

1LCB000001EG-EN– rev. 1

User's Manual

Assembly and Energizing Transformers of Small Power



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1 Object

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

2 Description

The recommendations, instructions and norms here contained will give it a guide to carry out labors of installation or assembly and set in motion or energizing of a small power transformer. But this information is not the only one requirement so that the transformer operates satisfactorily. It is required to count primarily with qualified personnel and tools and equipment designed for this purpose.

3 Order of assembly 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 that all bolts and nuts have been tightened.

- **Connection**

Check if all the electrical connections have been made correctly.

- **Cooling system**

Check if the entire radiator's valves are opened, and that the cooling control device and cooling fans are operating normally.

- **OLTC**

Check if the OLTC operates smoothly, and if the position of the Tapchanger corresponds to the desired tension. The control device for the OLTC (On-Load-Tapchanger) 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.

- **Dehydrating breathers**

Check their operation.

- **Valves**

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

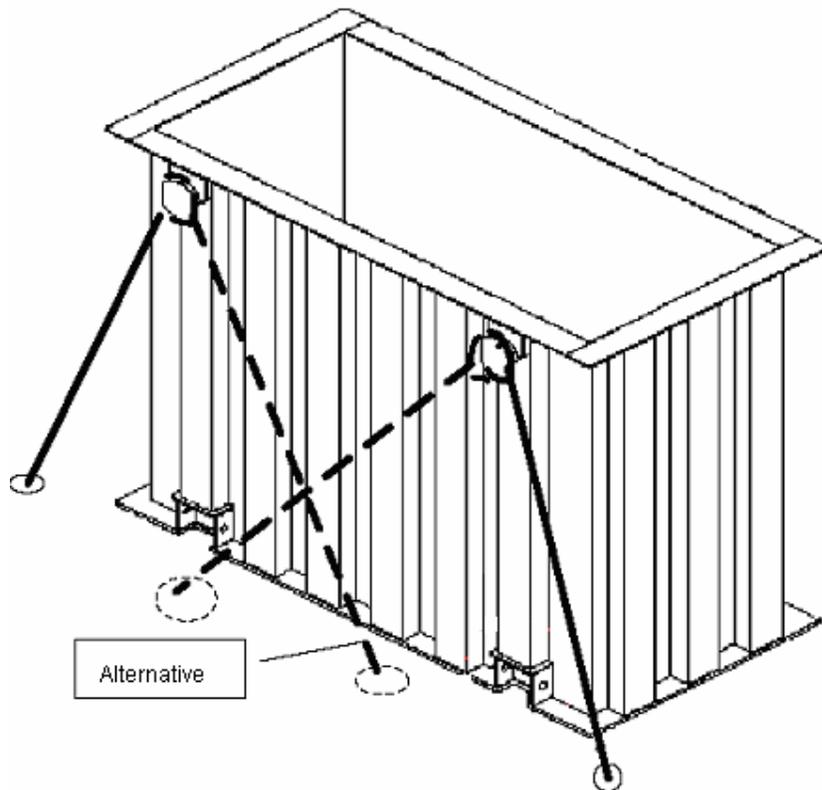


Figure 1. Tie-down hooks of the trailer

- 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.

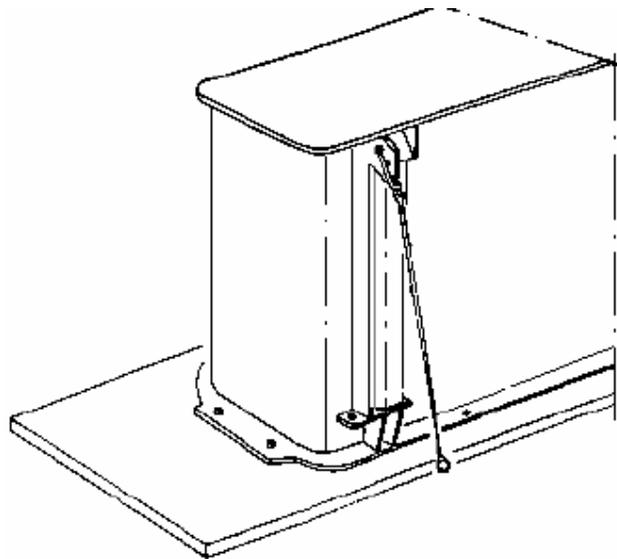


Figure 2. Position of the transformer on the trailer

- Check the condition of the tie-down hooks of the trailer and verify that they are in good condition.
- The expansion tank (if it is to be delivered with the transformer), must be placed behind the cabin of the truck.
- 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.
- 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.

- The transformer should never be lifted or moved by placing levers or hydraulic jacks 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:

- **Checking for gas pressure**

In order to avoid any humidity from entering the main tank, it is filled with dried nitrogen gas (approximately 0.2 kg/cm² to 20°C). Remove the protective cover from the pressure gauge mounted on the tank, open the connection valve and check the pressure of the gas. After checking, close the valve tightly. A positive reading will mean that no water or air has leaked to the interior of the tank. If the needle indicates zero, there may be water inside. In this case, measure the isolation resistance of the winding in order to establish the degree of humidity that has penetrated the transformer and to take the necessary corrective actions.

