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Liquid-Filled Transformer Instruction and Maintenance Manual

SUNBELT TRANSFORMER
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1 INTRODUCTION

The instructions in this booklet apply to liquid-filled transformers manufactured by Sunbelt Transformer in Temple, TX, Sharon, PA and Bakersfield, CA.

The instructions and guidelines provided should only be performed by trained personnel experienced in the use of this equipment and the familiar with good safety practices.

The electrical characteristics, weights and internal transformer connections are shown on the nameplate attached to the transformer. Additional physical details such as center of gravity and dimensions are shown on the outline drawings. If wiring exists, a wiring diagram and schematic is provided for control, fan and alarm wiring connected to the transformer control cabinet(s).

2 SHIPPING

Transformers are shipped completely sealed. Core and coils are assembled in a tank with insulating liquid covering the coils. The gas space above the oil is pressurized with 2-4 psi positive pressure of pure nitrogen.

This method of construction preserves the quality of insulation, the cooling and insulating liquid by preventing contamination from external sources.

3 INSPECTION ON RECEIPT

3.1 EXTERNAL INSPECTION

When a transformer is received, a thorough external inspection should be made before the unit is removed from the truck. If there is evidence of damage and/or indication of rough handling in transit, an inspector representing the carrier should be requested and the manufacturer immediately notified.

_____ Is there any sign of external damage?
_____ Is the paint finish damaged?
_____ Is there corrosion other than at handling or anchor points?
_____ Are any threaded fittings or valves leaking?
_____ Is there any damage to packaging or crates?
_____ Current tank pressure (PSI) (if a pressure vacuum gauge is supplied)
_____ Liquid level as read on liquid level gauge (if supplied)
_____ Top oil temperature (°C)

NOTE: If the transformer is received with the pressure/vacuum gauge reading zero psi, a leak may have developed in the transformer and moisture may have been allowed to enter the tank. The transformer should be pressurized with 2-4 psi positive pressure of 99.99% pure dry nitrogen and the temperature of the top oil should be recorded as noted above. If the transformer loses pressure again with no change in temperature Sunbelt Transformer should be contacted immediately.

4 INTERNAL INSPECTION

NOTE: An internal inspection is necessary only if internal damage is suspected because of external indications of rough handling. Only competent and qualified should open a sealed transformer. The gas space above the oil is filled with nitrogen that could cause asphyxiation or death. Monitoring of the oxygen levels inside a transformer should always be performed when entering a transformer.

If the delivering carrier is willing to permit internal inspection of the transformer on the railroad car or truck prior to unloading, without requiring consignee's signature on the delivery slip, Sunbelt Transformer should be called and an internal inspection made as outlined in the "Internal Inspection" section of this book.

If the delivering carrier will not permit internal inspection of the transformer on the truck, note on the acceptance slip for the shipment that there are "possible internal and/or hidden damages," and file a claim immediately for possible hidden damage. When the transformer has been moved to the installation site or some other convenient location to permit inspection of the internal assembly for damage in transit, proceed as outlined in "Internal Inspection." Request that a representative of the carrier be present during the inspection.

5 HANDLING

5.1 COMPLETE TRANSFORMER

The transformer should always be handled in the normal upright position unless information from the manufacturer indicates that it can be handled otherwise. Where a transformer cannot be handled by a crane, it may be skidded or moved on rollers into place, depending upon compatibility of transformer base design and the type of surface over which it is to be moved. During the handling operation, care must be taken to prevent overturning. The transformer should never be tilted at an angle greater than 15° from vertical.

When a transformer is shipped it is usually ready to be set in place after the crating and shipping braces are removed. Bushings and accessories, which are shipped separately, should be thoroughly protected against moisture until they are installed. Proper precaution must be taken during installation of these parts to protect the transformer against the entrance of moisture.

5.2 LIFTING WITH SLINGS

Lifting lugs and eyes are designed for lifting with a maximum sling angle of 30° from vertical. For lift angles of greater than 30° from vertical, spreader bars must be used to provide a vertical lift on the lugs.

