SÖNMEZ TRAFO

OPERATION AND MAINTENANCE INSTRUCTIONS FOR FLUID FILLED TRANSFORMERS

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1.0 INTRODUCTION

1.1 General

A transformer manufactured by STS, is designed, manufactured and tested with the latest technology and with strict quality control so as to ensure a long and problem free service.

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, STS should be consulted for specific recommendations on special conditions. Please do not hesitate to contact us for any question or comment.

CAUTION: Lethal voltages will be present inside all transformer tanks, enclosures, and at all external connection points. Installation and maintenance must 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.

1.2 Caution Notes

- No transformer should have rated service voltage applied to it until all preliminary work and tests and checks have been satisfactorily completed.
- No high voltage tests to be applied to any transformer without contacting STS.
- A transformer which has been installed and then removed from service for a long time should be rechecked as when first installed prior to re-energising and placing the transformer back into service.

1.3 Health and Safety

- Lethal voltages will be present inside all transformer tanks, enclosures, and at all external connection points. Installation and maintenance must be performed only by experienced and qualified personnel accustomed to working with such electrical equipment. De-energize the transformer and lock out/ tag out the main switch feeding the transformer before performing any maintenance or service work.

- Materials and Components that are liable to be exposed or handled in normal operation and maintenance and which present any hazard to health are covered here.

- In addition to the instructions given in this manual, IEC/ANSI/equivalent standards and local regulations must also be referred for other details regarding the design, materials and performance.

- Excessive and prolonged skin contact with transformer oil (mineral oil) should be avoided. For further information regarding oil handling, please read contact STS. A list of standards applicable to distribution and power transformers is given as below;

a- Power Transformers	IEC:60076-1
b- Bushings for alternating voltage above 1000V	IEC:137
c- Loading guide for oil immersed transformer	IEC:354

- Additional Information or suggestion will be given on request to STS.

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2.0 RECEIVING

2.1 Arranging for Shipping

- Each Fluid filled transformer is thoroughly dried out before dispatch. Isolation Fluid, whether in the transformer tank or in separate drums, is thoroughly filtered and tested, when dispatched.
- Parts that are liable to be damaged in transit could be removed and could be dispatched in separate cases along with the transformer if necessary (For high powers). Accessories like radiators, bushings, explosion vent, dehydrating breather, Buchholz relays, temperature indicators, pressure relief devices, conservator, etc. will be removed before dispatch(If necessary, especially for high powers)
- The fluid and the parts removed for shipping are generally referenced in the Packing List. Re-assembly of these parts should be carried out such that the tank is opened to the atmosphere for a minimum time. 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 Recommended Inspection

Transformers are properly packed and dispatched by suitable transport to the destination. In spite of all care being taken during dispatch, the equipment can get damaged during shipping. 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 or container. 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 has been removed for shipping, these will be noted on the Packing List as separate items. These items should be checked for shipping damage.

It is essential that loss, damage of any components, parts, paint works or shortage, leakage of fluid or any signs of tampering to be reported to STS immediately. And all possible evidence such as photographic/ video clips, copies of documentation and declaration from shipping contractors shall be submitted.

2.3 Unloading and Handling of Transformer

The transformer should be unloaded by means of a crane or suitable lifting device of sufficient capacity(for weight details, please refer to the name plate). Always use lifting mechanisms, crane, chain pulleys, etc. of adequate capacity. Lift transformer by the jacks which are painted yellow.

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 must be used to prevent tipping of the transformer.

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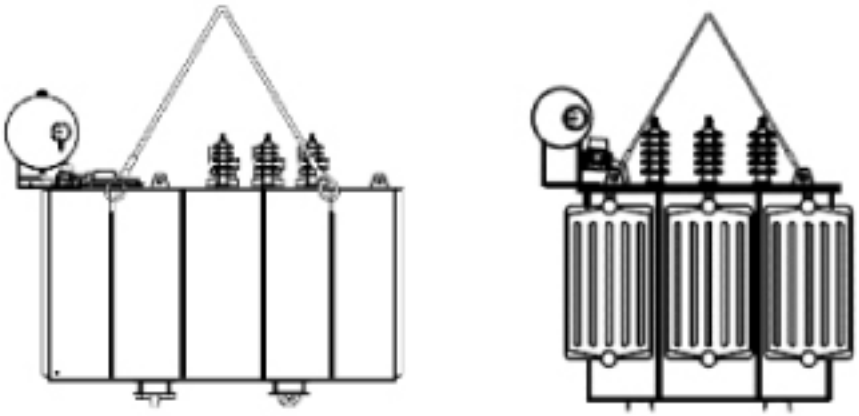
Skidding or rolling is an alternate method of handling the transformer if a crane is not available. Care must be taken to avoid tipping the transformer. It is preferred to roll the unit along the long axis. Multiple rollers should be used to evenly distribute the weight. The transformer may be pulled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



