

# User's Manual

## Assembly and Energizing For Special Transformers



## Table of contents

<b>1 Objective</b>	<b>3</b>
<b>2 Description of the Manual</b>	<b>3</b>
<b>3 The assembly order of the transformer</b>	<b>3</b>
3.1 Transportation and arrival at installation site.....	4
3.1.1 Handling .....	5
3.1.2 Recommendations during arrival at installation site.....	6
3.2 Storage.....	7
3.2.1 Storage of transformers with sealed tank .....	8
3.2.2 Transformers with expansion tank .....	8
3.2.3 Storage of insulating oil .....	9
3.2.4 Problems and solutions presented during the reception and storage .....	9
3.3 Preliminary fill up with oil .....	10
3.4 Radiators assembly .....	11
3.4.1 Fill up of the radiators .....	13
3.5 Final fill up with oil under vacuum .....	14
3.5.1 Vacuum treatment .....	14
3.5.2 Fill up with oil.....	15
3.6 Tests in field .....	16
3.6.1 Measurement of the insulation resistance .....	16
3.6.2 Polarity tests, phases rotation and transformation ratio .....	16
3.6.3 Insulation power-factor test and capacitance.....	17
3.6.4 Dielectric breakdown test, and moisture in the insulating oil .....	17
3.6.5 Increase in temperature test .....	17
3.6.6 Test of the alarm systems and the control units.....	17
3.6.7 Other .....	17
<b>4 General instructions</b>	<b>17</b>
4.1 Safety procedures .....	18
4.1.1 Cautions upon energizing the transformer .....	18
4.2 Necessary tools for assembly .....	19
4.3 Internal inspection .....	20
4.3.1 Internal connections .....	21
4.3.2 Connections .....	22
4.3.3 Inspection after connections .....	22
4.4 Allowable time of exposure for core and windings .....	22
4.5 Inspection of rubber gaskets.....	23
4.5.1 Maintenance of the gaskets and sealed surfaces of the clamp during the installation .....	24
4.6 Instruments for measurements and field test .....	24

## 1 Objective

This instruction indicates the order of the activities to accomplish in the assembly and energizing of special transformers.

## 2 Description of the Manual

The recommendations, instructions and procedures here contained will give you a guide to accomplish labors of installation or assembly and implementation or energizing of a special transformer. This information is not the only one requirement to the transformer operates satisfactorily. It is required to count firstly on qualified personnel and tools and equipment designed for this purpose.

## 3 The assembly order of the transformer

It is important to remember that these instructions are general and for some transformers is possible that certain instructions and/or recommendations will not be applicable. After assembly of the transformer, make sure to check:

- Construction

Make sure that all the pieces are found in their respective places, and all bolts and nuts have been tightened.

- Connection

Check if all the electrical connections have been made correctly.

- Cooling System

Check if all the radiators' valves are opened, and that the cooling control device (If exists) and cooling fans (If exists) are operating normally.

- OCTC

Check if the OCTC operates smoothly, and the position of the Tap Changer corresponds to the desired tension. The control device for the OCTC (Off-Load-Tap-Changer) must be in perfect conditions.

- Protection Relays

Check the correct operation of the contacts.

- Indicators

Check that the oil level indicators or the thermometers are displaying correctly the information on the scale.

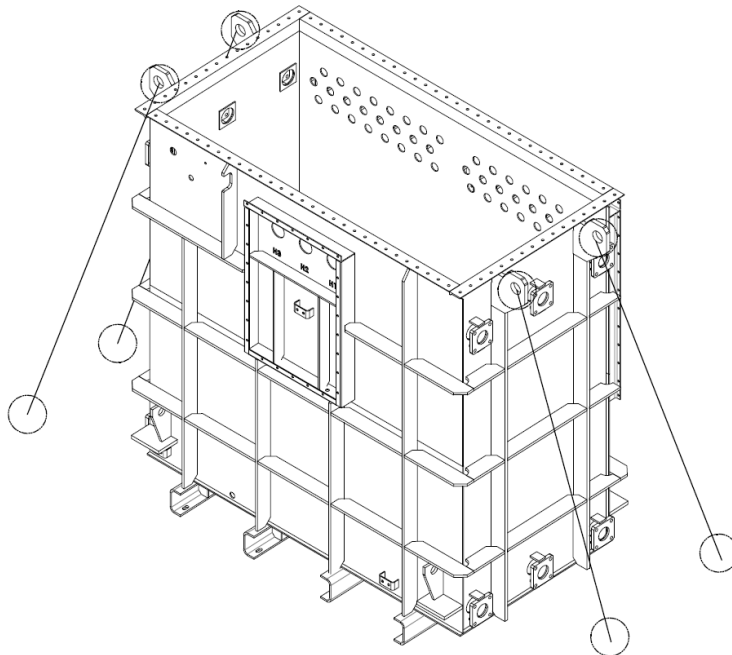
- Air Breathers (If exists) : Check their operation.
- Check if the valves are in the correct position.
- Grounding System

Make sure that the grounding system of the transformer is in perfect conditions. Since the adapters to ground have been painted to avoid any oxidation during transportation, remove all paint to obtain a good connection.