5.3 RAISING WITH JACKS

Jack bosses are provided on most transformers so that the transformer can be raised by means of jacks. On those transformers not equipped with bosses, the jacks may be placed under the transformer bottom plate at designated points. The manufacturer's drawings

Sunbelt Transformer Liquid-Filled Transformer Instruction and Maintenance Manual should be consulted.

Do not attempt to raise the transformer by placing the jacks under drain valves, pipe connections or other attachments. It is also recommended that these appendages not be subjected to a man's weight.

6 ACCESSORIES

6.1 DE-ENERGIZED TAP CHANGER

WARNING: Do not move or adjust the de-energized tap changer unless the transformer is disconnected from all power sources. Failure to do so can result in failure of the transformer and injury or death.

The de-energized tap changer is used as a means of adjusting the transformer to accommodate the user system voltages. The voltage settings for each switch position can be found on the transformer nameplate.

The tap changer handle has provisions for a padlock or key interlock system that can be coordinated with switchgear or other safety devices that ensure that the power is disconnected prior to adjusting the de-energized tap changer. To adjust the tap changer, any lock used must be removed and the center pin must be pulled out approximately one-half inch. The tap changer wheel should turn and seat in the next position. The pin can then be re-seated.

WARNING: Do not re-energize the transformer unless the pin is completely reseated. Failure to do so can result in failure of the transformer and injury or death.

6.2 PRESSURE RELIEF DEVICE

When required by the specifications, a mechanical automatic re-sealing type pressure relief device can be supplied. This device requires no adjustment after it operates. After relieving the pressure due to the gas build-up in the tank, it automatically re-closes and reseals. Optional alarm contacts are available which indicate the operation of the pressure relief device. The psi trip setting of this device is not adjustable and is matched with the pressure rating of the transformer tank.

WARNING: Do not disassemble the pressure relief device. Doing so could hinder its operation and result in death or injury.

6.3 PRESSURE-VACUUM BLEEDER DEVICE

When required by the specifications, a pressure-vacuum bleeder can be supplied. This device is designed to protect transformer from a slow build-up of pressure. The pressure and vacuum relief points are adjustable and are factory set to admit air when the vacuum exceeds -6.5 psi and exhaust internal gases when the pressure exceeds +6.5 psi to maintain a safe level of vacuum or pressure, respectively.

6.4 VACUUM-PRESSURE GAUGE

The pressure vacuum gauge measures the pressure with respect to the outside atmosphere. Maintenance is not expected. The vacuum-pressure gauge may be supplied with alarm separate adjustable contacts. Typical settings are 8.5 psi for a pressure trip and –1.5 for a vacuum trip setting.

NOTE: A zero pressure reading that does not change with temperature could be indicative of a leak. A leak will allow moisture to enter the transformer that will degrade the insulation and shorten the life of the transformer.

6.5 SUDDEN OR RAPID PRESSURE RISE RELAY

This relay actuates not on the absolute value of pressure, but on the rate-of-rise of the transformer tank pressure in a given time period. This rate-of-rise is not affected by the instantaneous tank pressure. This relay is used to sound an alarm, or cause a breaker to operate when a transformer experiences severe arcing or transformer failure that generates a large quantity of gas that increases pressure in a short period of time.

A seal-in relay panel is typically supplied in the transformer's control cabinet that captures the quickly resetting contact closure of the sudden pressure relay. The alarm or trip contact closure of the seal-in relay panel will remain closed until the reset button located on the panel is depressed.

6.5.1 Transformer Checks Following Sudden Pressure Relay Operation

_____Use a combustible gas detector to directly check for generated gases
_____Check for burned odor in released gases from bleeder
_____Field-test the relay and seal-in panel. Contact the factory for test kit availability
_____Perform insulation power factor and insulation resistance tests

If no problems are found, the decision to re-close the HV breaker or interrupter must be weighed against the possibility of further internal damage or failure.

6.6 DIAL TYPE THERMOMETER

When required by specifications, a dial type thermometer is mounted in a thermometer well located on the transformer's tank wall and can be easily removed. The thermometer reads the top oil temperature. As an option it is available with contacts, which can be used to sound an alarm, control fans, and/or actuate circuit breakers when a preset temperature is reached. The temperature settings of these contacts are adjustable with typical values being 60°C for first stage fans, 70°C for second stage fans, 100°C for alarm and 110°C for the trip point. There are no ANSI standard values for these settings.

