



TAO MANUAL

GENERAL INSTRUCTIONS

A - INTRODUCTION

The instructions in this manual have been prepared for users of our products, aiming at guiding them as to the necessary precautions and procedures for achieving a great performance of such products.

The recommendations hereby mentioned are in compliance with the items of the ABNT NBR-7037 standard, to which they apply.

B - TRANSPORTATION

Transportation must be conducted in a way that protects all the equipment against or damage due to dropping or mishandling (for example, to the paint)

In the cases in which the transformers are wrapped up, the material used and the packing arrangement must comply with the efforts performed during transportation in order to protect the transformer.

Transformers are shipped with their high tension windings connected in their highest tension, except in otherwise specified circumstances.

Upon reception, each unit must undergo visual inspection according to item 4.2. Should any abnormal event be noticed, the receiver must write the irregularities found on the shipping document and immediately notify **ZILMER**, the transporter and the insurance company in order for the necessary arrangements to be made in each case.

The report of the event must contain all the elements mentioned on the identification plate, as well as the specific details regarding the damage suffered to the transformer.

C – VISUAL INSPECTION

The equipment must be examined as to:

- a) whether the characteristics of the transformer's identification plate are in compliance with the request;
- b) the inexistence of fissures or cracks in the bushings or external damages in the tank or accessories (scratches or dents)
- c) the tone of the terminals and accessories;
- d) the right level of the insulating liquid (when the transformers are shipped with oil) or the internal positive pressure (when the transformers are shipped with inert gas). Otherwise, such fact will be taken as an indication of a leak and occasional entrance of humidity.
- e) the accuracy of the tools, by means of its readings;
- f) the external components of the change-over switch. In such occasion, one must conduct the change for all positions in order to determine the possible system flaws during transportation;
- g) the inexistence of leaks through bushings, plugs and welds;
- h) indications of corrosion on any part of the tank;
- i) the right mark of the terminals;



j) the state of the pack, whenever there is one.

D - HANDLING

4.1 - All the unloading and transportation services for the transformer must be conducted and supervised by specialized personnel, complying with the appropriate points of support.

4.2 - The lifting or traction must be performed by the points of support pointed out in the diagrams or instructions from the manufacturer, and it shouldn't use other points that, if used, might cause severe damage to the transformer.

4.3 - All the components and accessories must be handled with due care and complying with instructions from 4.2.

4.4 - The handling of the transformer must be performed in a planned and cautious way, and any rough movements and sudden stops are to be avoided.

It must be performed with appropriate equipment and materials, providing safety to both the personnel involved and the transformer.

E - RECEIVING

Whenever possible, the transformer must be unloaded directly on its permanent base. Before unloading it, a preliminary inspection must be performed by a specialized team on the transformer, thus verifying its external conditions, accessories and components, regarding any deformities and the condition of the paint. We must be immediately notified should any abnormalities arise.

All the unloading and transportation service of the transformer must be conducted by *specialized* personnel, in compliance with the *security* standards and making use of the appropriate points of support. The handling must be performed in a planned and cautious way, and any rough movements and sudden stops are to be avoided.

F - STORAGE

When the transformer is not immediately put into use, it must be stored with insulating liquid at its normal level. The storage must be performed, preferably, in such conditions so that the transformer is not exposed to bad weather conditions, great temperature variations and corrosive gases, so it doesn't suffer any mechanical damage.

We recommend that the transformers are not in contact with the ground. For that, boards or wood shims must be used.

For transformers that are stored with nitrogen gas exceptionally, before being placed, the oil must be submitted to the tests according to the NBR-5356 standards and present the characteristics and respective limit values specified in Resolution 6/72, from the CNP 16 standards and resolution I5/8, from the 06/Rev.I. technical regulation.

The accessories must be stored in appropriate places when taken off of the transformers.

The air dryer must be installed in order to avoid overpressure in transformers with a conservatory, even when de-energized.