2.4 Storage

Accessories/Fittings dispatched separately from main consignment are usually packed in case/crate, although certain items like conservator are sometimes dispatched without packing. All items as received should be stored in a dry and covered place provided there are no signs of damage or rough handling.

If isolation fluid received in drums is not to be used immediately, the drums should be stored in a covered space where the temperature variation is minimum. If it is necessary to store fluid outside, adequate protection must be provided at all times. Drums should not stand on end but should be placed on their sides in semi horizontal (lying) position with the bottom tilting at 45° downwards.

After arrival at site, it is desirable to erect and commission the transformer with minimum delay. In case this is not possible, the transformer should be fitted with conservator, dehydrating breather, etc. and filled with oil. The condition of desiccant (silica-gel) must be checked periodically, particularly during warm and wet periods.

Indoor type transformer must be protected from the weather. Outdoor units may be stored outside. However, care should be taken to avoid freezing of isolation fluid. Some kind of fluids pour points are shown below:

Type of Fluid	Pour Point
Mineral Transformer Oil	-47° C
BETA Fluid	-24° C
FR3 Organic Oil	-21° C

3.0 INFORMATION ABOUT FLUID FILLED TRANSFORMERS

3.1 General

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 like industrial furnaces.

Our all products are designed, tested and supplied as per the specification and standards quoted, order acknowledged and subsequent modifications as approved.

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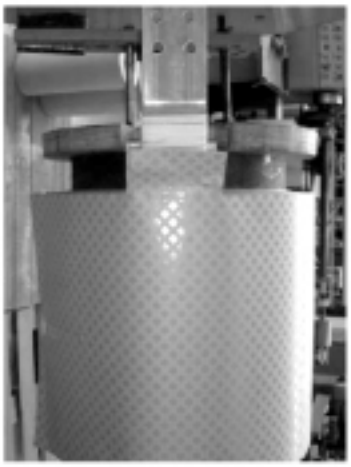
Some accessories, fittings, components referred in this manual are supplied only when specified and will not be incorporated into all the transformers supplied. Also as efforts are being constantly made to improve designs and service, the equipment supplied may differ in minor details from the data give herein. For this situations please refer to additional documents which given with this manual. For information about the equipment actually supplied, always refer to the drawings, technical specification sheet and all other documents furnished with handover documents.

3.2 Winding

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



3.3 Core Lamination

Rectangular or cruciform core is stacked to provide optimum electrical characteristics. The laminations are clamped through the steel. The laminations are cut from cold rolled, grain oriented silicon steel per customer needs and specifications.

3.4 Tank Construction

Transformer tanks are designed for and produced from heavy steel plates to provide full service life after installation.

2 different types of tank constructions could be designed regarding the application and customer needs. One of them is transformer with conservator tank (Standard). Another is hermetically sealed type transformers

3.4.1 With Conservator Tank (Standard)

Transformer's fluid has contact with atmosphere. Expansion of oil is stored on conservator tank. Dehydrating breathers must be used. The conservator is provided to take care of the expansion and contraction of oil taking place in the transformer due to temperature variation during operation of the unit. The conservator is a large cylindrical structure which contains oil in contact with the main tank oil.

3.4.2 Hermetically Sealed Transformers

The oil is preserved by a sealed tank system. Therefore transformer fluid has no contact with the atmosphere. This results in less transformer maintenance. Three different kind of hermetically sealed transformers could be designed and manufactured.

3.4.2.1 Hermetically Sealed Transformers with Corrugated Tank

Expanding oil is absorbed in the corrugated walls.

