.

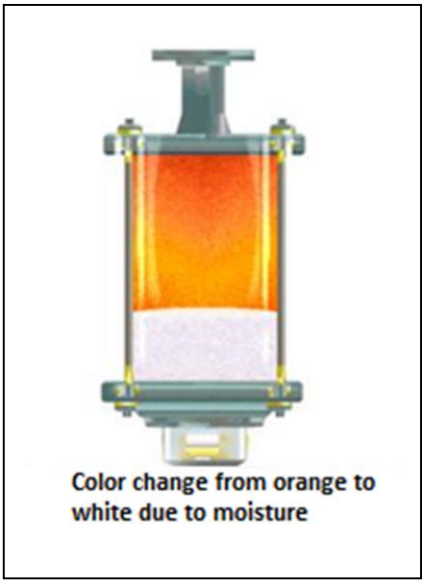


Figure 63: Silica gel breather

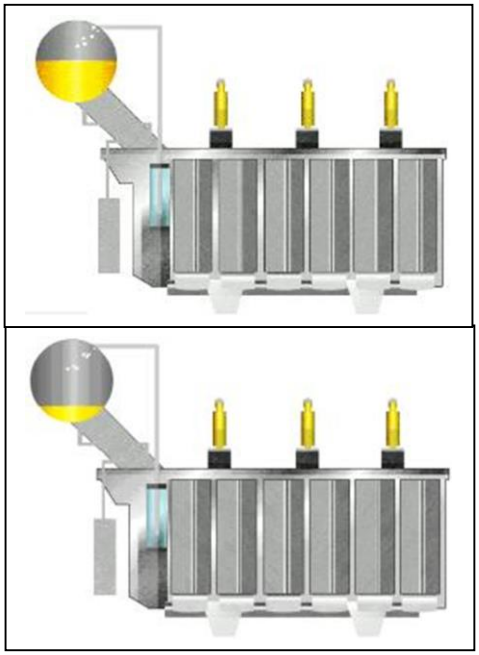


Figure 64: Expulsion and attraction of air when the insulating liquid expands or contracts.

10.3.16 Manovacuometer

It is an instrument designed to measure pressure; it is normally calibrated in psi.

Its main characteristic is to combine the functions of a pressure gauge and a vacuum gauge, since it is on charge of measuring both the relative pressure and the vacuum pressure.

Gauge readings should vary as transformer temperature changes and should normally indicate positive pressure, but in some application as photovoltaic plants negative pressure during night or cloudy days are normal too.

Figure 65: Manovacuometer

10.3.17 Fans

They are used to increase the heat dissipation capacity and therefore provide additional load capacity to the transformer.

Fans are used in transformers designed to operate with such forced ventilation capacity.
The fans used in the transformer are of the same capacity, their characteristics are shown on the motor data plate.

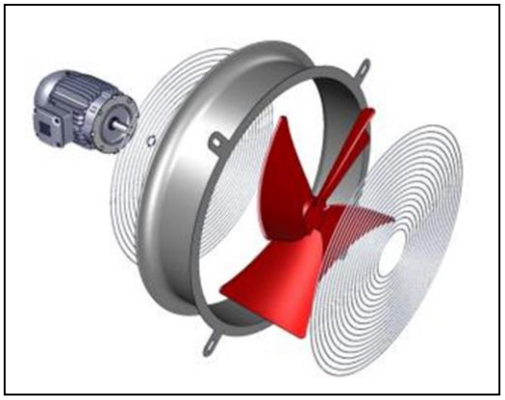


Figure 66: Fan for transformer

11. Terminal marking

The marking of the medium and low voltage terminals in this type of transformers depends on the standard (NTC or ANSI).

11.1 NTC standard marking

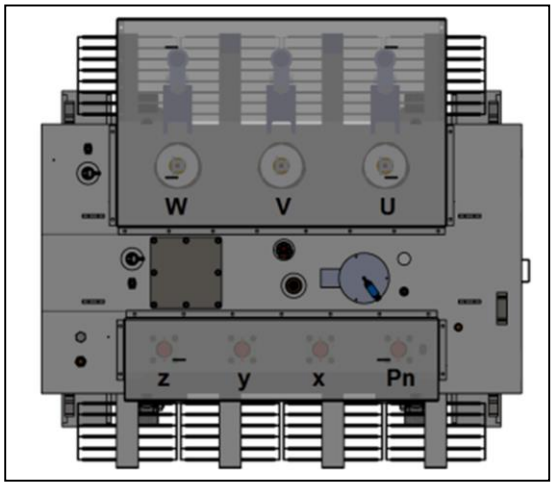


Figure 67: Example NTC marking

11.2 ANSI standard marking

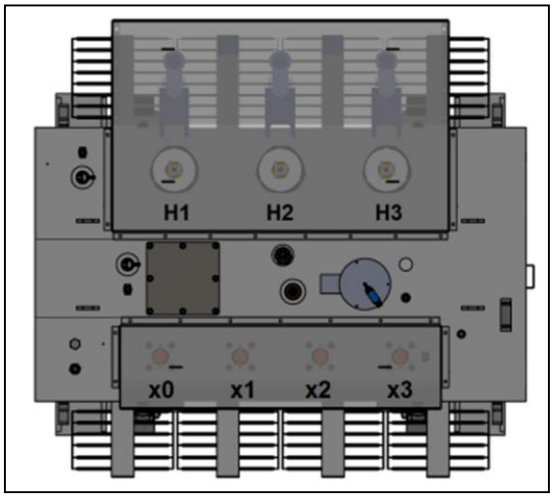


Figure 68: Example ANSI marking

- The markings in the medium voltage terminals are made with UPPERCASE letters and for the low voltage terminals they are made with LOWER CASE letters.

Three-phase transformers have two other very important factors for their connection:

- Connection group
- Hourly index

11.3 Hourly index

It represents the phase angle between the vector diagram of the electromotive forces (voltages) of the primary winding and the secondary winding, when the transformer is in no-load condition.

In other words, it is the phase difference, in degrees, between the primary voltage and the secondary voltage.

The hourly index is so called because the offset is expressed according to the hours of a clock. Every hour, from 12 o'clock, represents a lag of 30º.

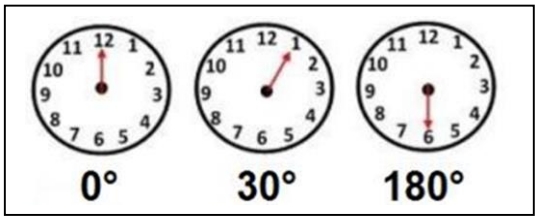


Figure 69: Hourly index examples

11.4 Connection group

It represents the type of connection for each of the windings, normally

there are just the primary winding and the secondary winding.
The connection group is represented by a series of letters and a number, as follows:

- The first letter, in UPPER CASE LETTER, represents the connection of the highest voltage winding.
- The second letter, in LOWER CASE, represents the connection of the lower voltage winding.
- The number represents the phase difference, in degrees, between the primary voltage and the secondary voltage (1 = 30°).
- If a third letter (N on) is observed in the connection group, it indicates that the star connection (Y oy) has an accessible neutral point.

Example:

Dyn5

D	Indicates the connection of the HIGHEST VOLTAGE winding (Delta or triangle)
y	Indicates the connection of the LOWER VOLTAGE winding (Star)
n	Indicates that the star connection (Y or y) has an accessible point
5	It represents the phase difference in degrees, between the primary and secondary voltage, in this case 150° (5*30°)

12. Review and tests before installation

12.1 Revision

Before installing the product, the customer must check the following:

- Remove all traces of dirt and foreign material from the low and medium voltage bushings.
- Clean transformer tank.
- Check that the accessories are in good condition and properly adjusted.
- Check that there are no insulating liquid leaks.
- Check that the transformer does not present blows or damage that could invalidate its proper functioning.
- Review the information on the nameplate and verify that it is in accordance with the requirements (power, voltages, etc.).
- Remove the base and crate (if equipped) from the transformer.
- Verify that the tap changer switch is well anchored and in the required position.
- Make sure the low voltage neutral point is properly grounded to the tank.
- Make sure that all the parts and/or accessories to be installed, if any, are complete and in good condition (conservative tank, radiators, silica gel breather, buchholz relay, etc.).