### 3.1 Transportation and arrival at installation site

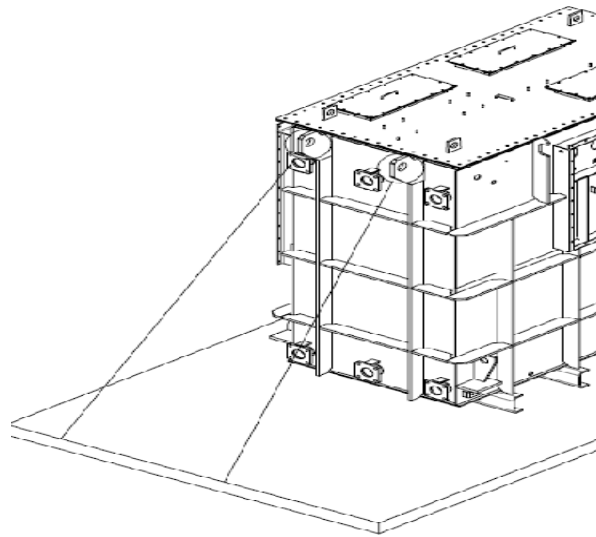
When is necessary to transport the transformer to its installation site, please follow these steps in order to avoid any damages to its structure or accidents to the personnel responsible of such operation:

- Select preferably, as means of transportation a "trailer" of a low platform



**Figure 1.** Tie-down hooks of the trailer

- Before the delivery of the transformer is strongly recommended to make a detailed revision of the route in order to anticipate to any possible obstacles (low clearance bridges), dangerous slopes, conditions of the highway, etc.
- As indicated in figure 2 the transformer must go as centered as possible in relation to the trailer.



**Figure 2.** Position of the transformer on the trailer

- Check the condition of the tie-down hooks of the trailer and verify that they are in good condition.
- In each corner there should be at least two (2) tie-down hooks to secure the tank.
- Use when possible a steel chain or cable properly tensed. Never use either rope or any other material that may stretch. Each cable must offer a minimal resistance to traction of 15 tons. No CS (carbon steel) parts shall touch the transformer tank (if it made by stainless steel). In order that there is an exigence to use CS parts (chain etc.), please make sure to use a non-metal between stainless steel and CS.
- During transportation there should not be any slopes greater than 25° longitudinal and 30° transverse.
- Before transportation, dismantle all the radiators.

### 3.1.1 Handling

- Before unloading the transformer from the vehicle observe if there are any missing pieces or deformations. If so, inform the manufacturer of these irregularities before starting any repair.
- When lifting the transformer, the suspension cables have to be maintained almost parallel to avoid any bending of the hooking bolts or other parts of the structure.
- When a transformer can not be handled by means of a crane, it may be moved by sliding it on skates or on rollers, but being careful of not to damage the base or of not to tilt it. If transformer is stainless steel, make sure to use a non-material part between tank and related Equipment (skates, rollers etc.)
- The transformer should never be lifted or moved by placing levers or under the purge valve, cooling oil drainage, connections of the radiators or any other devices.
- When large transformers are moved on rollers, beams must be supplied to distribute the forces on the base.

### **3.1.2 Recommendations during arrival at installation site**

Some times the transformers are transported disassembled and in several sections such as the main tank, the insulators, the conservator tank, the radiators and other parts. The disassembled components are placed in crates or in boxes. These parts must be matched against the supplied packing list.

Immediately after arriving to the assembly site, a revision must be performed in order to find any damage that may have happened during transportation, and to verify if there are any missing pieces. If the damages are found, please issue a claim as soon as possible:

- **Outer Inspection**

Check if the transformer has suffered any accidental drops or if they are any twisted the reinforcements or pipes.

If the paint is damaged or if any metal pieces are rusted, used sandpaper and use an adequate anti-corrosive paint.

Check that all screws and nuts are not found loose.

Check the condition of the protecting instruments that are attached to the main tank.

If any damage is found relating to the previous points, the manufacturer must be immediately informed of this situation.

- **Inside Inspection**

Normally it is not required an inspection of the inside; in the case of being required, consult the following section in the instruction manual: "*Allowable time of exposure for the core and the winding and internal works*".

