INSTRUCTIONS

Liquid Filled Transformers

SAFETY INFORMATION
IMPORTANT - READ CAREFULLY

WARNING - READ ALL INSTRUCTIONS CAREFULLY BEFORE ATTEMPTING TO HANDLE, INSTALL, USE OR SERVICE THIS EQUIPMENT. FAILURE TO FOLLOW INSTRUCTIONS COULD RESULT IN SEVERE INJURY, DEATH, OR PROPERTY DAMAGE.

CAUTION - THE EQUIPMENT COVERED BY THESE INSTRUCTIONS SHOULD BE INSTALLED, OPERATED, AND SERVICED ONLY BY COMPETENT TECHNICIANS FAMILIAR WITH GOOD SAFETY PRACTICES. THESE INSTRUCTIONS ARE WRITTEN FOR SUCH PERSONNEL AND ARE NOT INTENDED AS A SUBSTITUTE FOR ADEQUATE TRAINING AND EXPERIENCE IN SAFE PROCEDURES FOR THIS TYPE OF EQUIPMENT.

THESE INSTRUCTIONS DO NOT PURPORT TO COVER ALL DETAILS OR VARIATIONS IN EQUIPMENT NOR TO PROVIDE FOR EVERY POSSIBLE CONTINGENCY TO BE MET IN CONNECTION WITH INSTALLATION, OPERATION OR MAINTENANCE. SHOULD FURTHER INFORMATION BE DESIRED OR SHOULD PARTICULAR PROBLEMS ARISE WHICH ARE NOT COVERED SUFFICIENTLY FOR THE PURCHASER'S PURPOSES, THE MATTER SHOULD BE REFERRED TO THE NEAREST SALES OFFICE OF MGM TRANSFORMER COMPANY.

ALL APPLICABLE SAFETY PRACTICES INCLUDING, BUT NOT LIMITED TO, OSHA, NFPA, ANSI, REGIONAL AND LOCAL SAFETY CODES, SAFE WORKING PRACTICES AND GOOD JUDGMENT, AS THEY MAY BE APPLIED TO THIS TYPE OF EQUIPMENT MUST BE USED AND OBSERVED BY ALL PERSONNEL WHEN INSTALLING, OPERATING AND MAINTAINING THIS EQUIPMENT.

DO NOT MAKE ANY CONNECTIONS THAT ARE NOT AUTHORIZED BY THE NAMEPLATE OR CONNECTION DIAGRAMS.

TRANSFORMER MUST BE PROPERLY GROUNDED BEFORE ENERGIZING.

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ADDITIONAL SAFETY NOTES - READ CAREFULLY

1. KEEP THIS INSTRUCTION BOOK AVAILABLE TO ALL PERSONS RESPONSIBLE FOR INSTALLATION, MAINTENANCE, AND OPERATION OF THE TRANSFORMER.

2. **WARNING---**ALWAYS DE-ENERGIZE AND LOCK OUT THE POWER SUPPLYING THIS EQUIPMENT BEFORE MAKING ANY REPAIRS OR PERFORMING ANY MAINTENANCE. FAILURE TO DO SO COULD RESULT IN PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

3. **DANGER---**WHEN THE TRANSFORMER IS ENERGIZED, THE BUSHINGS AND COMPONENTS CONNECTED TO THE BUSHINGS, BOTH INTERNALLY AND EXTERNALLY, ARE AT HIGH VOLTAGES. COMING TOO CLOSE TO LIVE PARTS COULD RESULT IN DEATH BY ELECTROCUTION.

4. **DANGER---**THE CONTROL CABINET AND ACCESSORIES CONNECTED TO THE CABINET CONTAIN HIGH VOLTAGES. ALL POWER SOURCES SUPPLYING THE CABINET COMPONENTS MUST BE DISCONNECTED AND LOCKED OUT BEFORE ANY INSPECTION, MAINTENANCE OR REPAIRS ARE MADE ON THE CONTROL CABINET AND IT'S COMPONENTS. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

5. **WARNING---**CURRENT TRANSFORMER SECONDARY TERMINALS MUST BE SHORT CIRCUITED OR CONNECTED TO A LOAD WHILE THE TRANSFORMER IS ENERGIZED. IF THE SECONDARY TERMINALS ARE OPEN CIRCUITED, HIGH VOLTAGES ARE PRESENT AT THE TERMINALS. FAILURE TO PROPERLY CONNECT THE SECONDARY TERMINALS TO A CLOSED CIRCUIT COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

6. **CAUTION---**THE TAP CHANGER MUST ONLY BE OPERATED WHEN ALL POWER SUPPLYING THE TRANSFORMER IS DISCONNECTED AND LOCKED OFF. ATTEMPTING TO OPERATE THE TAP CHANGER WHILE ENERGIZED WILL RESULT IN INTERNAL ARCING AND POSSIBLE SEVERE PERSONAL INJURY AND/OR DAMAGE TO THE TRANSFORMER.

7. **WARNING---**THE TRANSFORMER TANK CONTAINS INSULATING LIQUID AND THE GAS SPACE NORMALLY CONTAINS NITROGEN. TO AVOID DEATH BY SUFFOCATION DO NOT ENTER TANK UNLESS AN ANALYSIS OF THE AIR IN THE TANK SHOWS AT LEAST 19.5% OXYGEN CONTENT.