12.2 Assembly of parts and/or accessories

12.2.1 Radiator assembly

- Remove the blind covers or flanges that protect the butterfly valves.
- Clean butterfly valves.
- Change the orings that seal between the valve and the radiator. It is advisable to do so since the glue used to hold the oring can crystallize and hinder the seal.

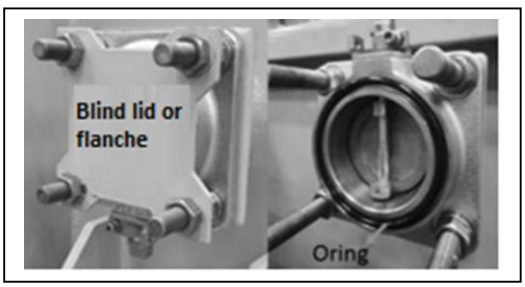


Figure 70: Flange - Oring

- The assembly of the radiators is done starting from 1 to 5.

Note: Although the radiators are the same, each radiator is marked to be located in the position that is marked on the main tank. This identification facilitates its assembly.

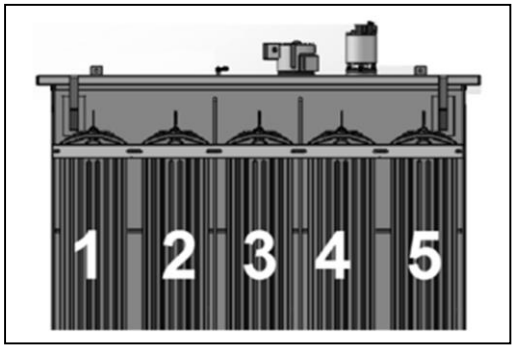


Figure 71: Assembly of radiators from 1 to 5 or from 5 to 1.

- Remove the cover or flange that protects the radiator, do it as you install them.
- Make sure the inside of the radiator tube is completely clean.
- Externally clean the radiator tube.
- Using a crane or forklift, lift the radiator off the lifting lug.
- Guide the radiator until it matches the perforations of the radiator flanks with the studs that hold the butterfly valves to the tank.

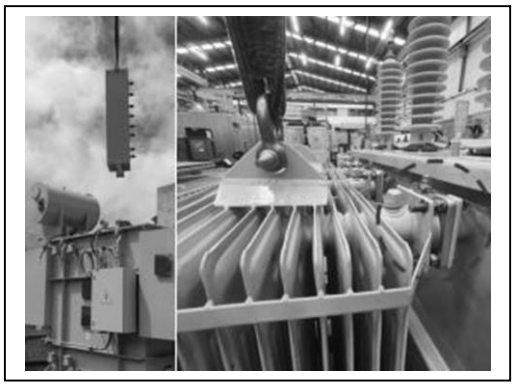


Figure 72: Raising and anchoring the radiator

- Secure radiator with lock washer and nut (stainless).
- Tighten the fastener with the recommended sequence and torque (92 lbf.ft for 5/8" stainless, see 17.1).

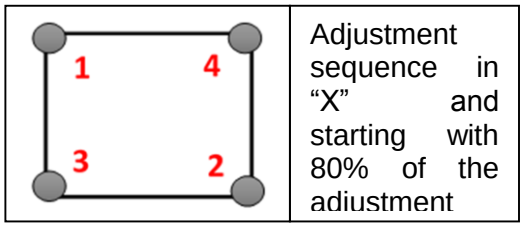


Figure 73: Tightening sequence and torque

- Repeat the assembly procedure until all radiators are installed.

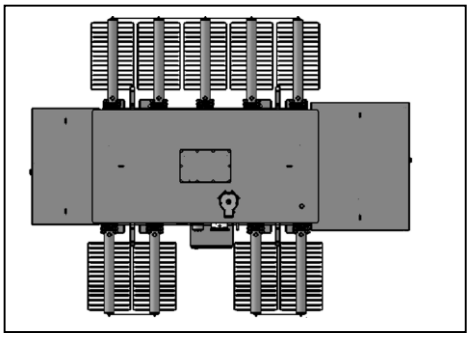


Figure 74: Completely assembled radiators

- Install the brackets that join the radiators, upper and lower.

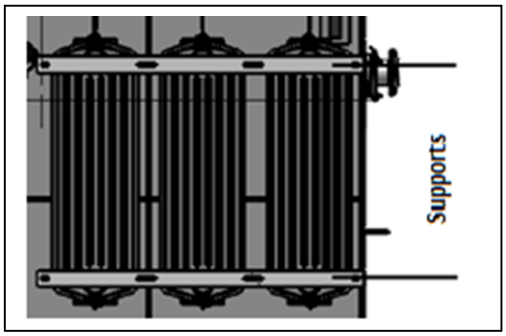


Figure 75: Supports that join the radiators

- Open the lower butterfly valves of the radiators, at this moment, the filling of the same begins.
- Purge each radiator by removing the top purge valve cap and loosening the screw.
- When no air comes out, tighten the screw and install the purge valve plug.
- Connect the insulating liquid filling machine (filter press) to the drain valve.
- Start filling the transformer up to:
  - ✓ The level of the insulating liquid installed in the main tank.
  - ✓ If the conservator tank is installed, up to its level of insulating liquid.
  - ✓ If you have an expansion tank and it is not installed, fill up to the top.
- Purge each radiator again.
- Purge the MV and LV bushings if they are installed on the cover.
- Clean the transformer.
- If you do not have an expansion tank, seal with dry nitrogen at 7 psi for 6 hours.
- Check that the transformer does not present leaks of insulating liquid.
- Install the accessories or components that go on the radiators (fans) and connect them.

Figure 76: Installation of fans

12.2.2 Assembly conservator tank and buchholz relay

- Clean the expansion tank, the buchholz relay and the valves.
- Using a crane or forklift, lift the conservator tank using the lifting lugs.

Figure 77: Conservator tank assembly

- Guide the conservator tank up to the base that will support it in the main tank and secure it with the screws, without tightening it completely.
- Change the gaskets of the buchholz relay. It is advisable to do so since the glue used to hold the packaging can crystallize and hinder the seal.
- Install the buchholz relay, ensuring that you face it in the correct direction.

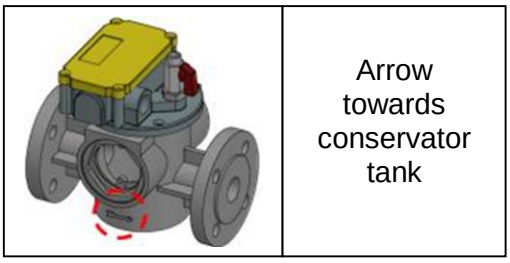


Figure 78: Buchholz relay address

- Tighten the buchholz relay hardware with the recommended sequence and torque (31lbf.ft for 7/16" stainless, see 17.1).

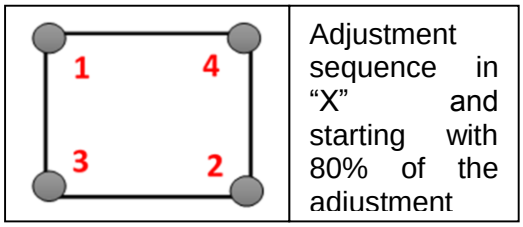


Figure 79: Tightening sequence

- Tighten conservator tank hardware to recommended torque (43 lbf.ft for 1/2" stainless, see 17.1).
- Install and connect the accessories that go on the conservator tank (oil level, thermometer, etc.).

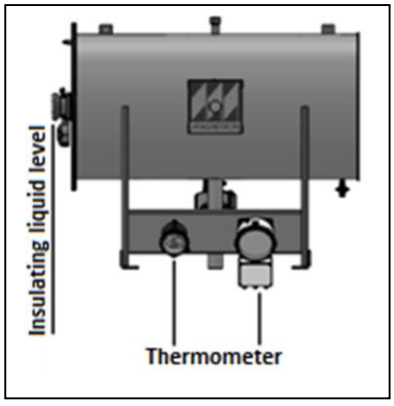


Figure 80: Accessories installed

- Install the cable that connects the conservator tank to the main tank (grounding).

Figure 81: Union conservator tank with main tank

- Remove the bushing plug installed at the top of the reserve tank or open the valve of the silica gel breather.

