Instruction manual for packaging, transport, handling, installation, storage and maintenance of self-protected single-phase and three-phase distribution transformers immersed in insulating liquid

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 S.A.S.

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 flow freely)
- 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 rotation system on field.
- Use screens or protective shielding, for radioactive sources.
- Apply the 5 golden rules when working with energy.

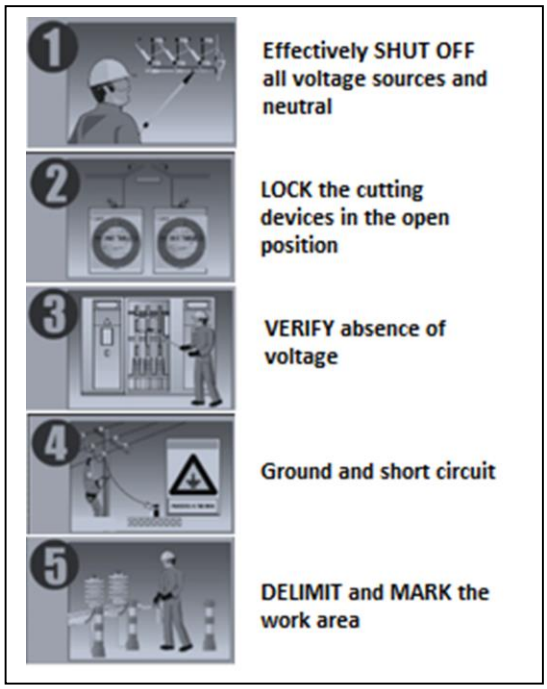


Figure 1: 5 golden rules

➢ 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, theoretically and practically, on 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 intervening in 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.

As described in numeral 3, a self-protected transformer is one which has internally, in addition to the normal operating accessories, protection elements against overvoltages, overloads and short circuits.

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

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

The self-protected transformers manufactured by MAGNETRON SAS are mainly used in residential service loads where electricity companies require load control.

2.1 Operating principle

The maximum load of a transformer is conditioned by two types of limitations:

2.1.1 Thermal limitation

The load causes a rise in the transformer temperature above a critical value and results in the premature aging of the insulation and the reduction of the useful life of the transformer.

Due to the fact that the effects of deterioration produced by temperature are cumulative, it is possible to obtain a satisfactory life of the transformer insulation with temperature peaks that exceed the values allowed under continuous load, as long as the duration of these temperatures is sufficiently restricted.

The protection elements must mainly control that the temperature does not exceed the critical value, interrupting the service when the overloads reach that temperature.

2.1.2 Economic limitations

It is the load from which the cost of the losses due to the Joule effect advises the replacement of the transformer by another one of greater power.

2.2 Basic types of self-protected distribution transformers

2.2.1 Surge Protection (SP)

The SP protection scheme includes the SPD transformer mount and expulsion fuse. It does not include a switch in any of its windings.

2.2.2 Overcurrent Protection (CP)

The CP protection scheme is equipped with medium voltage protection fuses and an internal switch that can be installed in both the medium voltage and low voltage circuits, depending on the customer's requirement. Does not include SPD mounting.

2.2.3 Fully Self-Secured (CSP)

In the CSP protection scheme:

- The lightning rod protects the transformer from surges caused by atmospheric discharges and/or switching operations.
- The protection fuse operates to disconnect the transformer from service in the event of an internal fault.
- The switch provides the transformer with a protection against overloads and short circuits, either in medium or low voltage, depending on the selected protection.

In this scheme there are two types of configurations:

- With BREAKER, for low voltage winding.
- With MAGNEX, for medium voltage winding

Note: The self-protected transformers can be supplied with a low voltage cabinet, at the customer's request. This cabinet is known as anti-fraud or armored.

A more detailed description is provided in ANNEX A.

2.3 Self-protection overview

2.3.1 Surge protection

They are voltage surges that can cause serious problems to the equipment connected to the line, from its premature aging to fires or destruction of the equipment.

The transformer has built-in elements that provide protection against external and internal surges that may occur during its operation.

2.3.2 Overcurrent protection

A CSP transformer incorporates elements that provide protection against the different types of overcurrents to which it may be exposed during its operation. Additionally, overcurrent protections must not operate when energizing currents (Inrush) occur, since they correspond to normal

operating conditions, typical of the transformer or the circuit they feed.

2.3.3 Overload protection

The purpose of overload protection is to prevent an accelerated deterioration of the transformer's insulation and therefore of its useful life.

The element in charge of the protection disconnects the load that feeds the transformer before the loss of useful life exceeds the value desired by the network operator.

The causes of overload are usually temporary, therefore, the protection element must allow the reconnection of the load once they disappear and the temperature inside the transformer is reduced.

2.3.4 External short circuit protection

The transformer has a protection that disconnects the power from the low voltage circuit, when short-circuit occurs due to faults in the secondary network.

This is, for all short-circuit currents whose magnitude is equal to or less than the nominal short-circuit current, determined by equation 1.

The protection element allows the load to be reconnected when the condition that caused the failure in the secondary network is eliminated.

2.3.5 Internal short circuit protection

In the event of an internal failure the transformer has a protection that disconnects it from the network, the protection operates for all those short-circuit currents whose magnitude is greater than that calculated by equation 1 and less than the short-circuit capacity of the network.

Once the protection element acts, it must not allow the reconnection of the transformer to avoid the repercussions caused by the connection of a transformer in fault conditions.

$$I_{ccn}(p.u) = \frac{100}{Z_{cc}(\%)}$$

Equation 1: Short-circuit current in pu

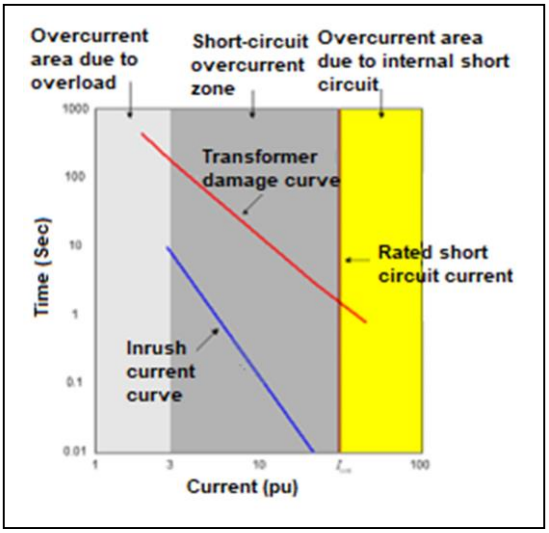


Figure 3: Self-protection protection zones

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

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

3. Definitions

3.1 Transformer

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

3.2 Fully self-protected transformer

Device that has incorporated from its design and manufacturing stage, protection elements against surges, overloads, external short circuits and elements to isolate it from the network in case of failure.

3.3 Emergency working condition

It is that situation in which the transformer, although it works under overload conditions, should supply the demand for electrical energy to the users connected to it. This emergency working condition decreases the expected useful life of the transformer under normal conditions.

3.4 Normal working condition

It is that situation in which the transformer supplies the electrical energy demand to the users within the limits of its capacity, conserving the minimum expected useful life of the equipment.

3.5 Self-protection function

Function integrated in the transformer to prevent external consequences as a result of a failure in it (explosion, tank rupture, electric arcs, splashing of substances, etc.).

3.6 Disconnection function

Automatic interruption of the connection between the medium voltage terminals and the active part of the transformer by operation of the self-protection and disconnection device. The purpose of this function is to eliminate voltage and current on the low voltage side.

3.7 Isolation link

Part that melts when current passes but does not have an extinguishing chamber and therefore cannot be used alone as a fuse. For this reason, it must be connected in series and coordinated with a fuse so that both open simultaneously. By leaving the circuit open and being in series with the fuse, this piece prevents the re-energization of the transformer.

3.8 Switch

Device designed to open and close a circuit manually or automatically, interrupting a current whose magnitude is less than or equal to its interruption capacity, without damaging it.

3.9 Overload current

Current whose magnitude is usually between 1 and 3 times the rated current of the transformer.

3.10 Overcurrent

It is any current whose magnitude is greater than the magnitude of the rated current of the transformer.

3.11 Surge

It is any voltage between phase and ground or between phases of the system, whose value is greater than the maximum voltage value when the system operates normally. Overvoltages are classified by their duration as temporary and transient.

3.12 Primary winding

Winding that is connected to a power source.

3.13 Secondary winding

Winding to which a load is connected.

3.14 Medium voltage winding

Winding with the highest voltage.

3.15 Low voltage winding

Winding with the lowest voltage.

3.16 Packaging

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

3.17 Packing basis

Flat and strong structure made of wood or metal that serves to protect and support the weight of the transformer.

3.18 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.

3.19 Danger

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

3.20 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

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
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
p.u	Per unit
PTS	Grounding system
Grd	Grounding
VSP	Overpressure valve

5. Handling

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

Keep the transformer on the base on which it is shipped to the site where it will be installed, as this provides greater protection.

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

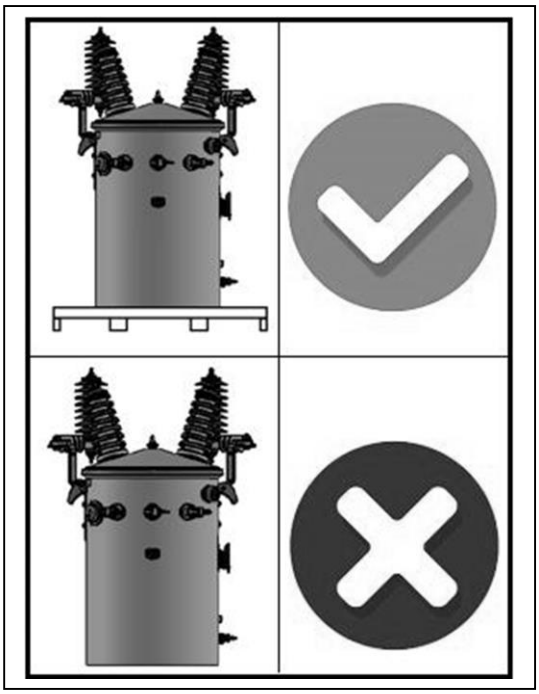


Figure 4: Transformer on the base and strapped to it

For no reason allow the transformer to be dragged directly on the floor, the tank may suffer deformations or the paint could deteriorate, giving rise to the oxidation of the metal sheet.

The transformer must not be lifted or moved by holding it by the medium or low voltage terminals or by any accessory that is not the lifting lugs, since they are very fragile parts and can suffer damage.

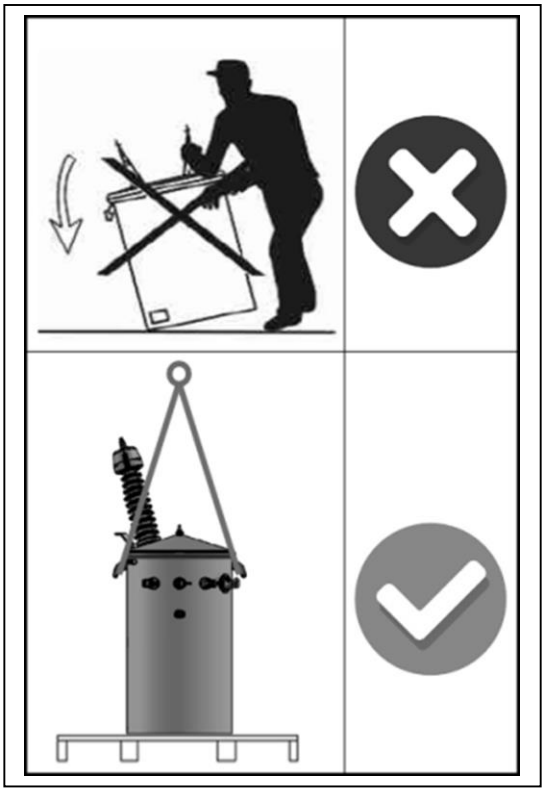


Figure 5: Handling transformers.