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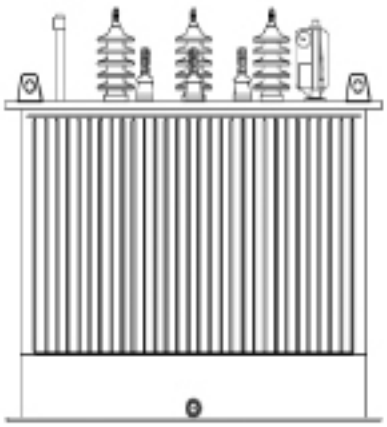
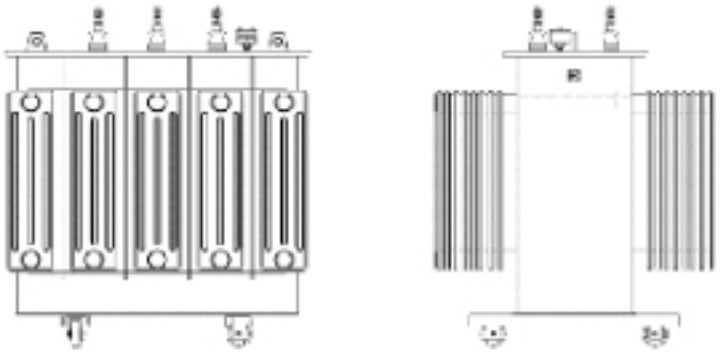


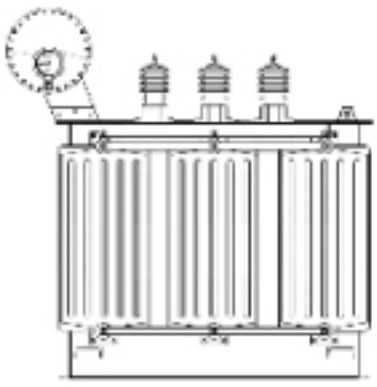
3.4.2.2 Hermetically Sealed Transformers with Nitrogen Gas

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.



3.4.2.3. Hermetically Sealed Transformers with Rubber Diaphragm

Transformer's tank is designed with conservator tank. But there is a rubber diaphragm in this conservator tank. This air bag is installed inside the conservator and fitted to it through the flange connected to the plate of the manhole. Thus, as the tank oil expands and contracts due to temperature changes, the flexible diaphragm accommodates these volume changes while maintaining a sealed oil environment.



3.5 Isolation Fluid

Different kind of isolation fluids could be used in fluid filled transformers according to customer's needs. Some of them are Mineral oil, FR3 fluid, BETA fluid, silicone oil etc. Our standard is Mineral Oil. (For detailed information please contact STS.)

3.5.1 Mineral Transformer Oil

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Characteristics of Mineral Tranformer Oil (refer to ASTM D3487)

Gravity	26.3 API
Flash Point	145 °C
Color	LO.5
Pour Point	-40 °C
Viscosity at 38 °C	60 Saybolt
At 100 °C	34 Saybolt
Dielectric strength Min.	30 kV

3.5.1.1 Handling and Storage of Mineral Transformer Oil

Because the sulfur in a natural rubber hose dissolves in oil, causing the dielectric strength to be lowered, metal, glass 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.

3.6 Standard Fittings

Following fittings are standards for liquid filled transformers. These are the minimum requirements for the safe and correct operation of a transformer.

- Diagram and Rating Plate
- Oil Level Indicator
- Oil Drain Valve
- Earthing Terminals
- Lifting Lugs
- Jacking Pad
- Thermometer Pocket

3.7 Optional Fittings

As per customer's specifications and needs, the optional fittings as listed below are provided for the additional protection operation of a transformer. Some of them could be also standard for transformers with some power and voltages.

- Oil temperature Indicator
- Winding Temperature Indicator
- Buchholz Relay
- Explosion Vent/Pressure Relief Device
- Wheels
- On-load Tap Changer
- Dehydrating Breather
- Conservator
- Marshalling box
- Surge Arresters
- Heat Exchanger
- Rubber Diaphragm in Conservator

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4.0 INSTALLATION

4.1 Location and Site Preparation

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. There must be at least 60 cm space between all walls and transformer.