G - INSTALLATION

a - Before any measure regarding the assembly of the transformer, the availability of qualified personnel should be verified, as well as the appropriate equipment and tools.

b - It's not advisable to assemble the transformer on rainy days.

c - Before the assembly of the transformer, a verification must be conducted, consisting of:

- 1) a visual inspection, especially regarding the correct leveling of the base. The transformer must have a slight upward angle in comparison with the conservatory, which is considered ideal for the correct functioning of the gas relay.
- 2) Correct mounting of the transformer through the inspection of the anchorage devices;
- 3) A visual inspection on the external part of the transformer's tank, in order to check on the non-occurrence of damages during the handling.
- 4) Check if the plate damages are compatible with the equipment's technical specification;
- 5) For reconnectable transformers, verify if the dispatch connection (expedition) meets the requirements.

d - For oil-free transformers, the gas pressure and dew point must be checked.

e - For transformers transported with oil, whenever possible, a sample of the insulating oil should be collected for a lab test.

f - The transformer's grounding connections must be checked.

g - Install the air dryer in transformers with a conservatory, even with the equipment de-energized.



H - TESTS AFTER THE ASSEMBLY

Before energizing the transformer, the following tests should be performed:

a) - INSULATION TESTS - Test with the "megger" of all the ground windings, as well as between the windings. The tests should be performed with a 2.500v "megger", after the external cleaning and drying of the bushings and after disconnecting the bushing connection such as connector wires, bars for the bushing terminal and lightning rods. Compare the results with the test reports.

b) - VERIFICATION OF THE CHANGING RELATION IN THE MAIN TRANSFORMER - The changing relation must be verified in all derivations with the switcher in the respective positions.

Verify the tension continuity during the change of derivations (it doesn't apply to the switch without any load) and measure the AT's excitement current if necessary. Also perform the gap test (angular displacement).

c) - CURRENT TRANSFORMERS - The polarity test, whenever required, can be performed by the inductive kick process with continuous current.

d) - OIL TESTS - Remove oil samples from the lower valves of the main tank, the switch tank and/or the deviation switch tank.

Perform the dielectric resistance test for one minute and also the breakdown test, in accordance with the effective standards.

e) - THERMOMETERS AND THERMOSTATS - Remove the thermometer's bulb and place it, together with a conventional thermometer, in an appropriate container full of transformer oil. Heat it up and stir the oil slowly, while reading the thermometer.

Adjust the transformer thermometer if necessary. Also check the signaling contacts and adjust them to the desired temperature. For transformers provided with thermometers for the oil and winding temperature, the values for adjusting the signaling contacts are recommended according to the following table, but they might be modified to meet the usual measurements from the client.

Transformers with cooling or forced ventilation

Oil Temperature

85°C

**Winding
Temperature**

95°C



The thermometer contacts used to activate oil pumps and ventilators in transformers cooled by forced circulation, are in general, set for 60°C if the thermometer is set according to the oil temperature, and 75°C if it's according to the winding temperature. In both cases, the choice must be made separately.

f) – GAS DETECTOR RELAY – The alarm circuits must be checked by blowing air under pressure of 45kgf/cm² in the relay, until the float drops. Check if the switch operates.

g) – OIL LEVEL INDICATOR – Move the float's arm of the oil level indicator between the extreme positions to verify if the mechanism doesn't get stuck in any position and if the signaling contacts function properly.

h) – OTHER INDICATORS – It's recommendable that all indicators such as safety valves, differential pressure switch for oil-water systems, flow indicators, sudden pressure relays, etc., if provided, be first tested before energizing the transformer. If possible, follow the existing instructions and check if all signaling, jolts occur appropriately.

i) – OIL LEVELS – Check the oil level on the transformer and the bushings. Adjust if necessary.

j) - DEGASSING – If the oil is purified in a filter without any degasser or put into a tank with partial vacuum only, it is impossible to avoid, during the filling, the entrance of air into the transformer, together with the oil.

The air suspended in the oil, in the form of small bubbles, reduces the oil's dielectric resistance, and it might also adhere to the windings, thus gradually making bigger bubbles that, afterwards, get loose and come up through the oil. If the transformer is energized, the bubbles might cause a corona or discharges, when passing through spots where the electric field is elevated.