Do not lift or move the transformer by placing crowbars or jacks under accessories, connections, 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.

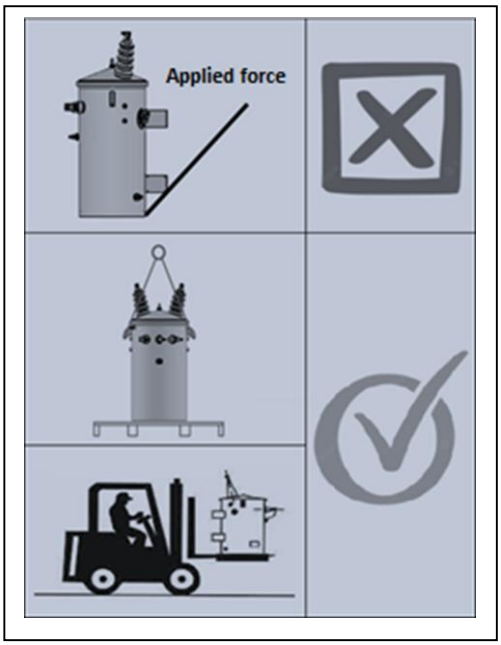


Figure 6: Levers or movements not allowed.

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.

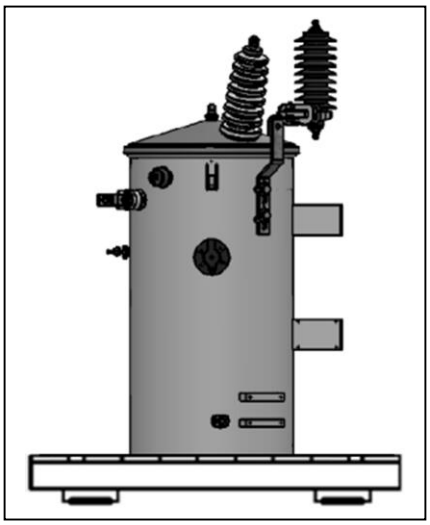


Figure 7: Use of skids for transportation

The transformers are provided with lifting devices or lifting lugs that are used to handle it with a crane, should be use fiber slings as these help protect the paint.

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

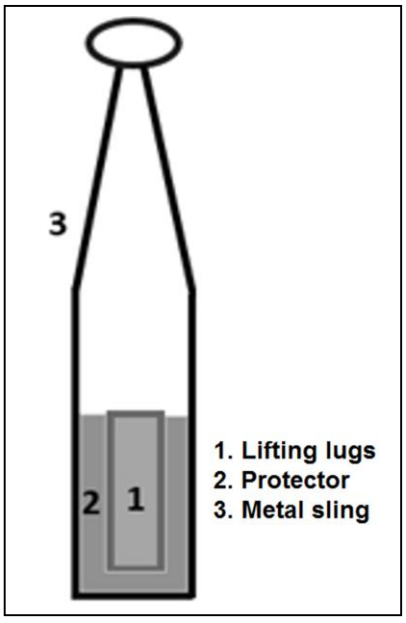
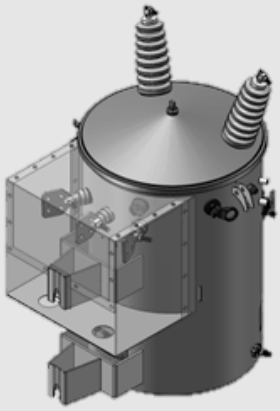


Figure 8: Paint protection on the lifting lugs

Do not use the lifting lugs to transport the transformer, these devices are designed for lifting only.

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

Caution: For no reason should it be supported or stopped on the transformer cabinets, the LV or MV bushings, or any control or protection element.



6. Packaging

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

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

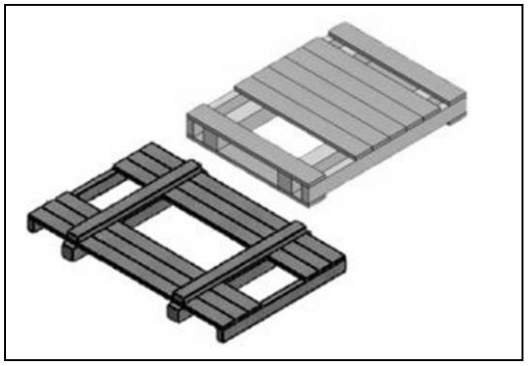


Figure 10: Wooden bases

The transformer must be attached to the base of the packaging, to prevent it from suffering issues caused by sudden movements. The coupling can be done, depending on the base of the transformer; through straps, screws or wedges in the supports to hang to the pole.

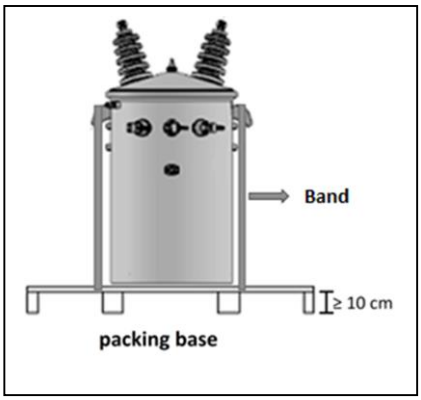


Figure 11: Transformer-base coupling with strap

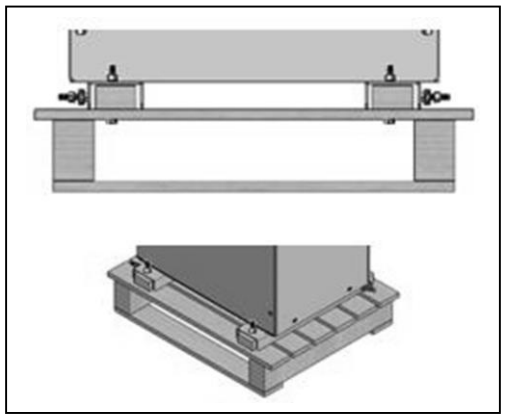


Figure 11-1: Transformer-base coupling with screws

For transformers that must be lifted or transported by crane (by weight or size) and that are crated, it must be ensured that the lifting lugs remain free and easily accessible for the location of the slings or slings.

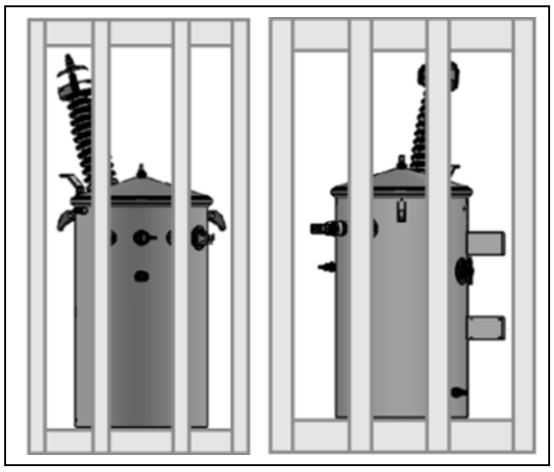


Figure 12: Easy Access Lifting lugs

The transformer packaging must be arranged in such a way that it does not obstruct access to the information stated in the nameplate, especially when it is crated.

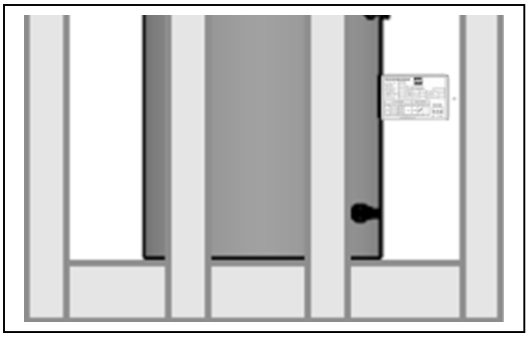
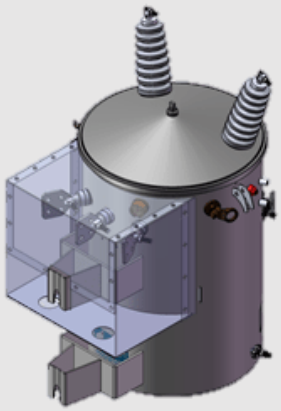


Figure 13: Visible nameplate

Caution: For no reason should it be supported or stopped on the transformer cabinets, the LV and MV bushings, or any control or protection element.



7. Transport

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.

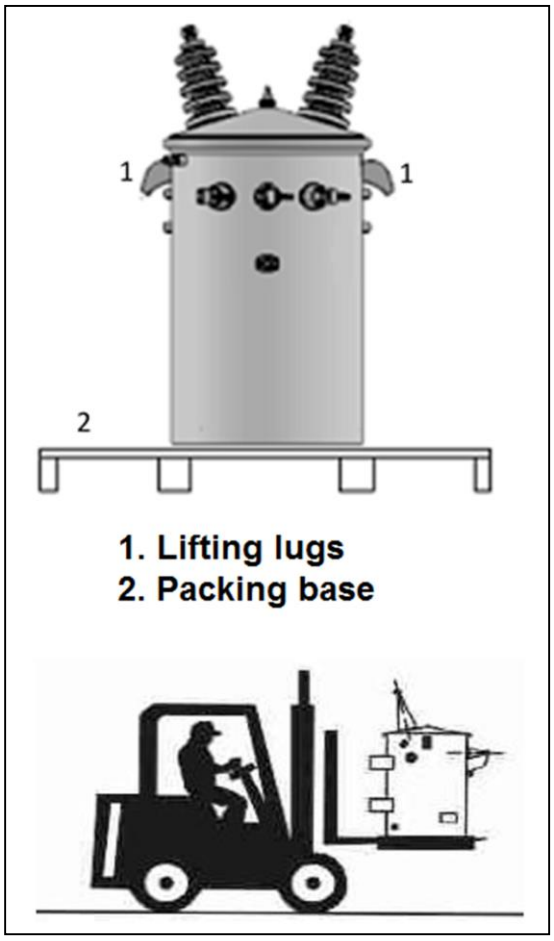


Figure 14: Parts to lift the transformer.

When lifting the transformer from the lifting lugs, be sure not to rub or touch the bushings or any accessories with the slings.

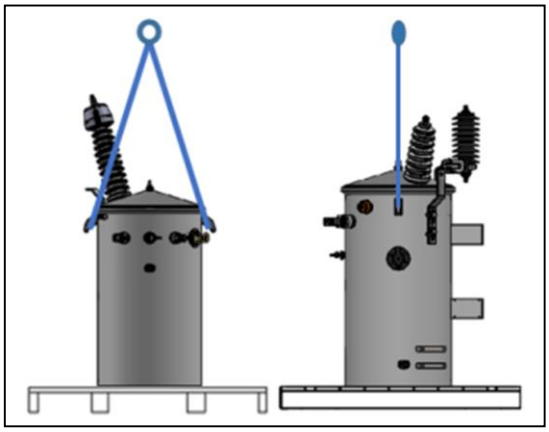


Figure 15: Elevation of the transformer from the lifting lugs

7.1 Load distribution

7.1.1 Transformers without crate

When a considerable number of transformers are transported, the load must be distributed within the truck or container.

The base of the transformers acts as a separator, when there are spaces between them, wooden wedges must be set between them and the floor.

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

Additionally, transformers must be slinged to the walls of the truck or container and to each other.

