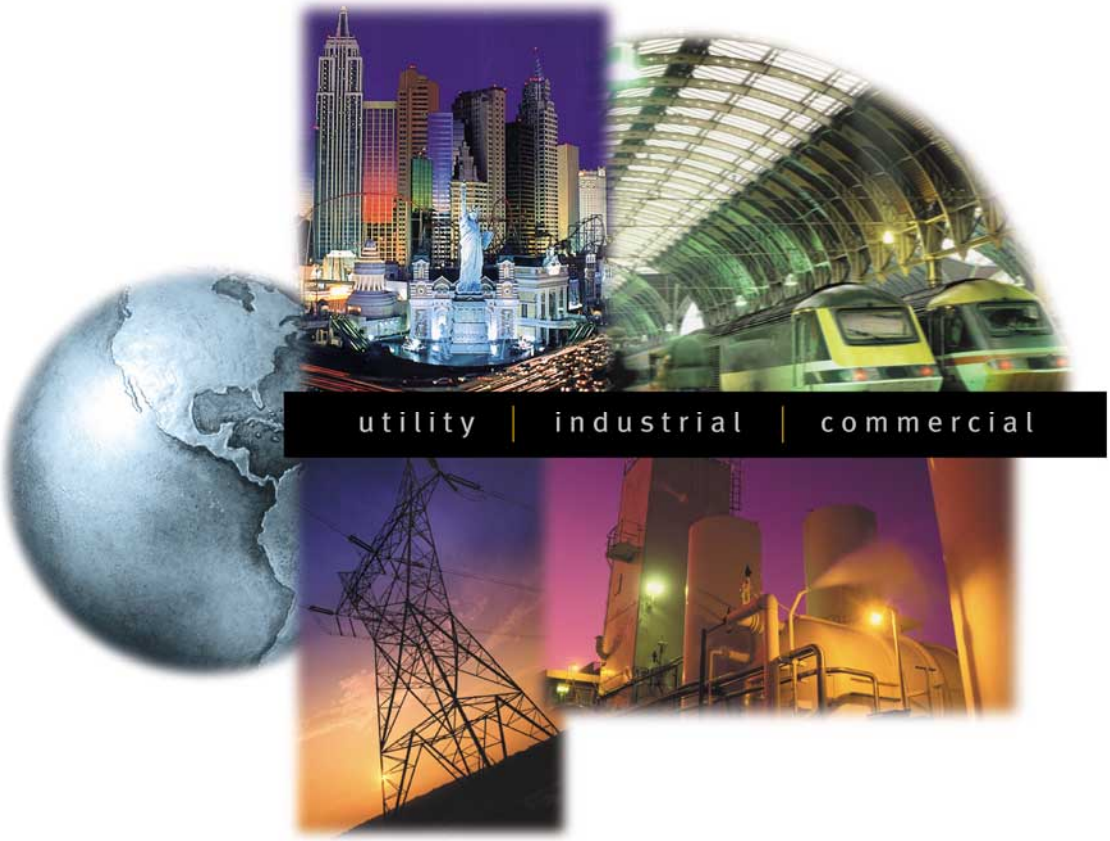

Instructions for

Receiving, Installing, Operating and Maintaining Liquid-Filled Transformers

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Danger: Entering the tank of a liquid-filled transformers through the manhole is classified as entering a confined space by OSHA.

Receiving, Installing, Operating and Maintaining Liquid-Filled Transformers

Table Of Contents

The information contained herein is believed to be accurate and reliable. However, the supplier assumes no responsibility for its use or misuse and warns the reader to exercise caution in the installation and maintenance of the products described herein.

Please read the entire document before following any part of it.

Megger reading per section 5.5 and date of energization must be recorded and sent to supplier within 15 days of energization for warranty to be valid.

1.0 General

This guide covers general recommendations for the operation and maintenance of liquid filled transformers.

The successful operation of these transformers is dependent on proper installation, unloading, and maintenance. The conditions under which they operate will determine, to some extent, the frequency with which they should be inspected. A regular program of inspection should be established and rigidly carried out.

In addition to this guide, the manufacturer should be consulted for specific recommendations on special conditions.

CAUTION: Lethal voltages will be present inside all transformer tanks, enclosures, and at all external connection points. Installation and maintenance should be performed only by experienced and qualified personnel accustomed to working with such electrical equipment. De-energize the transformer before performing any maintenance or service work.

2.0 Receiving

2.1 Radiators and oil

Units are shipped in one of the following configurations:

1. Welded radiators, tank charged with oil.
2. Demounted radiators, tank filled with oil; Partial fluid shipped separate.
3. Demounted radiators, tank charged with dry nitrogen; fluid shipped separate.