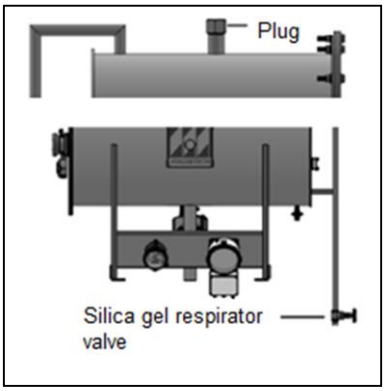
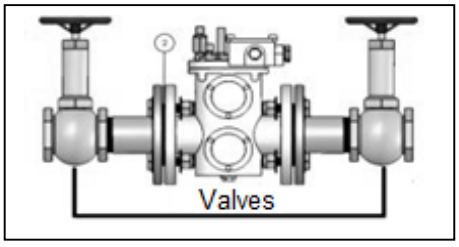


Figure 82: Transformer vents during filling

- Open the valves of the buchholz relay.



- Connect the insulating liquid filling machine (filter press) to the drain valve.
- Start filling the transformer until completing the level in the conservator tank.
- Bleed the buchholz relay, the MV and LV insulators if they are installed on the cover and the radiators with a butterfly valve.
- Adjust the level of the insulating liquid if necessary.
- Clean the transformer.
- Seal with dry nitrogen at 7 psi for 6 hours.
- Check that the transformer does not present leaks of insulating liquid.

12.2.3 Flexible membrane

The flexible separator is placed inside a cylindrical tank. On the outside it is in contact with the insulating liquid and on the inside with the atmosphere.

This type of assembly makes it possible the compensation of variations in the volume of the insulating liquid due to temperature changes, guaranteeing:

- An efficient barrier between the insulating liquid and the air.
- A protection against water vapor.

- The suppression of any gas bubbles formed in the insulating liquid.

- The compensation of large volumes, up to 15 m3.

When the transformer is equipped with this accessory, to assembly proceed as follows:

- The conservator tank must be without insulating liquid.

- Remove the plug from the bushing installed on the flange of the diaphragm cover.

- Install a pressure gauge and pressurize the membrane or flexible separator with dry nitrogen to 1.5 psi.

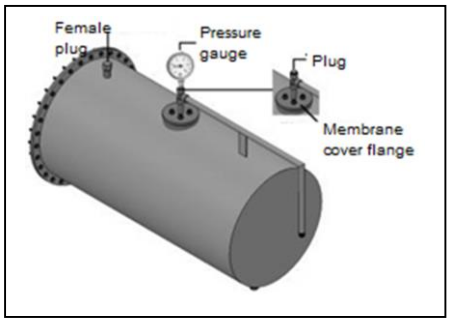


Figure 83: Pressure gauge location

- Remove the female plug from the bushing (breather).

- Fill the conservator tank up to the external indication of the oil level.

- Evacuate the nitrogen from the membrane and remove the manometer.

- Install the female plug and the flange plug of the membrane cover.

12.2.4 Silica gel breather assembly

This accessory is installed when the transformer is completely filled with insulating liquid. To do so, proceed as follows:

- Verify that the silica gel is dry (purple, blue, etc.), if there is evidence that it has acquired moisture (color change to pink or white), it should be changed.

- Verify that the cover glass is in good condition.

- Install the breather in the tube, use teflon tape to improve the seal,

- Fill the cup located at the bottom of the respirator with insulating liquid, up to the indicative mark.

- Open the valve installed on the silica gel respirator tube.

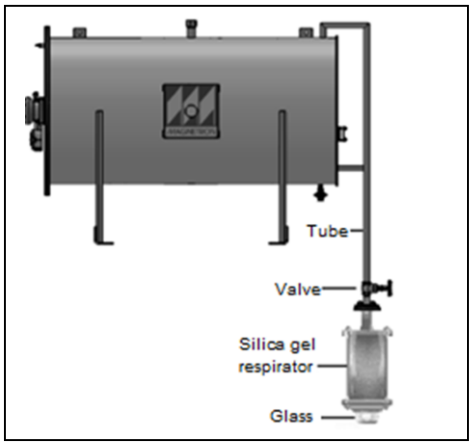


Figure 84: Silica gel respirator

12.3 Tests

In order to ensure the proper functioning of the product and not affect the warranty of the equipment, the following tests must be carried out to validate the installation and energization:

12.3.1 Transformation Ratio (TTR)

This test is performed to measure the ratio of voltages or turns between two or more windings.

Also, it is a test that allows to identify:

- The connection group.
- Short circuit between turns or layers.
- Failures due to burst or open terminals.
- Damage or misoperation of the commutator.
- Wrong or broken connections.

Depending on the equipment used, the test is performed as follows:

- **Analog or crank TTR**

With this equipment, the ratio of the transformer under test is compared with a reference transformer (internal to the equipment) whose ratio is adjustable in small steps.

The transformer under test and the TTR are connected in parallel applying voltage to the MV windings; the LV windings, in parallel, are connected to a sensitive detector which is forced to signal zero (0) by adjusting the transformation ratio of the reference transformer (TTR). The adjusted transformation ratio of the reference transformer (TTR) is then equal to the transformation ratio of the transformer under test.

This procedure must be carried out in all switch positions and in all phases if it is a three-phase transformer.

Figure 85: Analog or Crank TTR

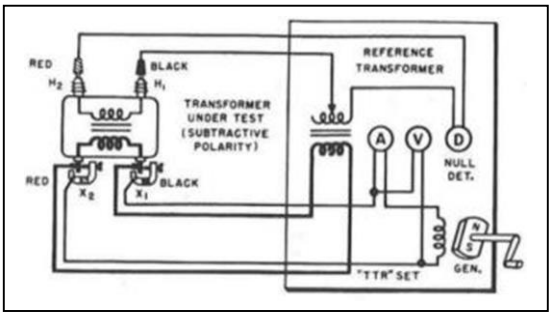


Figure 86: TTR connection to the transformer under test

- **Digital TTR**

With this equipment, an adjustable voltage is applied to the MV terminals and the output voltage of the winding corresponding to the LV is measured. The value of the transformation ratio results from the division of these voltages.

The MV and LV terminals of the metering equipment are connected to the MV and LV terminals of the transformer under test according to the marking of the corresponding phases. The equipment must be configured according to the connection group and the voltage to be applied, as standard 8V is used.

Figure 87: Digital TTR

- **Calculation of the transformation ratio**

They are carried out according to the connection group or the polarity of the transformer:

Phases	Connection type	Formula or calculations
1	Ii0 - Ii6	$RT = \frac{\text{Voltage MV}}{\text{Voltage LV}}$
3	Dd - Yy	$RT = \frac{\text{Voltage MV (Coil)}}{\text{Voltage LV (Coil)}}$
3	Dy	$RT = \frac{\text{Voltage MV (L-L)}}{\text{Voltage LV (L-L)} / \sqrt{3}}$
3	Yd	$RT = \frac{\text{Voltage MV (L-L)} / \sqrt{3}}{\text{Voltage LV (L-L)}}$

Figure 88: Ecuations to calculate the transformation ratio

12.3.2 Resistance of MV and LV windings

This test is performed to ensure that the internal connections of the transformer are not loose or open.

- Using an ohmmeter (multimeter) check the MV connection, connect the meter between each pair of MV terminals (UV, UW, and VW or H1-H2, H1-H3, and H2-H3).

  When the reading on the meter has stabilized, compare the results obtained with the values stated in the test certificate, there should not be a variation greater than +/- 5%.
- To verify the low voltage connection, connect the meter between each pair of LV terminals (xy, xz, yz or x1-x2, x1-x3, x2-x3).

  When the reading on the meter has stabilized, compare the

results obtained with the values stated in the test certificate, there should not be a variation greater than +/- 5%.