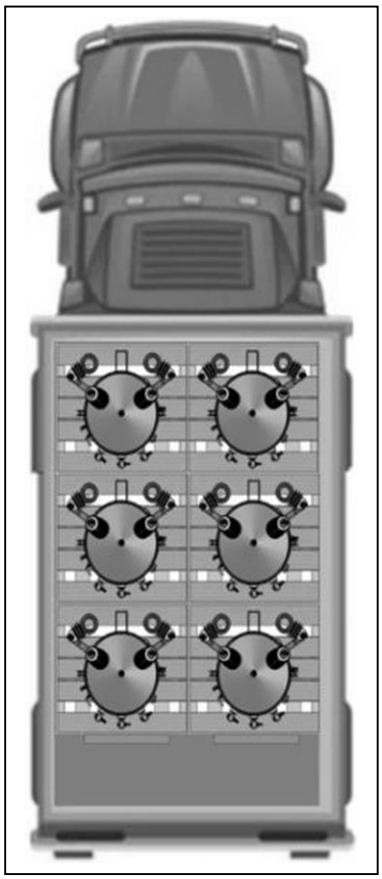


Figure 16: Loading, distribution and use of wedges in transformers

7.1.2 Transformers with crate

When a considerable number of transformers are transported, the load must be distributed within the truck or container in groups separated from each other.

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

The packaging of the transformers acts as a separator, when there are spaces between them, wooden wedges must be fixed between them and the floor.

Additionally, each set must be tied together to form a solid unit and between them to the walls of the truck or container.

These transformers can be loaded on up to two levels, as long as the weight of the load located on the second level does not exceed 400 kg.

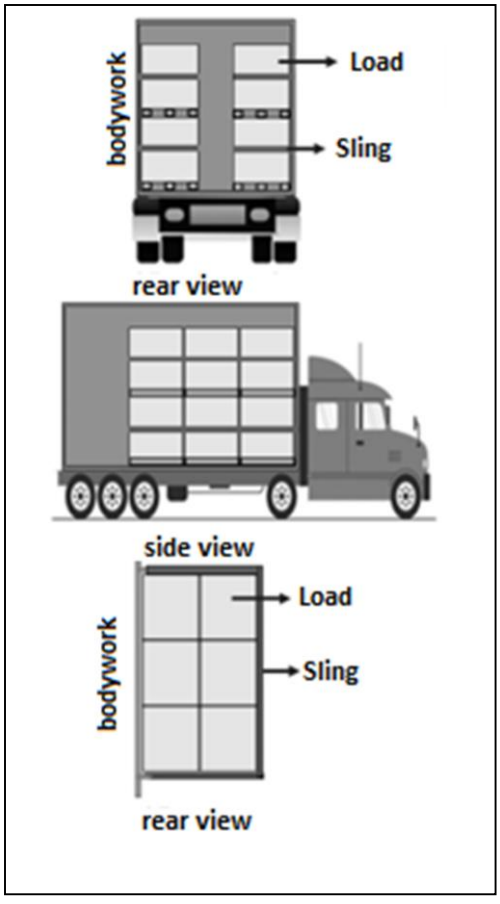


Figure 17: Proper way of loading and tying boxed transformers.

7.1.3 Load open top trucks

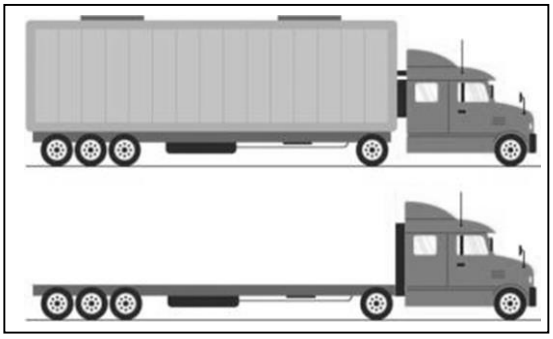


Figure 18: Normal and convertible truck

Loading on this type of truck has several advantages:

- By not having the tent, the rod and the sides, better use is made of the total available area of the plate.
- The load can protrude +/- 15 cm from the sides of the plate.

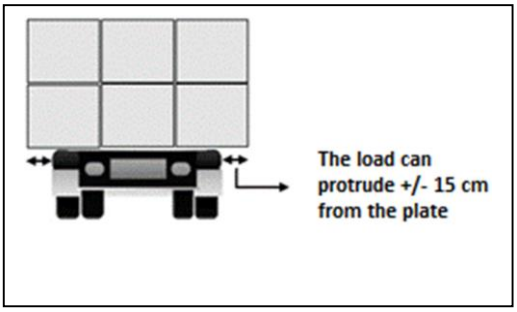


Figure 19: Load tolerance on the sides of the plate

- The total number of transformers in the load is increased.
- Reduces freight costs.
- Loading and unloading is done on the sides of the truck, reducing loading time.
- When loading boxed transformers, they can be stacked up to two levels, as long as the weight of the transformers on the second level does not exceed 400 kg.

Caution: For 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.

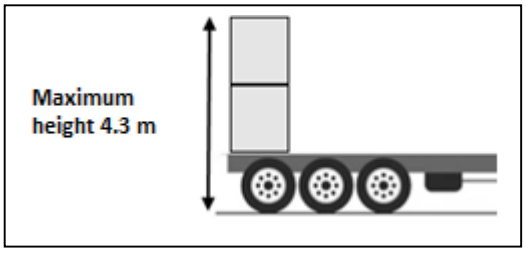


Figure 20: Maximum loading height

➢ Steps for loading

- Loading must be done from the front of the plate (near the cabin) to the back of it.
- With the help of the appropriate mechanical means (forklift, crane, etc.) load the first row of transformers.
- Once the transformers in the first row are located and aligned, secure them with a sling by securing the sling to the

truck chassis and passing it over the crates.

Figure 21: Loading and securing the first row

- Repeat the previous numeral until completing the total load of the truck.

Figure 22: Total truck load

- To prevent load shifting during transport, sling the last row of loaded transformers.

Figure 23: Securing the last row of loaded transformers

Precautions: All rows must be secured with slings, these must be well tensioned.

When the load is mounted partially on two levels, make sure it is done in the central part of the plate.

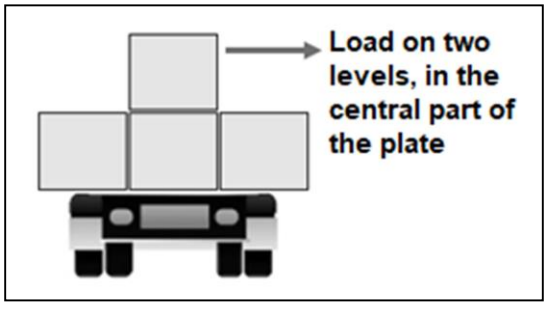


Figure 24: Two levels in the central part of the plate, load leveling.

7.1.4 Download

Precautions: Some transformers have attachments to raise the cover, NEVER use them to lift the transformer.

If you use stringsor 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:

- If you have doubts about the gross weight of the product, the lifting elements to be used, the method to unload the product or any other activity, refrain from maneuvering and contact MAGNETRON S.A.S.
- Always use the appropriate mechanical means, forklift, crane, etc.
- The mechanical means used must have at least twice the capacity of the weight of the transformer.
- Lift the transformer only by the lifting lugs or the bottom of the packaging.
- Personnel involved in the discharge must stay away from the transformer when it is elevated.
- Transformers oaded in open top trucks must be unloaded in opposite way to loading.
- In containers or trucks with the body installed, the transformers that are out of reach must be pulled until they are placed in the unloading position, to do this:
  - Attach a sling to the hoist or mechanical means used and pass it around the base of the transformer packaging.
  - Pull the transformer until it is within reach of the mechanical means used.
  - Download the transformer.

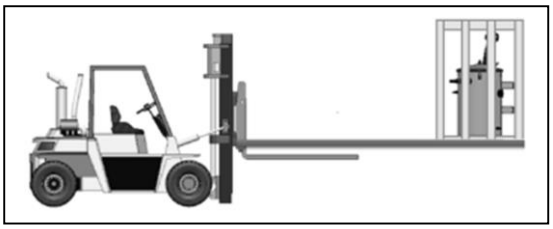


Figure 25: Proper way to pull a transformer on discharge.

8. Reception

Caution: Before discharging the transformer, should visually inspect of 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, are delivered fully assembled and ready for installation, however, taking into account the difficulties that arise during transportation, the following should be taken into account:

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

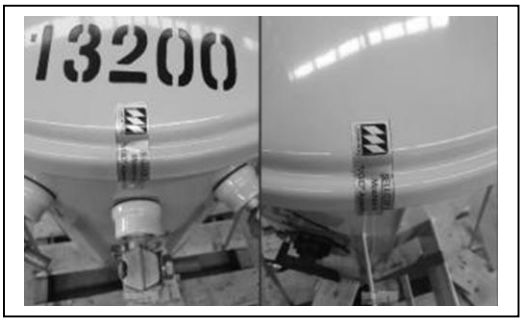


Figure 26: Security seal

- 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 26-1: Security seal on removable parts

- Check the state of the medium and low voltage bushings, they should not be loose or present damage.
- Check the state of the tank, it should not show bumps, cracks or damage to its paint.
- Check the condition of the other accessories that are part of the transformer (overpressure valve, source arresters, etc.).
- Verify that the indicator light (if equipped), is not blown.
- Check that there are no oil leaks.
- Inspect the wooden base, it should not show damage.
- Check that caster wheels (if fitted) arrive with the transformer.

- 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 SAS 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 moisture from entering the transformer, the overpressure valve MUST NOT be actuated for any reason.

If the transformer does not require immediate installation, follow the instructions below 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 transformer

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

- The storage of the transformers depends on their size and their packaging, if the transformer is crated:

  - In single-phase transformers, if the power is less than or equal to 100 kVA, they can be placed at two levels (one above the other) at most.

  - In three-phase transformers, if the power is less than or equal to 112.5 kVA, they can be placed at two levels (one above the other) at most.

- Transformers that exceed these criteria must be stored by units.

  Note: If storage is done outdoors, they can not be placed on two levels (one above the other).

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

- Do not store transformers on two levels (one on top of the other) when storage is longer than six (6) months.

10. Basic accessories

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

The accessories described in this numeral obey the basic accessories that are part of a self-protected single-phase or three-phase distribution transformer immersed in insulating liquid, however, reference is made to some protection or control accessories.

Also, it is worth clarifying, there are many references for each type of accessory, only reference is made to the accessory as such.

10.1 Medium voltage Bushings

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.

Figure 27: MV bushings

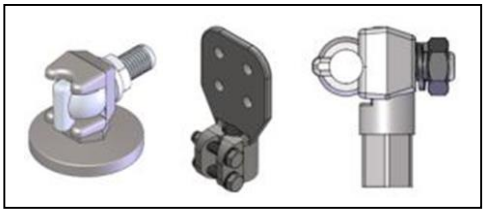


Figure 27-1: Examples of MV connectors

10.2 Low voltage 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.

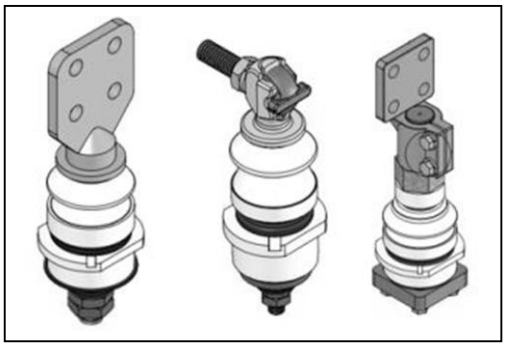


Figure 28: LV bushings with their respective terminals

10.3 Overpressure valve

Located at the top of the tank on the low voltage side. It is used to relieve the internal pressure of the tank when it exceeds the safe operating limits.