8. **WARNING---**THE TRANSFORMER TANK MAY BE UNDER HIGH PRESSURE. DO NOT REMOVE ANY BOLTS, PLUGS OR OTHER ACCESSORIES WITHOUT FIRST RELIEVING THE INTERNAL TANK PRESSURE. FAILURE TO RELIEVE THE PRESSURE COULD RESULT IN THE PART BEING REMOVED BECOMING A HAZARDOUS FLYING OBJECT. PERSONNEL COULD BE INJURED BY THE FLYING OBJECT. INSULATING LIQUID OR VAPOR COULD BE EXPELLED FROM THE TANK CREATING A POSSIBLE FIRE HAZARD.

9. **WARNING---**THE TRANSFORMER MUST HAVE THE CORRECT AMOUNT OF INSULATING LIQUID WHILE ENERGIZED. FAILURE TO MAINTAIN THE INSULATING LIQUID AT THE PROPER LEVEL COULD RESULT IN PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

10. **CAUTION---**IF THE PRESSURE-VACUUM GAGE READS ZERO AND DOES NOT CHANGE UNDER DIFFERENT TRANSFORMER LOADING CONDITIONS, THE TRANSFORMER SHOULD BE CHECKED FOR POSSIBLE LEAKS. A LEAK WILL ALLOW MOISTURE AND AIR TO ENTER THE TRANSFORMER WHICH WILL DEGRADE THE INSULATION AND LIQUID. THE LIFE OF THE TRANSFORMER COULD BE REDUCED IF LEAKS ARE NOT REPAIRED.

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1.0 RECEIVING

Liquid filled transformers are usually shipped F.O.B. factory and are normally completely assembled, liquid-filled and ready to install. Immediately upon receipt of the equipment, examine the transformer and any separate parts packages for any damage which may have occurred during shipment. If injury or rough handling is evident, file a damage claim with the transportation company and notify the nearest Sales Office of MGM Transformer Company.

Tighten any parts which may have worked loose, such as nuts and leads and check the materials against the shipping list for possible shortages.

A notation should be made of the reading of the pressure vacuum gage and the liquid level gage.

An internal inspection is not required unless there is evidence of rough handling, tank damage, damaged accessories or an inoperative tap changer.

If an internal inspection is required, the following instructions should be adhered to:
1) Do not attempt an internal inspection in an area unprotected from the weather during precipitation or in an area where the air may contain dirt or other particles. Any foreign matter entering the inside of the transformer could cause a failure.
2) The liquid temperature should be equal to or greater than the outside air temperature. If it is not, moisture condensation may degrade the dielectric strength of the insulting fluid.
3) Before attempting to unbolt the handhole or manhole cover, bleed off any internal pressure to prevent the bolted cover from becoming a hazardous flying object. **WARNING---*The transformer tank may be under high pressure. Do not remove any bolts, plugs or other accessories without first relieving the internal tank pressure. Failure to relieve the pressure could result in the part being removed becoming a hazardous flying object. Personnel could be injured by the flying object. Insulating liquid or vapor could be expelled from the tank creating a possible fire hazard.***
Internal pressure may be relieved by manually operating the pressure relief valve or opening the gas sampling valve and waiting until the internal pressure equalizes.
4) After removing the handhole or manhole cover, ventilate the gas space with dry air to purge the nitrogen gas it contains. WARNING--- *The gas space normally contains nitrogen. to avoid death by suffocation do not enter tank unless an analysis of the air in the tank shows at least 19.5% oxygen content.*
After removing the handhole check for any internal damage which might have occurred in shipment. Pay close attention to the tap changer, bushings, electrical connections, leads, insulation, coils, etc.

If any internal damage is found, include it on the damage claim with the transportation company and notify the nearest Sales Office of MGM Transformer Company for further instructions.

After the internal inspection is complete, replace the handhole or manhole cover and gasket and purge the gas space with dry nitrogen. Check the tank for leaks-See Section 4.3.

2.0 HANDLING

Lifting hooks are provided for lifting the complete transformer. In addition, where necessary, additional lifting eyes are supplied for lifting other various parts. Lift the transformer by utilizing all four of the main lifting hooks, using cables long enough to obtain cable pull angles not over 30 degrees from vertical. When lifting the transformer, the cover should be securely fastened in place to prevent buckling the tank walls. All four lifting hooks must be used when lifting the complete transformer.

The transformer may be skidded or moved on rollers. When using rollers, be sure that a sufficient number are used to distribute the weight.

Refer to the transformer outline drawing for the location of the jacking provisions. Do not attempt to move the unit by placing jacks under drain valves, cooling radiators or other attachments.

At least two jacks should be used and adjacent corners raised simultaneously to avoid damaging the base assembly.

Liquid filled transformers should always be handled in the normal upright position and in no case tilted more than 15° from the vertical, unless instructions have been given to the contrary.

Bolt-on terminal chambers, when provided, can be removed to facilitate moving the transformer.

3.0 STORING

Before placing a transformer in storage, make sure the insulating liquid is at its proper level, add dry nitrogen in the gas space until the pressure reaches 3 psi (20.7 kPa) and then seal the unit. Before placing a transformer in service after a period of storage, relieve the internal gas pressure by venting to the atmosphere. See paragraph on "Venting". Make a through inspection of the transformer before energizing.