### **3.2 Storage**

After a transformer has been received at its final destination, it is advisable to put it (full of oil) on its permanent place, even if it is not going to be placed in operation immediately. If this is not possible, the transformer has to be placed in a dry place and the transformer must be filled with oil. If the unit is going to be located outdoors, the water vapor will condense inside the tank, due to the variations in temperature and humidity. This will be absorbed by the winding and it will be necessary to dry the unit before putting it on operation. Therefore, it is preferable to place the transformer in a place where the temperature is slightly high and stable, following the recommendations that are given below:

- The transformers for installation indoors have to be stored in a closed place. However, if it is going to be installed in open places, these places will have to be well covered to avoid the humidity and any foreign matters enter the tank.
- The transformers to be used outdoors must be stored whenever possible indoors.
- The base or the platform for the storage of the transformers must be sufficiently resistant as to withstand its weight and be perfectly flat.
- If the transformer is going to be stored outdoors, make sure that the area for storage has a good drainage system.
- Any incidental loss of oil will not harm the environment.
- Install all the necessary protection against corrosion and mechanical damages to the tank.
- Whenever possible, charge the control cabinets with their corresponding electrical tension to avoid any moisture from entering their interior.

After a transformer has been received from the factory, it is recommended to put it on service on the shortest possible time. If the transformer is not going to be placed on operation immediately, it must be stored indoors and in a dry place by following these instructions:

### 3.2.1 Storage of transformers with sealed tank

- Transformers completely assembled

Check the internal pressure of the transformer: If the pressure gauge indicates a vacuum or pressure lower than 0.1 atm. (2 Psi), pressurize with 2 or 3 pounds of Nitrogen and check at least every month the internal pressure. In these conditions the transformer can be stored indefinitely.

If the pressure is higher than 0.3 atm (5 Psi), let escape the excess pressure.

- Transformers with detachable radiators

The transformer should be assembled totally, fill up with oil and pressurize it with Nitrogen to a pressure of 0.2 atm (3 Psi); following the recommendations from the numeral 1.1. In case of not being able to assemble it totally, the parts and pieces should be maintained sealed to avoid moisture from getting inside the parts.

#### **WARNING**

*In the event of doubts or lack of knowledge of the qualities of the available oil and before filling the transformer, samples will be sent for tests to a competent laboratory. Oil that do not comply with our specifications, can not be used.*

### 3.2.2 Storage of insulating oil

Insulating oil will be kept exclusively in clean containers and will be protected against humidity by placing the containers in a place where the temperature is maintained unchanged and on horizontal position. It will be avoided carefully any mixture with other liquids (oil for cables, lubricating and heating) or with solid particles. Small quantities of impurities can highly alter the qualities of the insulating oil. All the containers for storage are carefully checked and a detailed record will be kept of cleanliness and of perfect impermeability. It will be the responsibility of the selling company whenever possible to wash the dirty and/or used containers. In the event that becomes necessary a cleaning at the same installation site, these steps will be followed:

- The container will be sprayed with unleaded gasoline or with refined petroleum, until the cleaning liquid does not present some coloration.
- Once the container has been emptied thoroughly, will be placed to an oven or will be let to dry by means of a dried air flow for several hours. (Warning: There is explosion risk).
- After drying the container(s) will be closed hermetically, so no air would enter the container.

### 3.2.4 Problems and solutions presented during the reception and storage

- Oil leaks



Through the gaskets :

Adjust the tie down devices (screws, flanges, etc.)

- Through pores or loose accessories or cracks

Make the necessary adjustments to avoid that any moisture continues penetrating the transformer.

When there are oil leaks of great consideration, adjustments to avoid this are done, and it is filled the interior of the transformer with nitrogen gas until a pressure of 2Psi is obtained and is communicated to the nearest distributor.

- Blows and dents

When the transformer or some of its elements presents signs of hits or impacts, inform the nearest distributor or the factory to indicate the impact place and receive relevant instructions.

- Deterioration of the paint

When deterioration of the painting is presented, clean the surface of any dirt (dust, oil, grease, etc) use degreasers or soapy water; then dry the surface, sand down the deteriorated spot, clean any new dust and apply a coat of epoxy paint. Let it dry this and during time intervals of drying, apply as many coats of paint as necessary, to return to the required thickness.

- Loose accessories

When there are loose accessories, tighten them again until they are returned to their correct position. Check that there are no cracks and no moisture is found in the interior of the transformer.

If any of these cases is presented, it is recommended after taking the indicated corrective measures, to perform the following tests:

- Test of the dielectric strength of the oil
- Test of the isolation resistance (Megger)
- Test of transformation ratio (+TTR)
- Tightness test by applying nitrogen gas to a pressure of 4 Psi.

If any of these tests does not give the expected results, contact the nearest distributor or with the factory directly.