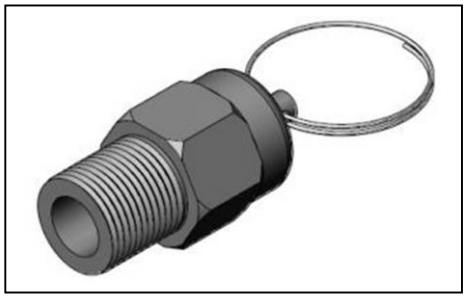


Figure 29: Overpressure valve

Note: It must not be operated manually, doing so implies the entry of humidity inside the transformer.

10.4 Tap changer

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

This device allows the transformation ratio to be varied to guarantee that the required voltage is delivered at low voltage.

In self-protected transformers, two types of switches are used:

- Circulars (1 and 3 bodies)
- linear

10.4.1 Steps to operate the CIRCULAR tap changer

- 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 bushings.
- 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.

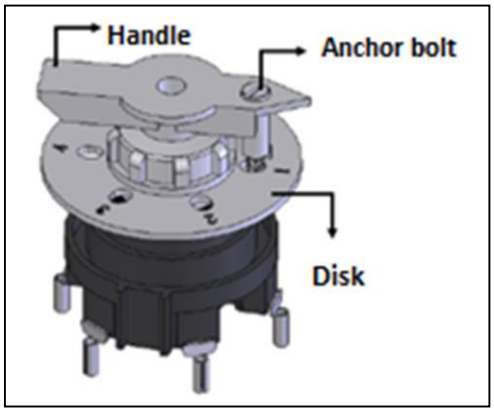


Figure 30: One body branch tap changer

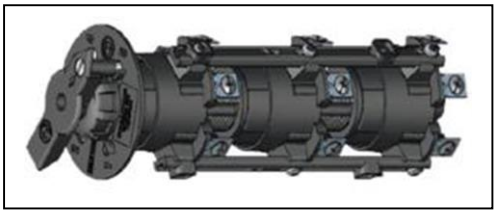


Figure 30-1: Three-body tap changer

10.4.2 Steps to operate the LINEAR tap changer

- 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 bushings.
- Pull the knob until it is released from the disc anchor.
- Turn the knob and bring it to the needed 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 bushings to ensure that the switch is properly engaged.
- Re-energize the transformer.
- Measure the voltage on LV, confirm that it is the needed voltage.

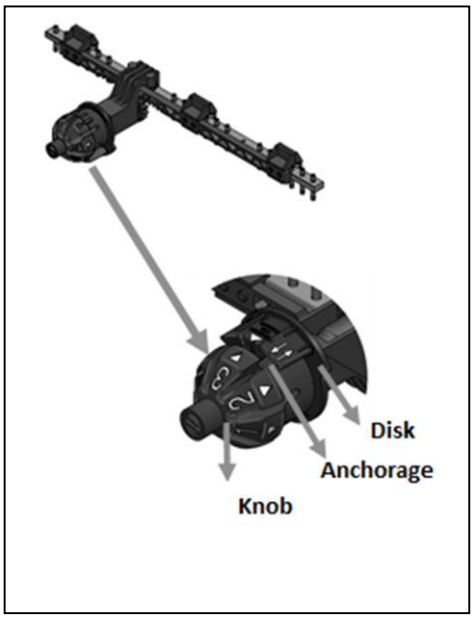


Figure 31: LINEAR switch

10.5 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 32: Example rating plate

10.6 Grounding system

The transformer is provided with two screws 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.

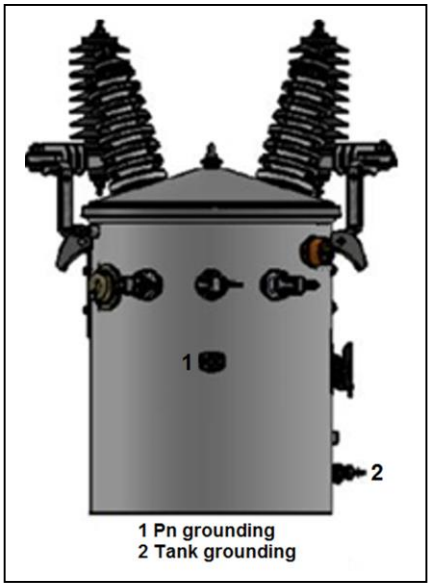


Figure 33: Grounding points

10.7 Lifting lugs

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

They are used for hoisting or lifting only and not for transporting.

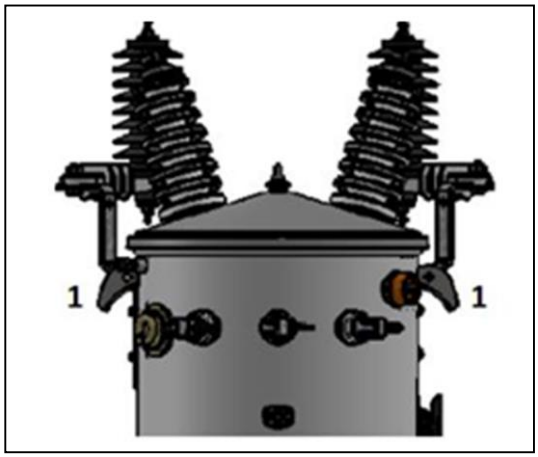


Figure 34: 1. Lifting lugs

10.8 Internal indication of insulating liquid level

Internal marking that is made by paint or other indelible marking in a visible place to the user when the transformer is uncovered.

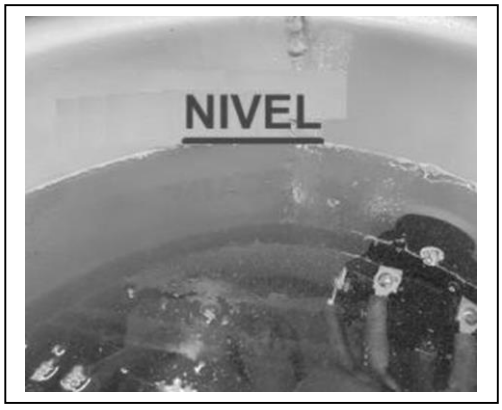


Figure 35: Internal level

10.9 Support to hang on the pole

Devices designed with the size and adequate mechanical resistance to support the transformer completely assembled and filled with insulating liquid and installed on the pole.

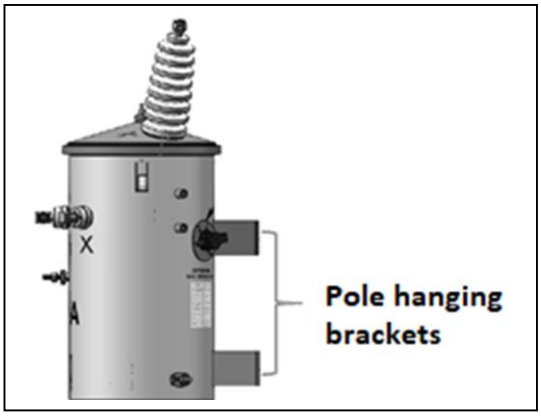


Figure 36: Pole Hanging Brackets

10.10 SPD mounting device

Each transformer has either two internally threaded bushings or two welded studs to the tank for each MV bushings, which are used for mounting the SPDs.

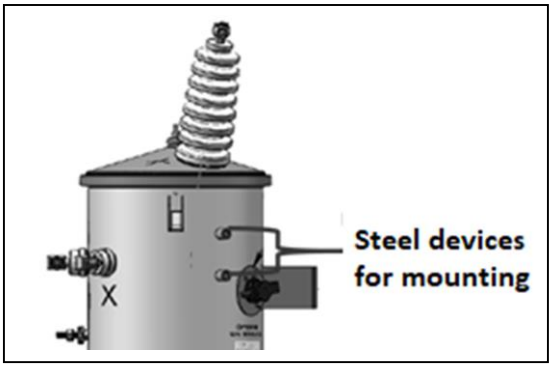


Figure 37: SPD mounting devices

10.11 IFD Internal Fault Detector

The IFDTM is a sensor that detects internal arc faults in distribution transformers, its installation is made to order.

IFD makes it easy to quickly identify the faulty transformer from +/-20 m away from the pole.

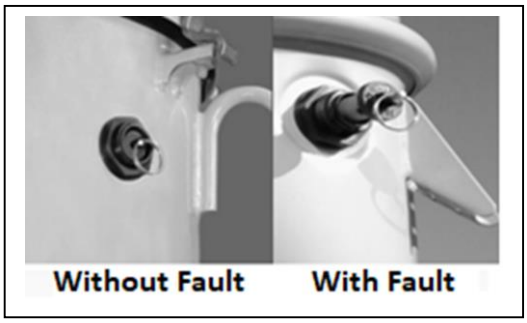


Figure 38: IFD in operation

When an internal fault occurs and the tank pressure rises rapidly at a rate of 0.5 psi for 5 to 7 ms, the IFD signaling device activates, releasing a highly visible orange signal.

The signal alerts the operator or crew so that the transformer is not energized again.

The internal fault detector is equipped with a 10±2 psi relief valve.

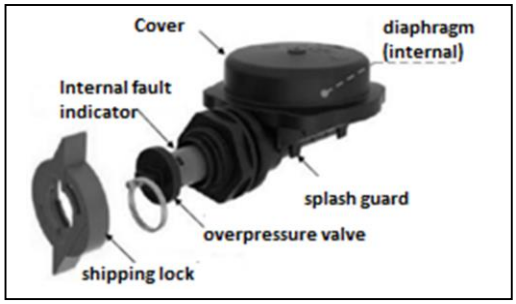


Figure 39: Parts of the IFD

10.12 Temperature indicator (thermometer)

It is an instrument that measures the temperature of the liquid in degrees Celsius and includes a resettable 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 40: Temperature indicator

10.13 Insulating liquid level indicator (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" fluid level, then the transformer should be de-energized and inspected to determine the cause of the low fluid level. A low level of liquid can cause dielectric failure,

overheating of the transformer and a reduction in its useful life.

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.

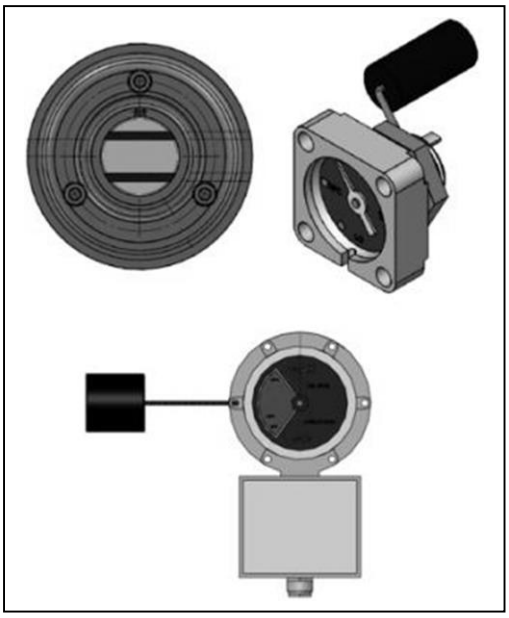


Figure 41: Insulating liquid level indicators

10.14 Drain valve

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

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

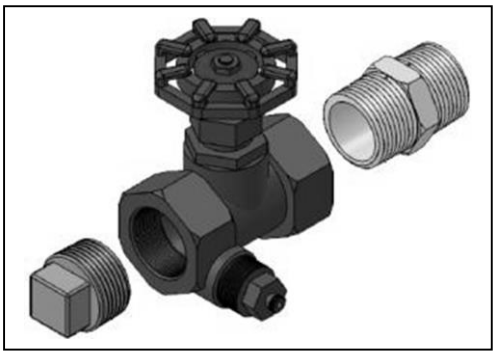


Figure 42: Drain valve

10.15 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.