- No special installation is necessary to install a transformer except a leveled floor base of sufficient strength to support the weight and prevent accumulation of water.
- A foundation including special oil drainage/collection facilities in case of fire and emergency is strongly recommended for large transformers.
- The transformer should be positioned on the foundation so that easy access is available all around to access the diagram plates, thermometers, valves, oil gauges, marshalling box, etc, to be easily reached or read.
- The Buchholz relay located side of the transformer should be elevated by 1 cm.
- Adequate electrical clearances are also to be provided from various exposed live parts of the unit to any earth point.
- Any transformer should always be separated from other transformers, reactors and any other such heat generating equipment. Transformers should be placed sufficiently away from all walls/partitions to permit free circulation of air/ventilation. (at least 60 cm)(Not necessary for water-cooling transformers)
- Bushing arcing horn gap must set correctly. Gaps should be as followings:

Rated Voltage	Gap
6.3 kV	55 mm ± 5 mm
10 kV	75 mm ± 5 mm
15 kV	110 mm ± 5 mm
20 kV	140 mm ± 5 mm
36 kV	220 mm ± 5 mm

- Wheels, if fitted, shall be suitably clamped/ locked to prevent any movement of transformer from its designated position in relation with HV/LV side terminations.
- External power conductors, power cables, control cables, earthing conductors, etc., shall be so positioned/ supported such that no pressure is exerted on the transformer bushing terminals/cable box.
- Naturally cooled transformers depend entirely upon the circulation of air to assist in removal of all heat generated due to internal losses. For indoor installation, therefore, the room must be well ventilated so that heated air can escape and be replaced by fresh cool air. Air inlets/outlets should be sufficient to allow adequate air to cool the unit. The inlets shall be near the floor and outlets shall be near the ceiling. If necessary, exhaust fans can be installed to assist process.
- If wheels are not fitted, a level concrete plinth with bearing plates/mounting channels of sufficient size/strength can be used for outdoor transformers. To prevent rust formation, it is essential to avoid air/water between plinth and the transformer base. If required, bitumen or such similar substance shall be used on the transformer base for weather-proof protection.
- For small capacity pole mounted type transformer, proper care must be taken that all the supporting poles/structures, mounting brackets/clamps are of suitable materials and strength to bear the both the static and dynamic weight of the transformer .

Suitable provision shall be made for all non-current carrying metal parts used for the transformer support/base such that they can be earthed, preferably at two points.

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4.2 Assembly (If Necessary)

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 or on the Packing list. These items should be reassembled in the following order:

4.2.1 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 4.2.1 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 listed above in section H.

4.2.2 Fans

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).

4.2.3 Lightning Arresters

Lightning arresters and lightning arrester 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 standards.

4.2.4 Demounted Conservator Tank

A. Complete the installation of the radiators and other accessories on the main tank of the unit.
B. Do not assemble the pipe connection between conservator vessel and the tank before putting the conservator.
C. Install the support structure to install the conservator on the tank.
D. Lift the conservator with the help of lifting eyes/lugs on the top and place it in position on the support structure.

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E. Connect the pipe circuit between conservator and the tank. In case of Buchholz relay check the direction of oil flow in the relay before mounting.

4.2.5 Dehydrating Breather

Dehydrating Breather could be separately shipped. In this case Dehydrating Breather should be re-assembled to check the saturation degree of silica-gel please refer to section 6.5

Important Note: The oil cap at the bottom of the breather must be removed, filled with insulating fluid up to the mark and the cap must be replaced.

4.3 Insulation Fluid

Important notes about insulation fluid listed following:

- Fluid acts as both insulant and coolant. Cooling radiators fitted with the tank will be either fixed type or detachable type radiators for ONAN (Oil natural Air natural) cooling.
- Fluid from different sources may not completely mix together and may remain separated in layers. There may be a greater tendency to form acidity or sludge in a mixture of oil from two different sources than in a mixture of oils from a single source.
- Our standard supplied fluid with the transformer is a pure hydro-carbon mineral oil for insulating fluid. When exposed, oil can be easily contaminated. It is very important to keep the oil free from contamination, moisture, etc.. All equipments to be used for handling the oil should be first cleaned and flushed with clean insulating oil.

Important Note: Contaminated/used oil must be discarded only in accordance with the environmental regulations.

4.3.1 Insulating Fluid Levels

If the fluid level has been lowered for inspection, or if the unit was shipped without being completely filled with fluid, the unit must be filled to the proper level before energization. See Maintenance Section 6.1, for the proper filling and handling techniques.

4.3.2 Vacuum

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

4.3.3 Insulation Fluid Filling

A. Fill the fluid in the main tank after application of vacuum.

B. Ensure that the valve between conservator and main tank is closed when the fluid is filled in the main tank.

C. Open the valve and raise the fluid level in the conservator, by pushing fluid in the main tank.

D. Fluid level in the conservator is to be maintained as per the liquid level gauge provided on the conservator.

E. In case of diaphragm type conservator unit, the diaphragm needs to be inflated to about 50 mbar before start of filling fluid in conservator. Fluid should come out freely into the atmosphere. This will ensure that all air inside the conservator is expelled and the space surrounding the air cell is full of fluid.