The thermometer has a drag pointer that indicates maximum temperature reached. The drag hand can be reset by turning the reset knob, located on the center face of the gauge counter clockwise until it reaches the temperature pointer. When operating at less than the maximum load the winding hottest point temperature should not exceed 80°C plus the ambient temperature.

6.7 LIQUID LEVEL INDICATOR

When required by specifications a liquid level gauge is mounted on the tank wall. This device utilizes an internal float arm that is linked to the gauge face with a magnet. The gauge face can be removed without contact with the oil. The magnetic gauge is available with or without contacts that can be used for alarm circuits. The liquid level gauge is calibrated at the factory to read correct at the 25°C fill mark, HI at 85°C and LO at -20°C.

6.8 WINDING TEMPERATURE GAUGE

Also known as a Dial-Hot Spot Gauge, this device measures the temperature of the top oil that is preheated by a resistive coil that adds heat proportional to the load of the transformer. A current transformer sends current proportional to the load of the transformer to a resistive element wrapped around the temperature sensor. Because there is no direct contact with the actual hottest point of the windings the winding hotspot is a simulated temperature and is calibrated based on design criteria.

This gauge is provided with standard contacts that can be used to sound an alarm, control fans, and/or actuate circuit breakers when a preset temperature is reached. The temperature settings of these contacts are adjustable with typical values being 70°C for first stage fans, 80°C for second stage fans, 115°C for alarm and 122°C for the trip point. There are no ANSI standard values for these settings.

The winding temperature gauge has a drag pointer that indicates maximum temperature reached. The drag-hand is reset by turning the reset knob on the center of the gauge. When operating at less than rated load the maximum temperature should not exceed 85°C plus the ambient temperature.

7 INTERNAL INSPECTION

If the transformer is still within the warranty period, Sunbelt Transformer should be contacted prior to entry into the transformer for other than routine or assembly purposes.

WARNING: The transformer gas space is filled with pure nitrogen. To prevent death from suffocation never allow anyone to enter the transformer unless the gas space is purged with dry air and the oxygen content is greater than 19%. If entering the transformer is necessary a person should always remain outside the transformer to ensure the safety of the person entering the transformer.

7.1 PURGING THE GAS SPACE

WARNING: Explosive gases can build up in the gas space of a transformer while in operation. If the transformer has been energized the gas space should be purged prior to opening to prevent an explosion that could result in death.

7.1.1 Method I – Utilizing Vacuum Pump

7.1.1.1 Pull a vacuum of at least 5 psi negative pressure on the gas space.

7.1.1.2 Pressurize the gas space using dry nitrogen with less than 0.03% moisture content.

7.1.1.3 A regulator set at less than 5 psi should be used to control the flow of nitrogen to the

unit.

7.1.2 Method II – Blowing out Nitrogen

7.1.2.1 Remove pipe plug or open sampling valve in transformer gas space.

7.1.2.2 Allow dry nitrogen with less than 0.03% moisture content to free-flow into the transformer through the pressurization fitting. A regulator set at less than 5 psi should be used to control the flow of nitrogen to the unit. The nitrogen flow should be continued until the oxygen content is less than 5%

7.1.2.3 Close the vent plug or valve and allow the pressure to increase to 4 psi in the gas space.

7.1.2.4 Let transformer stand for one day.

7.1.2.5 Open sampling valve and allow pressure level to drop to 0 psi.

7.1.2.6 Pressurize to 4 psi positive pressure with nitrogen.

7.1.2.7 Repeat steps 5.1.2.4 through 5.1.2.6 as necessary to drop the oxygen content below 5%.

Note: It is a waste of nitrogen to try to reduce the oxygen content to less than 3%. This is due to oxygen that is dissolved in the oil. It takes about four times as much nitrogen to purge oxygen down from 3% to 1% as it does to reduce the oxygen content from 20% to 3 percent.

7.2 PRIOR TO OPENING THE TRANSFORMER

WARNING: Avoid possible serious accident. Be sure to relieve tank pressure or vacuum before attempting to loosen and remove manhole cover.