- **External Inspection**

Verify if the transformer has suffered any accidental drops or if there are any twisted reinforcements or pipes.

If the paint is damaged or if any metal pieces are rusted, use sandpaper and adjustment a suitable anticorrosive 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. When a severe damage is found relating to the previous points, the manufacturer must be immediately informed into the case

- **Internal Inspection**

Normally it is not required an inner inspection; 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 from factory, 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 must be filled with oil. If the unit is going to be located outdoors, the water steam will condense inside the tank, due to the variations in temperature and humidity. The winding will absorb this and it will be necessary to dry the unit before putting it on operation. Therefore, it is preferable to place the transformer in a site 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.
- To avoid any moisture from entering the tank, a periodic revision of the respirators of silica - gel and/or of the nitrogen pipes should be performed when the tank is partially filled with oil.
- Take the necessary steps to prevent that water condensation is formed in the accessories and parts that are delivered separately. Use the adequate protection against the weather elements. If it is necessary place Silica gel driers inside the bags and/or containers.
- 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.

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 without our approval.

3.2.2 Transformers with expansion tank

- Fully Assembled

Place the silica gel breather following the instructions "Assembly of breathing silica gel".

WARNING

If during transportation the silica gel has absorbed any moisture (pink color), it will have to be dried in an oven to 150-180 °C, until it recovers its original blue color, or if it is possible to change it by a new silica gel.

In oil immersed transformers, the color of the silica gel will be controlled carefully every four (4) weeks, and in tropical climates every two (2) weeks. As it has been said previously, the silica gel will be replaced or will be dried in an oven, if more than half of the content of the present breather presents discoloration.

- Partially filled with oil

The expansion tank will be mounted and will proceed to fill it up with oil up to the corresponding level. Once the fill up is finished with oil, the silica gel breather will be mounted.

A transformer completely full of oil can be stored indefinitely. This storage is preferable than a transformer filled with gas.

3.2.3 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 strangulation valves

Adjust the hatches of the valves and flanges that protect them.

- 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 7 Psi.

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

3.3 Preliminary fill up with oil

In order to avoid during the assembly of the transformer direct contact of the winding and the insulation with the atmosphere, it is recommended to fill up the transformer previously with insulating oil up to a level that is 25 cm below the cover of the tank, In the case of a transformer equipped with expansion tank or 85°C labeled on the indicator level in the case of a sealed transformer.

Before filling up with oil, it is necessary to conduct the dielectric resistance test of the oil stored in drums.

Take a sample from each drum and make sure that the dielectric characteristic correspond or not to the specified. See standard ANSI/IEEE C57.106-1991, IEEE Guide for Acceptance and Maintenance of Oil in Equipment. In a negative case, that is to say, the oil does not possess the dielectric characteristics specified, filter totally the content of the oil. The Fill up with oil must be done only after the test values are found to be within the specified values.

There are two methods to conduct an oil fill up.

The first of them consists of filling the tank with oil through the drainage valve while gradually the nitrogen contained in the tank is released. The pressure of the nitrogen contained in the transformer tank must be kept between 0,05 and 0,2 kg/cm² during the oil fill up.

The second method consists of filling with oil after reaching vacuum in the transformer.

See fill up with oil under vacuum. This method is recommended by ABB by being the safest method of the two.

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:

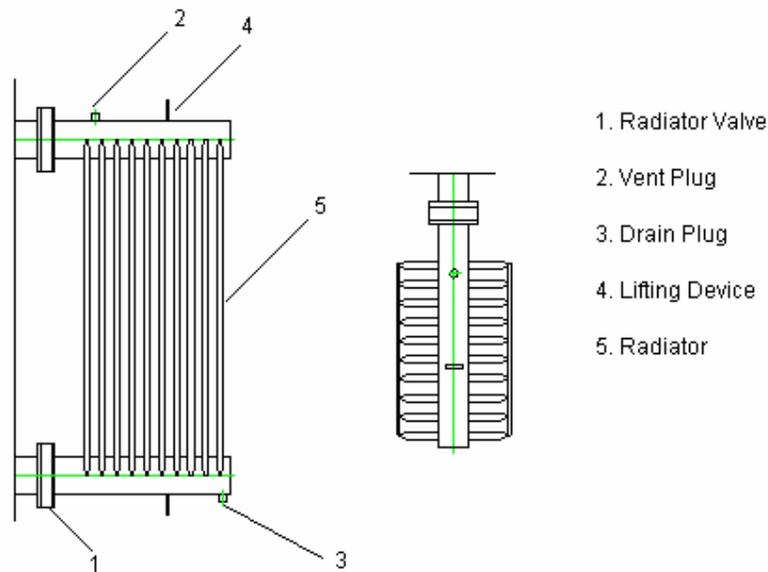


Figure 3 Radiator parts

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/cm², 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

Open slowly the lower throttle 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. 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 by breaking vacuum*". When oil comes out without bubbles through the purge, this will be closed with the stopper nut provided for such effect. After, open the upper throttle valve. After a prudent rest time, purge again all the radiator.