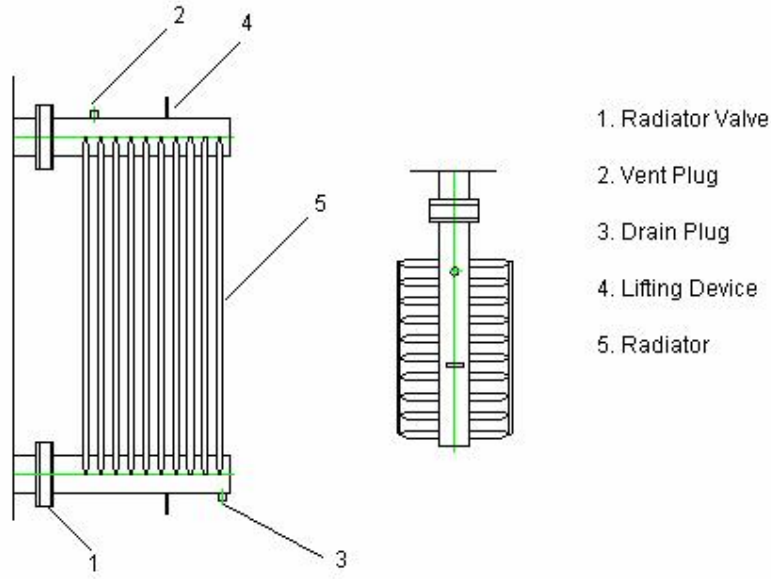
### **3.4 Radiators assembly**

When it is necessary to dismantle the radiators for transportation, They will be sent tightly closed with blind lids. The strangulation valves that are found welded or bolted to the main tank are dispatched in their close position and, are protected with blind lids. The general arrangement of the radiators is illustrated in the figure 3.

Upon receiving the radiators and removal from the crates, verify that they did not suffer any mechanical damages during transportation.

Remove the blind lids and check that the radiators are found clean and without moisture. In the event of moisture or impurities is found, it will be necessary to wash them with oil at 60 °C and to cover them to prevent than more moisture enters the radiators.

Before removing the protection lids from the strangulation valves, verify the type of insulation protection against moisture during the delivery. Normally, we find two types of preservation for shipment :



**Figure 3** Radiator parts

1. Transformers totally filled with nitrogen
2. Transformers partially filled with oil and nitrogen gas

For the first, we recommend to follow the instruction PRELIMINARY FILL UP WITH OIL, before conducting any assembly on-site. However, if the only assembly to be done is for the radiators, it is possible to assemble the radiators with the tank full of nitrogen, but maintaining a positive internal pressure between 0,05 and 0,2 kg/cm<sup>2</sup>, during the assembly.

For the second option, the transformer should be kept sealed and you should place a container (bucket, etc.) under the valve to collect oil that may spill out. Remember that this type of valve does not close completely to drip test. Therefore, you must not hit the valve to close hermetically.

For installing the radiator, follow these steps:

1. Raise the radiator from its storage position, and pay attention to avoid damages to the other radiators with the tools used for hoisting.
2. Remove the blind lid and the packing from the radiator.
3. Check visually the interior of the radiator.
4. Clean the surface of the assembly clamp of the radiator.
5. Remove the purge stopper (2) indicated in figure 2.
6. Remove the blind lid and the packing placed on the strangulation valve of the transformer.

7. Clean and if possible paint the surface of clamp of the valve from the radiator.
8. Clean the groove for gasket of the valve. Apply a small amount of adhesive in the groove and put the new specified gasket.
9. Lift the radiator with a crane.  
Though the radiators are identical, each radiator comes labeled to be installed in the position that has been indicated on the main tank. You must follow this labeling in order to avoid delays in the placement of the same.
10. Move the radiator by hand, tilt it and drain any residual oil.
11. Align the radiator to the radiator valve.
12. Align the radiator valve and the surface of the clamp of the radiator and tight it with nuts.
13. Tight a pair of nuts located diagonally one after the other in order to tight them evenly.
14. Tight firmly until the radiator valve and the radiator clamp become one whole unit. Upon adjusting, the radiators should not be exposed in any case to mechanical tensions that may lead to breakings caused by vibrations.
15. Install the purge stopper (2) indicated in the figure 3. if the tank is filled with nitrogen, if the tank is partially full with oil. See Fill up of radiators.
  
16. Once finished with the assembly of the radiators, place the supports symmetrically and the clamps of the radiator.

#### **3.4.1 Fill up of the radiators**

- Tank totally filled with nitrogen.

Open all the strangulation valves and fill the tank following the instruction "Final fill up of oil under vacuum". The radiators will be filled automatically at the same time. After minimum of a (12) hour resting time, purge the radiators.