When the radiators are demounted for shipment, the tank is usually overfilled with insulating fluid. This fluid is to be drained into the radiators after they are installed. Additional fluid to top off the level, if required, is shipped separately.

2.2 Bushings and Accessories

Bushings, radiators, auxiliary cooling equipment, arrestors, and accessory devices may be removed and shipped separately. All tank openings are sealed with gasketed plates.

2.3 Shipping

The transformers are shipped by truck unless otherwise required by the customer. The heavier transformers may be shipped by rail.

Shipping braces, when used, are painted a different color. These must be removed, but only after moving into a permanent location.

2.4 Inspection Upon Arrival

Transformers are normally shipped F.O.B. factory. It is important that inspection be made upon arrival of the transformer for any signs of damage incurred during shipment. This inspection should be made before removal of the transformer from the truck.

The following items should be inspected closely for damage:

1. High voltage and low voltage bushings should be checked for cracks, chips, and leaks.
2. All external accessories should be checked for breakage, loss, and leaks.
3. Tank and radiators should be inspected for leaks, dents, scratches, and other signs of rough handling.

4. Paint should be inspected for damage.

5. Pressure vacuum gauge, liquid level gauge, and top liquid temperature gauge readings should be noted along with ambient temperature measurement.

If any parts of the transformer have been removed for shipping, these will be noted on the Bill of Lading as separate items. These items should be checked for shipping damage.

External damage, or evidence of rough handling, may be an indication of internal damage. Note on bill of material and file a claim with the carrier. If an internal inspection is deemed necessary, the factory should be immediately notified. Certain precautions must be taken in order to prevent further damage or contamination of the insulating liquid:

1. Hand/man hole covers should not be removed under conditions of precipitation or excessive humidity.

2. Warm dry air should be pumped continuously into the gas space if the transformer is opened under conditions of humidity exceeding 70%.

3. Care must be taken to prevent tools, hardware, or other foreign items from falling into the transformer.

CAUTION: The transformer is shipped with nitrogen in the gas space. The nitrogen should be purged by pumping dry air into the gas space for a period of 1/2 hour before entering the tank.

Nitrogen will not support life and should not be inhaled. Suffocation could result from carelessness.

4. If the insulating liquid must be drawn down for inspection, equipment must be available for clean storage during inspection and for filtering of the liquid prior to refilling the tank. Liquid level should not be lowered below top of windings.

5. Vacuum equipment should be available for final closing of the transformer after inspection.

2.5 Handling

Lifting hooks are provided for handling all liquid filled transformers. Care must be taken to avoid damage when lifting. Lifting cables or chains should not come in contact with any bushings or other devices, etc. Spreaders should be used when the cables or chains are not long enough to allow proper clearances to these parts. Four chains or cables should be used to prevent tipping of the transformer.

Skidding or rolling is an alternate method of handling the transformer if a crane is not available. Care must be taken to avoid tipping the transformer. It is preferred to roll the unit along the long axis. Multiple rollers should be used to evenly distribute the weight. The transformer may be pulled from the eyes in the base.

The transformer should be jacked at the ends directly below the wall corners. Radiators, radiator flanges, drain valves, or any other external attachments should not be used for jacking. Four jacks should be used and the transformer should not be tipped from an upright position.

3.0 DESCRIPTION

Liquid filled transformers are offered for use in distribution and power substations, secondary load centers, unit substations, to step down distribution voltages for industrial, commercial or residential service, or to supply power directly to high load equipment. Years of experience working with varied requirements have given us the ability to translate specific criteria into the design of a quality product.

3.1 Winding

Different windings are used to meet the requirements of a given application: continuous disc, barrel, sectional or sheet.

3.2 Core Lamination

Rectangular or cruciform core is stacked to provide optimum electrical characteristics. The laminations are clamped without any bolts through the steel. The laminations are cut from the highest grade, cold rolled, grain oriented silicon steel.

3.3 Tank Construction

Transformer tanks designed for and produced from heavy steel plates, give full service life after installation. A sealed tank oil-preservation system is used, with welded on covers. Welds are cleaned and smoothed to provide an ideal surface for paint adhesion. A rust-inhibiting primer coat is applied to the unit to seal against corrosion. Following the primer coat, two coats of paint are used for finishing the tank. The inside of the tank is protected well below the oil level. The outside finish will resist wind abrasion and weathering, minimizing maintenance and providing a long lasting, attractive appearance.

