META
POWER SOLUTIONS

GROUNDING TRANSFORMER INSTRUCTION MANUAL

Meta-Power Solutions ®

Contents

Safety information

The instructions in this manual are not meant to be used as substitutes for proper training and experience in safely operating the described equipment. Only “competent technicians” should be allowed to install, operate, and service the equipment.

A competent technician should have the following qualifications:

- They are thoroughly familiar with the instructions given here.
- They are properly trained in industry-accepted low-voltage and high-voltage safe operating procedures and practices.
- They are adequately trained and fully authorized to energize, de-energize, ground, and clear power distribution equipment.
- They are properly trained in the care and use of protective equipment such as rubber gloves, face shields, safety glasses, hard hats, clamp-stick, arc flash clothing, hot-stick, etc.

Safety instructions

The following statements are general warning and caution statements that apply to three-phase grounding transformers. For specific tasks and procedures, additional warning and aution statements are provided throughout this manual.

Danger

Hazardous voltage. Contact with hazardous voltage can cause severe injuries and even death. Personnel working around low-voltage and high-voltage lines and equipment should follow all locally approved safety procedures and practices.

WARNING:

Carefully read and understand the contents of this manual before installing, testing, operating, or maintaining a three-phase grounding Transformer unit. Improper handling, operating, or maintenance of the equipment can cause equipment damage, severe injuries to personnel, and even death.

WARNING:

A grounding transformer is not intended for the protection of human life. Locally approved practices and safety procedures should be followed while installing or operating this equipment. Non-compliance with these safety procedures can result in equipment damage, severe injuries to personnel, and even death.

WARNING:

The selection of power distribution and transmission equipment should match its intended application, with installation and servicing conducted by trained and competent personnel who understand safety protocols. These instructions are intended for such personnel and should not replace proper safety training and experience. Failure to correctly select, install or maintain power distribution and transmission equipment can lead to severe personal injury, equipment damage, and even death.

Safety requirements

Before you start work

Never work on an energized transformer.

Verify the transformer is de-energized and grounded before proceeding with any work.

Check your supplies and tools

Before starting your work on the transformer, check your supplies and tools, and ensure that the required equipment is available and in good working condition.

While you are working

Protect yourself!

As you work on the transformer, make sure to follow all the safety procedures, practices, and regulations established by your employer. Wear adequate protective gear and clothing like gloves, masks, helmets, goggles, boots, etc., provided by your employer for job safety.

Make sure to follow the manufacturer's instructions, warnings, and precautions when installing an attachment or using an apparatus. Electrical equipment can be dangerous and should be handled with care and respect. Do not operate or service a system-connected transformer before evaluating the system's circuit and load current conditions.

Take care while lifting and moving the transformer!

First, check the transformer nameplate to find the unit's total weight. Then, check the lifting capacity of all available hoisting and lifting equipment, and only use the cranes and forklifts if their load capacity exceeds the transformer weight. Use only the lifting lugs to lift units from above; do not use the bushings instead of handles. Do not use damaged hooks, slings, or cables. Take care when taking down the unit from the truck so it does not get damaged

When you make the system connection

Ensure that the transformer tank is grounded!

Before working on the transformer, ensure the tank is grounded through a permanent, low-impedance ground.

Ensure that all terminals and bushings are clean before making system connections!

Remove all grease, dust, dirt, or foreign material from the terminal lugs, bushings, and connection points before making connections.

Ensure that the neutral connections are complete before making further system connections!

All the available transformer neutrals and the system neutrals should be connected before making any other types of connections to the system.

Keep the system wiring away from unused leads!

All unused leads must be insulated from the ground, as well as from other connections and leads.

Install attachments by following the manufacturer's instructions!

Install attachments and accessories according to the manufacturer's instructions. Ensure that the chosen connectors have the required ratings for the expected application.

Inspect the insulating fluid level before the transformer is energized!

Only energize the transformer unit if the insulating fluid inside the transformer tank is at the required level.