3.5 Assembly of the conservator tank Tests in field

There are three types of conservator depending on the degree on protection that is required and/or of the accessories included. These are:

3.5.1 Conventional conservator tank

The most common type found in transformers. Upon installing the conservator on the transformer, it is necessary to pay attention to the following items.

3.5.1.1 Assembly of the Buchholz relay (31)

If the transformer is provided with a Buchholz relay, install it in the conservator before proceeding with the assembly of the same in the transformer. The relay is found connected to the conservator through a clamp and four (4) screws. Normally in the connection pipe, there is a valve installed for future maintenance of the Buchholz relay. Remove a blind lid from the surface of the clamp, and replace the gasket with a new one. Install the relay in the conservator and tight it firmly and evenly the bolts. Make sure of putting the relay in the direction indicated on its characteristics plate or on the body of the relay.

Place the conservator tank on the bases destined for the attaching to the main tank of the transformer and place the eight screws, but do not tighten them completely at this stage. Align the clamp of the Buchholz relay with the connection clamp from the main tank and secure it with screws, making sure that no mechanical forces are placed on the relay. Once concluded this installation, make sure that the expansion tank is secured to the main tank and give final tightening to the screws. For more details on the relay check the relay manual.

3.5.1.2 Assembly of the Silica Gel Breather (33)

Once the transformer has been filled with oil, proceed to install the respirator following these steps:

- Verify that the silica is dry (purple color); if not, dry it by following the steps that are indicated in the maintenance handbook.

Thread the breather into the pipe given for such use. To obtain better tight seal, it is recommended to use Teflon tape in the screw thread.

-Fill up with dielectric oil the container located in the lower part of the breather up to the indicated level.

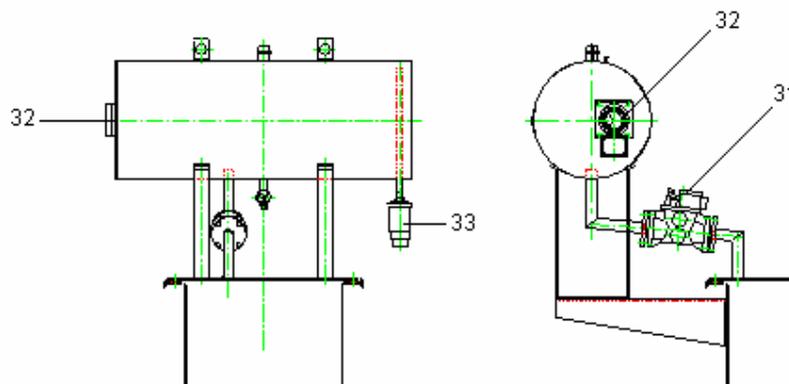


Figure 4. Conventional conservator tank

3.6 Test 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.

3.6.3 Insulation power-factor test and capacitance

The values revealed by this test must be kept and be used as reference to determine the humidity and/or the aging of the insulation with the course of the time. Also, it must be registered the temperature at which the measurement was accomplished.

It is recommended to perform an insulation power factor test of the insulating oil.

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.

Regarding the box of the mechanism of the tap changer which is triggered by motor, if it is available, start it up and observe if there are any abnormalities or not. Verify the manufacturer's manual.

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.

The lights that are used inside the tank should have a protection against blows, and when possible to explosions test. Extreme caution should be taken by the persons that are working on the upper part of the transformer when it is opened, any object that falls within the unit will cause huge delays in putting it in service.

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. For this, use a vacuum pump. To create vacuum, it is required approximately 12 hours, if the transformer is of less than 100 kV and 16 hours for transformers of 110 kV or more.

It is recommended that the degree of vacuum established be of 1 mm Hg or less. Once the waiting period mentioned above is over (12 or 16 hours depending on the transformer), you may start the fill up process. When the degree of vacuum is less, stop temporarily the fill up and wait until the vacuum conditions improve.

- 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

4.3 Inspection of rubber gaskets

The disassembled gaskets in the field must be checked and examined to decide their use or not according to the following table:

REUSABLE	NOT USABLE
Without breaks or stretching Very small Stretching but without grooves or dents Only it stays the shape of the corresponding groove to the gasket T Exists partial stretching but no grooves exist in the original width. T	1. Very deep grooves and stretching 2. Deep grooves and dents are observed on the surface of the gasket.

Table 3. Inspection method of gaskets

4.3.1 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.

4.4 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 cooling fan, 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 Resistance Bridge**

This is necessary to test the resistance of the windings of the transformer. It must be capable of measuring between a range of 0.001 - 10 ohms

The Kelvin bridge is acceptable. You must have at hand some batteries.

- **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 current, changing the range. It is used to verify the controlling wiring or the electrical parts.

- **Pressure Vacuum gage**

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 gage capable of measuring up to 0.01 mm Hg

- **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.



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