3.3.1 Sealed Tank - Oil Preservation

The oil is preserved by a sealed tank system. In this system the transformer is sealed and airtight. In addition to containing sufficient oil to cover the core and coils, the sealed tank system provides a gas space above the oil. When the oil expands, this serves as a pressure buffer. Normal operation causes relatively small pressure variations in this space.

4.0 Storage

4.1 Field Storage Instructions For Oil Filled Transformers

Oil filled transformers may be stored outdoors. They should be inspected annually for leaks, moisture absorption, and physical damage. Sufficient Nitrogen gas pressure must be maintained to allow a positive pressure of 1-2 PSI in the transformer at all times through high and low ambient temperature. The pressure-vacuum gauge, if supplied with the transformer, will show pressure variations with ambient temperature. Pressure readings and ambient temperature readings should be recorded regularly. See Section 7.5 for details of oil testing.

5.0 Installation

5.1 Location

Installation location of a transformer must be considered carefully. Transformers, as is the case with most electrical equipment, generate a substantial amount of heat during operation. This heat must be removed in order to allow the transformer to maintain its designed maximum temperature limits. If a transformer is located outdoors the heat will be removed by natural convection cooling unless the radiator air flow is restricted by surrounding objects.

Indoor installations require adequate ventilation to remove the heat of transformer operation. Inlet ventilation openings should be as low as possible, and outlet ventilation openings as high as possible. Average temperature over 24 hours must not exceed 30 °C and the temperature of the room should not exceed 40 °C. Care should also be taken to prevent restriction of air circulation. Adequate space must be maintained between transformers, or between the transformer and nearby equipment or walls. Separation is especially important near the transformer radiators, with a spacing equal to the radiator panel depth being recommended.

5.2 Assembly

Transformers, with equipment or accessories removed for shipment, must be reassembled after being placed on the installation site. All items removed for shipment will be noted on the Bill of Lading. These items should be reassembled in the following order:

5.2.1 Demounted Radiators

A. Inspect all radiator panels and flange mating surfaces for shipping damage.

B. Check that all valves on tank flanges are closed and remove blank shipping plates.

C. Remove blank shipping plates on radiator flanges and inspect for moisture or contamination inside radiator headers. If the radiators are contaminated, flushing will be necessary (see 5.2.1 F.)

D. Clean all mating surfaces on the tank and radiator flanges. Apply a small amount of rubber cement to hold gaskets in place during installation of the radiators. Inspect and reuse "O" ring gaskets on valves. Replace with spare gaskets shipped with unit if any nicks or tears are found.

E. Lift the radiators by means of the single lifting eye at the top. Install the radiators with matching numbers on tank flanges. Bolts should be drawn up evenly, alternating across corners, top and bottom, until spring washers are fully compressed. Tighten each nut 1/2 turn further.

F. Flush radiators if they are contaminated. DO NOT OPEN the tank flange valves prior to flushing the radiators. Remove the top and bottom pipe plugs from the radiator headers and circulate clean insulating fluid through the radiators using a filter press. Reverse the flushing procedures so that the radiators are flushed top to bottom and then bottom to top. Reinstall the pipe plugs after flushing using Teflon thread sealing tape.

G. Relieve the tank pressure or vacuum, and vent the tank by removing a hand hole cover, shipping plate, or plug, whichever is most convenient. This opening must be above oil level.

H. Open first the bottom and then the top flange valve on each radiator in succession until all valves are open. After all radiators are installed the unit should be re-evacuated and topped off to the proper (25 °C) cold oil level.

I. If unit is shipped with demountable radiators mounted but isolated and empty, follow the valve opening and filling in H. Above.

5.2.2 Bushings

A. Remove the blank bushing plates, using care not to damage the gasket. Draw leads, if used, will be attached to the under side of the blank plate.

B. Secure the lead connector for the draw lead bushings with a length of wire at least 12 inches longer than the bushing. Remove the bushing top cap hardware and insert the wire up through the bushing. Pull the draw lead connector into place while lowering the bushing onto the flange. Install the locking pin at the top of the bushing and remove the pull wire. Install and tighten the bushing flange hardware to apply even pressure to the flange gasket. Install and tighten the gasket and the top cap assembly.

C. With fixed bushing studs and connectors, transformer leads inside the tank must be connected after the bushing is secured to the flange. If necessary, the oil level must be lowered to provide entry into the tank.

CAUTION: Care should be taken that all electrical connections are tight. All leads and connectors inside the tank must be checked for proper electrical clearances after the bushings are installed.