Transformers stored for use as spares should be maintained in the same condition as those in service. Make periodic inspections of the liquid level, its dielectric

strength, and when furnished, fans, alarms, and control circuits. Also check the pressure gauge to make sure the transformer seal is being maintained and inspect junction boxes and other compartments for evidence of moisture condensation.

4.0 INSTALLATION

CAUTION---*This transformer is to be installed in such a manner and location as to minimize the hazards to all those who have access to it.*

The only foundation necessary is a level floor or pad of sufficient strength to support the weight of the transformer. The transformer should be located at least 18 inches and preferably 24 inches or more away from walls and other obstructions which might prevent free circulation of air around the unit. Transformer finishes and components are designed for normal life in a non-corrosive atmosphere. Atmospheres which include corrosive agents may require additional protective measures.

Different high voltage and low voltage configurations may be provided depending on the specified requirements. The HV and LV bushings may be cover mounted for overhead connections. Sidewall mounted bushings with integral flanges or flanged throats are provided when close coupling to switchgear is required. Air filled terminal chambers are used when cabling direct to the transformer is required.

Before placing the transformer in service, check the level and dielectric strength of the insulating liquid in all compartments as explained under "Sampling" and "Testing".

At higher altitudes, decreased air density reduces transformer cooling efficiency and lowers bushing over voltages. Lower atmospheric pressures may require venting of the transformer before placing in service in order to equalize internal and external pressures. If the transformer is to be installed at an elevation above 3300 feet (1000 meters) check the nameplate for maximum elevation transformer was designed for. If the transformer is to be installed at an elevation higher than it's nameplate rating contact the nearest Sales Office of MGM Transformer Company relative to the transformer's suitability for operation at the higher altitude.

4.1 CONNECTIONS

The necessary hardware for making interconnections between a transformer and its coordinated switchgear may be supplied with either the transformer or the switchgear. Bus bar joints should be properly aligned before bolting to prevent undue strain on the bushings. When making line connections, long sections of unsupported conductor should be avoided and leads should be flexible enough to allow for expansion and contraction. Make no connections except those authorized by the transformer nameplate.

Transformers having internal terminal boards are normally shipped connected for the highest rated voltage. When shipped otherwise, a tag fastened to the nameplate will indicate the connections that have been made. Before applying voltage to a transformer, see that all connections are tight and that the windings are connected for the desired voltage.

Ground the transformer permanently and effectively by means of the ground pad located at the bottom of the tank. Unit substation transformers can usually be connected to the common substation bus. A reliable, low-resistance ground is essential for adequate protection. A poor ground may be worse than none at all as it gives a sense of false security to those working around the equipment and may result in serious personal injury or damage to the transformer.

When a transformer is designed for use on a system having a solidly grounded neutral, be sure that the neutral lead is permanently and solidly grounded.

4.2 PIPE FITTINGS

When assembling pipe fittings, clean the threads thoroughly to remove all insulating liquid, grease, old compound and dirt. Apply pipe joint compound compatible with the insulating fluid or apply Teflon tape to the threads and screw the mating parts tightly in place.

4.3 LEAK TESTS

Inspect the entire transformer for evidence of leaks and make the following pressure test if evidence of a leak exists. Introduce dry nitrogen until the pressure in the transformer reaches 5 psi (34.5 kPa). Seal the tank at this pressure and make an examination for leaks over a period of 12 hours. The pressure should remain constant except for a small fluctuation caused by changes in the ambient air pressure. If after 12 hours the transformer pressure has remained at 5 psi it can be concluded the pressure seal is intact and there are no leaks. If the pressure has dropped steadily then proceed to look for the source of the leak. Leaks above the liquid level can be located by applying a liquid soap solution to all gasketed joints, pipe fittings, etc. Leaks below the liquid level will be visible due to the presence of insulating fluid being present at the source of the leak. If a leak is found notify the nearest Sales Office of MGM Transformer Company.

4.4 VENTING

The transformer should be vented to the atmosphere before it is placed in service if it has been pressurized for leak tests or storage, or if the unit has been opened and resealed. Venting should take place with the liquid temperature at 25°C. If it is necessary to vent at other temperatures, re-vent as soon as the unit returns to 25°C. This operation is necessary to prevent excessive operating pressures or vacuums.

5.0 VAULT VENTILATION

If the transformer is to be installed in a vault, provide ventilation which is adequate to keep the room temperature from exceeding that of the incoming air by more than 5°C. The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. In general, provide about 20 square feet (1.86 m^2) each of inlet and outlet openings for every 1000 kVA of transformer capacity is required.

Arrange the air inlets and outlets so that they are permanently open. Do not use as ventilators, windows or doors which may be opened and closed by attendants. There would be a danger of excessive heating in case they are inadvertently left closed during periods of heavy load or high temperature.

If forced ventilation is used, supply about 5000 cubic feet (141 m^3) of air per minute for each 1000 kVA of transformer capacity, and conduct the incoming air directly to the transformer so that it will flow up through and around the radiating members of the tank. If this cannot be done and the air is merely moved through the room, provide about 10,000 cubic feet (283 m^3) per minute for each 1000 kVA.