- Tank partially filled with oil and nitrogen.

Open slowly the lower strangulation valve corresponding to the radiator that it is already installed. Oil will flow into the radiator from bottom to top, and the air will escape through the purge stopper. During this process, the oil level in the tank must be controlled and oil will be added in such a way that the oil will cover the windings.

To maintain oil level, follow the instruction "final fill up with oil under vacuum"

When oil comes out without bubbles through the stopper, this will be closed with the stopper nut provided for such effect. Next, open the upper strangulation valve. After a prudent rest time, purge again all the radiator

### **3.5 Final fill up with oil under vacuum**

Cautionary steps needed to create vacuum and fill up with oil.

1. Upon opening oil drums, pay attention in order to avoid that any humidity or moisture is condensed inside the drum. It is recommended to perform the fill up operation when the relative humidity in the air is low. The drums should be opened only when the oil is needed. Before fill up with oil, take samples of the oil contained in the barrels and test them for their dielectric characteristics. Refer to ANSI/IEEE C57.106-1991, IEEE Standard. Guide for Acceptance and Maintenance of Oil in Equipment.

2. The machine or equipment used for fill up with oil must be clean and free of humidity, pay close attention to avoid the insertion of moisture to the oil through the oil line.

3. Do not energize the transformer while performing vacuum or while it is being filled up with oil.

#### **3.5.1 Vacuum treatment**

1. Remove all the air from the transformer for more than 12 hours using a vacuum pump, and check if the vacuum level inside the transformer is less than 3mm Hg using a vacuum gauge.

2. After confirming the vacuum level, stop temporarily the vacuum pump and conduct the stop test.

The criterion for the stop test is by means of the level of vacuum, and its increase 15 minutes after the stop, as is specified below. If the result of the stop test is satisfactory, proceed to fill up with oil

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### 3.5.2 Fill up with oil

- After performing the vacuum treatment previously described in the transformer, maintain vacuum for an hour. Then, open the oil drainage valve and pump degasified oil to the tank. Insulating oil must pass through oil press filter and the pre-conditioner of oil for vacuum.

In order to make more effective the fill up, it is recommended to place the contents from the barrels in a metallic tank or if possible in a collapsible tank.

The internal surface of the oil tank must be cleaned and free of dust or any debris. It must be a sealed tank that will not allow the filtration of rain or air when is installed outdoors.

If air filters into the tank of oil, place a container with silica gel where the air is leaking into the tank, in order to prevent any moisture from getting in. It is convenient to put an indicator in the level of the oil or a transparent pipe.

- During fill up with oil, continue the operation with the vacuum pump. When the degree of vacuum is higher than 3mmHg, stop temporarily the fill up, and operate only the vacuum pump to reach the required degree from vacuum.
- When the indicator of oil level reaches a level scale at 20 °C, stop the fill up. Shut off the pipeline of the oil.
- After filling the transformer with insulating oil, a dehydrating breather will be installed if the transformer comes with a conservator tank or it will be sealed if it is of sealed tank type, and each valve will be placed in the work position.
- Release any air that may be inside by loosening the air purge stoppers. If necessary, change the packing or gaskets of the purge stoppers with new ones.
- Take an oil sample from the sampling stopper and conduct the dielectric tests of the insulating oil. Register the measured values.

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- Wait for more than 8 hours to allow the oil to penetrate the various submerged parts, and then drain some oil until you obtain the normal oil level

### **3.6 Tests in field**

The transformer has been tested in factory and is guaranteed that it will meet with the objectives for which it was built.

Of the size of the transformer, the importance of the supply, and the number of parts that had to be assembled on-site, depends the need of performing some or all of the following tests.

The tests that must be performed during and after the assembly are the following:

#### **3.6.1 Measurement of the insulation resistance**

##### **3.6.1.1 Body of the transformer**

Measure the isolation resistances between two coils and between each one of the coils and ground using a device of more than 1000V, to register the measured values. The values of the insulation resistances will change according to the temperature, therefore make sure to record the temperature of the transformer too. It is necessary an insulation resistance of more than 1000Mohms for a temperature of 30°C inside the transformer.

##### **3.6.1.2 Control Panel**

Measure the insulation resistances between two terminals from the terminal box and between each terminal and ground; from terminal to terminal, and register the value of the insulation resistance and the temperature. In the case of current transformer type BCT bushing in particular, make sure of measuring the resistance of the insulation between two BCT, as well as the insulation resistance of each BCT and ground, at a temperature of 30°C, it is required more than 100Mohms.

#### **3.6.2 Polarity tests, phases rotation and transformation ratio**

IPerform the polarity and rotation tests of phases with the tap changer in the nominal position. Turn Transformer Ratio or TTR

Yet, in the case of a transformer of three phases, it can be measured by using one source of energy of one phase, and will be very precise. Measure the transformation ratio in each one of the positions of the tap changer, considering each phase.