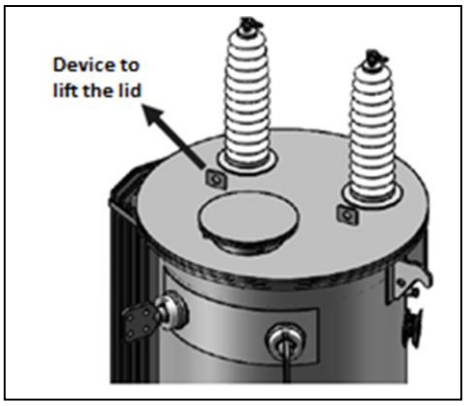


Figure 43: Devices for lifting the lid

10.16 MV-LV source arrester (DPS)

Device whose function is to protect the transformer from high transient voltages. Usually, they are non-linear resistors that, once subjected to an overvoltage, conduct current and limit the voltage value between its ends,

reducing the value of direct overvoltages on the protected equipment.

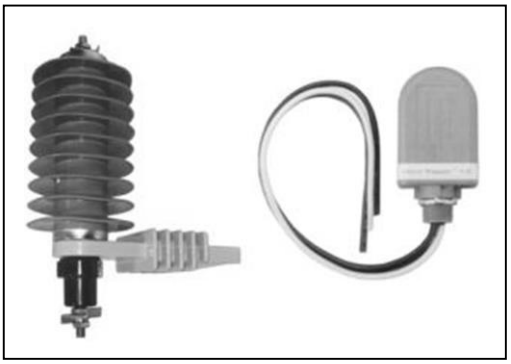


Figure 44: MV and LV source arrester

10.17 Isolation link

This item is not a fuse as it does not have the ability to interrupt. Its function is to melt in the event of internal faults to prevent the failed transformer from being energized.

Operates to disconnect the transformer in case an internal fault occurs.

The insulating link is connected in series with each of the phases at the output of the medium voltage switch.

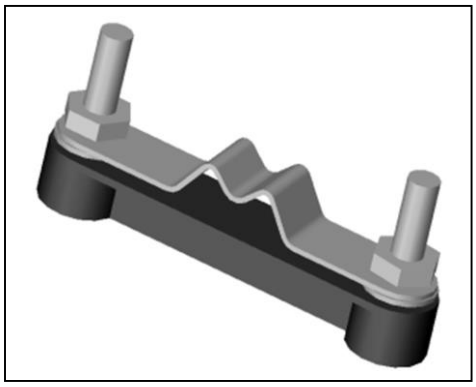


Figure 45: Isolation Link

10.18 Breaker

This accessory protects the equipment against overloads and failures in the secondary circuit (short circuits), protecting the useful life of the transformer.

Its function is to displays alarm and/or trip signals when the internal temperature of the transformer reaches dangerous levels or when the insulating liquid reaches low levels, exposing the bimetallic.

The breaker performs the same function as a fuse, with the advantage that it can be restored manually instead of having to be replaced (if a pole is used for this, the handle is located on the outside of the transformer).

When there is a short circuit on the load side, the breaker operates when the thermomagnetic switch trips. Once the fault condition has been verified and cleared, it can be reconnected by resetting the switch mechanism.

Depending on the power of the transformer, the breaker can be thermal or thermomagnetic.

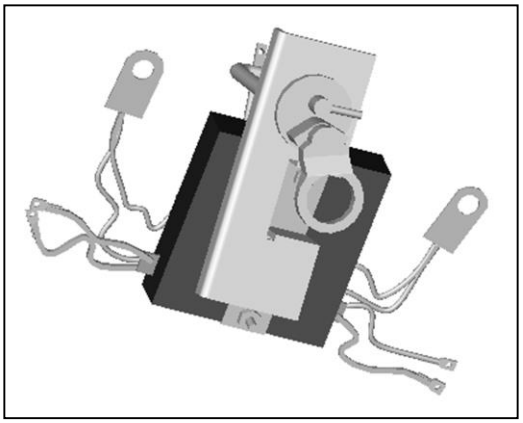


Figure 46: Breaker

10.19 Pilot light for breaker

It operates as a preventive alarm without the need to disconnect the user. It Indicates as an alarm when the transformer is approaching the breaker trip temperature.

This self-protection system is an easy and economical way to detect any abnormal thermal operating condition without the need for expensive measurement and monitoring methods.

The pilot light off indicates a normal situation in the network and in the load. If it is on, it indicates an abnormal situation, the transformer is thermally overloaded.

The light mechanism does not self-reclose when the load decreases, the light remains on, it can only be disconnected by operating the outer handle of the breaker.

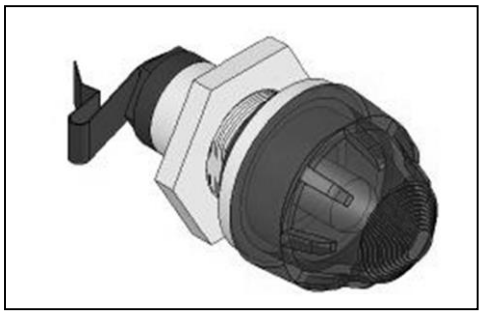


Figure 47: Pilot light or light signal

10.20 Magnex

It is an overcurrent protection device that protects transformers from damaging overloads and secondary faults.

As a protection device the Magnex combines safety and efficiency with economical operation.

It's an all-in-one assembly, using no troublesome link or requiring calibration, making installation and operation quick and trouble-free.

Secondary faults and overloads will trip the Magnex “OPEN”; however, the device can be rebooted once the condition is corrected.

Primary faults are cleared by the Magnex in coordination with an isolation link or current limiting fuse.

The Magnex can be ordered with an optional Emergency Overload (EO) feature. When the transformer is taken out due to

overload, the OE function can allow an additional 30% load to quickly restore service.

The Magnex breaker can also be used as a main breaker to disconnect the transformer windings, not just the load. This eliminates core (no-load) losses in non-service transformers.

This self-protection device uses a flag-type opening visual signaling mechanism, with an easily observable color, indicating that the switch has operated and must be reset, once the cause of the failure has been verified.

Additionally, the Magnex has a built-in float, which avoids its manual operation in conditions of low level of the insulating liquid

Figure 48: Magnex

10.21 Expulsion fuse

It is installed immersed in insulating liquid, either inside the medium voltage insulator or mounted on an insulating support conveniently fixed to the metallic structure of the transformer.

Its connection is made internally between the winding and the MV bushing, whose specific function is to support the operation of the breaker and act only in the event of an internal failure of the transformer in order to separate it from the network.

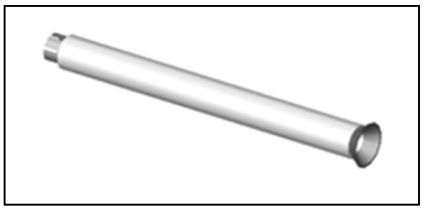


Figure 49: Fuse

10.22 Current transformer

Its function is to reduce the current characteristics in an electrical system to normal and non-hazardous values, in order to transmit a signal and allow the use of measuring instruments or protection or control devices.

Figure 50: Current transformer

11. Terminal marking

The markings of the medium and low voltage terminals in this type of transformers depend on two factors:

- Standard (NTC or ANSI)
- Polarity (additive or subtractive)

11.1 Polarity

The polarity in single-phase transformers is defined by standard (ANSI C57.12.70) as follows:

Any single-phase transformer with power ≤ 200 kVA **and** MV voltage ≤ 8660 V will be ADDITIVE POLARITY, the other Transformers will have **SUBTRACTIVE POLARITY.**

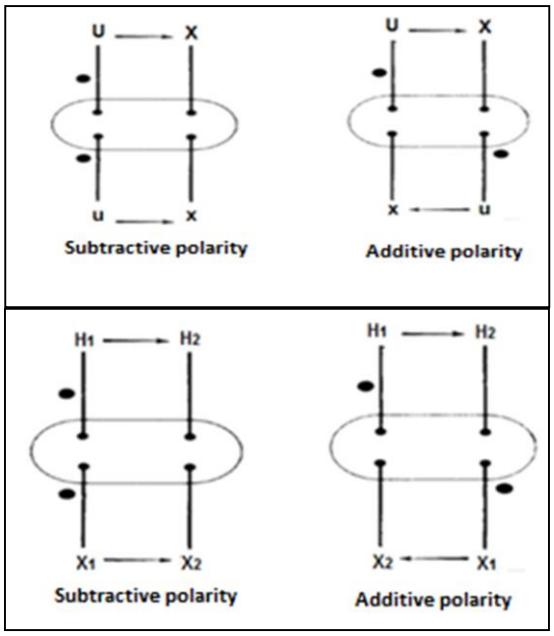


Figure 51: Polarity according to NTC and ANSI

- **Examples of polarity according to the characteristics of the single-phase transformer**

Power (kVA)	Voltage MV	Polarity
5	19920	Subtractive
5	4160	Additive
10	13200	Subtractive
15	13200	Subtractive
25	2400	Additive
37.5	7620	Additive
37.5	10000	Subtractive
50	7620	Additive
75	13200	Subtractive
100	11400	Subtractive
167	2400	Additive
250	4160	Subtractive
250	13200	Subtractive
333	11400	Subtractive
333	2400	Subtractive
500	13200	Subtractive

Notes:

- A single phase transformer can change polarity by customer's request.
- The polarity in single-phase transformers is very important when they are used to build three-phase banks.