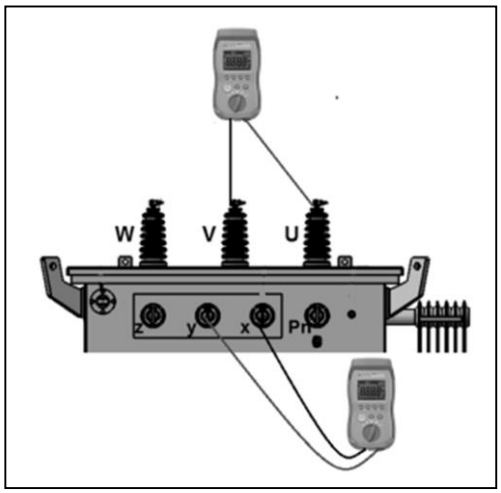


Figure 89: MV and LV continuity measurement

If, when carrying out the test, any of the following cases occurs, the transformer has suffered internal damage:

- When measuring the MV winding, some of the values returned are more or less double what is stated in the test certificate (figure 90).
- When measuring the MV winding, the meter does not register a measurement value.
- When measuring the LV winding, one of the values returned is more or less double that stated in the test certificate or does not register any value (figure 91).

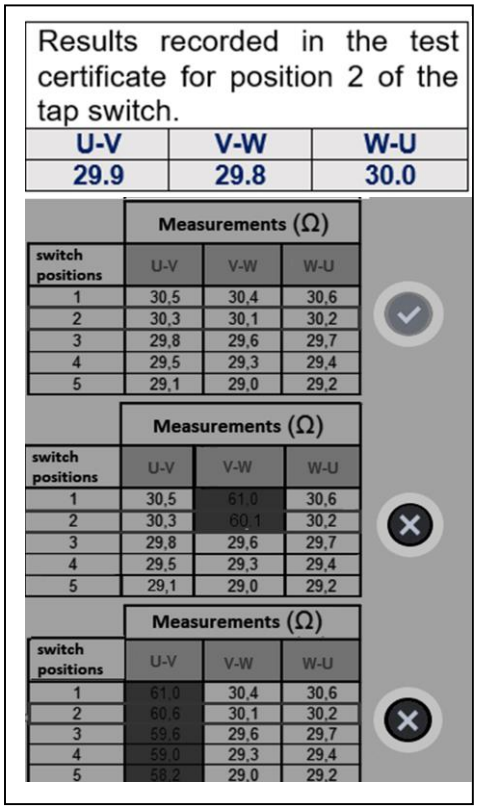


Figure 90: Examples of MV measurement

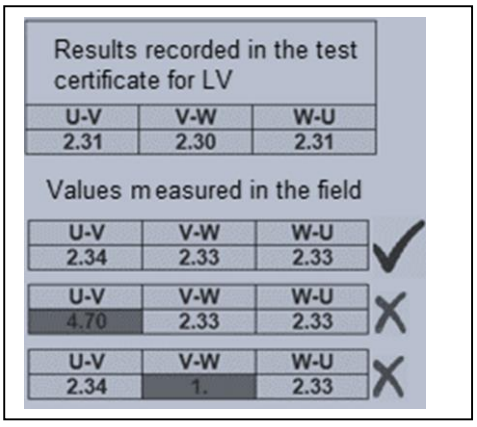


Figure 91: Examples of LV measurement

12.3.3 Insulation resistance

This test is carried out to have a vision of the state of the insulation in terms of contamination by the presence of water, metal particles or foreign elements suspended in the insulating liquid.

- Use a 5 kV megger with a measurement range of 50 MΩ mínimum (use the same factory test voltage to minimize drift).
- Test for one (1) minute for each measurement (MV vs LV, MV vs Grd, and LV vs Grd).
- Proceed as follows:

- Short circuit the MV terminals (U-V-W or H1-H2-H3).
- Short circuit the LV terminals (x-y-z or x1-x2-x3).

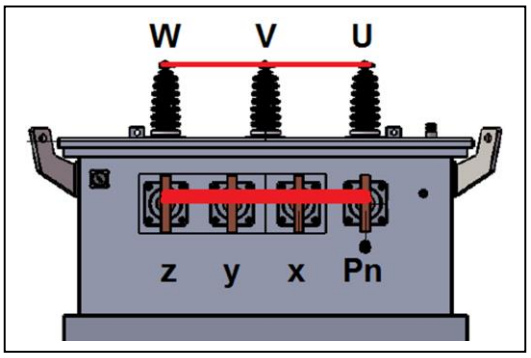


Figure 92: Short-circuit medium and low voltage terminals

- To carry out the different measurements (3) the cables are connected as follows:

- MV-LV: Power cable (+) in MV and black cable (-) in LV, the reference cable in a ground terminal.
- MV-Grd: Power cable (+) in MV and black cable (-) in Grd, the reference cable in LV.
- LV-Grd: Power cable (+) in LV and black cable (-) in Grd, the reference cable in MV.

- **Results analysis**

This test has no correspondence between the nominal power value, the transformer voltage and the insulation resistance, which is why the minimum values are left to the discretion of the manufacturer.

To verify if the values measured at the installation site are in accordance, keep in mind the following criteria:

- Compare the results obtained against those reported by MAGNETRON S.A.S. in the test certificate, these should be very close to or above what was measured at the factory.
- Take into account the minimum values established by MAGNETRON S.A.S. according to the class of the transformer.

Class (kV)	Minimum resistance (MΩ)
1.2	1,000
fifteen	10,000
34.5	50,000

- Apply James Biddle's empirical formula to calculate the minimum value of insulation resistance:

$$R = \frac{CE}{\sqrt{kVA}}$$

R = **Resistance at 20°C of the insulation measured in 1 min**

C = **Constant for measurements at 20°C**
C= **1.6 for transformers in oil**
C= **30 for dry transformers**
KVA= **rated power**
E= **Rated voltage in volts of the winding under test**

Caution: If you have any questions or think that water has entered the transformer, contact MAGNETRON S.A.S.

12.3.4 Frequency response analysis (SFRA)

It is a useful and sensitive method for testing the mechanical integrity of the core and windings of transformers, especially power transformers.

This test detects potential electrical and mechanical problems that other methods find don't find, such as:

- Deformations and/or displacement of windings.
- Movement of core and/or laminations in short circuit.
- Broken fixing structures.
- Defects in wire connections.

The SFRA test consists of applying a signal to the winding under test and measuring its response at different frequencies, expressing its behavior in unique graphs, like a "fingerprint", which are evaluated by comparison between them or with previous graphs.

- The SFRA test should be performed:
  - Before and after transportation.
  - Before and after the short circuit test.
  - After faults occur at high currents.
  - When an increase in dissolved gases is detected in the insulating liquid.
  - When deviations are detected in the transformation ratio test.

- Instructions things to keep in mind before running the test:

  - It must be carried out by qualified personnel.

  - Ensure that tests have not been carried out with direct current, which can affect the test results.

  - The transformer under test must be solidly grounded.

  - Configure the measurement equipment according to the connection group of the transformer under test.

  - Validate the correct operation of the measuring equipment.

12.3.5 Power factor (PF) measurement

The main objective of the power factor test is to diagnose the condition of the insulation, with this you can identify changes in their dielectric properties due to:

- Insulation failure
- Aging
- Particle pollution
- Partial discharges
- Presence of water

For the measurement of the power factor in the insulation of the transformer, the weather conditions and the temperature of the oil inside the transformer must be taken into account. ANSI C57.12.91 establishes that the tests must be carried out between 10°C and 40°C.

To carry out the test, the MV and LV Bushings must be short-circuited, taking into account that for star (Y) connections, the neutral must not be grounded.

- Instructions things to keep in mind before running the test:

  - It must be carried out by qualified personnel.

  - Locate the transformer under test in an area that has a security system or is demarcated.

  - Carry out an inspection of the test area, verifying that there are no outside personnel.

  - Make firm connections and check that the joints of the cables and the clamps do not tend to come loose.

  - Check that the equipment and transformer under test are properly grounded.

  - While the test is being carried out, personnel must be at least 1 meter away from the transformer.

  - When changing connections, block the

equipment with the security key.

- At the end of the test, make sure that the equipment is not injecting current, observe that the indicator lights are off.
- Disconnect the transformer.
- Use personal protection elements, they are mandatory and they reduce the risk of accident.

For the measured values of the power factor greater than those of reference, the possible failures within the transformer must be analyzed and in new insulating liquids, the possibility of polarization or water content must be analyzed.

Power Transformers	< 0.5%
Distribution transformers	< 1.0%
Remanufactured Power Transformers	
Remanufactured Distribution Transformers	< 1.5%
New insulating liquids	< 0.05%

Figure 93: FP reference values

12.3.6 Tests of protection accessories

All the alarm and trip signals of the transformer protection devices must be verified for their proper operation.
Among the devices to be checked are: winding thermometer, insulating liquid thermometer, buchholz relay, liquid level, etc.