If you have available a transformer standard (TTR), it is recommended to use it for the tests of transformation ratio and polarity.

### **3.6.4 Dielectric breakdown test, and moisture in the insulating oil**

The values shown in this test determine the degree of dryness of the insulating oil and serve to take the decision of energizing or to reprocess the insulating oil contained in the transformer. It is also recommended to accomplish a visual checkups, interfacial tension, color and number of neutralization or acidity.

### **3.6.5 Increase in temperature test**

This test generally is not done even though there are numerous methods. Such as: method of the short circuit, where a coil is connected in short circuit and the impedance voltage is sent to other coil. The practical recommendation is to do a close follow-up at the temperatures of the transformer during the first operating days.

### **3.6.6 Test of the alarm systems and the control units**

You can trigger each accessory, such as the pressure release device, the revealing Buchholz, etc., or you can create a short circuit in the terminal of the accessory; verify its operation with the terminals and with the alarm panel.

### **3.6.7 Other**

Put in the transformer a continuous pressure of 0.3 Kg/cm<sub>2</sub> (obtained with nitrogen gas) for more than 24 hours and check if there is no oil leak. Furthermore, examines the appearance, dimension and other characteristic of the transformer, consulting the drawings. It is recommended to measure also the resistance of the coils.

## **4 General instructions**



Practical and rigorous procedure must be followed during the inspection, assembly, energizing and transformers maintenance. These must be strictly followed for the protection and safety of the workers and the transformer.

#### **4.1 Safety procedures**

The tank of the transformer must be grounded at all times. All the windings and bushings must be connected to ground unless there are performing electrical tests. This reduces the possibility of static discharges that can be dangerous for the personnel, even to the point of starting a fire and/or an explosion. Electrical test should not be conducted when the transformer is found in vacuum conditions. An arch can occur at low tension due to the vacuum conditions, causing serious problems in the transformer.

The secondary windings from the current transformers can dangerously induce high tension through them unless they are shorted out or connected to an ammeter.

There are examples of electrical phenomena that can happen on or about transformers, therefore, it is necessary to work with qualified personnel under good supervision during any assembly operation, maintenance or maneuvers.

Before using an electrical source for motor tests or control, make sure that all the sources of auxiliary power have been disconnected.

Fire extinguishers must be supplied in the event of emergency. One must be in the upper part of the transformer when working on upper part of the tank. No smoking next to the oil treatment machine or in the upper part of the transformer when some cover is removed or a hole is open.

If a fire extinguisher is used inside the transformer, there is serious danger of damaging its insulation.

Before removing any lid, it is necessary to make sure that no pressure exists in the tank, by opening slowly a valve in the upper part of the tank above the oil level.

##### **4.1.1 Cautions upon energizing the transformer**

Once all the inspections and preliminary tests ended, the transformer is ready to be in service. Simply take into account the following recommendations:

- Place the position of the switch in relation with the tension line.
- Apply tension to the transformer without load.
- Maintain it under observation during for (24 hours) and make sure that it is in normal conditions.

- Also, it is necessary to observe the transformer during an hour after that it has been loaded.
- Once installed and energized, the transformer must be checked periodically.

## 4.2 Necessary tools for assembly

Below are listed the articles, specifications and warnings for all the tools required for the assembly of the transformer.

- Crane

It is convenient to use a crane to install the radiator, the conservator, etc. It is acceptable a crane with a load capacity of 10 tons and with a length of the extension arm of approximately 10 meters. A qualified conductor must handle the crane. Before lifting the part, lift a load of a similar weight to check that the crane works adequately.

- Oil Tank made of steel plates, or collapsible rubber.

The internal surface of the tank must be clean and free of dust and dirt. It must be guaranteed its total tight sealing and cleanliness.

- Oil Filtering Press.

Use an oil filtering press to transfer oil from the drum to the tub. Use a new paper filter and perfectly dry for the filtering press, since its function consist of removing the particles or the dust contained in the oil.

Generally, an oil filtering press with a capacity of 1,000 to 5,000 lt/hour is adequate.

- Oil Purifier.

Use an oil purifier to transfer oil from the steel tank or collapsible tank to the transformer. The principal task of the oil purifier is to eliminate the gas contained in the oil. Also, it eliminates the dust and debris. Therefore, this purifier must have the following parts: a vacuum pump, a heater, a filter, an injection pump, etc.

Generally, it is used a purifier with a capacity of 1000 to 5000 lts/hour.

Perform a flow test before filling with oil the transformer, in order to drain any residual oil from the purifier and to clean the inner parts of it.