6.0 GASKETS

A number of different types of gaskets are used on liquid filled transformers, depending on the application and the insulating fluid used. Gaskets used to maintain the transformer seal have been selected for their ability to resist deterioration by the insulating liquid and to avoid any contamination of the liquid. No substitution should be made for these original gasket materials without the approval of MGM Transformer Company. Replacement or spare gaskets can be purchased to size through the nearest Sales Office of MGM Transformer Company. Identify the parts wanted as shown under "Renewal Parts List".

All of the gaskets used to maintain the transformer seal can be reused many times unless damaged. Before installing a new gasket or replacing an old one, thoroughly clean the gasket surfaces. Although in most cases no adhesive is required, an adhesive may be used if desired, except on "O" ring assemblies. Compress the gasket approximately one-third, or to the stops when provided in either the mating parts or in the gasket itself. Gaskets are compressed to the stops when there is a noticeable increase in the torque required to tighten the bolts. A leak test is recommended following the opening and closing of any gasketed joint affecting the transformer seal.

6.1 WEATHERPROOF JOINTS

For connecting the transformer throat or flange with it's associated switchgear, air terminal chamber or a transition section a rubber gasket is normally furnished with each outdoor unit for the purpose of weatherproofing the joint. Install the gasket on the throat flange before bolting the joining the sections together.

To install the rubber gasket, clean the surface on which it is to be mounted, strip the backing from the adhesive side of the gasket and press the gasket against the metal with enough pressure to make good contact.

When a retaining strip is provided the gasket should be assembled with its inner edge in contact with the strip. Tighten the gasket down to this stop or in the absence of a stop, compress it to approximately 1/2 it's size.

7.0 ACCESSORIES

Not all accessories are provided on all transformers. Refer to the transformer outline drawing for accessories provided and their location.

7.1 LIQUID-LEVEL GAGE

A magnetic liquid level gage is used to indicate the level of the insulating liquid in the main transformer tank and in associated compartments. It consists of a two piece assembly. One piece contains the float arm, a magnet and the flange for sealing to the tank. The other piece contains the gage itself with a magnetically operated pointer.

As an option the liquid level gage may be supplied with a snap-action switch that can be wired to give an alarm when the liquid level approaches a point too low for safe operation of the transformer. A cam on the indicator shaft will operate the switch when the pointer drops to the "LOW" mark on the dial. As the liquid level rises the pointer indicates the change, but the switch will not clear the alarm circuit until the pointer has advanced from above the "LOW" mark.

7.2 DIAL TYPE TOP LIQUID THERMOMETER

The dial type top liquid thermometer is used to indicate the top liquid temperature of the transformer. The standard type top liquid thermometer without switches is shown.

The thermometer is mounted with its temperature sensitive bulb in a well which extends into the transformer's top liquid and is secured with a union nut. The well is liquid-tight thus permitting removal of the thermometer without lowering the liquid level or breaking the transformer seal.

Dial calibration is in degrees centigrade with a white pointer to indicate top liquid temperature and a red pointer to show the maximum temperature which has been attained since last reset. To reset the maximum reading pointer, rotate the magnet at the center of the dial until the red pointer returns to rest against the white indicating pointer.

During normal operation the top liquid thermometer should read less than the sum of the ambient temperature and the rated temperature rise of the transformer. A 65°C rise transformer operating in a 25°C ambient should not read more than 90°C (25 + 65) A higher reading would indicate the transformer is being overloaded.

As an option it may be provided with 1, 2 or 3 over temperature internal contact switches. These switches can be used to control fans or initiate an alarm or trip. The snap-action switches are operated by cams on the indicating pointer shaft. Switch No. 1 is intended for fan control and Switches 2 and/or 3 when provided can be used to initiate an alarm or trip circuit. When Switch No. 1 is used in a fan control circuit, a fan control "Hand-Auto" switch is included in the control circuit and wired in parallel for manual operation of the fans.

To check operation of the thermometer or the temperature at which the switches operate, remove the unit and place the detector bulb in a container of liquid. Heat the liquid and using an accurate centigrade thermometer, compare readings and check switch operating temperatures. If the unit is not operating satisfactorily contact the nearest Sales Office of MGM Transformer Company regarding repairs or replacement.

7.3 PRESSURE·VACUUM GAGE

The pressure-vacuum gage is of the compound type and is normally calibrated in psi. Gage readings should vary as the transformer temperature changes and should normally indicate a positive pressure (The instrument should not be expected to read accurately near the zero point.) When the transformer is de-energized or is operating under light or no-load conditions in a low ambient temperature, the gage may indicate a vacuum within the tank. A lack of any change in reading with changes in temperature is an indication of a leak in the transformer seal and should be investigated.

7.4 PRESSURE RELIEF VALVE

A manual/automatic pressure relief valve is normally supplied on all liquid filled transformers. The valve is supplied with a manual pull ring which can be used to vent the transformer to the atmosphere before being placed in service or to manually relieve the internal tank pressure. The valve will also operate automatically at 10 psi to relieve excessive pressure in the tank.