12.3.7 Insulating liquid tests

The tests on the insulating liquid must be carried out when the transformer:

- During commissioning to ensure the good condition of the oil during the transformer transportation.
- When storage has been carried out outdoors or indoors for more than 2 months.
- When the insulation resistance results do not meet the criteria.
- When doubts arise due to the possible presence of water (moisture).

The tests on the insulating liquid are carried out to determine its conditions, ONLY with satisfactory results, the product can be energized.

The minimum tests required are:

12.3.7.1 Dielectric strength

This test measures the ability of the insulating liquid to withstand tension without failing.

Dielectric breakdown voltage is used to indicate the presence of contaminants such as water, dirt, or

conductive particles in the fluid, one or more of which may be present in significant concentrations when low breakdown voltages are obtained.

12.3.7.2 Water content

This test method covers the measurement of water present in insulating liquids by coulometric Karl Fischer titration.

The electrical characteristics of an insulating liquid can be negatively affected by excessive water content. A high water content can make a liquid insulating may not be suitable for some electrical applications due to deterioration of properties such as dielectric breakdown voltage.

12.3.7.3 Color

This test method covers the visual determination of the color of a wide variety of petroleum products, such as lubricating oils, heating oils, diesel fuel oils, and petroleum waxes

Using a standard light source, a liquid sample is placed in the test container and contrasts against colored glass disks ranging in value from 0.5 to 8.0. When an exact match is not found and the sample color falls between two standard colors, the larger of the two colors is reported.

12.3.7.4 Aspect (visual)

The insulating liquid should be optically clear in appearance to allow visual inspection inside the equipment tank.
When the insulating liquid presents a change in its appearance, it is an indication of oxidation, deterioration or contamination, product of the corrosion of metal or other undesirable materials.

12.3.7.5 Dissolved Gas Analysis (DGA)

This test should be performed only for transformers that have been working but for any reason were disconnected and store for more than two months.

The purpose of this analysis is to know exactly the different substances that make up the gases dissolved in the insulating liquid of the transformer.

According to the nature of the dissolved gases, the cause of the abnormality can be determined and corrective measures taken before failure occurs.

When the transformer is subjected to abnormal thermal and electrical stress, due to the degradation of the insulating liquid and insulating papers, certain combustible gases are generated. The type and concentrations of gases generated are important, as the normal aging process produces extremely small amounts of gases, while incipient conditions or declared failures generate large amounts.

Detection of an abnormal condition requires an evaluation of the generated gas concentration and generation trend. The amount of each gas, with respect to the total volume of the sample, indicates the type of failure that is in process.

There are two ways to represent the results of dissolved gases: From the individual concentrations and by the relationships between gases.

The typical gases generated by some incipient faults in power transformers are:

- Hydrogen,
- Oxygen,
- Nitrogen,
- Methane,
- Carbon monoxide,
- Ethane,
- Carbon dioxide,
- Ethylene,
- Acetylene.

The most common failure mechanisms are:

- Electric arcs in the insulating liquid and in the solid insulation; Corona, Low energy electrical discharges in solid insulation and general overheating or hot spots.

12.3.7.6 Other tests

Other tests that can be performed on the insulating liquid are listed below:

- Interface tension,
- Specific gravity,
- Neutralization number,
- PCB's content,
- Viscosity,
- Corrosive sulfur.

These tests are should be done when any of the following situations occurs:

- When the results of the minimum required tests show results that are very close to the minimum or maximum allowed,
- By request of MAGNETRON S.A.S.
- By customer request,
- At the request of an external entity.

12.3.7.7 Sample Quantity Required

To carry out the tests on the insulating liquid, the following are required:

Test	Quantity
Water content Dielectric strength Color and appearance Interface tension Specific gravity Goo	1000 ml
Oil power factor at 25 °C	1000 ml
Corrosive sulfur	100 ml
Dissolved gas analysis	50 ml
Quantitative analysis of PCB's	500 ml

12.3.7.8 Reference values

- Mineral oil

Method and test	Reference value
Dielectric strength ASTM D1816	≥35kV
Water content ASTM D1533	≤35ppm
Color ASTM D1500	≤0.5
Aspect ASTM D1524	clear and bright

- Vegetable oil

Method and test	Reference value
Dielectric strength ASTM D1816 1mm gap 2mm gap	 ≥20kV ≥35kV
Water content ASTM D1533	≤200ppm
Color ASTM D1500	≤1.0
Aspect ASTM D1524	clean and clear

Note: Any deviation from the tests and reviews listed in this section must be notified to MAGNETRON SAS in order to receive instructions on how to proceed and not put the transformer at risk. Failure to do so will result in the loss of the warranty.

13. Installation and commissioning

Caution: For Colombia, the installation of the transformer must be done according to the requirements of the technical standards NTC-2050, NTC-3582 and the technical regulation of electrical installations (RETIE).

For other countries, the rules or laws that apply to them must be followed.

The installation of the transformer is not the responsibility of MAGNETRON SAS (unless otherwise specified in the contract), however, as an interested party that the product fulfills its function in the best conditions, the following considerations must be followed:

13.1 Mounting

The installation of the transformer must be carried out in an easily accessible place, where assembly and removal by crane or forklift is guaranteed, with the capacity to lift and transport the transformer.

The transformer must be installed in a place with a sufficient area that allows easy access to carry out inspection, cleaning, maintenance, etc.

If the installation of the transformer is done in closed places (interiors), good ventilation must be guaranteed to avoid abnormal heating.

If the transformer is equipped with fans, it must be ensured that they run in the correct direction.

13.2 Grounding system

- The low voltage neutral point, the tank and the SPDs must be solidly grounded.

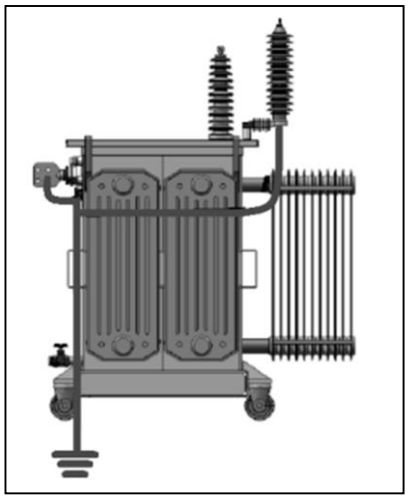


Figure 94: Grounding parts of the transformer

Note: Cabinets and control and protection accessories that require it must also be grounded.

- The grounding system has the following objectives:

  - Guarantee the safety of living beings.
  - Protection facilities.
  - Electromagnetic compatibility.
  - Allow protection teams to quickly clear faults.
  - Serve as a common reference to the electrical system.

- Reference values for the grounding system.

Application	Maximum values of grounding resistance (Ω)
Structures and metallic turrets of lines or networks with guard cable	twenty
High and extra high voltage substations	1
medium voltage substations	10
lightning protection	10
Low voltage connection neutral point	25
Networks for electronic or sensitive equipment	10

13.3 Connection sequence

- Make all connections to the grounding system.
- Make the LV connections.
- Make the MV connections.

Caution: The connections cannot be stressed. The medium voltage ones must have a shape and mechanical rigidity that does not allow them to move with the wind or vibrations.

13.4 Commissioning

Caution: To energize the product, it must be guaranteed that the tests and revisions listed in numeral 12 of this manual gave compliant results; otherwise, the energization cannot be carried out and you must contact MAGNETRON SAS personnel to receive instructions.

Also, remember to use the appropriate tools and protections, such as: Pole, dielectric gloves, rubber boots, etc.

- Once the transformer is installed, leave it at rest for a minimum of 12 hours for transformers with mineral oil and a minimum of 18 hours for transformers with vegetable oil.

- Energize the transformer at no load (no load), keep it like this for about 12 hours.

- Make sure that the transformer does not produce abnormal noises (humming, crackling, flickering, etc.).

- Check the output voltage and check that is balanced and within what is required.

- Gradually install the load and keep checking the output voltage.

- Once all the load is installed, check the operation of the transformer for several hours.

- Keep a written record of the final installation conditions.

- Clean and order the work area.