- Vacuum pump.

When transferring oil from the tub of oil to the transformer, using the oil purifier, it is necessary to have vaccum in the interior of the transformer.

When the degree of vacuum is less, stop temporarily the fill up and wait until the vacuum conditions improve.

- Nitrogen gas cylinder

The cylinder of nitrogen gas must be equipped with a reducing valve, a gauge and a rubber hose.

- Tools needed

- \* Drum opener
- \* Scissors
- \* Stripping wire pliers
- \* Jack with lifting capacity of 10 tons.
- \* Monkey wrench
- \* Regulating wrench
- \* Small bar with tweezers.
- \* Set of wrenches of several dimensions

#### *WARNING STEPS*

- Keep to a minimum the number of persons that can get into the transformer.
- Before entering the transformer, all persons must check their pockets and make sure that they are empty. Also, check that all buttons are well attached to their garments and will not fall. These people must be wearing clean and dry shoes.
- Tie the wrenches or other tools to the waist or the wrist before using them inside the tank.
- Have a written record of the tools used inside the tank and check after ending any work to see if nothing was left in the tank.
- Use work lights that come with protective device for the bulbs. Do not replace any bulb inside the tank.
- Have an assistant near to the manhole for any assistance. The assistant always must care for the worker inside the tank, and never abandon the work area during any work in progress.
- Supply the parts or the required materials one at a time. Never, provide simultaneously many parts and/or many materials.
- No smoking is allowed in or near the transformer. Make sure to take the necessary steps to prevent a fire.

### **4.3 Internal inspection**

Listed below the items to survey, if they are applicable. During the inspection, do not step nor rest on the coils and conducting threads.

- Tap lightly with a hammer the screwed portions of the metallic pieces such as yokes and clamps.
- Examine the insulation in the extreme of the windings and the clamping devices mounted between the cores and yokes such as the studs, supports and cradles.
- Examine the appearance of the coil.
- Examine the supports of the conducting thread, studs and insulating nuts. If loosened, tight it carefully. Do not apply too much torque to the studs and above-mentioned nuts.
- Examine the insulation in the conducting threads of the HV. Remove any damaged paper if there is some, and wind the crepe paper impregnated in oil with half lapped until the original diameter of the insulation.
- The length of the sharpened union will not be less than 10 times the thickness of the insulation.
- Examine the appearance of the bare conducting threads and their joints.
- Examine the appearance of the tap changers without tension and conducting threads. Confirm that the tap changer mobile contacts are found in a corresponding position to the indication No. 1 tap and in the center approximated between the contacts.
- Examine the appearance of the on load tap changer and the conducting threads. Confirm that the mobile contacts of the selector of tapping are found in the approximate center of the fixed tapping, when the design of the changer allows it.
- Examine that all CT's are installed certainly in the normal position, and that their terminal and secondary conducting threads are in perfect conditions.

#### **4.3.1 Internal connections**

- **Preparation**

To accomplish the internal connections in the shortest possible time, prepare the following tools and insulating materials before beginning to work.

- **Tools**

- Set of torque wrenches
- Foresail keys (LLAVE DE TRINQUETE)
- Sharp blades
- Convex ruler
- Lamp(s)

- **Insulating materials**

- Crepe paper impregnated in oil
- Kraft Paper impregnated in oil
- Tapes

*NOTE: Maintain in the interior of the tank the insulating materials. If they are stored outside, submerge them in insulating oil in order to prevent any moisture from being absorbed, and extract them immediately before being used.*

#### 4.3.2 Connections

- Due that the thread conductors consist of fine intertwined copper wires, do not cut these wires.
- Use the TORQUE WRENCH to tighten the bolt terminals or bare conductors. It is listed in following table, the torque required for the different size screws:

SIZE OF THE BOLT	TORSION PAR	
	kg - cm	Lbs - Inches.
M6	50 ± 10%	44 ± 10%
M8	120 ± 10%	104 ± 10%
M10	250 ± 10%	217 ± 10%
M12	600 ± 10%	522 ± 10%
M16	1000 ± 10%	870 ± 10%

**Tabla 2.** Size of the bolt and torsion par

#### 4.3.2 Inspection after connections

Below are the items to check.

- Examine that all the connections are according to the drawings or the reference markings.
- Examine that the screws and the nuts are tightened.
- Check that the required insulation distances are maintained between the conductors and the others parts.
- Make sure that no tool or material was forgotten inside.

#### 4.4 Allowable time of exposure for core and winding

While some activities are performed such as the internal inspection, bushings installation, internal connections, etc., with the manhole of the transformer open, the core and the windings will absorb the moisture from the atmosphere.

Therefore, the exposure time of the core and the winding will have to be limited within the specifications that are mentioned below.