Before opening a transformer, take samples of the insulating liquid from the top and bottom of tank and test the dielectric strength. The dielectric strength should be 27.5 kV or higher. If it is lower, the transformer should not be placed in service until the dielectric strength has been restored by filtration.

To avoid the entry of moisture into the tank, the transformer should have approximately 0.5 to 1.0 lbs positive pressure when opening the manhole or any valve exposed to the outside atmosphere. If the transformer has a negative pressure (vacuum), it should be pressurized to 0.5 to 1.0 psi positive pressure with 99.99% pure nitrogen.

7.3 OPENING THE TRANSFORMER

If possible, **DO NOT** permit the coils or insulation to be exposed to the air. If oil is to be drained from the transformer, 99.99% pure nitrogen should be fed into the transformer with the transformer sealed while oil is being removed.

7.4 CORE-AND-COIL ASSEMBLY

After lowering the insulating liquid to the top of the core-and-coil assembly, inspect the interior to see if any damage has occurred. Examine the top of the core-and-coil assembly, all horizontal surfaces and the underside of the cover for signs of moisture. If there are signs of moisture inside the tanks steps should be taken to determine the extent of it and the manner in which the moisture entered the transformer. The transformer should then be reassembled and Sunbelt Transformer should be contacted to make recommendations concerning further checks and steps for drying out the transformer.

If the transformer appears to have been damaged internally or if it is desirable to remove the core-and-coil assembly for inspection or drying, the transformer may be untanked as

Sunbelt Transformer Liquid-Filled Transformer Instruction and Maintenance Manual follows:

Remove the hand-hole lid and disconnect high and low voltage leads if the bushings are in position. Remove both primary and secondary bushings.

Small bushings may be left on the cover if they are protected and the cover is carefully handled. Remove cover. Remove thermometer, tapchanger and oil gauge and all other accessories and associated wells, which project in the tank and which, might interfere with untanking operations.

Use slings for removing the core-and-coil assembly.

Particular care must be taken in handling tools and other loose articles when working with a transformer. Metallic objects, if dropped in the windings and allowed to remain there, can cause a severe fault.

8 STORAGE

It is advisable to locate a transformer, complete with liquids in its permanent location even if it will not be placed in service for some time. It is well to check the paint finish and to repair all damaged painted surfaces. If the transformer is shipped and stored in dry inert gas, the gas pressure should be maintained and periodically tested.

Radiators should be stored on their shipping pallets. Oil-filled condenser bushings should be stored upright, if possible, for extended periods of time.

If a transformer has been stored for greater than ninety days prior to energization additional testing will be required. This is noted in the section of this manual covering field testing.

9 LOCATION

Accessibility, ventilation and ease of inspection should be given careful consideration in the location of transformers.

Self-cooled transformers depend entirely upon the surrounding air for carrying away their heat. For this reason, care must be taken to provide adequate ventilation.

For indoor installation, the room in which the transformers are placed must be well ventilated so that heated air can escape readily and can be replaced by cool air. Inlet openings should be near the flow and distributed so as to be most effective. The outlet opening(s) should be as high above the apparatus as the construction of the building will permit. The number and size of the outlets required will depend on their distance above the transformer and on the efficiency and load cycle of the apparatus. In general, about 60 square feet of outlet opening or openings should be provided for each 1000 kva of transformer capacity. Air inlets should be provided with the same total area as the outlets.

Self-cooled transformers should always be separated from one another and from adjacent walls, partitions, etc., in order to permit free circulation of air about the tanks. This separation should not be less than 30 inches.

10 PREPARING FOR SERVICE

10.1 ASSEMBLY

NOTE: Bushings and radiators should only be attached to the transformer under dry conditions. All flanges should be completely dry to avoid moisture from entering into the transformer. The pressure-vacuum gauge bleeder or air test valve should be opened to ensure that the transformer is maintaining a slightly positive pressure.

10.1.1 Radiators

Radiators shipped separately have disposable flanges and are sealed to prevent moisture from entering. To prevent corrosion and moisture from standing against the removable flanges radiators should be left on the pallets that they are shipped in if they are to be stored.