13.4.1 Energizing transformers with vegetable oil at temperatures below -20°C

Caution: For no reason activate the mobile components (disconnector, switch, magnex, breaker, etc.) before or shortly after their energization.

The C57.12.00-1993 standard considers that initial temperatures below –20 °C are unusual service.

The energization of the transformers immersed in vegetable oil at temperatures below -20°C, can follow the same sequence of the immersed transformers. in mineral oil, as long as the following criteria are met:

- Store transformers in such a way that no mechanical movement is required to energize the transformer (ie: disconnect switch in CLOSE position, tap changer anchored in work position, etc.), taking this approach, no mechanical movement should be required. Mechanical movement to energize the transformer.

- Do not activate mobile components (disconnector, switch, magnex, breaker, etc.) before or shortly after energizing; in extreme temperature conditions, the insulating liquid becomes more viscous (begins to thicken and, over time, may gel), hindering the mechanical maneuvering of the components and extinguishing electrical arcs more slowly.

- Energize the transformer empty (no load), keep it like this for a minimum of 18 hours.

  Note: Monitor the temperature of the insulating liquid, until it is above room temperature.

- Gradually connect the load.

- After all the load is installed, observe the operation of the transformer for a while.

- To change an internally damaged component (a BAY-O-NET fuse, for example), when the ambient temperature is below -30°C, the transformer must be heated to make the vegetable oil more liquid.

- In transformers with forced ventilation system (fans), during cold start, the insulating liquid of the radiators will heat up more slowly than the insulating liquid of the main tank. For this reason, the fans should not be turned on immediately, they should be turned on when additional cooling is required.

For more information, you can consult the following standards:

- C57.12.93,
- C.57.106
- C.57.12.00.

Or, the guidelines of Cargill, supplier of vegetable oil (FR3):

- G2200S “Transformer Repair Guide”.

- G2300S “Guide for storage, installation, commissioning and maintenance of transformers immersed in FR3 fluid”.

- R2120 “Cold Start Recommendations for Envirotemp FR3”.

13.4.2 Energizing transformers with mineral oil at temperatures below -20°C

The C57.12.00 standard considers initial temperatures below –20°C to be unusual service.

For starting temperatures below –20 °C, energize the transformer and keep it without load for a minimum of 12 hours.

Dielectric fluids can exhibit a drop in dielectric strength at lower temperatures if moisture precipitates. If, at any temperature, the density of the insulating liquid is greater than the density of water, free ice or free water could exist in the system and cause dielectric discontinuity and possible failure.

Any extremely cold transformer should be energized with no load and then gradually increase the load.

Temporarily, localized temperatures may exceed normal values.

These transient conditions are easily tolerated by a properly designed transformer.

At very low ambient temperatures, it will take some time before external radiators are effective, but at these low temperatures, additional

cooling should not be necessary.

Never energize a transformer with mineral oil with temperatures under -40 Celsius, this represents a big risk of failure, the transformer must be heated by external elements before energization.

14. Transformers with two or more months in storage

If the transformer has been stored for a period equal to or greater than two months, without being energized or since its last energization, the following procedure must be followed:

- Perform the tests described in this guide, from 12.2.1 to 12.2.5.
- If and only if the results are satisfactory, proceed as follows:
  - ✓ Energize the transformer without load, for a minimum of 12 hours for mineral oil transformers and a minimum of 18 hours for vegetable oil transformers.
  - ✓ Once the minimum energizing time without load has expired, gradually connect the load, according to the following table:

Connection of the load once the energization time has elapsed (Hours)	% Burden
3	25
6	50
9	75
12	100

- Once all the load is installed, periodically check the operation of the transformer.
- Keep a written record of the final installation conditions.
- Clean and order the work area.

If during the execution of the tests described in this guide, from numeral 12.2.1 to numeral 12.2.5, you encounter any inconvenience, take into account the recommendations in the table below:

Note: If the inconvenience(s) persist(s), do not intervene on the transformer and contact MAGNETRON S.A.S.

Inconvenience presented What to review?	Does not give transformation ratio	It does not give resistance of the windings in MV	Very low insulation resistance	short in insulation resistance	Insulating liquid does not meet the criteria
Check condition of measuring equipment and cables	X	X			
Check correct interlocking of the switch	X	X			
Check disconnector, properly closed	X	X			
Check connection of the TTR to the transformer, according to the connection group,	X				
Check the status of the BAY-O-NET fuses	X	X			
Check correct adjustment of the fuses to the BAY-O-NET	X	X			
In mesh or ring type transformers, check that the equipment is connected in the well or insert bushings according to the position of the disconnector	X	X			
Check measuring equipment, that it is in the correct range		X			
Cleaning of MV and LV terminals			X		
Test temperature			X		
Correction results by temperature			X		
Check that the neutral point is disconnected from earth				X	
If it has an electrostatic screen, it must not be grounded.				X	
Review sampling process					X
Take a second sample to validate results					X
Take sample when the no-load energization time has elapsed					X

15. Maintenance

Caution: If it is not carried out and evidence of the execution of preventive maintenance, it will cause the loss of the guarantee.

Caution: During the warranty period, report all failures or eventualities to MAGNETRON SAS, for no reason does the transformer intervene.

To intervene on the transformer, disconnect the MV and LV voltage sources in order to put it out of service.

Disconnect the MV terminals, short them and connect them to the grounding system.

Disconnect the LV terminals, short them and connect them to the grounding system.

Delimit and mark the work area.

The transformer is an electrical machine designed and manufactured to function 20 years or more under normal conditions of use.

The owner of the transformer is responsible for inspecting, maintaining and keeping it in good condition.

Periodic maintenance and permanent inspection will contribute to the safe and reliable operation of the transformer.

To help you for this purpose, the following must be followed instructions:

15.1 Preventive Maintenance

The following inspections can detect potential operational problems before they become critical, should be done at least once a year:

- External inspection
- Internal inspection
- General inspection
- Insulating liquid tests
- Routine electrical tests
- Tests to protection devices

15.1.1 External inspection

Review and record the external conditions of the transformer.

The inspection must include the following points:

- Leakage of insulating liquid
- Grounding System Conditions
- State of the paint, verifying possible oxidation points.
- Control box Internal inspection of terminal blocks
- Fan operation
- Verification of external electrical connections.
- Verification of tap changer operation.
- State of silica gel
- Status of control or protection accessories
- Condition and cleanliness of the tank.

- Condition and cleanliness of the MV and LV bushings.
- Condition and cleanliness of the source arrestors (DPS).
- Condition and cleanliness of the packaging.
- Condition and cleanliness of the overpressure valve.
- Condition of the junction boxes, verifying that they do not show signs of oxidation, presence of water or loose or misaligned terminals.

Eventualities that may arise must be corrected.

15.1.2 Internal inspection

It will only be carried out if a transformer failure is detected or suspected. This inspection will be carried out by MAGNETRON SAS personnel or by personnel from an authorized workshop.

15.1.3 General inspection

The inspection includes checking the temperature of the insulating liquid and the windings, the level of the insulating liquid and the internal pressure.

It is important to record the measurements, they serve as a reference for future inspections and help identify potential failures or abnormalities.

15.1.4 Insulating liquid tests

Tests must be carried out on the insulating liquid every year, the tests that must be carried out are:

- Dielectric strength (ASTM 1816, ASTM D877).
- Power Factor (ASTM D924).
- Specific Gravity (ASTM D1298)
- Color (ASTM D1500)
- Interface tension (ASTM D971).
- Neutralization Number (ASTM D974).
- Water content (ASTM D1533).
- Dissolved Gas Analysis (ASTM D3612).

15.1.5 Routine electrical tests

Electrical tests must be performed with the transformer de-energized. They must be carried out every year, when there are doubts about its proper functioning or when an external event occurs.

The tests to be carried out are:

- Transformation relation
- Insulation power factor
- Winding resistance
- Insulation resistance

15.1.6 Tests to control or protection devices

The proper functioning of these devices must be checked every year.

15.2 Corrective maintenance

- During the warranty period, report all failures or

eventualities to MAGNETRON SAS, for any reason whatsoever, do not intervene on the product.

- For interventions outside the warranty period, contact MAGNETRON S.A.S. or use a specialized transformer workshop.