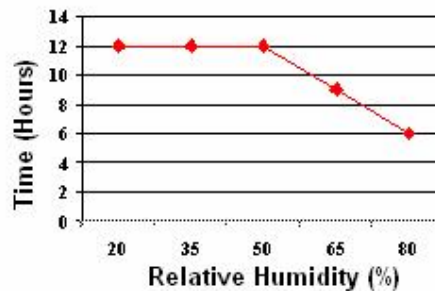
The transformer should not be opened when it is raining, there is the threat of rain or the relative humidity of the air is more than 80 %.

The manhole and other openings will have to be closed and be sealed immediately after any internal work is done or suspended. However, the time elapsed during a opening will let atmospheric air to enter the tank, and it must be considered as exposure time outdoors. Therefore, the core and the windings will absorb humidity during this period.

In the case of the tank is filled with atmospheric air and sealed in these conditions, the exposure time must be recorded as four (4) hours for one time during the installation of the transformer.

When the extraction of the dry nitrogen gas takes place, it is considered that the transformer will be filled with atmospheric air, situation that is recorded as two (2) additional hours of exposure.

The total allowable time of exposure is indicated in fig. 7.



**Figure 7.** Relative Humidity average

## **4.5 Inspection of rubber gaskets**

### **4.5.1 Maintenance of the gaskets and sealed surfaces of the clamp during the installation**

- Clean any dirt and oil from the reusable gaskets and from the sealed surface of the clamp, using a rag soaked in a dissolvent, that it can be alcohol or gasoline.

#### *NOTES*

- The gaskets should never be in contact with the dissolvent.
- The dissolvent should be used only for cleaning any dirt to avoid that the dissolvent or

dust penetrates the interior of the transformer.

- The gaskets and the surfaces of the clamps will have to be mounted when the dissolvent used for cleaning have dried thoroughly.

#### **4.6 Instruments for measurements and field test**

Complete the inspection and the field test during and after the assembly of the transformer, using the following tools:

- **Oil Testers**

It is used to measure the dielectric characteristics of the oil. Though the Standard ANSI/IEEE C57.106-1991, specifies a good quantity of tests, is required at least to have a high dielectric breakdown tester and a measuring device of ppm of water (humidity) by the Karl Fisher method. The stages by which these measurements should be taken are:

- \* Select several drums and inspect them.
- \* After the oil is poured in the tank of the oil and before transferring it to the transformer.
- \* After the oil is in the transformer, take a sample from the bottom of the drum. Compare the results of the test with ASTM, BS or any other equivalent standard.

- **Voltmeter**

It is required an AC voltage meter for the following tests:

- \* Polarity test
- \* Monitoring of the vector graph
- \* Test of the sequence of the control circuit.

It is necessary a set of each one of the following voltmeters of double range precision for AC:

AC 150/300 V one set

AC 30/75 V one set

- **Ammeter**

A set of each of the following precision ammeters of double range is required to measure the excitation current. When it is applied in low voltage to the transformer, and to measure the current of the auxiliary devices of the transformer, such as the, the oil pump, etc., in case it comes with the transformer.

AC 20/100 A one set

AC 10/50 A one set

For some applications, it is sufficient with a pair of ammetric tweezers.

- **Measuring device for the insulation resistances (megger)**

A hand-held device with a range of approximately 2000V and 2000 Megaohms is acceptable.

- **Universal tester or VOM**

This is a portable tester that can measure the AC voltage, the resistance and the DC It current, changing the range. is used to verify the controlling wiring or the electrical parts.

- **Turn Transformer Ratio (TTR)**

This device is very useful to check easily the relationship of transformation without requiring external feeding sources and/or to induce voltages in the winding dangerous for



the workers. With this same equipment, you can check the polarity and depending on the model, the vector group.

- **Rotation phases meter**

Meter used to verify the direction of the rotation phases of a three-phase electrical motor, etc.

- **Vacuum Meter (Vacuometer )**

It is necessary to prepare the vacuum meter for measurement of the degree of vacuum during the use of the vacuum pump. It must be used a vacuum meter capable of measuring up to 10-2 mmHg

- **Pressure Indicator**

To check any oil leak under pressure after mounting the transformer, a pressure indicator is needed. A reading device Bourdon, pipe type (compound) with a measuring range of 0 to 1.0 Kg/m2.

- **Other**

Prepare to necessary instruments to perform the tests, such as tangent delta (insulating power factor or dielectric loss) and capacitances.

The values shown by this test should be kept and be taken as reference to determine the humidity and /or the aging of the insulation with the course of time.



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Document Title

User's Manual

Document No.	Date & Rev. Ind.	No. of Pages	Page
UM - 316	10.11.2015 - 01	25	25