During Operation

Verify the transformer ratings by inspecting the transformer nameplate. MPS designs its transformers to operate at rated loads with a temperature rise equal to or less than the temperature rise printed on the transformer's nameplate. A transformer unit should never be operated beyond its specified ratings. If transformers are operated under conditions that exceed the operating standards described in IEEE Std C57.91™, their insulation systems deteriorate at an accelerated rate. Coil insulations are carefully manufactured using thermally upgraded materials that ensure long life at rated loads. However, overloads on mineral-oil-filled transformers that are especially severe and prolonged can result in overheating, accelerated aging, and premature failure of the insulation system.

WARNING:

Operating a transformer by exceeding its ratings may result in personal injury and equipment damage.

Receiving

Once it is received, the transformer unit should immediately be inspected for signs of mishandling and damage that might have occurred during the shipment. Notify your MPS representative in case any evidence of a defect or damage is identified, and file your claims for damage with the delivering carrier. Parts and attachments of the transformer that became loose or damaged during the shipment should be tightened, repaired, or replaced before the transformer is moved

CAUTION:

First, check the transformer nameplate to find the unit's total weight. Then, check the lifting capacity of all available hoisting and lifting equipment, and only use the cranes and forklifts if their load capacity exceeds the transformer weight. Use only the lifting lugs to lift units from above; do not use the bushings and other accessories in place of handles. Do not use damaged hooks, slings, or cables. Take care when lifting the unit and removing it from the truck so it does not get damaged.

Moving the Transformer

Moving Transformer Shipped on Pallets

If the transformer and other equipment are shipped on pallets, they may be moved using cranes, hoists, and forklift trucks of proper capacity.

WARNING:

Non-palletized transformers and other equipment should not be lifted with forklift trucks because doing so could result in personal injury and equipment damage.

Lifting the Transformer by Crane or Hoist

Lifting lugs should be used to unload the transformer. These are found near the top of the transformer tank. The pull angles for the lifting cable should not exceed 30° from the vertical plane. If they exceed this angle, the lifting cables should be held apart with the help of spreaders to avoid any bending in the lifting hooks or the tank itself. Oblong hooks, links, and other similar lifting hardware should not be used under the lifting lugs because they could compromise the load rating of the lugs. The transformer should not be lifted by looping a chain or cable around the unit or lifting lugs

WARNING:

Use all the provided lifting pads and lifting lugs to lift the transformer. Using transformer apparatus like cooling fans and radiators for lifting could result in personal injury and equipment damage.

Skidding/Rolling Transformers

The design of MPS transformers allows them to be skidded or rolled into place without needing overhead lifting devices like cranes and hoists. If the unit must be rolled into place, then sufficiently thick and strong rollers must be used to support the weight of the transformer unit. Multiple rollers may be used to ensure the unit's weight is distributed uniformly throughout the moving process. The path to the installation place should be level and free of debris and obstructions.

Storage

Always store a transformer unit with liquid in place to prevent moisture absorption and contaminants. The storage location should be dry and have no radical or rapid temperature changes. If the permanent transformer foundation has already been prepared at its permanent location, it should be used to store the transformer. If such a foundation is not yet available, then the device can be stored by placing it upright and level on top of a temporary foundation, given that this foundation can withstand the weight of the transformer without being deformed.

CAUTION:

A transformer should be stored upright on a pallet to give it the necessary elevation to keep it away from standing water, thus preventing the water from damaging the device. Do not stack up multiple devices or store them in places where they might be subjected to damage due to mechanical stress.

Installation

Understand the differences between various equipment and accessories and their functions and purposes. Ensure that you use any protective equipment or clothing required for a task. If possible, use a hot stick to perform all disconnect, grounding, reconnect, and testing operations. Remember to treat a transformer unit as an energized device until you verify its actual state and condition.

Before applying a voltage to the transformer:

- Inspect the liquid level inside the transformer tank.
- Verify that the oil and temperature levels are correct.
- Check the transformer for oil leakages and stains.
- Check the electric connections and tighten them if required.
- Verify that the transformer tank is properly grounded.
- Check the grounding connection of the neutral terminals (H0 or X0).
- Remove all tools and objects from near the transformer.
- Make sure that all hand holes and manholes are secured properly.
- Ensure nobody is near the three-phase grounding transformer before it is energized.