5.2.3 Pressure Vacuum Gauge

Remove the 1/4" pipe plug located on the tank front and approximately 5" below the top cover. Install the gauge and tighten using Teflon sealing tape.

5.2.4 Fans

If necessary, attach the fans to the radiators using the supplied hardware between the panels. The fans will be located, generally, at the top of the radiator panels (consult outline drawing for fan location details).

5.2.5 Rapid Pressure Rise Relay

Install the rapid pressure rise relay at the top of the tank. This relay should be positioned with the lead connector down, if mounted in the horizontal position, for proper operation. Connect the flexible lead connector between the control box and the rapid pressure rise relay connector.

5.2.6 Lightning Arresters

Lightning arrestors and lightning arrestor brackets will be mounted in accordance with the outline drawing. Care should be taken that all ground connections are securely made in accordance with all applicable local and national codes.

5.3 Closing and Filling

5.3.1 Inspection

A final internal inspection should be made on every transformer before it is energized, particularly if any work has been done inside the tank. All electrical connections should be checked for tightness. All of the bushings should be checked for tightness of the gaskets, and all draw lead connections should be checked. All electrical clearances inside the tank should be checked. One final check should be made that all tools, or any extra materials that have been used inside the transformer, have been removed.

5.3.2 Closing

Reinstall all handhold and manhole covers that have been removed. All gasket groves should be cleaned, with all gaskets in the correct position.

To properly install a dome type manhole cover, the following procedure should be followed:

1. Lubricate the gasket with petroleum jelly or transformer oil.
2. Place gasket around the manhole opening making sure the colored dots are facing up.
3. Firmly press the gasket down until stopped by the rim.
4. Place the cover over the gasket and press firmly in position. Verify that the gap between the cover and the manhole rib is equally spaced.
5. Place the retaining ring around the cover assembly and rib. The dimples in the ring should face down.
6. Install the bolt, washers, and nut through the retaining ring.
7. Hand tighten the nut.
8. If vacuum facilities are available, pull a vacuum on the transformer to help pull the cover down.
9. If vacuum is not available, use a rubber mallet to tap the cover into position.
10. Tighten the nut securely.
11. Break vacuum with dry nitrogen and apply 3 to 5 psi nitrogen to gas space.

5.3.3 Torque Values

All nuts on the bushing flanges and hand hold covers should be torqued to the following values:

Bushing Clamps	Porcelain	60 in-lbs.
	Epoxy	100 in-lbs.
Handhold Cover	170 in-lbs.	

5.3.4 Oil Levels

If the oil level has been lowered for inspection, or if the unit was shipped without being completely filled with oil, the unit must be filled to the proper level before energization. See MAINTENANCE, for the proper filling and handling techniques.

5.3.5 Vacuum

A vacuum may be applied to the designed level during filling or prior to final purging. All accessories that may be damaged by vacuum should be removed and the openings covered with solid covers or plugs.

5.4 Testing for Leaks

The simplest method for testing for leaks is by gas pressure. The gas space in the unit should be pressurized at 5 PSI with dry nitrogen. The gas pressure should be monitored for a period of approximately 24 hours. A change in pressure does not necessarily indicate a leak. Any temperature increase or decrease in the transformer will result in a subsequent increase of decrease of the gas pressure in the unit.

Ambient temperatures and tank pressure should be monitored for the 24 hour period.

If there is a significant drop in pressure during the 24 hour period, without an accompanying decrease in ambient temperature, the tank must be checked for leaks. Re-pressurize the tank at 5 PSI. Using a solution of liquid soap and soft water, brush all weld joints above the oil level, all bushing gasket flanges, and all handhold cover gaskets. Any leaks in the gas space above the liquid will be shown in the gas form of soap bubbles. Use chalk dust below the liquid level to check for leaks of liquid from the tank. All the soap solution must be rinsed off or wiped off with a clean wet rag before removing pressure.

5.5 Determining Dryness

The core and coils of all transformers are thoroughly dry when they are shipped from the factory, and every precaution is taken to insure that dryness is maintained during shipment. However, due to mishandling or other causes, moisture may enter the transformer and be absorbed by the oil and insulation. It should, therefore, be determined that the oil and insulation are dry before the transformer is energized.

For transformers shipped with the core and coils immersed in oil, samples of the oil should be drawn from the bottom sampling valve and tested for dielectric strength. If the oil tests at 26 kV or more, and there is no evidence of free water in the bottom of the transformer, and the insulation resistance readings are satisfactory, it can be assumed that the insulation is dry and the transformer can be energized.