7.5 PRESSURE RELIEF DEVICE

The mechanical self-resealing pressure relief device is used on transformers to protect against excessive and dangerous pressures which may build up inside the transformer tank. When a predetermined pressure is exceeded, the force of the pressure build-up lifts the diaphragm and vents the tank. The pressure relief device is normally mounted on top of the transformer either on the main cover or on a manhole cover. As an option the pressure relief device may be supplied with a switch contacts that can be wired to an alarm or trip to indicate the device has operated. This switch must be manually reset. After device operation, a complete check of the transformer should be made to find the cause of the excessive pressure. It may be an indication of internal arcing and possible transformer failure.

CAUTION---*Removal. The pressure within the transformer tank or any separate compartment is acting on the pressure relief device. Bleed off this pressure before attempting to remove the pressure relief device*.

CAUTION---*Disassembly. Should it be necessary to disassemble the pressure relief device, caution must be exercised when removing the protective hood because the springs are under compression*.

Painting. If the pressure relief device is painted in the field, care must be taken that paint is kept away from the space between diaphragm and flange, and away from the indicator bushing.

Description
The pressure relief device consists of a dome-shaped stainless steel diaphragm held in place by compression springs, suitable gaskets, a protective hood, and a lightweight plastic pin which gives visual indication that the unit has operated.

Operation
When the force of the pressure buildup within the tank against the stainless diaphragm in the pressure relief device exceeds the force of the compression springs, the diaphragm lifts slightly and gas is exhausted through the space between the diaphragm and the lower casting. The

tank pressure then spreads over the entire diaphragm area, causing the device to open rapidly and remain open until the pressure within the tank falls well below the tripping pressure. Then the diaphragm reseals the tank to prevent entrance of moisture or foreign material.

As the diaphragm rises during operation it lifts and brings into view a plastic pin located in the center of the cover. This indicates that the relief device has operated. This pin will remain visible until reset manually by being pushed down flush with the top of the pressure relief cover. The tank operating pressure is shown on the transformer nameplate and the operating pressure of the relief device is shown on the relief device cover.

If a high fire point liquid filled transformer is located in a poorly ventilated indoor area, provisions should be made either to absorb or to carry off any discharged gases. Refer to the National Electric Code for regulations pertaining to the indoor installation of high fire point liquid filled transformers.

7.6 ELECTRICAL CONTACTS

When electrical contacts are furnished with the various accessory devices, refer to their respective wiring diagrams for contact type, ratings and connections.

7.7 TAP CHANGER

The tap changer provides a means of changing the voltage ratio of a de-energized transformer without breaking the transformer seal. It is shipped in place and is set on the position corresponding to the rated voltage shown on the transformer nameplate unless otherwise requested by the user.

Tap leads from the transformer windings are connected to the tap changer terminals. A bridging contact on each deck connects two adjacent terminals. Normally, a three phase transformer will have a tap changer with three decks, one deck per phase with a common operating shaft and operating handle.

When the external operating handle is turned the bridging contacts move from one voltage position to the next.

The operating handle is normally provided on the tank wall. Refer to the transformer outline drawing for its location. It is padlockable and should be kept locked at all times.

Operation

DANGER---*The tap-changer must not be operated while the transformer is energized! Serious personal injury, death, property damage and/or damage to the transformer may result if this is attempted.*

A table on the transformer nameplate gives the voltage and current rating for each tap position. The tap positions are indicated by numbers or letters on both the handle mechanism and the transformer nameplate.

De-energize the transformer, unlock and remove the padlock, unscrew the locking screw if provided, and rotate the handle to the desired tap position. After the change has been made, screw the locking screw back in and replace the padlock.

7.8 FORCED-AIR COOLING EQUIPMENT

Fans are used on transformers to increase the rate of heat dissipation and thus provide additional transformer load capacity. Fans are to be used only on those transformers designed to operate with a forced-air-cooled rating. Mounting arrangements differ according to the particular application. Fan motor ratings are given on the motor nameplate. Ratings are also shown on the transformer Outline drawing. Fan motors are equipped with a thermal protector to prevent overheating due to overloads or failure to start. When a motor is shut off by the thermal protector, it will start again automatically after cooling.

One or more switches are furnished to permit manual operation of the fans for test purposes or automatic control by a thermal relay. Two types of thermal relays are available, those which respond to changes in top liquid temperature and those which respond to an equivalent of the winding hotspot temperature. The fan control circuit also includes a motor relay and a circuit breaker. The temperature at which the fans operate and detailed information concerning the thermal relay are contained in a separate wiring diagram.

A periodic inspection should be made of the forced-air cooling equipment to be sure it is in satisfactory operating condition. Motor bearings are permanently lubricated and require no maintenance.

Do not paint the fan blades. Doing so except under controlled conditions will frequently cause the blades to become dynamically unbalanced. When placed in operation, the imbalance will set up excessive vibration which can eventually lead to destruction of the blade.

8.0 BUSHINGS

Porcelain and epoxy are used as the major insulation in the transformer bushings. Normally porcelain is used in bushings rated 2.5 kV class and above and epoxy is used in 1.2 kV class. Upon receipt, an inspection should be made for chips, cracks and leaks in the bushings. If there is evidence of damage or rough handling, file a claim with the transportation company promptly and notify the nearest Sales Office of MGM Transformer Company. If it becomes necessary to replace a bushing, contact the nearest Sales Office of MGM Transformer Company for additional instructions and replacement parts

9.0 INSULATING LIQUIDS

Liquid filled transformers are available with three types of insulating fluids: oil, R-Temp® or silicone. Before adding fluid to the transformer refer to the transformer nameplate or outline drawing to determine which fluid was originally supplied with the transformer and use only the same type of fluid as originally supplied. A small amount of a different fluid can significantly alter the characteristics of the original fluid.