F. Ensure to release air from various points on the top cover specially from air release valve which located on conservator tank.

4.3.4 Sampling of Insulating Fluid

A large mouth clear plastic bottle with a lid 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. For DGA sampling, a syringe should be used to take the oil sample. Test samples should not be taken until the oil has settled. This time varies from eight

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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 about 1 gallon(4 Liters) of 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.

4.3.5 Draining Insulating Fluid

A. Drain fluid from conservator by gravity only in case of sealed type with rubber diaphragm construction. Skid should not use for draining oil from conservator.

B. In case of conservator without rubber diaphragm, skid can be used for draining the oil.

4.4 Testing for Leaks

The simplest method for testing for leaks is by gas pressure. The gas space in the unit should be pressurized at 250 mbar 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 significant decrease in ambient temperature, the tank must be checked for leaks. Re-pressurize the tank at 250 mbar.

Using a solution of liquid soap and soft water, brush all weld and threaded joints above the oil level, all bushing gasket flanges, and all hand hold cover gaskets. Any leaks in the gas space above the liquid will be shown in the gas form of soap bubbles.

Paint welds with chalk dust dissolved in alcohol. Apply the 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.

4.5 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 insulating fluid and insulation. It should, therefore, be determined that the fluid and insulation are dry before the transformer is energized.

For transformers shipped with the core and coils immersed in fluid, samples of the fluid should be drawn from the bottom sampling valve and tested for dielectric strength. If the fluid tests at 30 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, refer to IEEE C57.106-2002, 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

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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, STS must be informed immediately and the core and coils must be dried before voltage is applied to the transformer.

4.6 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. 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 transformers secondary should be checked to assure that they are either loaded or short circuited.

DANGER: Open circuit current transformer secondary 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.

WARNING: All protection relays must be connected to circuit breaker before energizing the transformer.

5.0 OPERATION

After the satisfactory completion of installation, the following pre-commissioning checks and tests on instruments must be performed before putting the transformer into service. Prior to commissioning work, for specific help and information on the accessories

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supplied, refer to the manufacturer's instruction booklet/product catalogue etc. furnished with the handing-over documents.

5.1 Commissioning Tests

5.1.1 Insulation Resistance (IR) Test

A. Before starting this test all the power terminal bushings should be thoroughly cleaned with a dry clean piece of cloth.

B. During IR test, no external power lines /cables, lightning arresters, neutral earthing, etc., should be in the power circuit. And ensure that transformer is completely isolated and locked out at HV&LV sides and all on-current carrying conductors are earthed.

C. At all the tap positions, IR values of windings to earth and between windings shall be measured with designated insulation tester of suitable ratings and readings noted.

Between HV Winding and Earthuse 5000V or 2500V Insulation Tester (Megger)

Between HV and LV Winding use 5000V or 2500V Insulation Tester (Megger)

Between LV winding and Earth use 1000V or 500V Insulation Tester (Megger)

D. IR values obtained should be similar to those indicated in the STS's test report, furnished with handing-over documents. In humid weather, IR values obtained may be lower due to condensation on the terminal bushings.

E. If IR values are very low and unacceptable, STS should be informed and it may be necessary to filter the oil /dry out the winding till the insulation reaches satisfactory values.

5.1.2 Break-Down Voltage (BDV) Test

A. Oil sample from tank bottom, tank top, radiator, etc. shall be carefully taken and tested for BDV value, as per section 4.3.4 in this manual(Sampling of Insulating Fluid).

B. BDV value of oil should be more than 50kV(rms) for 1 minute in standard test cell.

C. If BDV value is very low and unacceptable (30kV(rms) or less for 1 minute) than STS should be informed immediately.

5.1.3 Voltage Ratio Test

A. Apply 3-phase, AC voltage on the HV side and the Voltage Ratio at all tap positions can be derived using suitable precision voltmeter connected to the LV side. A ratio meter, if available can be used for a more accurate measurement.

B. The ratio values obtained should be similar to those indicated in the STS's test report, furnished with the handing-over documents.