If the tests indicated low dielectric strength, further investigation should be made to determine the cause before the transformer is energized. It is required that the insulation resistance measurements be taken and submitted to the factory for recommendations. Insulation power factor may be measured for comparison with periodic measurements made during the life of the transformer. In order to obtain a uniform insulation temperature, the transformer oil should be at normal ambient temperature when the insulation resistance or power factor measurement is made. The top and bottom oil dielectric test results should accompany the power factor reading. If the tests, or visual inspection, indicate the presence of moisture, the core and coils must be dried before voltage is applied to the transformer.

5.6 Final External Inspection

All external surfaces of the transformer, and accessories, should be examined for damages that may have occurred during shipment or handling. The liquid level gauge, thermometer, pressure-vacuum gauge, tap changer, and other accessories should be checked for proper operation. Bushings should be checked for cleanliness and, if necessary, should be cleaned with Xylene or other non-residual solvent.

All valves should be checked for proper operation and position. Radiator valves, if supplied, should be in the open position. If a conservator tank is supplied, the connection between this tank and the main tank should be open. Gas expansion piping from the top of main tank to tank braces should be open. The upper filter press valve should be closed.

All liquid levels should be checked, including those in any oil filled switches or conservator tanks, if supplied. The conservator tank should also be properly vented. All electrical connections to the bushings should be checked for tightness. Proper external electrical clearances should be checked. All cables or

bus connected to the transformer bushings should be checked to avoid strain on the porcelain insulators. All winding neutral terminals should be checked to assure that they are properly grounded or ungrounded, according to the system operation. All tank grounds should be checked. All current transformer secondary wires should be checked to assure that they are either loaded or short circuited.

CAUTION: Open circuit current transformer secondary wires can achieve dangerously high potentials.

Study the nameplate data carefully and compare to the planned application to assure proper usage of the equipment.

Surge arrestors, when required, must be installed and connected to the transformer bushings/terminals with shortest possible leads. Surge arrestors may be necessary to protect the equipment from line or switching surges and lightning.

A suitable HV disconnect means must be available to de-energize the transformer in order to operate the no load tap changer. The tap changer position must match the incoming line voltage as closely as possible. The tap changer should be padlocked in the correct position for operation. All cooling fans and control circuits should be checked for proper operation.

Obtain a sample of liquid and check it for dielectric strength. The liquid should be filtered if it tests low. See Maintenance for proper method of drying the liquid.

6.0 OPERATION

6.1 Placing Into Service

After applying full voltage, the transformer should be kept under observation during the first few hours of operation under load. After several days, check the oil for oxygen content and dielectric strength.

All temperatures and pressures should be checked in the transformer tank during the first week of operation under load.

6.2 Parallel Operation

If transformers are to be used in parallel, it is important to check the nameplates to make sure that they are suitable for parallel operation. The following characteristics must be checked for parallel operation:

1. Voltage ratios must be within 1/2 of 1%.

2. Vector relationships must be identical.

3. Impedance based on common KVA should be the same.

Current should be carefully monitored between both units to make sure that one unit is not carrying a larger portion of the load under parallel operation. The units should be monitored for an additional period of at least one week to make sure that there is no abnormal temperature rise on either unit.

6.3 Loading

Except for special designs, transformers may be operated at their rated KVA if the average ambient temperature of the cooling air does not exceed 30 °C in any 24 hour period, and the altitude does not exceed 3300 feet.

For complete and detailed information on loading, and particularly overloading, reference should be made to "Guide for Loading oil Immersed, Distribution and Power Transformers" C57.92, published by the American National Standards Institute.

7.0 MAINTENANCE

7.1 Periodic Inspection

The following is a checklist of the more important points to be checked at least semi-annually, or as recommended below, or as needed.

7.1.1 Determine that the oil level in the transformer tank and all liquid filled compartments, such as junction boxes or switches, is satisfactory. Test the dielectric strength of the liquid. Oil from the tank bottom that tests 24 kV or less should be filtered. Check often based upon need.

7.1.2 Clean all bushings if dirty, and inspect the porcelain for cracks.

7.1.3 Check the pressure relief device, if furnished.

7.1.4 Check temperature gauge, liquid level gauges, pressure gauges, and other indicators. Record quarterly.

7.1.5 Check temperature gauge drag pointer to see if there is evidence of excessive loading at some time in the past.

7.1.6 Make megger check or power factor check of insulation for comparison with previous observations.

7.1.7 Clean fan blade and check fan operation by turning control switch to "Manual".

7.1.8 Check paint on tank and accessories and repaint when required.

7.1.9 Make certain that no tools or other objects have been left in, or on, the transformer.

7.1.10 Close all openings after completion of inspection. Purge with clean, dry nitrogen and re-pressurize to 3 PSIG.

7.2 Insulation Power Factor and Resistance Measurements

Regular insulation resistance or power factor measurements provide a means of observing and recording changes in the insulation due to moisture accumulation or chemical deterioration. Insulation resistance and power factor measurements are also necessary in indicating the progress of drying a transformer or its oil.