Inhibited Oil---Standard inhibited oil meets all the requirements of ASTM D-3487, Type II. Oil filled units are suitable for outdoor installation or indoor when enclosed in a vault and with the complete installation meeting all the requirements of the National Electrical Code.

R-Temp Fluid---R-Temp fluid is a high fire point fluid and is classified by Underwriters Laboratories and approved by Factory Mutual Research Corporation for use per section 450-23 of the National Electrical Code.

Silicone Fluid---Silicone fluid is also a high fire point fluid and like R-Temp is classified by Underwriters Laboratories and approved by Factory Mutual Research Corporation for use per section 450-23 of the National Electrical Code.

CAUTION---*Transformer oil should always be handled as a flammable liquid. Sealed tanks may under certain conditions accumulate explosive gases, and oil handling procedures may generate static electricity. Safety precautions should include purging the gas space with nitrogen gas before oil filling or filtering and grounding the transformer tank, bushings and all oil handling equipment to prevent a static electric arc which could ignite the oil.*

The insulating liquid must be maintained at the proper level (see nameplate) and for the longest possible service life of the transformer, the dielectric strength of its insulating liquid should be maintained at a high value. It is recommended, therefore, that the liquid be sampled and tested after the first few days of operation, again after six months, and yearly thereafter. Keep accurate records of the tests and filter or replace the liquid whenever the dielectric strength drops below the minimum values stated in Section 9.6.1, Dielectric Strength.

The sampling and testing procedures are outlined in subsequent paragraphs. Where suitable equipment and qualified personnel are not available for conducting these tests, the user may wish to avail himself of an independent testing service.

9.1 HANDLING INSULATING LIQUIDS

When handling insulating oil or R-Temp, use only metal or oil-resistant synthetic rubber hose for oil lines since the sulfur in natural rubber hose will dissolve in the oil.

9.2 FILLING TRANSFORMERS

Transformers are normally shipped liquid filled. It should become necessary to refill a transformer, make sure all joints are tight and vent the tank to the atmosphere while filling. In order to prevent aeration, it is preferable to fill the transformer through the drain valve with a filter system. Fill to the level indicated on the transformer nameplate in accordance with the prevailing temperature.

If tests on the insulating liquid are satisfactory and no filter system is available, fill the transformer through a cover opening. Strain the liquid through two or more thickness' of muslin or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. Use at least one set of cloths for each transformer.

9.3 SAMPLING INSULATING LIQUIDS

In the sampling and testing of insulating liquids, strict attention should be given to the cleaning and drying of sampling and testing receptacles. Samples should be taken when the insulating liquid is at least as warm as the surrounding air to avoid the possibility of moisture condensation. If the transformer or drum is outdoors, the sample should be taken on a clear day with precautions being taken to guard against contamination by windblown dust, etc. Observe the following procedure to obtain consistent results from samples taken either for field or factory tests.

9.4 SAMPLING FROM TRANSFORMERS

1) Impurities which tend to affect the dielectric strength of the liquid will generally be found at the bottom of the transformer. Therefore the sampling valve is located on the main drain valve near the bottom of the tank.

2) A one quart, small neck, brown glass bottle is the preferred sampling container. For testing at the site other containers may be used provided they are thoroughly cleaned. If metal containers are used be sure all traces of soldering flux are removed from the seams. Do not use rubber or a composition of rubber for the gaskets or stoppers.

3) To clean the bottles, rinse with a dry, hydrocarbon solvent such as kerosene. Then wash with strong soapsuds, rinse thoroughly with distilled water, and dry in an oven at 105°C to 110°C for at least 8 hours. After drying, the bottles must be tightly sealed. Store them in a dry, dust-free cabinet or compartment.

4) Carefully clean the sampling valve or plug and allow enough insulating liquid to run out to remove any moisture or foreign matter which may have collected.

5) Rinse the bottle carefully, at least three times, with small portions of liquid drawn from the sampling valve. Allow the sampling bottle to drain thoroughly between rinses.

6) Draw a sample into the bottle, leaving sufficient air space [approximately one inch (25.4 mm)} to allow for possible expansion of the liquid. Reseal the transformer and carefully seal the container to prevent exposure to the atmosphere.

7) When making repeated samplings, observe the transformer liquid level and add make-up liquid as required.

9.5 SAMPLING FROM DRUMS

1) Drums should remain undisturbed for at least eight hours before being sampled.

2) Glass thieves should be cleaned, dried and stored in the same manner as outlined for bottles.

3) Take the sample about 1/3" (8.5 mm) from the bottom observing the precautions previously outlined.

9.6 TESTING INSULATING LIQUIDS

9.6.1 Dielectric Strength

Proper testing routines are covered by ASTM Method D877. The following paragraphs give a general outline of the procedure.

I) Set the spacing of the 1.0 inch (25.4 mm) diameter electrodes at 0.100 inch (2.5 mm).

2) Wipe the test cup and electrodes clean with dry, calendered tissue or clean, dry chamois and thoroughly rinse with a dry, hydrocarbon solvent such as kerosene.