11.2 NTC standard marking and polarity in single-phase transformers

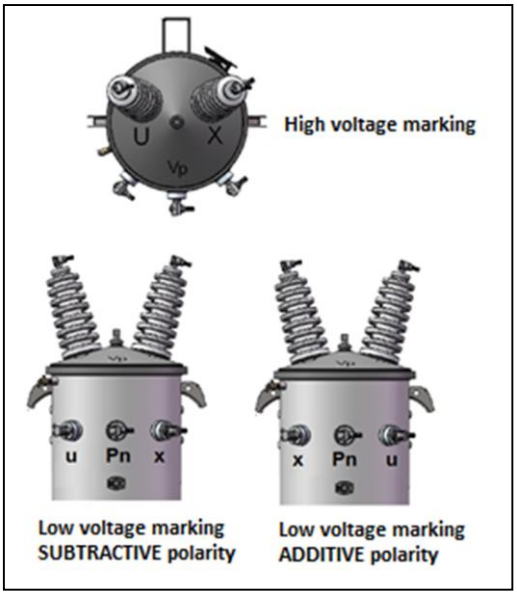


Figure 52: Marking according to NTC

11.3 NTC standard marking on three-phase transformers

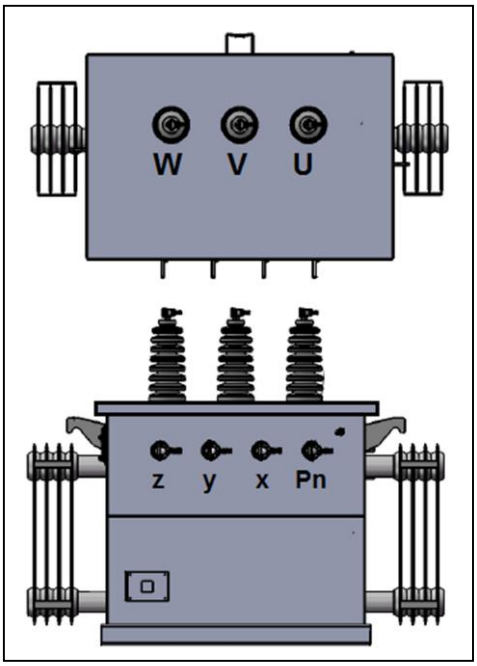


Figure 53: NTC dialing

11.4 ANSI standard marking and POLARITY on single-phase transformers

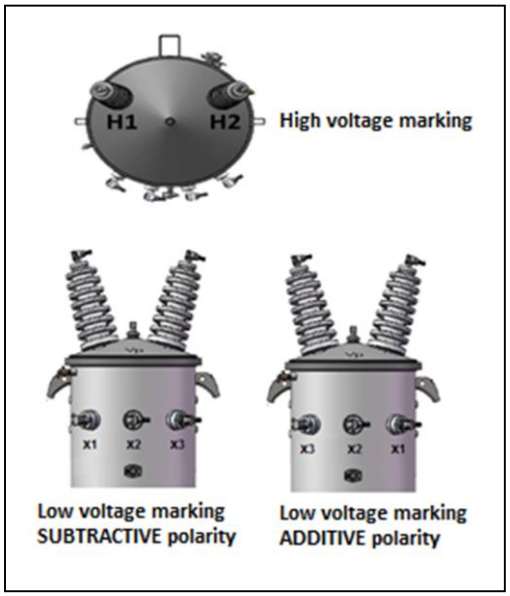


Figure 54: ANSI marking

11.5 ANSI standard marking on three-phase transformers

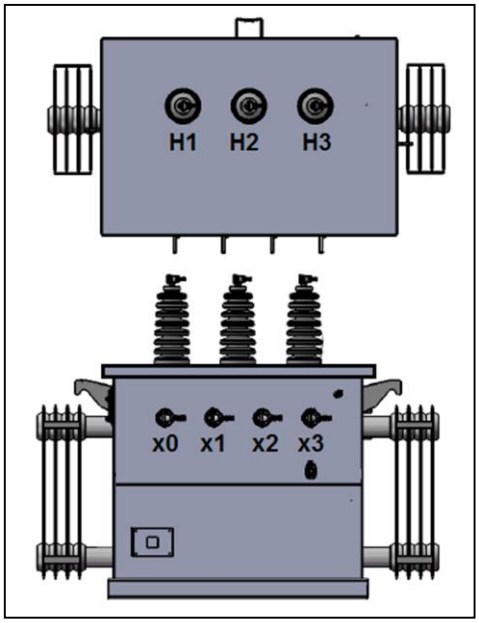


Figure 55: ANSI marking

- The markings in the medium voltage terminals are made with UPPER CASE 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

11.6 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.

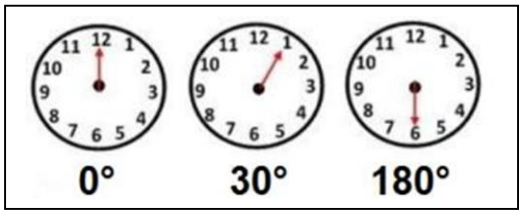


Figure 56: Hourly index examples

11.7 Connection group

It represents the type of connection for each of the windings, normally 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, 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 o n) is observed in the connection group, it indicates that the star connection (Y o y) has an accessible neutral point.

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.
- Make sure 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 switch is well anchored and in the required position.
- Make sure the low voltage neutral point and SPD are properly grounded to the tank.

12.2 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 of the same:

12.2.1 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 broken 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 57: Analog or crank TTR

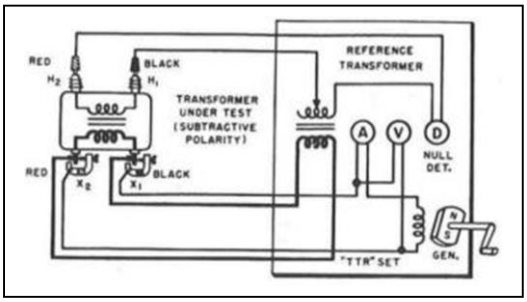


Figure 58: TTR connection to the transformer under test

- **Digital TTR**

With this equipment, an adjustable voltage is applied to the MV bushings 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 bushings 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 59: Digital TTR

- **Calculation of the transformation ratio**

They are carry 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 60: equation to calculate the transformation ratio

12.2.2 Resistance of MV and LV windings

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

- With an ohmmeter (multimeter) check the medium voltage connection, connect the meter between each pair of MV terminals as follows:

- In three-phase transformers between UV, UW, VW, or H1-H2, H1-H3, H2-H3.

- In single-phase transformers between U-X or H1-H2.

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 LV connection, connect the meter between each pair of terminals as follows:

- In three-phase transformers between xy, xz, yz or x1-x2, x1-x3, x2-x3.

- In single-phase transformers between u-x or x1-x2

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%.

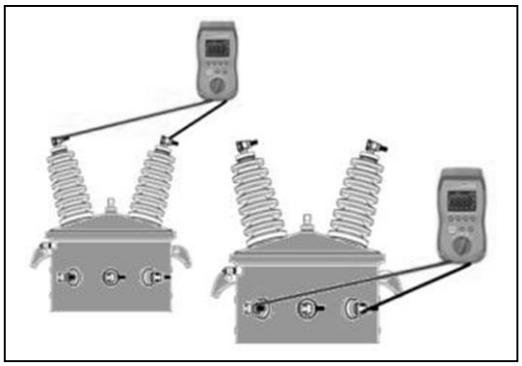


Figure 61: MV and LV winding resistance measurement

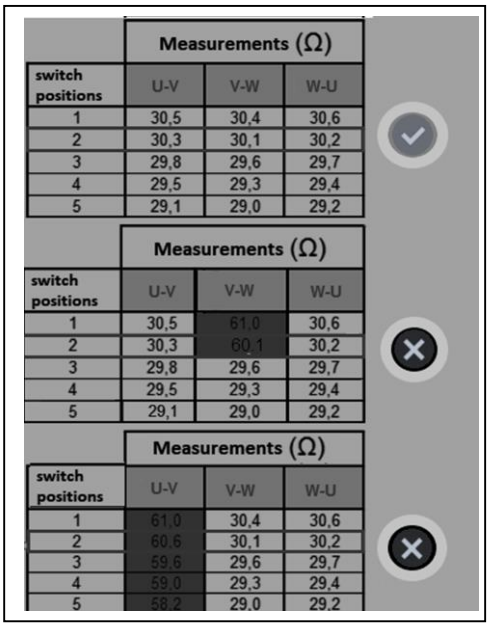
If, when carrying out the test, any of the following cases occurs, the transformer has suffered internal damage:

- When measuring the MV winding, some of the values optained are more or less double what is stated in the test certificate (figure 62).

- When measuring the MV winding, the meter does not

record 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 63).

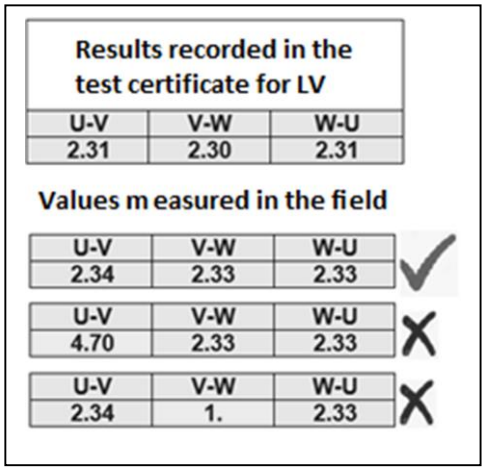


Measurements (Ω)			
switch positions	U-V	V-W	W-U
1	30,5	30,4	30,6
2	30,3	30,1	30,2
3	29,8	29,6	29,7
4	29,5	29,3	29,4
5	29,1	29,0	29,2

Measurements (Ω)			
switch positions	U-V	V-W	W-U
1	30,5	61,0	30,6
2	30,3	60,1	30,2
3	29,8	29,6	29,7
4	29,5	29,3	29,4
5	29,1	29,0	29,2

Measurements (Ω)			
switch positions	U-V	V-W	W-U
1	61,0	30,4	30,6
2	60,6	30,1	30,2
3	59,6	29,6	29,7
4	59,0	29,3	29,4
5	58,2	29,0	29,2

Figure 62: Examples of MV measurement



Results recorded in the test certificate for LV		
U-V	V-W	W-U
2.31	2.30	2.31

Values m easured in the field

U-V	V-W	W-U	
2.34	2.33	2.33	✓
U-V	V-W	W-U	
4.70	2.33	2.33	✗
U-V	V-W	W-U	
2.34	1.	2.33	✗

Figure 63: Examples of LV measurement

12.2.3 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 meter 5 kV with a measuring range of 50 MΩ mínimum (use the same factory test voltage to minimize drift).

➢ Proceed as follows:

- In single-phase transformers, short-circuit the MV bushings (U-X or H1-H2) and the LV bushings (u-Pn-x or x1-x2-x3).

- In three-phase transformers, short-circuit the MV bushings (U-V-W or H1-H2-H3) and the LV bushings (Pn-x-y-z or x1-x2-x3).

- It is recommended to apply the test voltage, taking into account the class of the winding under test:

Class (kV)	Voltage DC (kV)
≤ 1.2	1
> 1.2	5

- Test for one (1) minute for each measurement (MT vs LV, MV vs Grd, and LV vs Grd).

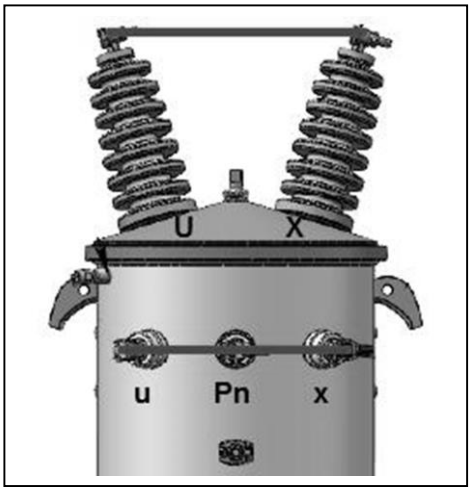


Figure 64: Short-circuit medium and low voltage bushings

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

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

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

  - BT-Grd: Power cable (+) in LV and black cable (-) in Grd, the reference cable s 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 SAS 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
15	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 Insulating liquid tests

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

- It has been stored for a period of more than one (1) year.
- When storage has been carried out outdoors.
- 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 the conditions of the same, ONLY with satisfactory results, the transformer can be energized.

The minimum tests required are:

12.3.1 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.

12.3.2 Water content

This test method covers the measurement of water present in the insulating liquid 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.

12.3.3 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.

12.3.4 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.

12.3.5 Other tests

Other tests that can be performed on the insulating liquid to confirm its status are listed below:

- interface tension
- specific gravity
- disable number
- power factor
- PCB's content
- Viscisity
- corrosive sulfur

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

- When the results of the minimum required tests 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.

12.3.6 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 bright

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 Pole mount

- Substations with pole transformers can be installed, without any type of enclosure, as long as it does not exceed 250 kVA or 800 kgf, taking into account the following:

Power (kvA)	Max weight (kgf)	A POST min breaking strength (kgf)
≤ 112,5	600	510
112.5 < kVA ≤ 150	700	750
150 < kVA ≤ 250	800	1050

- The use of double pole structures for the installation of transformers should be avoided, since they generate greater visual impact and discomfort in mobility.

- In rural installations or small houses, transformers up to 25 kVA can be installed on wooden poles with a breaking resistance less than or equal to 510 kgf.

- All pole-type substations must have overcurrent and overvoltage protection (DPS) on at least the primary side of the transformer.

- The DPS should be installed as close as possible to the primary bushings (+/- 50 cm).

- The transformer fixing elements must support at least 2.5 times its weight.

- The transformer, when fixed to the pole, must be left with an inclination of 90° +/- 2°.