The radiators should only be lifted using the top-end lifting eye for installation. The removable flanges should only be removed prior to installation and the insides should be thoroughly inspected for moisture or foreign matter. If moisture is present the radiators should be drained and heated to evaporate the moisture. Once the radiator is dry, transformer liquid should be used to flush corrosion from the radiator.

Once all the radiators have been installed, the top vent plug should be loosened and the bottom radiator valves opened. Fluid will then flow into the bottom valve and push the ambient air out through the vent plug. Be prepared to close the vent plug to prevent fluid from escaping. This will also ensure that any foreign matter in the radiator is flushed back into the radiator.

If additional liquid is required the oil-filling procedures below should be followed.

10.1.2 Fans

Universal mounting brackets are supplied to mount the fans to the radiators. The radiators should be mounted in the location indicated on the outline drawing.

10.1.3 Draw-lead Connected, Oil-Filled Condenser Bushings

10.1.3.1 All bushings should be removed from their packing and checked for chips or cracks and cleaned. If possible perform the bushing insulation power factor test prior to installation. The top cap and terminal should be removed and a piece of cotton tape should be threaded through each bushing and the ends should be tied together.

10.1.3.2 The internal pressure should be lowered to slightly positive pressure. There will be a blank or “blind” flange over the mounting boss where the bushing will go. At this point all the blind flanges should be loosened allowing gas to blow outward. This will force any loose particles or moisture from falling into the transformer. Clean each mounting flange but do not disconnect the lead connected to the disposable plate.

10.1.3.3 Connected to the inside of the disposable flange will be the lead that should be connected to the bushing that mounts on that flange. Do not completely remove the

blind flange until the bushing is positioned over the mounting boss with a crane or hoist. Untie the cotton tap looped through the bushing and tie the bottom end to the internal transformer lead.

10.1.3.4 As the bushing is lowered into place, the lead should be drawn up through the center of the bushings. The lead terminal threads inside the bushing cap and the cap then threads onto the top of the bushing.

10.1.3.5 Tighten the bushing cap to 70 ft-lbs of torque and the flange bolts to 25 ft-lbs of torque.

10.2 OIL FILLING

10.2.1 Checking Oil

Check the dielectric strength of oil while it is still in containers. If free water is present, drain off the water before putting the oil through the filter press. Continue passing oil through the filter press until the prescribed dielectric strength is met.

10.2.2 Non-Vacuum Filling

In cases where vacuum filling is not required, the tank should be filled through the upper filling valve. A second opening at the top should be provided to relieve the air being displaced. Full voltage may not be applied to the transformer for a period of 24 hours.

10.2.3 Vacuum Filling

Entrapped air is a potential source of trouble in all transformers. In general, therefore, it is desirable to fill transformers with oil under as high a vacuum as conditions permit. It is essential to vacuum-fill high voltage transformers shipped in nitrogen or dry gas in order to develop their full insulation strength before they are energized.

10.3 PRELIMINARY INSPECTION

Before any work is done on a transformer in preparation for service, a careful inspection of all external parts is needed to disclose any evidence of mistreatment or damage. This inspection should include performing the checks listed in the section of this report on receiving inspection. In addition to these checks, accessible bolted parts should be checked for tightness. Pressure tests should be taken and the liquid checked to determine both its physical level and dielectric strength. Any indication of leaks, which may have resulted in moisture entering the transformer should be noted and appropriate action taken.

NOTE: Pressurized and sealed at ambient temperature at time of manufacture. It is common that a pressure vacuum gauge if supplied could read negative due to lower temperature at the site of installation. This is not an indication of an abnormality, but that the tank is properly sealed.

10.4 FIELD TESTING

All field tests should be performed prior to making external connections to the transformer.

10.4.1 Insulation Resistance (Meggar) Test

This test is required for all new installations. This is a simple test to ensure that the insulation has not suffered damage or that the windings are no longer electrically isolated from each other and from ground. It is recommended that this test is performed at 1 kV for at least thirty (30) seconds. The value obtained should continuously increase and should be greater than 500 mega-ohms.