3) Fill the test cup with dry, solvent and make a breakdown test under standard conditions of voltage applications (3 kV per second rise). If the cup has a dielectric strength above 25 kV, it is considered suitable for testing purposes. Observe the usual precautions in handling solvents.

4) Immediately after the final rinsing with solvent, rinse the test cup with the sample under investigation, and proceed with the test at once.

5) The temperature of the sample when tested should be the same as that of the room, which should be between 20°C and 30°C (68°F and 86°F). Tests made on samples above this temperature can be misleading. Under no circumstances should the test cup be colder than the sample being tested.

6) Agitate the sample gently before each filling to prevent variations in results due to a settling of contaminants. Pour the liquid into the receptacle slowly to avoid the formation of air bubbles and fill to overflowing. If air bubbles are present, gently rock the test cup a few times and wait at least 3 minutes before applying voltage.

7) Fill the cup at least five times, making one test per filling, and average the results.

Since the liquid is a major portion of the insulation system in the transformer, its dielectric strength should be maintained as high as possible. A low breakdown voltage is an indication that impurities such as moisture, conducting dust, lint, or carbonized particles have entered the liquid. Fluids testing lower than the following minimum values should be should either be filtered to bring it back to it's original condition or be replaced, depending on the condition of the liquid.

MINIMUM DIELECTRIC VALUES
FOR CONTINUED USE OF AGED FLUIDS:

26 kV for inhibited oil
24 kV for R-Temp Fluid
25 kV for silicone fluid

9.6.2 Other Tests

Although a low dielectric strength indicates the presence of contaminants, a high value is not always a certain indication of their absence. A number of other tests can be performed on an insulating liquid to determine its condition and therefore no one test should be considered conclusive. ASTM Method D117 defines the standard tests and contains cross references to other ASTM Designations for detailed descriptions of each method.

9.6.3 Field Test For Moisture Control

The following field test can be used to detect the presence of excessive amounts of moisture in the insulating liquid:

1) Obtain a sample of the insulating liquid when the transformer is at operating temperature. (Preferably above 40°C).
2) Starting with the hot sample, rinse a clean, dry test tube with the liquid to be tested, fill half full and stir continuously with a centigrade thermometer while cooling to approximately 20°C. Cool as much as possible in the ambient air and complete the cooling by momentarily dipping the test tube in an ice bath, removing and stirring and then redipping, etc.

3) Observe the sample carefully and note the temperature at which initial cloudiness appears. Wipe the outside of the tube with a clean rag or paper towel to facilitate observation of the slight moisture cloud that may form. Compare to clean insulating liquid at ambient temperature

in a similar tube if necessary. Examination for the presence of a cloud should preferably be made against a dark background and not directly into the sunlight.

4) If cloudiness appears at 20°C or above, high to excessive moisture content is indicated.

A. Inspect the unit for free water.
B. If free water is not present, a sample should be forwarded to an independent laboratory for a quantitative analysis and results can be forwarded to the nearest Sales Office of MGM Transformer Company for recommendations on treatment of the unit.

5) If cloudiness does not appear until the temperature is below 20°C, an acceptable moisture content range is indicated.

6) This field test for moisture should be regarded as a rough test only and if there is any reason to question the condition of the insulating liquid, a sample should be sent to an independent laboratory for an accurate analysis.

10.0 FILTERING AND DRYING

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the liquid through a filter system. Any free water in the transformer should be removed before the filter operation is started.

A transformer contaminated with moisture will not only have moisture suspended in the insulating liquid, but also in the windings and insulation. The most efficient temperature for filtering moisture from the transformer is between 20°C and 40°C, but at this temperature the transfer of moisture from the windings and insulation to the insulating liquid is quite slow. In order to completely dry the transformer, the filtering operation should be followed by a short-circuit heat run.

10.1 DRYING A TRANSFORMER

Recommendations regarding the drying of any particular transformer can be obtained from the nearest Sales Office of MGM Transformer Company. Requests for this information should include the serial number of the transformer and the voltages and kVA available for drying, including any available step-up or step-down transformers, etc.

The first step in drying a transformer consists of removing any free water and the water in solution as previously explained under "Filtering and Drying Insulating Liquids." The moisture remaining in the windings and insulation can then be driven off by heating the transformer. Exercise caution when heating the transformer to avoid damaging the insulation. The maximum winding temperature as determined by resistance measurements should not be allowed to exceed 95°C.

CAUTION---*Any drying method which involves heating an oil filled transformer when it is exposed to the atmosphere also creates a serious fire hazard. No smoking or open flames should be permitted near the transformer and suitable fire extinguishers, preferably the carbon dioxide type, should be on hand before beginning the dry out.*

Heating the transformer can be accomplished by shorting one winding and applying a suitable voltage on the other. Full-load current can be obtained by applying the impedance volts of the transformer. Be sure to load the entire winding. If the transformer is at room temperature at the start of drying, 125 per cent load may be applied until the top liquid temperature reaches 65°C. At this point, the current should be reduced in accordance with the following table:

Max Allowable Short Circuit Amps In Percent of Full Load	Maximum Top Oil Temperature In Degrees C
100	75
85	80
50	85

Since the windings are at a higher temperature than the insulating liquid, the insulation may be damaged if these values are exceeded. Filtration during the heat run will not greatly hasten the drying process, because at these temperatures the filter press loses its ability to remove any appreciable amount of moisture.