5.1.4 Winding Resistance Measurement Test

A. Winding Resistance of every phase of each winding should be measured using suitable DC Resistive Bridge or similar.

B. Winding Resistance values obtained should be similar to those indicated in the STS's test report, furnished with the handing-over documents.

5.1.5 Marshalling Box Scheme Check

A. All the auxiliary wiring from various accessories to marshalling box shall be checked with marshalling box scheme drawing furnished with the handling-over documents.

B. During testing of accessories like buchholz relay, etc., operation of all the alarm/trip contacts shall be checked at marshalling box terminal blocks ensuring both operation and wiring are checked correct.

5.1.6 Buchholz Relay Test

A. Relay operation for alarm and trip contact shall be checked by injecting air inside the relay through test petcock. Injected air collected inside the relay allows the alarm float /flap

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and trip float/flap to fall thereby operating their respective switch

5.1.7 Temperature Indicator Test

A. Indicators operation for alarm and trip contact shall be checked by manual stimulation.

5.1.8 Off-Load Tap Changer Check

During shipment, the Off-Load Tap Changer has not been separated from the transformer so it is not necessary to recheck the internal connections of tapping and internal mechanism.

Means of protecting the Off-Load Tap Changer from unauthorized operation is provided by using pad locking arrangement at designated tap position.

5.2 Sensible Additional Checks

5.2.1 Before Switch on, Ensure that:

A. All the oil shut-off valves are open and draw-off valves are closed.

B. All thermometer pockets are near filled (85%) with fluid.

C. Insulating Fluid is at correct level in the Bushings, Conservator, etc.

D. Desiccant color in breather is blue for blue silica-gel or yellow/orange for envirogel(For detailed information please contact STS)

E. Earthing Connection of Main Tank, Neutral Bushing, Marshalling Box, Control Gear Box, Cable Box, Arcing Horn, etc., are correctly made.

F. Bushing arcing horn gap is set correctly

G. All CT secondary circuits are closed

H. All Air-Release Plugs of Main Tank, Radiator, Conservator, Buchholz Relay, Bushings, etc., are free of air pocket/bubbles.

Note: After Oil-Filling or before Commissioning, at least 12 hours should be allowed for the oil to settle-down and air is released from all points at 2 hourly intervals.

5.3 Placing Into Service

It is recommended that the transformer is initially energized ad No-load only and checked for any abnormalities for the next 6 to 8 hours.

After switching on no-load, if the primary side circuit breaker is tripped, investigate the cause thoroughly and re-energize the transformer only after ensuring that the fault is properly cleared.

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, dielectric strength, and DGA content of combustible gasses.

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

5.4 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:

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

b- Vector relationships must be identical.

c- 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.

5.5 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,

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and the altitude does not exceed 3300 feet.(1000 meter)

For complete and detailed information on loading, and particularly overloading, please refer to "Guide for Loading oil Immersed, Distribution and Power Transformers" C57.91, published by the American National Standards Institute.

6.0 MAINTENANCE

If a transformer is to give long and trouble-free service, it should receive a reasonable amount of maintenance, which consists of regular inspection, testing and reconditioning when necessary. Records should be kept giving details of any abnormalities during service and also of any periodic test results taken.

Main objective of any maintenance is to preserve the original properties of the materials in good condition. Moisture, dirt, excessive heat/over-loading, mishandling, etc., are the main causes of insulation deterioration.

DANGER: No maintenance work to be done on the transformer, unless all the external circuits are disconnected and locked out and that all the windings are solidly earthed.

6.1 Insulating Fluid

Insulating fluid is a very important liquid being used both as a coolant and dielectric in the transformer and thus keeping the fluid in good condition will prevent deterioration of the paper and other such solid insulation materials immersed in it.

IEC:60422- "Maintenance of Insulating Oil" gives recommendations in detail for the preservation of insulating oil. A few short notes on the subject are given as below.;

A. Fluid level should be checked at frequent intervals and any excessive leakage of fluid must be investigated thoroughly. There may be a slight loss of fluid by evaporation; this need not cause concern if the tank is topped off at regular intervals.

B. All minor leaks or sweating should be repaired as quickly as possible.

C. Fluid shall be topped-off as per instruction of this manual. It is once again emphasized that any new fluid to be added shall preferably be from the same source as the original fluid. For standard mineral oil filled transformers, new oil from a different source may be added as make-up only but not exceeding about 10% of existing oil volume. In this case, suitable records must be kept.