Precautions:

- Every measurement should be taken carefully, using the same procedure in each case to be consistent.
- Do not use an instrument having a voltage output in excess of the voltage rating of the winding being tested. Record the readings every two hours when measurements are made in connection with drying a transformer. When vacuum drying, take readings after each vacuum period, before and after filling with oil.
- Before taking measurements, make sure bushings are clean and dry, as dirty porcelain may cause low readings.

7.2.1 Power Factor

Short circuit all windings at the bushing terminals when measuring power factor. All windings except the one being tested should be thoroughly grounded. No windings should be allowed to "float" during the measurement. Any winding that is solidly grounded must have the ground removed before the power factor can be measured on that winding. If this is not possible, do not include the winding in the power factor measurements, as it must be considered part of the ground circuit.

Power factor readings should be taken for each winding to all other windings and ground.

Examples of the readings to record for a two winding transformer are:

1. HV: LV, GND

2. LV: HV, GND

Temperature affects power factor readings considerably. Therefore, it is necessary to determine the insulation temperature at the time the readings are taken for correct interpretation. It is usually sufficient to take top and bottom oil temperatures. When checking the top oil, use alcohol thermometer rather than a mercury thermometer, as there is less danger to the transformer in case of breakage. The bottom oil temperature can be measured by placing a thermometer in a stream of oil drained from the bottom filter valve.

7.2.2 Insulation Resistance

Insulation resistance can be measured with a megger or megohm bridge. Be sure the scale of the instrument reads higher than the insulation resistance being measured.

Insulation resistance measurements will vary widely from transformer to transformer. For new equipment an approximate minimum value for insulation resistance is 25 megohms per kV of rated line to line voltage.

During the drying process, insulation resistance measurements are necessary and should be taken at two-hour intervals at fairly constant temperatures. Both the resistance and temperature of the insulation should be recorded. Short circuit and ground all windings except the one being tested.

When meggering, take the reading after the megger voltage has been applied to the winding for about a minute. Keep this period of time consistent for all readings throughout the drying process.

7.2.3 Interpretation of Measurements

Power factor measurements are the most reliable in determining dryness and should be taken in preference to insulation resistance, especially in large and high voltage transformers.

As the drying proceeds at a constant temperature, the insulation power factor will generally decrease. Finally it will level off and become reasonably constant when the transformer becomes dry. In some cases, the power factor may rise for a short period early in the drying process. The insulation resistance will generally increase gradually until near the end of the drying process, and then the increase will become more rapid. Sometimes, the resistance will rise and fall through a short range one or more times before reaching a steady high point. This is caused by moisture in the interior parts of the insulation working through the portions that have already dried.

The drying process should be continued for approximately 12 hours after the insulation power factor becomes consistently low and the insulation resistance becomes consistently high.

When vacuum drying is used, it may be more difficult to obtain insulation power factor and resistance measurements at convenient temperatures. Such irregularities, however, do not outweigh the value of drying the transformer by this method. It is recommended that in case of questionable readings, the log of insulation power factor and resistance readings with time and temperatures be submitted to the factory for comments. Include in this information the transformer serial number, description of measuring instruments used, drying out procedure, methods of taking temperature readings, and any other pertinent data.

7.3 Determining Dryness

(See Section 5.5)

7.4 Methods of Drying

There are a number of approved methods of drying out the transformer core and coils, any of which will be satisfactory if carefully performed. But remember, if the drying out process is carelessly or improperly performed, great damage may result to the transformer insulation through overheating. Please contact the factory if it is necessary to dry out the transformer.

7.5 CARE OF OIL

7.5.1 Characteristics of Insulating Mineral Oil (for RTemp or Silicone, see attached sheets)

Gravity ..... 26.3 API

Flash..... 145 °C

Color..... LO.5

Pour..... below - 40°C

Viscosity 38 °C ..... 60 Saybolt

100 °C ..... 34 Saybolt

Dielectric KV Min. 30

7.5.2 Handling and Storage of Transformer Oil

Because the sulfur in a natural rubber hose dissolves in oil, causing the dielectric strength to be lowered, metal or oil proof hoses or pipes must be used for handling transformer oil. Dissolved sulfur also deteriorates the conductor in transformer windings.