The air space in the transformer must be thoroughly ventilated to remove the water vapor given off. This can be done by removing manhole covers, the pressure-relief device, or the entire cover. If drying is done indoors, provide good ventilation to exhaust vapors from the room. If the cover is left in place, it should be thoroughly insulated to prevent condensation. The required temperatures can be more readily obtained by blanketing the transformer with heavy paper, cloth, building felt, etc.

Take liquid samples every four hours and make tests of the dielectric strength. Liquid filled transformers should be sampled from both the top and bottom. To determine the drying progress, plot curves of load current, top liquid temperature, and dielectric strength versus time. A decrease in dielectric strength indicates that moisture is passing from the windings and insulation into the insulating liquid. As the moisture is driven out of the liquid, the dielectric strength will increase, indicating that the drying process is progressing satisfactorily.

Continue the drying until four consecutive samples test at least 26 kV and preferably 30 kV or higher. When the drying operation has been completed, the liquid removed for sampling must be replaced. To avoid the possibility of entrapping air bubbles in the windings, it is recommended that the liquid be returned through the upper filter press connection.

11.0 MAINTENANCE

The condition of the external transformer surfaces should be examined at regular intervals. If it is found that weathering is taking place, the surface should be cleaned thoroughly and repainted with a good grade of durable paint recommended by MGM Transformer Company. Before painting refer to the pressure-relief device section of this instruction book for important caution statements.

12.0 RENEWAL PARTS LIST

- High-Voltage Bushing
- Low-Voltage Bushing
- Dial Type Top Oil Thermometer
- Magnetic Liquid Level Gage
- Pressure-Vacuum Gage
- Drain Valve with Sampler
- Top Filter Valve **
- Automatic/Manual Pressure Relief Valve
- Fan **
- Rapid Rise Pressure Relay **
- Rapid Rise Seal-In-Relay **
- Gaskets, High-Voltage Bushing
- Gaskets, Low-Voltage Bushing
- Gasket, Liquid Level Gage
- Gasket, Rapid Rise Relay **
- Gasket, Tap Changer
- Gasket, Cover Pressure-Relief **
- Gasket Handhole

Refer to the transformer outline drawing for the location of these parts and for any unlisted items. Note: Items marked ** are optional and may not be included.

Orders for Renewal Parts should be placed with the nearest Sales Office of MGM Transformer Company. Specify the quantity required and give the TRANSFORMER SERIAL NUMBER, and DESCRIPTION of the desired parts. If the required items are not identified on this list or the outline drawing, describe the part(s) in detail and include the TRANSFORMER SERIAL NUMBER.

Materials that are unaffected by silicone have been used in constructing silicone transformers and no substitution should be made for these materials without the approval of MGM Transformer Company. Any renewal parts supplied will be manufactured from the same or similar materials as those used for new transformers. Successful operation of the renewal parts is contingent upon proper field assembly, the condition of the remaining parts and a thorough drying cycle if moisture has entered the transformer.

13.0 SERVICE

If you need service on products manufactured by MGM contact the nearest Sales Office of MGM Transformer Company. Be sure to include a complete description of the problem and the SERIAL NUMBER from the transformer nameplate.

14.0 INSULATING FLUID SPECIFICATIONS

INHIBITED OIL - TYPICAL SPECIFICATIONS

Characteristic	Value
Dielectric Strength, ASTM D877, kV, min:	30
Dissipation Factor, ASTM D924, 25°C, %, max:	.05
Interfacial Tension, ASTM D971, 25°C, dynes/cm, min:	40
Neutralization Number, ASTM D664, mg KOH/g, max:	0.3
Flash Point, ASTM D92, °C, min:	145
Viscosity, ASTM D445, 100°C, cSt, max:	3.0
Pour Point, ASTM D97, °C, max:	-40
Moisture Content, ASTM D1533, ppm, max:	35

R-TEMP® FLUID - TYPICAL SPECIFICATIONS

Characteristic	Value
Dielectric Strength, ASTM D877, kV, min:	30
Dissipation Factor, ASTM D924, 25°C, %, max:	0.01
Interfacial Tension, ASTM D971, 25°C, mN/m, min:	38
Neutralization Number, ASTM D664, mg KOH/g, max:	0.03
Flash Point, ASTM D92, °C, typical:	284
Fire Point, ASTM D92, °C, min:	300
Viscosity, ASTM D445, 100°C, cSt, max:	15
Pour Point, ASTM D97, °C, max:	-18
Moisture Content, ASTM D1533b, ppm, max:	35

®R-Temp is a registered trademark of Cooper Power Systems.

SILICONE FLUID - TYPICAL SPECIFICATIONS

Characteristic	Value
Dielectric Strength, ASTM D877, kV, min:	30
Dissipation Factor, ASTM D924, 25°C, %, max:	0.01
Neutralization Number, ASTM D974, mg KOH/g, max:	0.01
Flash Point, ASTM D92, °C, min:	300
Fire Point, ASTM D92, °C, min:	340
Viscosity, ASTM D445, 25°C, cSt:	47.5-52.5
Pour Point, ASTM D97, °C, max:	-50
Moisture Content, ASTM D1533, ppm, max:	50