D. Samples of fluid should be tested at regular intervals and results recorded.

E. Dielectric strength alone does not give a true indication of insulating fluid condition. If dry, even highly deteriorated fluid can give a high dielectric strength.

F. Normal oil filtration method can maintain the dielectric strength only, but does not give indication of the deteriorated condition of the oil. It is not advisable verifying its chemical composition. Reconditioning by centrifugal separation or filtration does not remove the acidity from oil but will remove moisture, sludge, dust, dirt etc. and will tend to retard, the process of deterioration. Filtration with Fuller Earth will help to reduce acidity in oil and in addition improve the resistance value of the oil.

G. If the dielectric strength is below 30kV (rms), the oil should be reconditioned by passing it through either a centrifugal separator or a filter. After reconditioning, the dielectric strength should be such that fluid can withstand a minimum of 40 kV(rms)

H. For standard mineral oil; if acidity value is 0.5 to 1.0 mg KOH per gm of oil, it is recommended that the oil be kept under observation. If the acidity is increasing rapidly, or exceeds 1.0mg KOH per gm of oil, the cover should be removed to ascertain the condition of the interior of the tank and of the core and windings. Oil is then be treated or discarded, if sludge or corrosion is evident. Advice should be obtained from the suppliers.

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6.1.1 Testing of Insulating Fluid

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.

6.1.1.1 Sampling of Insulating Fluid

Please refer to section 4.3.4 in this manual

6.1.1.2 Testing Dielectric Strength

Please refer to section 5.1.2 in this manual.

The minimum dielectric strength of the oil is 50 kV when it is shipped. Oil that tests below this should not be put into the transformer. Oil that tests below 30 kV in service should be filtered or reprocessed.

6.1.2 Filtering of Insulating Fluid

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 fluid separately, drawing it from the transformer into a separate tank. When water and dirt have been removed so that the fluid tests 30 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.

6.2 Terminal Bushings

Outdoor porcelain insulators and rain sheds should be cleaned at regular intervals. Metallic scrubber can be used effectively to remove dirt/stains.

During cleaning, the outdoor porcelain bushings should be examined for oil leakage, cracks or other defects and effective ones should be replaced.

Arcing horns, if fitted, shall be checked for any arcing dents /welds and correct gap settings. And any arcing horn with dents/welds are replaced or rectified.

6.3 Cooling Radiators

Cooling radiators should be checked for any oil leakages along all the welded joints, gasket joints, plugs, etc.

STS should be informed about any bend, dent etc. and should be rectified as soon as possible.

6.4 Insulating Fluid Gauges

Fluid gauge should be kept clean and any damaged glasses should be replaced immediately. The gauges are normally fitted with strengthened plate glass which is unbreakable under normal service conditions.

6.5 Dehydrating Breather

The dehydrating breather should be regularly checked for color of desiccant. When the majority of gel becomes saturated, the same shall be replaced or reactivated.

In a dehydrating breather, Envirogel (self indicating silica-gel)(standard) or Blue Silica-Gel could be used.

In case of Envirogel, for visual indication of degree of saturation, the silica-gel is

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impregnated with suitable non-toxic dye. Envirogel in YELLOW/ORANGE color, indicates ACTIVE state or readiness to absorb moisture and when in GREEN color, indicates the INACTIVATE/saturated state or presence of moisture or inefficient to absorb further moisture.

In case of Blue Silica-Gel, for visual indication of degree of saturation, the silica-gel is impregnated with Cobalt Chloride[Class 2 Carcinogen]. When Silica-Gel is a BLUE color, this indicates the ACTIVE state or readiness to absorb moisture and when it has become PINK it's unable to absorb further moisture.

To activate the saturated silica gel, heat it in a pan/oven at 120-130 ºC temperature until the original color is regained within 2 to 3 hours, otherwise always replace with new gel and properly discard the used gel.

When the fluid filled transformer is fitted with the de-hydrating breather ALWAYS reactivate/replace the desiccant once the color indicates the saturated state, irrespective of whether the transformer is energised or not.