10.4.2 Transformer Turns Ratio (TTR) Test

This test is required for all new installations. Testing the ratio of the turns of one winding with respect to another is done to check that no internal connections have been changed following factory testing and that the proper output voltages will be obtained. If the transformer has an internal terminal board this test will verify that it is in the proper connection. The allowable tolerance is 0.50% and should match factory values.

10.4.3 Phase Relationship

This test is required for all new installations. This refers to the time lag or degree angle between the HV and the LV sinusoidal waveforms. The standard terminology is to give the connection of the input side (delta, wye or zigzag) followed by that of the output side followed by an integer multiple of 30 degree lag. This should match the factory test value exactly.

10.4.4 Winding Resistance

This test is required for all new installations. The resistance, measured in ohms, must be measured by a micro-ohmmeter. The value should match the factory values to within 10%. This measured value must be temperature corrected to 20°C as follows and compared with the factory values.

Corrected resistance = (Measured Resistance) X (Correction Factor)
Where the correction factor equals (Tk + 20 + Temperature Rise)/(Tk + Tm)
And Tm is the measured top oil temperature and Tk is 224 for aluminum and 234.5 for copper.

10.4.5 Insulation Power Factor and Bushing Insulation Power Factor Tests

This test is recommended for all new installations higher than 34.5 kV, but required if the transformer has been in storage for longer than ninety days. This test verifies the amount of energy lost through an insulation system, either from winding-to-winding, winding-to-ground, or bushing-to-ground through the porcelain or epoxy insulator material. Follow the guidelines of the specific test equipment used. The tested values match those provided on the factory certified test report or bushing nameplate.

SUNBELT TRANSFORMER FIELD TEST FORM

CUSTOMER		TESTED BY		DATE	
LOCATION OF TESTS		AIR TEMP	WEATHER	OIL TEMP	HUMIDITY
MFR	SERIAL NO.	AGE	FLUID TYPE	KVA RATINGS	
FREE BREATHING ☐	SEALED ☐	GAS BLANKET ☐	CONSERVATOR ☐	PHASE RELATIONSHIP:	GALLONS OIL:

ON LOAD TAP CHANGER? HV ☐/ LV ☐	BUSHINGS	MFR	TYPE	CLASS	DWG.NO.	CAT.NO.	KV	YEAR
OFF LOAD TAP CHANGER? HV ☐/ LV ☐								
HV SIDE _____kV Yn☐ Y☐ Δ☐								
LV SIDE _____kV Yn☐ Y☐ Δ☐								
TV SIDE _____kV Yn☐ Y☐ Δ☐								

INSULATION POWER FACTOR TESTS SET ID#

	WINDING TEST CONNECTIONS				EQUIVALENT 10 KV READINGS				%DISSIPATION FACTOR AS READ			CONVERSION TO % POWER FACTOR			CAPACITANCE (PICOFARADS)	
					MILLIAMPERS		WATTS									
TEST	HOT	GND	GAURD	KV	METER	mA	METER	W/mW	NORM	REV	AVG	%PF CALC	TEMP CORR	%PF 20°C	MULT X DIALS	pF
GST 5 CH	HIGH	------	LOW													
GST 5 CL	LOW	------	HIGH													
UST 3	HIGH -LOW	------	------													

BUSHING INSULATION POWER FACTOR TESTS SET ID#

BUSH-ING	PHASE	TEST KV	BUSHING SERIAL NO	Dielectric Loss Readings		% POWER FACTOR		COLLAR TESTS	
				MILLIAMPERES	WATTS	MEASURED	**CORRECTED**	(WATTS/CURRENT)	INSULATION RATING

INSULATION RESISTANCE (MEGGAR) TESTS (Minimum 30 Seconds @ 1 kV) SET ID#

NOTE:UNSPEC-IFIED WINDINGS	HV - GROUND	LV – GROUND	TV - GROUND	HV to LV	HV to TV	LV to TV	Series Transformer Core Ground	Main Transformer Core Ground
ARE TIED TO GROUND	MΩ	MΩ	MΩ	MΩ	MΩ	MΩ	MΩ	MΩ