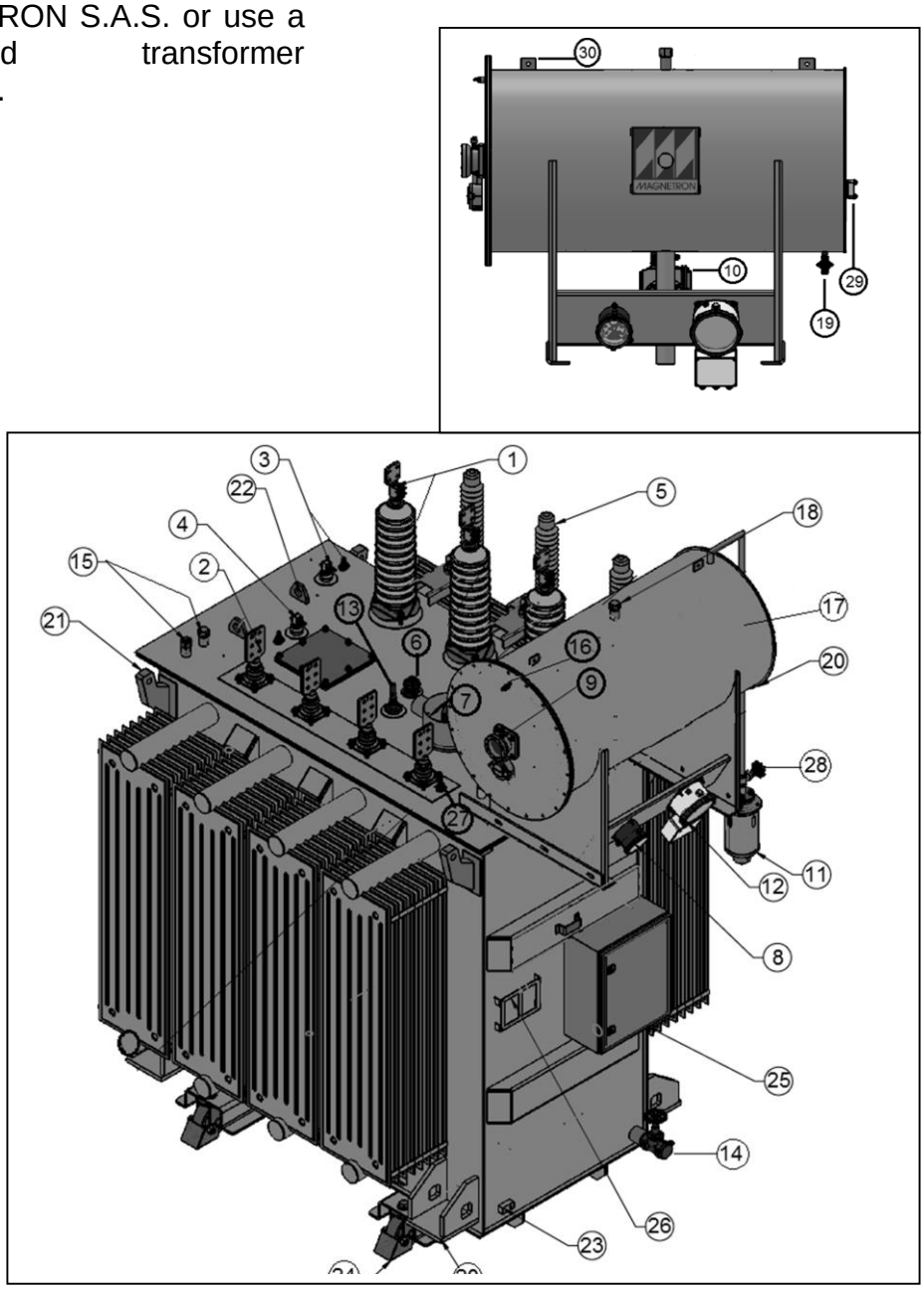


Figure 95: External parts of the transformer

Item	Description
1	MV insulators and terminals
2	LV insulators and terminals
3	Electrostatic shield insulator + grounding
4	Core insulator + landing
5	Damage dealer + supports
6	Switch
7	Overpressure valve + contacts
8	Insulating liquid thermometer + contacts
9	Oil level + contacts
10	Buchholz relay
11	Silica gel respirator
12	Thermometer windings + contacts
13	Current transformer
14	Drain and Sampling Valve
15	Valve or filler nipple + filler nipple with filter
16	Nitrogen Fill Valve
17	Expansion tank (conservative)
18	Expansion tank filling (conservative)
19	Expansion tank drain valve
20	Crawling and pulling device
21	Transformer hoisting devices
22	Lid lifting devices
23	Tank grounding
24	Caster wheels
25	Control panel
26	Rating plate
27	Neutral point grounding
28	Silica gel respirator valve
29	Contactless oil level
30	Expansion tank lifting device

16. Repair

- The owner of the transformer is responsible for inspecting, maintaining and keeping it in good condition.

- During the warranty period, report all failures or eventualities to MAGNETRON S.A.S. for any reason whatsoever, do not repair the product without prior written authorization.

- All repairs under warranty must be done by MAGNETRON SAS or an authorized service workshop.

- For repairs outside the warranty period, contact MAGNETRON SAS or use a specialized transformer workshop.

17. Problems and possible Soliciónsolutions

- Remember to fully comply with the numerals of “Review and tests before installation” and “Installation and commissioning” (numerals 12 and 13).
- The adjustment of the accessories must be done with a torque wrench, applying the torques listed in numeral 18 "Adjustment torques"**.**
- Adjustment of accessories is done externally only, for internal adjustments please contact MAGNETRON S.A.S. or with an authorized workshop.

Inconvenience presented **What to review?**	Expels the canuelas	Blow the fuses	Voltage difference between LV phases	It does not give voltage output in LV	Insulating liquid stain on the VSP	Insulating liquid stain on accessories
Connection of the transformer to the MV line	X			X		
Lightning rod state	X					
Lightning rod characteristics	X					
Energize no load	X	X				
Check condition of fuses		X				
Check that the fuses are correct (amperage)		X				
Correct landing of the transformer (tank)		X	X			
Correct landing of the Pn			X			
Check wiring connection settings			X	X		
Clean and monitor if persists					X	X
Check tightening torque (externally)					X	X
Check input voltage				X		
Check input voltage		X				
Correct anchoring of the commutator				X		
Test the transformer	X			X		

Inconvenience presented / What to review?	Does not give transformation ratio	It does not give resistance of the windings in MV	Very low insulation resistance	short in insulation resistance	Insulating liquid does not meet the criteria
Check condition of measuring equipment and cables	X	X			
Check correct interlocking of the switch	X	X			
Check disconnector, properly closed	X	X			
Check connection of the TTR to the transformer, according to the connection group,	X				
Check the status of the BAY-O-NET fuses	X	X			
Check correct adjustment of the fuses to the BAY-O-NET	X	X			
In mesh or ring type transformers, check that the equipment is connected in the well or insert bushings according to the position of the disconnector	X	X			
Check measuring equipment, that it is in the correct range		X			
Cleaning of MV and LV terminals			X		
Test temperature			X		
Correction results by temperature			X		
Check that the neutral point is disconnected from earth				X	
If it has an electrostatic screen, it must not be grounded.				X	
Review sampling process					X
Take a second sample to validate results					X
Take sample when the no-load energization time has elapsed					X

18. Tightening torques

Caution: The torques listed correspond to the hardware described in each accessory, consult MAGNETRON S.A.S. whenever an adjustment is required.

Not all the accessories that are part of the transformers are listed.

The different adjustments that are made in the external accessories of the transformer, should be to do following the recommendations of the suppliers regarding torques and sequence of adjustment. The most relevant are listed below:

18.1 Screws in general

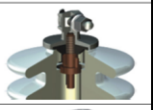
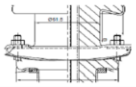
Torque (lbf * ft)						
Iron				Stainless steel		
Diameter	Grade 2	Grade 5	Grade 8	Diameter	A304	A316
1/4	5,5	8	12	1/4	6	7
5/16	11	17	25	5/16	11	12
3/8	20	31	44	3/8	20	21
7/16	32	49	70	7/16	31	33
1/2	49	75	107	1/2	43	45
9/16	70	109	154	9/16	56	59
5/8	97	150	212	5/8	92	96
3/4	173	266	376	3/4	127	131
7/8	166	429	606	7/8	194	202
1	250	644	909	1	286	299
1-1/8	354	794	1287	1-1/8	413	432
1-1/4	500	1120	1875	1-1/4	523	546
1-3/8	655	1469	2382	1-1/2	888	930
1-1/2	870	1950	3161			

Note: The tightening torques in the table correspond only to the screws, wh used to hold accessories (porcelain, polymers, etc.) the tightening torque is defined by the material.