Containers of oil should be stored in a closed room having a constant temperature. If stored outside, they must be protected from the weather. Drums should be placed on their sides with their bungs down and tightly closed.

Unless tests are required, drums or other containers should not be opened until the oil is to be used. Before opening, be sure that the oil temperature is as high or higher than that of the surrounding air to prevent condensation. Containers that are to be filled with transformer oil should be thoroughly cleaned and rinsed with the liquid before they are used.

7.5.3 Testing

The dielectric strength of liquid should always be checked before putting it into the transformer. After filling the transformer, samples should be taken for dielectric strength test.

7.5.3.1 Sampling of Transformer oil

A clean large mouth glass or plastic bottle should be used for collecting samples of transformer oil. Before using the bottle, clean it with Xylene or other non-residual solvent and dry it well. Rinse the container several times with the oil to be tested before collecting the sample. If a dielectric test only is to be made, one pint of transformer liquid will be sufficient; however, if other tests are to be made, drain off one quart.

Test samples should not be taken until the oil has settled. This time varies from eight hours for a barrel to several days for a large transformer. Cold oil settles more slowly and not as completely as warm oil. Always take samples from the sampling valve at the bottom of the tank or storage drum.

When sampling, drain off sufficient liquid to be sure that a true specimen is obtained and not one that may have collected in the pipes. A clear container is best for observing the presence of free water and other contaminants. If any are found, an investigation should be conducted to determine the cause, and the situation remedied. Although water may not be present in sufficient quantity to settle out, a considerable amount of moisture may be suspended in the oil. The oil should, therefore, be tested for dielectric strength. Care must be taken to prevent contaminating the oil sample after it has been collected. The sample should be taken on a clear, dry day when the oil is as warm or warmer than the surrounding air. A small amount of moisture from condensation or other causes may produce a poor test.

7.5.3.2 Testing Dielectric Strength

A standard cup for liquid testing should be used when checking the dielectric strength. Clean the cup thoroughly and rinse with a portion of the liquid to be tested. The liquid and the gap receptacle should be at room temperature, or about 25 °C. Tip the sample container and swirl the liquid a few times before filling the test cup to aid in mixing impurities which might be present in the sample. Avoid vigorous agitation that might introduce an excessive amount of air into the liquid. Completely fill the test cup and allow three minutes for air to escape before applying voltage. Voltage should be increased at a rate of about 3000 volts per second. One breakdown should be made on each five fillings of the test cup. Any individual test that deviates from the average by more than 25 per cent should be disregarded and replaced by an additional test. The average of the first five tests within the allowable deviation can be considered to represent the dielectric strength of the liquid.

If the dielectric strength for the sample tests below 22 kV for oil, then collect a new sample making certain that the liquid does not become contaminated after it is collected.

The minimum dielectric strength of the oil is 26 KV when it is shipped. Oil that tests below this should not be put into the transformer. Oil that tests below 24 KV in service should be filtered or reprocessed.

7.5.4 Filtering

When filling a transformer with liquid, filtering is recommended to prevent dirt, lint, and moisture from entering the tank.

A filter press is effective for removing all types of foreign matter, including finely divided carbon and small deposits of moisture. Begin the filtering process with new blotter paper and replace it frequently, depending upon the amount of moisture removed. Blotter paper must be thoroughly dried and kept warm until the time it is used.

Lose no time when transferring filter paper from the oven to the press. Hours of drying time can be wasted if the filter paper is exposed to the air more than a few minutes. To extract free water and sizable amounts of moisture, a centrifuge is more practical than a filter press. However, when used in combination (the liquid passing through the centrifuge first) much better results will be obtained for liquid in poor condition.

If tests show the presence of a large quantity of moisture and dirt, filter the bottom oil separately, drawing it from the transformer into a separate tank. When water and dirt have been removed so that the oil tests 27 KV or greater, change the filter connection to the upper filter press valve and return the liquid to the top of the transformer. Continue filtering from the bottom and returning to the top until the tests reach the accepted standard.

7.5.5 Filling With Liquid

Check the dielectric strength of the liquid while it is still in containers. If free water is present, drain off the water before putting the liquid through the filter press. Continue passing the liquid through the filter press until a dielectric strength of 26 KV or higher for oil is obtained.

7.5.5.1 Non-Vacuum Filling

In cases where vacuum filling is not required, the tank should be filled through the upper filter press connection. A second opening above the oil level should be provided to relieve the air being displaced Full voltage should not be applied to the transformer for a period of 48 hours after filling.