WINDING RATIO TESTS SET ID#

WINDING RESISTANCE (OHMS) SET ID#

TAP VOLTAGE	PHASE A RATIO	PHASE B RATIO	PHASE C RATIO	BUSHINGS TIED	TAP:	TAP:	TAP:	TAP:	TAP:	TAP:

11 ENERGIZING THE TRANSFORMER

Before applying voltage to transformer, initial or provide values for the following items:

_____Are feeder cables on bus connected to bushing terminals without stressing the porcelains?
_____Ensure the transformer output is disconnected by an open circuit breaker or other means?
_____Are winding neutral terminals properly grounded or ungrounded as required by system operation?
_____Is tank solidly grounded at grounding pads located near bottom of tank?
_____Are all current transformers connected to a load or short-circuited?
CAUTION: Open secondaries can produce voltages dangerous to humans and connected equipment.
_____Is the de-energized tap changer set in desired position?
_____Have all tools and foreign objects been removed from transformer?
_____Are all openings and joints sealed?
_____Are all top and bottom radiator valves opened?
_____Is the tank filled to the appropriate level? Also level in liquid-filled compartments (if supplied).
_____Are all fans and control circuits (if supplied) operational?
_____Is insulating dielectric strength of oil at least 27.5 kv? If tests are less, filter the liquid.
_____Are all personnel at a safe distance from the transformer and live equipment?

After energizing, watch transformer closely for the first three hours of operation for evidence of abnormal conditions.

12 APPLYING LOAD TO THE TRANSFORMER

Unless specifically designed to do so, transformers are suitable for full-load operation at rated temperature rise without abnormal loss of life when operated within the following limits:

1. Ambient temperature does not exceed 40°C; or average more than 30°C over any 24-hour period.

2. Installed elevation does not exceed 3,300 feet (1,000 meters) above sea level.

13 MAINTENANCE

13.1 PERIODIC ON-LINE INSPECTION AND MAINTENANCE

MANUFACTURER SERIAL# _____ ID #_____ DATE_____

It is recommended that the following be checked after approximately six months of operation under normal conditions. If the transformer is operating in caustic environments, environments below -20° C or above 40° C, or beyond nameplate ratings, this interval should be shortened.

13.1.1 OIL TESTS – MAIN TANK AND LTC COMPARTMENT

Caution: 2-4 PSI positive tank pressure should be present prior to sampling main tank or LTC fluid to prevent ingress of moisture into tank which could result in transformer failure.

_____Dielectric strength (ASTM D-877) should be 26 kV or greater (0.8 inch gap)
_____Oil Power Factor should be <0.15% for 69 kV and below, <0.10% above 69kV
_____A dissolved gas sample (DGA) should be obtained for monitoring trends
_____Water content should be below 25 ppm (40 ppm for aged equipment)

13.1.2 EXTERNAL TANK INSPECTIONS

_____Verify of liquid level
_____Record present value/ maximum of liquid temperature
_____Record present value/ maximum of winding temperature(s)
_____Record present value of tank pressure (vacuum)
_____Record present ambient temperature and weather conditions
_____Obtain transformer kVA loading level (if available)
_____Visually check for corrosion, leaks and damage
_____Check operation of all fans and pumps and lubricate

Caution: Disconnect power source to fans prior to lubrication or performing maintenance to fans or pumps to prevent possible injury or death.

_____Check operation of flow gauges on forced-oil cooled transformers
_____Check cabinet ventilation specifically looking for corrosion inside control cabinet
_____Check operation of control cabinet heater (if supplied)
_____Inspect oil level of condenser bushings
_____Inspect bushings for cracks or chips on sheds
_____Inspect bushings for buildup of contamination
_____Record volume of nitrogen remaining if equipped with nitrogen regulator/cylinder

13.1.3 ON-LOAD TAP CHANGER INSPECTIONS – (if so equipped)

_____Verify fluid level
_____Record present value of LTC compartment pressure (vacuum)
_____Verify voltage regulator relay readings of current and voltage
_____Check counter operation while verifying control operations below
_____Check operation of remote/local controls in MANUAL control

Caution: Manually operating the on-load tap changer while in operation will result in the load-side voltage changing. Verify the effect of removing from AUTOMATIC position.