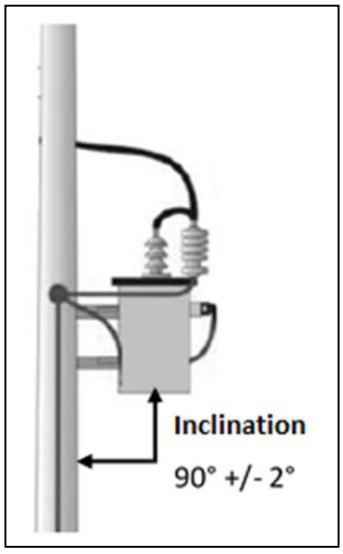


Figure 65: Degree of inclination

Caution: A degree of inclination outside the specified limit causes energized parts to remain outside the level of the insulating liquid, causing a jump between live parts or damage to the transformer.

13.2 Grounding system

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

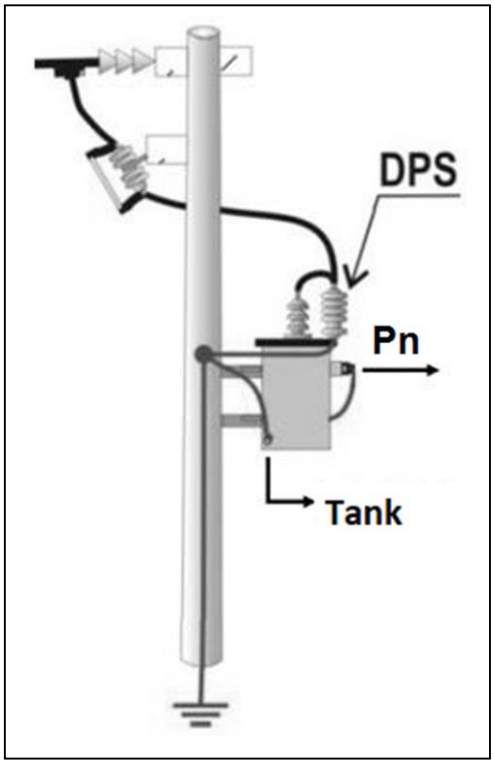


Figure 66: Grounding system

- The grounding system has the following objectives:
  - Guarantee the safety of living beings.
  - Ensure the protection of 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	20
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. Medium voltage connections must have a shape and mechanical rigidity that does not allow them to move with the wind or vibrations, in such a way that they come into contact with parts that should not be energized or approaches that produce electric arcs.

13.4 Commissioning

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

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

- Make sure the switch (Magnex or breaker) is in the “CLOSE” position.
- If the switch is equipped with an emergency lever (EO), make sure it is in the normal position (N).
- Once the transformer is installed, leave it at rest for a minimum of 4 hours for transformers with mineral oil and a minimum of 6 hours for transformers with vegetable oil.
- Energize the transformer at no load (no load).
- 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 transformers immersed in vegetable oil at temperatures below -20°C, can follow the same sequence as transformers immersed 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 (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 externally heated to make the vegetable oil more liquid.

For more information, you can consult the following standards:

- C57.12.93, C.57.106 and 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 12.3.5.
- If and only if the results are satisfactory, proceed as follows:
  - ✓ Energize the transformer without load, for a minimum of 4 hours for mineral oil transformers and a minimum of 6 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)	% Load
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 12.2.3.5, you encounter any inconvenience, take into account the recommendations in the table below

Note: If the inconvenience persists, do not intervene on the transformer and contact MAGNETRON SAS

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 connection of the TTR to the transformer, according to the connection group,	X				
Check that the magnex is in the CLOSED position (close)	X	X			
Check that the breaker is in the CLOSED position (close)	X	X			
Check correct interlocking of the breaker	X	X			
Check measuring equipment, that it is in the correct range		X			
Cleaning of MV and LV bushings			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: To intervene on the transformer, disconnect the MV and LV voltage sources in order to put it out of service.

Disconnect the MV (power supply) terminals, short them and connect them to the grounding system.

Disconnect the LV (load) 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 working conditions.

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

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

15.1 Preventive Maintenance

- During the warranty period, report all failures or eventualities to MAGNETRON S.A.S.
- Once a year, you must inspect the transformer, verifying the following:
  - Condition and cleanliness of the tank.
  - Condition and cleanliness of the MV and LV bushings.
  - Condition and cleanliness of the lightning rods (DPS).
  - Condition and cleanliness of the packaging.
  - Condition and cleanliness of the overpressure valve.
  - Adjustment of the connections.
  - Paint condition.
  - Confirmation that there are no leaks of the insulating liquid.
  - Operation and correct interlocking of the derivation switch.
  - Operation and correct interlocking of the switch (Magnex or breaker).
  - Condition and adjustment of the accessories for ground connections.

- Condition, cleanliness and operation of the other control or protection accessories.

- Condition of the junction boxes, verifying that they do not show signs of oxidation, presence of water or loose or misaligned terminals.

- Tilt on the pole.

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.

Item	Description
1	HV insulators and terminals
2	LV insulators and terminals
3	DPS + Supports
4	Switch
5	Overpressure valve
6	Insulating liquid level
7	Transformer lifting device
8	Lid lifting devices
9	Tank grounding
10	Neutral point grounding
11	Rating plate
12	Switch (Magnex or breaker)
13	Pilot light
14	Pole hanging brackets
15	Radiator
16	BT protection (on request)

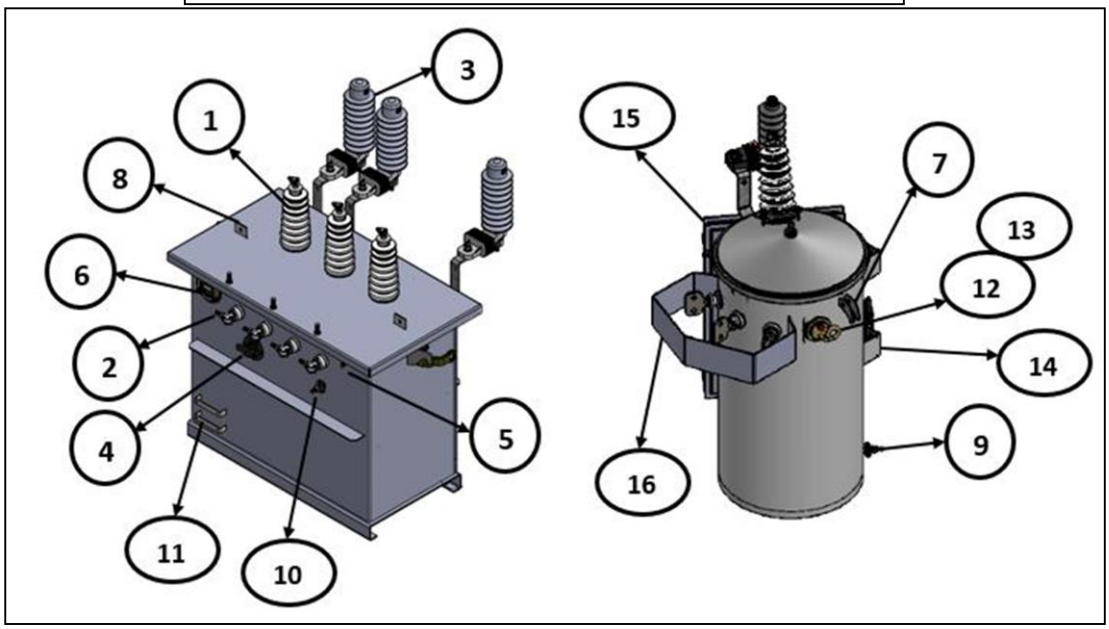


Figure 67: External parts of the transformer

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 S.A.S. or an authorized service workshop.

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

17. Problems and possible solutions

- 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 torque**”.**
- The adjustment of the accessories is done only externally, 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 connection of the TTR to the transformer, according to the connection group,	X				
Check that the magnex is in the CLOSED position (close)	X	X			
Check that the breaker is in the CLOSED position (close)	X	X			
Check correct interlocking of the breaker	X	X			
Check measuring equipment, that it is in the correct range		X			
Cleaning of MV and LV bushings			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

The different adjustments that are made in the external accessories of the transformer must be done following the recommendations of the suppliers in terms of torque and adjustment sequence. 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.

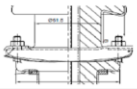
18.2 Cover adjustment in single-phase transformers

Tank diameter (mm)	Torque (lb ft)	Beam screw
312	18	Short
345	21	
370		
406	28	
442	32	
478		Long
514	34	
550		
586		

18.3 Cover adjustment in three-phase transformers

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

18.4 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	

18.5 Tap changer

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

18.6 Overpressure valves

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

18.7 Magnex

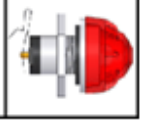
Brand	Subjection	Tightening torque (lbf.ft)	Image
Cooper	External	8 to 10	

18.8 Breaker

The tightening torque varies according to the brand of the device.

Brand	Subjection	Tightening torque (lbf.ft)	Image
ERMCO	Internal	18	
HINDÚ	External	30	

18.9 Pilot light

Brand	Subjection	Tightening torque (lbf.ft)	Image
ERMCO	Internal	4 to 5	

19. Environment

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

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

Likewise, MAGNETRON S.A.S. 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 S.A.S.

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

In case of leakage of the insulating liquid, must be collectedin 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.

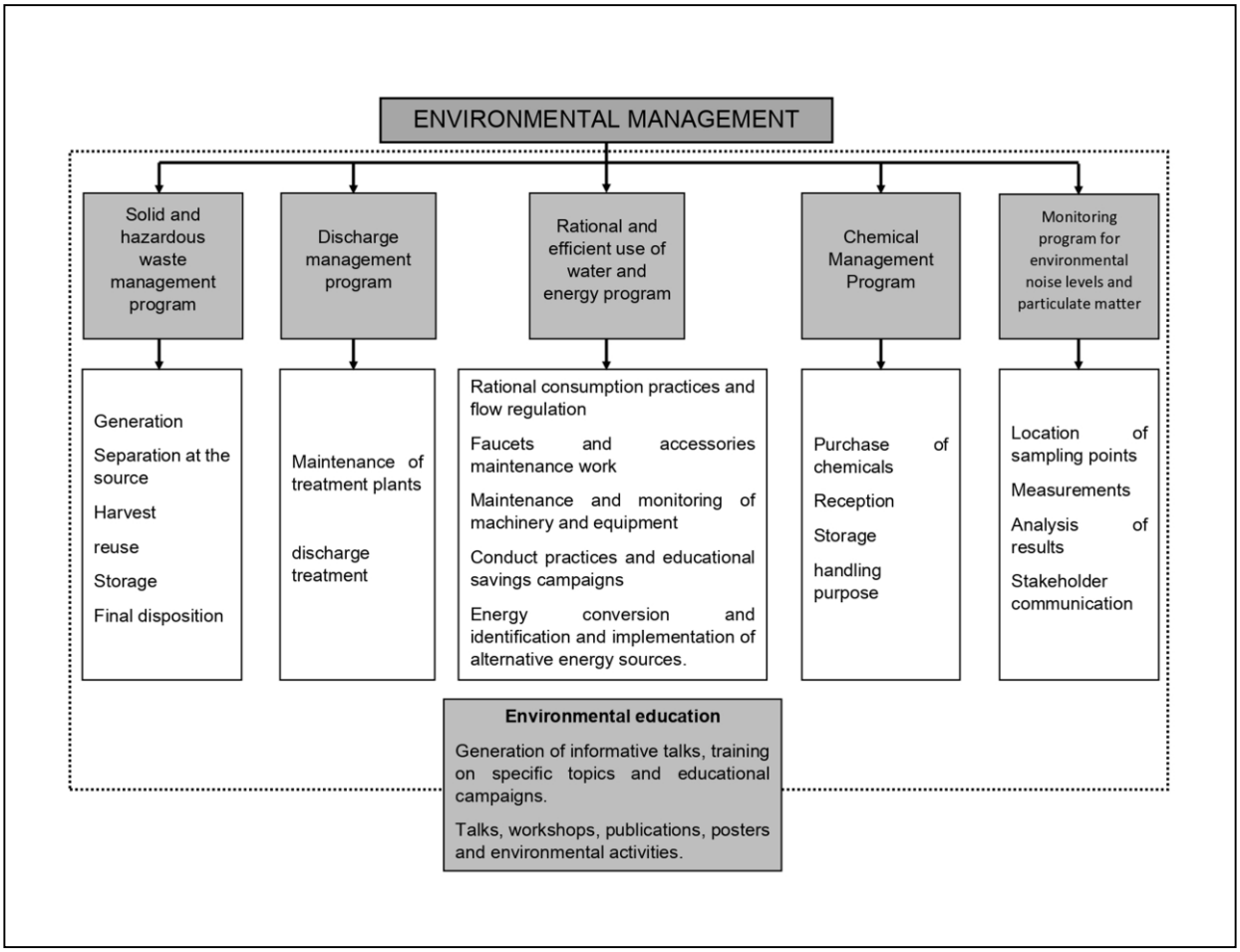


Figure 68: MAGNETRON S.A.S. Environmental Management Plan

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. Annex A

21.1 Anti-fraud or shielded CSP transformers

The self-protected transformers can be supplied with a low voltage cabinet, upon customer request. This cabinet is known as anti-fraud or armored.