7.5.5.2 Vacuum Filling

Entrapped air is a potential source of trouble in all transformers. In general, therefore, it is desirable to fill transformers with liquid under as high a vacuum as conditions permit.

The transformer tank must be air tight except for the vacuum and oil connections. The vacuum level applied to the transformer case should never exceed the vacuum level shown on the nameplate. After obtaining a vacuum as high as the tank construction will permit, this vacuum should be maintained by continuous pumping for at least four hours. The filling may then begin. The liquid line should be connected to the upper filter press connection or other suitable connection on top of the tank. The filtered liquid is admitted through the connection with the rate of flow being regulated by a valve at the tank so that the vacuum does not fall below 90 percent of the original value. Any air bubbles in the liquid will explode in the vacuum and the air will be drawn out by the vacuum pump. The vacuum should be maintained for three or four hours after the transformer is full.

CAUTION: DO NOT allow transformer liquid to enter the vacuum pump.

8.0 Removing From Service

If a unit is to be de-energized but not moved physically, there are no special requirements for shutdown. Follow instructions for "placing into service" when returning the unit to service. If the unit is to be moved, it will be necessary to remove all necessary detachable parts for proper handling. Shipping braces that might protect the assembly during movement should also be replaced.

9.0 Trouble Shooting

Transformer failures may occur in either the electric, magnetic or dielectric circuits.

Symptom	Cause
	Electric Circuit
Overheating	Continuous overload Wrong external connections Poor ventilation - High surrounding air temperature (Rating is based on 30 °C average temperature over 24 hour period with peaks not to exceed 40 °C)
Reduced or Zero Voltage	Shorted turns - Loose internal connections - Faulty Tap changer.
Excess Secondary Voltage	Input voltage high - Faulty tap changer.
Coil Distortion	Coils short circuited.
Insulation Failure	Continuous overloads - Mechanical damage in Handling - Lightning surge
Breakers or Fuses Opening	Short Circuit - Overload - Inrush current Internal or External.
Excessive Bushing Heating	Improper bolted connection.
High Voltage to Ground	Usually a static charge condition (using rectifier or VTVM meter)
	Magnetic Circuit
Vibration and Noise	Low Frequency - High input voltage, Core clamps Loosened in shipment or handling
Overheating	High input voltage.
High Exciting Current	Low Frequency - High input voltage - Shorted turns
High Core Loss Low frequency	High input voltage.
Insulation Failure	Very high core temperature due to high input voltage or low frequency.
	Dielectric Circuit
Pressure Relief Device Operation	Insulation failure.
Burned Insulation Lightning surge Broken bushings, taps or arrestors.	Switching or line disturbance
Overheating	Inadequate ventilation
Breakers or Fuse open	Insulation failure
Bushing Flashover	Environmental contaminants - Abnormal voltage surge.
	Mechanical
Cracked Bushing	Overstress due to cable load - Mechanical handling
Loss of Pressure	Check gaskets, cracked bushing, welds

If any of the above symptoms are noticed, the transformer should be immediately removed from service. Immediate attention may save a large repair bill. Many times the trouble can be quickly determined and the transformer returned to service

If the trouble cannot be definitely corrected, the transformer should be taken out of service until the cause has been found.

It may be necessary to remove the Man/Hand hole cover for a closer examination. If no apparent fault can be found, the core and coil may have to be removed for a detailed inspection. Removal of the core

and coils is usually a factory or service shop operation. As this will mean replacing many parts when reassembling, it is advised that the trouble be reported to the factory before removing the core and coils. The advice from the factory may again save a large repair expense. When writing, describe the nature of the trouble, the extent and character of any damage, and list full nameplate information.

10.0 Renewal Parts

Should a transformer be damaged and new parts needed, write to the factory giving full nameplate information, particularly the serial number, and a description of the part required. If the proper name of the part is in doubt, a simple sketch or photograph will expedite prompt response to you.

11.0 PCB Certification

Cooling liquid is purchased from manufacturers in sealed drums or in tanker loads. We keep records of lot numbers with manufacturer's PCB content certificates. We do not handle any PCB contaminated transformers. Each unit is shipped with the following warning label:

Important Receiving Information

This unit is classified as non - PCB transformer containing less than 50 PPM PCB per OSHA and TSCA. If in doubt inform within 5 days of receipt of material in order to obtain manufacturer certificate.

In case of doubt you can request manufacturer oil certificate from us. However, we do not assume any responsibly of any nature if receiver fails to test PCB content within specified time AS WELL AS BEFORE installation.

The Purchaser is to follow these instructions at no cost to the Seller.