_____Verify return to target voltage by returning to AUTOMATIC control
_____Verify selsyn/remote position indication against indicator on side of LTC

13.2 MAINTENANCE DURING PERIODS OF SHUTDOWN

In addition to performing the inspections suggested in the section, "PERIODIC ON-LINE INSPECTION AND MAINTENANCE", the following maintenance should be performed during shutdown periods.

CAUTION: Before entering a transformer that has been in service, BE SURE to lock open the line switches on both the HV and LV side, then connect a grounded line to transformer terminals in order to discharge any stored energy in the windings.

DO NOT ENTER THE UNIT UNTIL THE GAS SPACE ABOVE LIQUID HAS BEEN PURGED WITH DRY AIR. BREATHING THE NITROGEN ABOVE THE TRANSFORMER LIQUID CAN CAUSE ASPHYXIATION.

Clean any contamination from bushings

Rotate the tapchanger handle back and forth a few times. This will clean the contacts. Be sure to return the handle to its original position if no change in voltage ratio is desired.

13.3 CHECKING FOR LEAKS

Check pressure vacuum gauge daily the first week of transformer operation. If pressure-vacuum gauge stays at zero reading, it indicates a faulty seal. If transformer cannot be de-energized, be careful to not come into contact with live parts such as bushing terminals and leads.

13.3.1 Determining Leak Location

Caution: Observe field safety procedures if transformer is energized or installed.

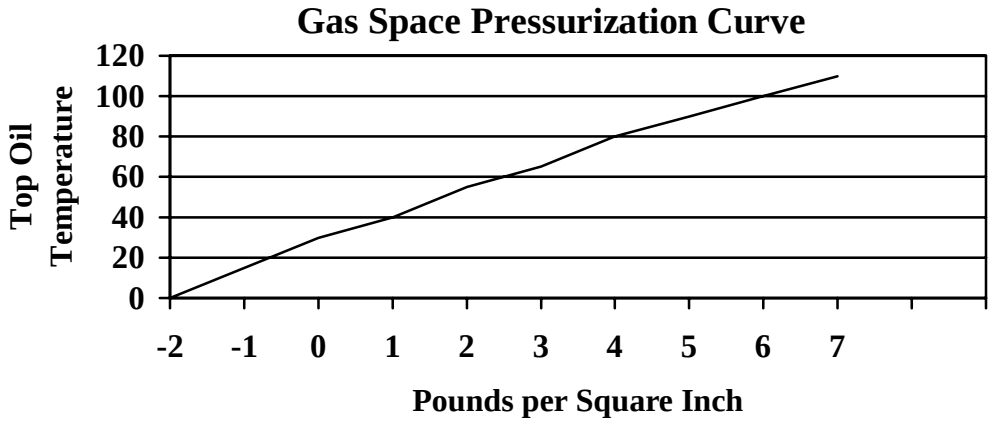
13.3.1.1 Under-oil Leaks

Wipe down the area with a dry rag. Create a solution of chalk dust in rubbing alcohol paint on the area with a dry brush. The alcohol will dry quickly leaving the dry chalk residue. The oil leak will be quickly visible.

13.3.1.2 Gas Space Leaks

Pressurize the gas space to as high psi of dry nitrogen as the tank will withstand as is indicated on the transformer nameplate.
Brush on a soap water solution that will create bubbles to reveal the leak location.

After leak is repaired, add sufficient dry air or nitrogen to provide 0.5 Psi gauge pressure at 25°C (top liquid temperature). Refer to curve for normal pressure at other top liquid temperatures.



13.4 TRANSFORMER REPAIR

WARNING: Always de-energize the transformer when performing repair to avoid injury or death.

Report all warranty issues to Sunbelt Transformer prior to performing any work. All warranty work must be performed under the guidance of Sunbelt Transformer.

Due to the large number of accessories and features available with power transformers, repair information is not included for all parts. Contact Sunbelt Transformer for additional information particular to external accessories. For a specific repair procedure contact Sunbelt Transformer. Sunbelt Transformer repairs and refurbishes transformers from 500 kVA through 50 MVA of all design types.