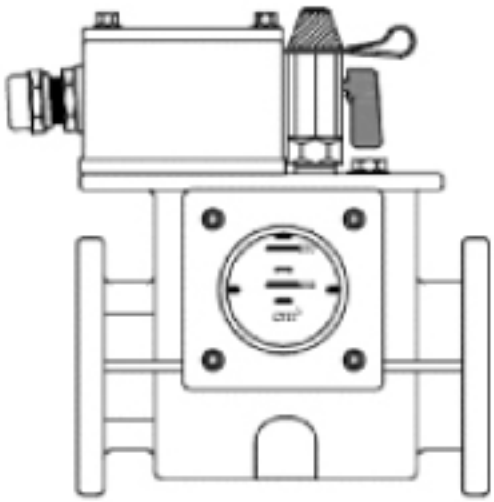
The oil cap at the bottom of the breather should be removed, filled with insulating fluid up to the mark and the cap replaced. The fluid seal ensures that breather does not absorb moisture when the transformer is not breathing.

When refilling the desiccant, do not expose the same to the atmosphere for an undue length of time, otherwise it will start absorbing the moisture and thus impair its purpose. Also, after fixing the breather, ensure fluid seal is filled with insulating fluid up to the mark.

6.6 Buchholz Relay

The relay should be routinely inspected and the operation of relay is ensured by injecting air into the relay and check that floats are able to fall/rise freely and that the magnetic switches are switching the contacts.

During service, if the relay is operated due to an accumulation of gas and not due to fall of conservator oil level. Any internal faults can be identified to a great extent by a chemical analysis of gas. Sometimes, on analyzing the gas, it may be noticed that the gas collected is only air. This may be that the oil is releasing any absorbed air during oil filtration or due to change in temperature.



6.7 Temperature Indicators

The level of insulating fluid in the thermometer pockets should be checked and the fluid replenished, if required. The capillary tubing should be fastened down again if it has become loose. Dial-glasses of temperature indicators should be kept clean and, if broken replaced. Temperature indicators if found to be reading incorrectly should be re-calibrated with standard thermometer immersed in hot oil bath.

Important Note: Any abnormality occurring during service, should be reported to STS. And advice from STS should be obtained.

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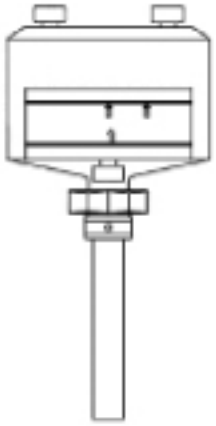

7.0 REMOVING FROM SERVICE

If a unit is to be de-energized but not moved physically, there are no special requirements for shutdown. Follow instructions for "Operation"(Section 5.0 in this manual) 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.

8.0 TROUBLE SHOOTING

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

8.1 Electric Circuit

Symptom	Cause
Overheating	- Continuous overload or harmonics - Wrong External Connections - High Surrounding Air Temperature - Faulty Ventilating
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
Excessive Bushing Heating	- Improper Bolted Connection
High Voltage to Ground	- Usually a static charge condition(using rectifier or VTM meter

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8.2 Magnetic Circuit

Symptom	Cause
Vibration and Noise	- Unrated Frequency or Harmonics - High Input Voltage - Core Clamps Loosened in shipment or handling
Overheating	- High Input Voltage
High Exciting Current	- High Input Voltage - Shorted Turns
High Core Loss,	- High Input Voltage - Damaged Core
Insulation Failure	- Fluid or Solid Insulation Material Failure

8.3 Dielectric Circuit

Symptom	Cause
Pressure Relief Device Operation	- Insulation Failure - Short-Circuit
Burned Insulation Lightning Surge Broken bushings, taps Or arrestors	- Switching or Line Disturbance
Breakers or Fuse Open	- Insulation Failure
Bushing Flashover	- Environmental Contaminants - Abnormal Voltage Surge

8.4 Mechanical

Symptom	Cause
Cracked Bushing	- Overstress due to cable load - Mechanical handling
Loss of Pressure	- Check Gaskets, Cracked Bushings, welds

8.5 Solutions

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.

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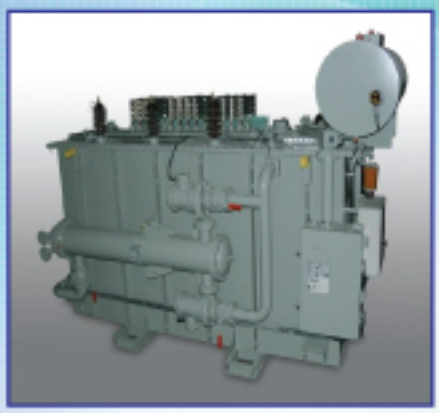

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