The pole hanging brackets can be located on the same side of the low voltage terminals or opposite them.

For installation, it is recommended to keep in mind the following instructions:

- Remove the top of the cabinet before mounting it on the pole.

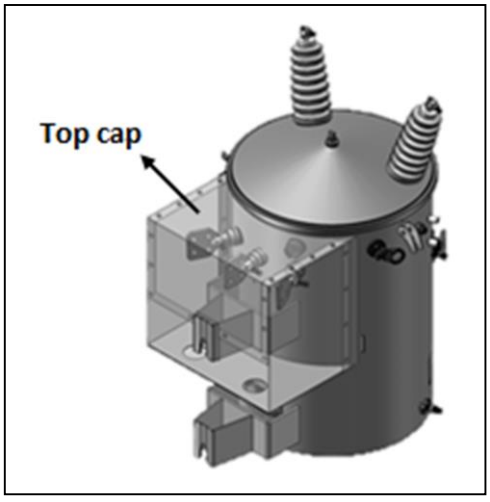


Figure 69: Cabinet top cover

- Install the transformer on the pole.

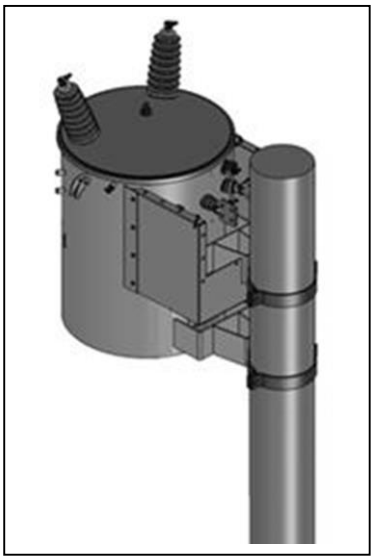


Figure 70: Transformer on pole

- Connect the load to the low voltage terminals.

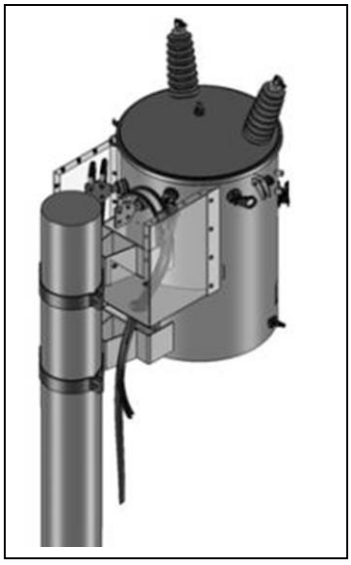


Figure 71: Load connection

Note: When the supports to hang the pole are in low voltage side, it is very important that the cables of

the load connections do not pass through the supports, this can induce currents.

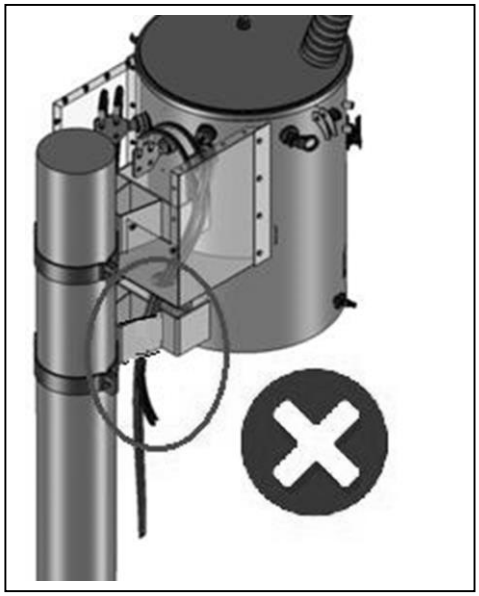


Figure 72: Not allowed, cables in the middle of the brackets to hang on the pole

- The load wires should exit through the bottom knockouts in the cabinet.

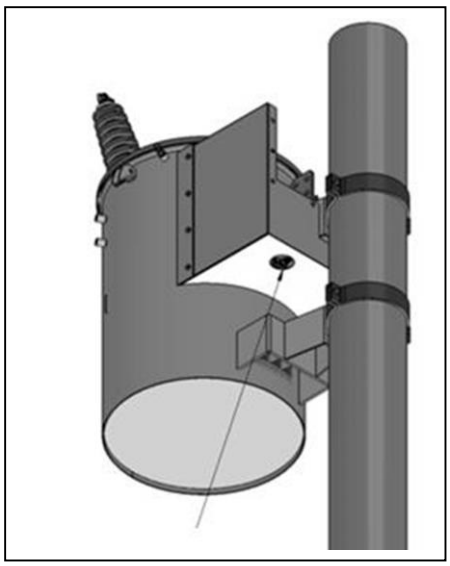


Figure 73: Lower perforations

- Position and secure the top cover.

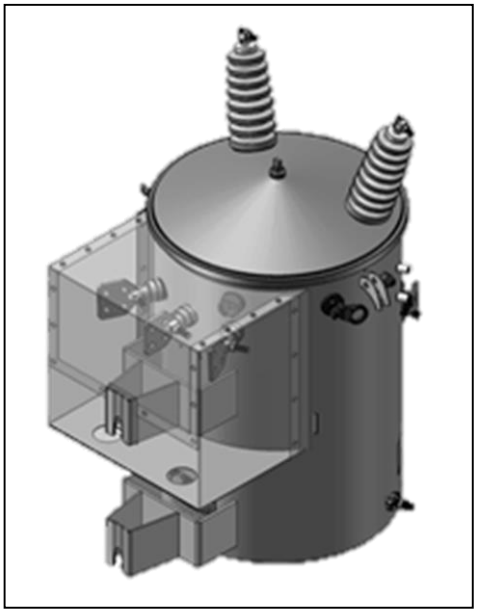


Figure 74: Armored with supports to hang on the pole in LV

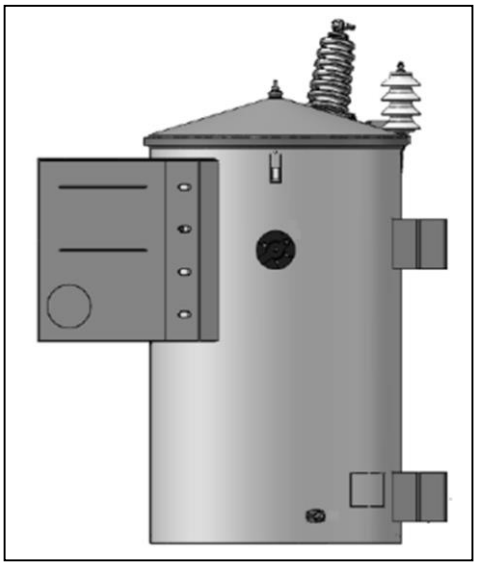


Figure 75: Armored with supports to hang to the pole in MV

20.2 Connection diagrams self-protected transformers

The diagrams illustrated below are for reference only, they may vary according to the type of transformer and the protections used.

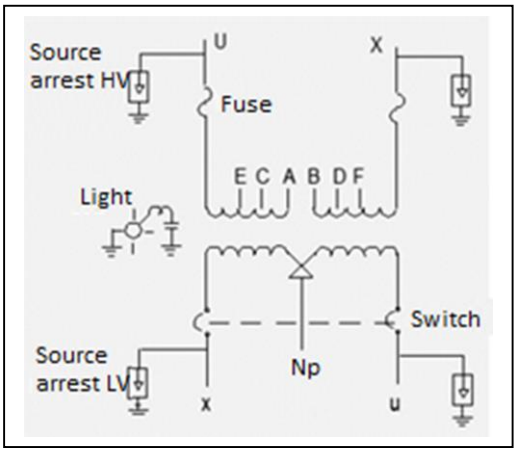


Figure 76: CSP transformer with breaker, MV winding in phase-phase connection

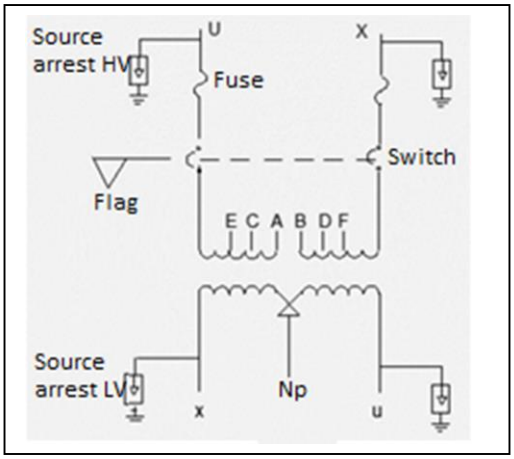


Figure 78: CSP transformer with magnex, MV winding in phase-phase connection

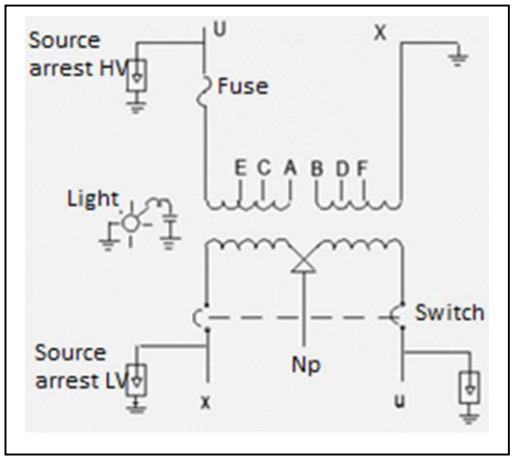


Figure 77: CSP transformer with breaker, MV winding in phase - grounding connection

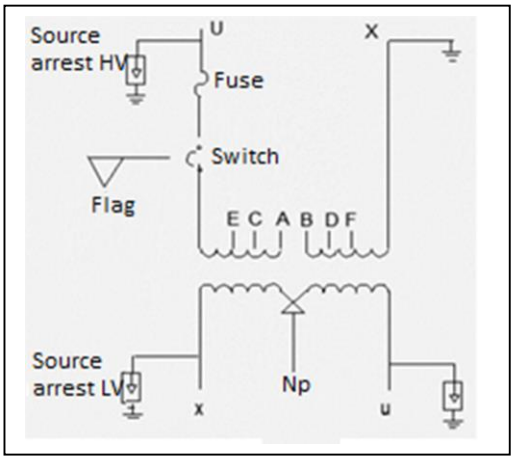


Figure 79: CSP transformer with magnex, MV winding in phase - grounding connection

22. 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 109