18.2 Lid-Tank screws adjustment

Screws		
Torque (lbf * ft)		
Diameter	80%	100%
5/16"	14	18
7/16"	32	40

18.3 MT and LV bushings

Product	lbf * ft	Image
MT spider nut	70	
BT spider nut	29	
BT aluminum nut	35	
Stud adjustment to connect MT	18	
Anchor adjustment 7 mm to 11.9 mm	13	
Anchor adjustment 12 mm to 16 mm	15	
Anchor adjustment 19 mm to 32 mm	19	
Bolt adjustment for external clamping flanges	12	

18.4 Tap charger switch

Accessory	lbf . ft	Image
SWITCH nut	8 to 9	
Linear commutator nut	11	

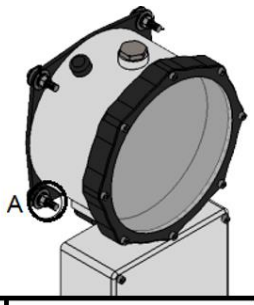
18.5 Overpressure valves

Overpressure valve	Tightening torque	Image
1/4"	20 to 25	
1/2"	54	
3/4"	83	
1-1/4"	121	

18.6 Winding thermometer

Detail	Description	TORQUE (lb-ft)
A	3/16" INOX thread fitting	4.6

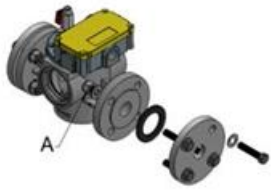
18.7 Two (2) Contacts Oil Thermometer



Detail	Description	TORQUE (lb-ft)
A	1/4" stainless screw adjustment	6

18.8 Buchholz relay

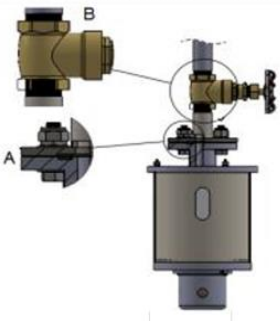
Recommended tightening torques		
N° ITEM	Description	TORQUE (lb-ft)
A	Stainless steel screw adjustment 7/16"	31



18.9 Silica gel breather

CONSIDERATIONS: ADJUST WITH THE RECOMMENDED NUMBER OF TURNS (TPFT), IF YOU CANNOT ACHIEVE THE ADJUSTMENT IN THE ACCESSORIES, PROCEED APPLYING THE ASSIGNED TORQUE.

RECOMMENDED TIGHTENING TORQUE			
DETAIL	DESCRIPTION	# OF TURNS (TPFT)	TORQUE (LB-FT)
A	STAINLESS STEEL SCREWS ADJUSTMENT	-	31
B	3/4" NPT AND VALVE NIPPLE ADJUSTMENT	1.5 to 3	78



19. Environment

MAGNETRON SAS is a company committed to the environment, for this reason, our transformers meet all the requirements related to the subject.

MAGNETRON SAS has identified potential risks that may cause harmful environmental effects on the environment.

MAGNETRON SAS itself provides its clients with a series of environmental advice, in order to prevent and minimize contamination throughout the life cycle of the transformer.

The environmental councils are consigned in the environmental management plan, made up of 5 environmental management programs.

If you want to know more about environmental programs, contact MAGNETRON SAS

The final receiver of the transformer must comply with current legislation and that applies to it.

In the event of leakage of the insulating liquid, must be collected in a container, avoid it falling on the ground.

- If insulating liquid has been spilled on the floor, clean it up with an absorbent material (example: sawdust).
- The insulating liquid that has been collected and the media used for cleaning must be treated as toxic and hazardous waste.
- Waste should not be mixed.

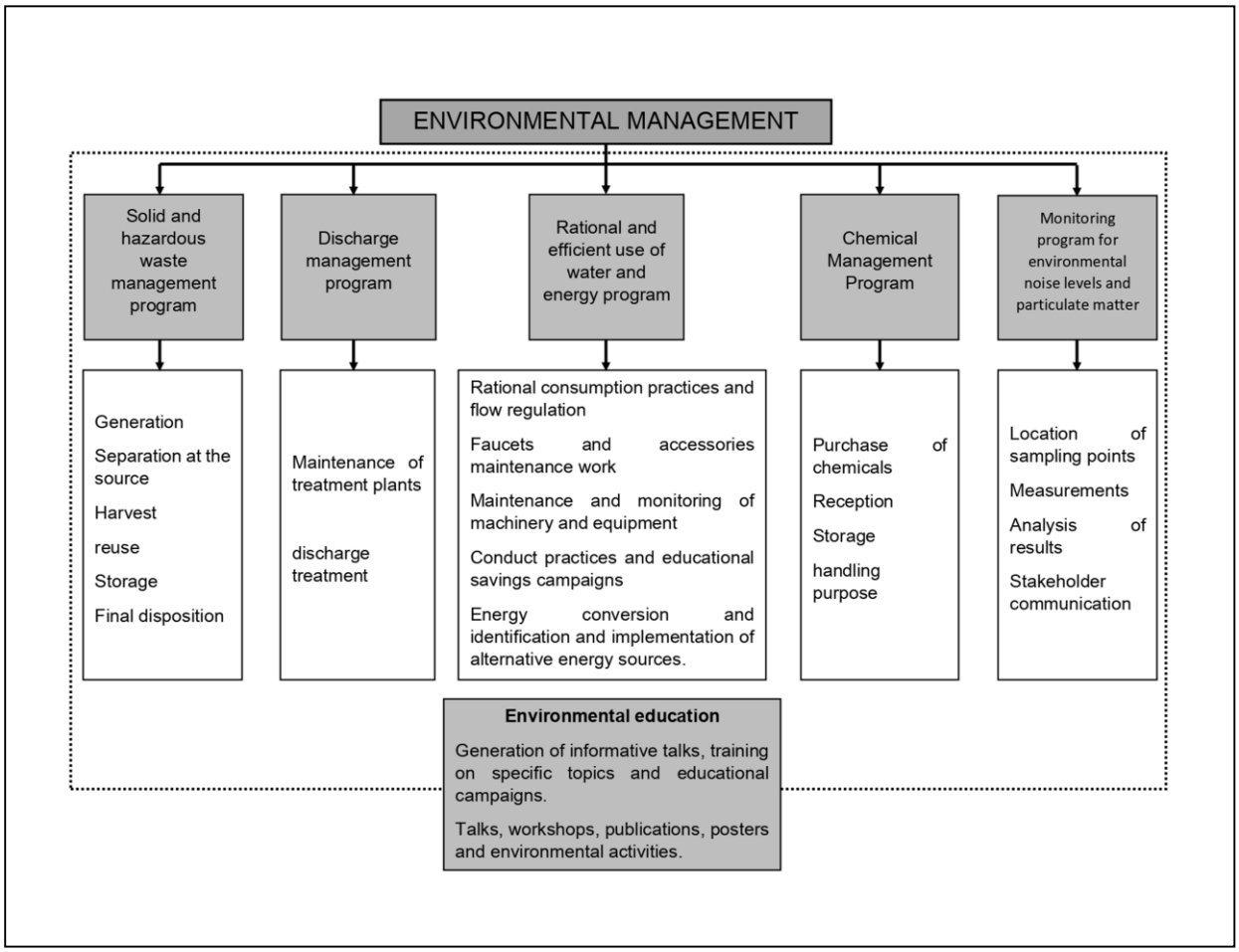


Figure 96: MAGNETRON SAS Environmental Management Plan

20. Warranty terms and conditions

Refer to the guarantee certificate that is delivered with each product; behind it, there are the instructions that must be followed to make the guarantee effective and the conditions that invalidate it.

21. Contact Us

For more information or to provide technical support, contact us through the following means:

	servicioexterno.magnetron.com.co
	customerservice.magnetron.com.co
	(57) 3187117456 (57) 3157100 extension 101