Another inconvenience is that the air might cause a false gas alarm when passing through the gas relay detector, with clear disturbances for the service. Therefore, it's advisable to make sure that there isn't air stuck in the central tubes of the condenser bushings, in the container of the bushings or any other elevated point in the transformer cover, such as grooves for radiators or heat exchangers.

k) – SWITCH WITHOUT ANY LOAD – Check the locking key provided and adjust it if necessary. Also check if the transformer circuit breaker functions when trying to activate the switch. Put the switch in the intended position and lock it with a padlock.

I - GENERALITIES:



Verify and, if necessary, adjust:

- 1 - The silica and the oil level in the air dryer
- 2 - If all the valves are correctly placed;
- 3 - If the transformer and the control panels are hermetically sealed and clean;
- 4 - If all the connections with the lines and collecting bars, as well as to the ground, are satisfying;
- 5 - If there's enough distance between the tension terminals and the ground (on some transformers, the lugs for suspension must be removed);
- 6 - If all gasket screws are sufficiently tightened;
- 7 - If any equipment or tools, etc. are left in the transformer;
- 8 - If all damage to the paint was touched up.

J – ENERGIZING:

a) – PROTECTION RELAY – Verify if the protection relays are all connected and functioning properly. The relays themselves must have been previously tested.

b) - TESTS UNDER NOMINAL TENSION – If there's any self-sufficient power generator available for the test, the tension must be gradually increased from a low initial value up to the nominal value. (A surge of approximately 25% can be kept for a few minutes, if wanted).

Otherwise, the transformer can be connected directly to the line. After energizing the transformer, it must be kept under strict observation for a while.

After the functioning, between one or two weeks, the gaskets will probably seal and the respective screws should be retighten.

K-MAINTENANCE: PREVENTIVE /CORRECTIVE

Transformers in service are frequently submitted to a considerable amount of mechanical and electric effort. In order to prevent flaws and complications, it is extremely important that the transformers are carefully inspected.

At first, attention must be paid to the oil, its temperature, as well as the temperatures from the different parts of the transformer.



PERIODIC INSPECTIONS: Every 12 months, an exterior inspection must be performed with the transformer energized, limiting it to an observation from a distance of the conditions of the device, consisting of:

- a) checking for the inexistence of fissures, cracks or dust in the bushings and external damage in the tank or accessories (scratches or dents);
- b) the conditions of the terminals and connections of the transformer;
- c) possible leaks through the bushings, covers, plugs and welds;
- d) indications of corrosion on any part of the tank;
- e) checking for the inexistence of mechanic or electric abnormal noises;
- f) checking the transformer mounting;
- g) checking the grounding and protection equipment of the transformer;
- h) checking the level of the insulating liquid, when the indicator is external.

Every 5 years, the following tests must be performed, according to the user's criterion:

- a) resistance of the insulation.
- b) removal of the insulating liquid sample for lab analysis.

This must be conducted as follows:

- carefully clean the valve or existing device for this purpose;
- use a transparent glass container, with capacity for approximately one liter, which must be cleaned first with water, then with alcohol or benzene.

This container must be dry and be, next, washed with the oil from the very transformer;

- let it pour about half a liter through the transformer valve before filling the container;
- carefully fill the container with transformer oil, avoiding the entrance of any impurity;
- seal the container hermetically with a grounded glass stopper, preferably soaking it in paraffin

If the values point to the need for a full review of the transformer, it's recommendable to send the unit to the shop.

Every 10 years, a full review of the transformer must be performed, in which case it's necessary to send the unit to the manufacturer.

OIL: The transformer oil is hygroscopic and, therefore, it easily absorbs the air humidity. However, this absorption is fully preventable if the transformer is sealed, or nearly fully preventable with the aid of a conservatory tank and the silica-gel dryer. This dryer must be under constant observation and the silica must be renewed or recovered, when its ability to absorb humidity starts to decrease.



If any service exposes it to air humidity, the tension of the oil's electric rupture must be checked. This oil check must always be performed in large transformers, after regular time intervals.

The oxygen from the air also causes the oxidation of the oil. In this process, besides water, it produces acids and asphalts, which cause the deposit of "mud" into the windings, the core, etc. The cooling of the winding and the core is jeopardized, thus reducing the insulation resistance.

If it starts to make mud, the oil changes its color, becoming darker. The appearance of the oil is normally muddy. By means of filtering, it's possible to remove the mud, however, once it's started, the production of mud increases over time. The oil in such conditions must be changed, as soon as the service conditions enable it.

Another deterioration process, associated with the production of mud, is the increase of the content of free acids in the oil. If such content doesn't exceed 0.5 mg of KOH per gram and, besides, the oil presents good properties, it's appropriate for use. Otherwise, the oil must be changed. If, when tested according to the Pensky-Martens method, the ignition point is inferior to 130°C and, besides, the oil smells burnt, an oil decomposition (cracking) might have occurred.

In this case, the transformer must be inspected (suspension of the active part or opening of the inspection covers) to check any possible overheating in the core or windings.

The oil change in a transformer must be preferably performed when the transformer is hot and the oil viscosity is low. The change must be as thorough as possible, as the mixing of new oil with old oil, in time, takes up the properties of the oil with the lowest quality.

The experience also showed that, if two oils of different qualities are mixed, the property of the mix won't be any better than the worst oil.

When it's about replacing the oil that was removed or has leaked, as long as it is small amounts, it's enough that the added oil is dry and pure and, at least, is the same amount as the existing oil in the transformer.

The oil that is not over-oxidized can, in certain cases, be recovered, but this only becomes economic for fairly large amounts. The recovery must be performed by a competent company, which will chemically treat the oil.

TEMPERATURE: A transformer's lifespan depends a lot on the prevailing temperature in the windings and the core of the transformer in use. It's important, thus, that the temperature is constantly under observation.

The increases of temperature allowed are specified in the transformers' standards, and they vary a bit from country to country.



The ABNT Standards (NBR-5356) allow a temperature increase of 55C for oil and 65°C for the windings. These values are based on the maximum temperature in a cooled environment of 40°C for air and 30°C for water. When the temperature of the cooled environment is low, the transformer can be overcharged. However, the allowed overcharge must not be assessed only after the increase of the oil temperature over the cooled environment, as the winding-oil temperature gradient increases by the rate of 1.6 of the charge increase.

Sometimes, the capacity to endure an overcharge is limited by the transformer's accessories, for example, bushings, switch, etc.

It's advisable to probe whether each accessory has a continuous overcharge capacity equal or higher than 20%.

Sudden charge variations affect the oil temperature only gradually, whereas the winding temperature stabilizes much more quickly.

If there's a trend of a temperature increase in a transformer, without any increase of the charge, the cause can be a deficiency in the cooled environment. In oil-water cooling systems, there might be a deposit of mud in the cooling tubes, which will evidently cause an increase in the oil temperature.

Another reason for an abnormal increase of temperature might be if the oil started the deposit of mud in the transformer's windings and core. This way, the cooling of such parts is jeopardized and the respective temperatures will increase. If abnormal temperatures are verified, the thermometers must be checked first.

COOLING SYSTEM: In transformers with natural cooling or forced ventilation, it's not necessary to provide any special requirements to keep the cooling surfaces clean, as long as the oil is in good condition. If there's any production of mud in the core, it might deposit in horizontal portions in the radiators or heat exchangers. In this case, these devices must be cleaned, while at the same time an oil change and an overall inspection in the transformer is performed. If the mud doesn't come off with the oil flow, use benzene, trichloroethylene, etc. and then an oil bath.

Deposits of water sediments are also common in oil-water heat exchangers. Most of the time, the deposits are made of mud, but there are also organic deposits consisting of long fibers, especially if the water from rivers is used for cooling.

GAS DETECTOR RELAY: The gas detector relay is a helpful device to supervise the transformers in use.

Such relays are included among the standard accessories for ZILMER INELTEC transformers, from a specific power rating on.



TANK COVER: It's advisable that the transformer is kept under regular inspection. In case there's a need for any adjustment, perform it as soon as possible.

ACCESSORIES: Test all accessories once every year. Review all devices, electrical and conductor wires, signaling devices or room operation or command panel. The "megger" test is also recommended.

WHEELS: When the transformer has wheels, these must be removed during transportation and, after the transformer has been installed in a definitive place, they must remain shimmed/locked.