It is recommended to perform the following field tests on transformer units that must be energized after a storage period of six months or more:

- Check the insulation resistance between windings and each winding to ground.
- Determine the turn ratio for the full windings.
- Ensure that the insulating liquid has a dielectric strength above 30kV/mm

Mounting the transformer

Transformer units must be mounted on horizontally level concrete pads. The concrete pads must have adequate strength to not deform under the weight of the transformer unit. The mounting site must be prepared in a way that it does not tilt the transformer unit by more than two degrees from horizontal.

WARNING:

Improperly installed, non-leveled transformers have a higher risk of catching on fire. Therefore, transformer installation sites should be prepared carefully so they do not tilt transformer units by more than two degrees from the horizontal plane

If a transformer is tilted by two degrees during its service life, the transformer cables start to cause mechanical stress on the transformer bushings and bushing gaskets. Also, such a tilt can cause the internal components of the transformer device to come out of the oil. Excessive tilting beyond the two degrees level can even result in transformer insulation dielectric strength going below its basic insulation level (BIL), as rated on the device nameplate. Reduced basic insulation levels can result in an internal dielectric breakdown with a risk of explosion, tank rupture, or fire. Such transformers are a serious safety risk that can cause severe personal injuries and even death.

Connections

All transformer units with bottom connections are designed so that cable sizes can be easily accommodated per NEC standards. Cables that must carry 100 amps of current or less may have a temperature rating of 60° C or higher, whereas cables that must carry more than 100 amps of current may have a temperature rating of 75° C or higher. All transformer cables must be in the lower part of the enclosure and routed according to the markings on the enclosure.

CAUTION:

Do not make any connections that are not found on the transformer nameplate and connection diagrams. Before energizing the transformer, ensure that all tap jumpers are in proper locations and that all bolted connections have proper tightness.

Ground Connections

The transformer tank must be permanently grounded through a low resistance before making any other electrical connections. Treat a system-connected transformer unit as an energized device if it is not solidly grounded. Contact with the tank of such an energized transformer device is extremely dangerous and can cause shocks, burns, or even death.

WARNING:

Check the nameplate information and diagrams to find the connections that can be made for the transformer. Connected the available transformer neutrals to the system neutrals. Ensure to insulate the unused connections and leads from all other leads and ground. Improper connections could result in equipment failure or severe personal injury.

Lugs and cables should be installed with a minimum electrical clearance as defined by ANSI and NEMA standards. All questionable electrical clearances must be insulated for the applied voltage. Shielded cables should be handled with special care to ensure sufficient clearance between the ground termination of a shielded cable and the different manufacturers-installed live parts and insulated parts.

Reducing Sound Levels

Transformer noise is an inherent transformer characteristic that originates from within the steel core of the transformer. Transformer noise cannot be eliminated; thus, the transformer location should be carefully selected, especially in buildings with low ambient sound levels.

The sound level of a transformer is often unintentionally amplified due to improper installation. This amplification causes the transformer to appear considerably louder than it is. Transformer sound levels get amplified due to the traveling sound waves in the air that get reflected from surrounding objects and due to the resonance of the transformer mounting construction and its electrical connections. The amplification situations should be avoided wherever possible. The correct noise level can be determined by connecting the transformer for its rated voltage and frequency operations and energizing it at no load.

The sound level problems of a transformer can also be minimized by following the installation recommendations given here:

1. Install the transformer case on vibration mounts.
2. Use flexible conduit couplings to reduce the transfer of vibrations from the case to the outgoing and incoming conduits.
3. Select the installation site where possible sounds are least objectionable/ harmful.
4. Before installation, square or level all surfaces that may strain or distort the transformer case.
5. Plant shrubbery near the transformer device in outdoor installations to break up the sound pattern. Ensure that none of the sprinklers are aimed toward the transformer.
6. Check the noise-generating transformers adjacent to your device and isolate them with acoustical barriers.
7. Check the panels, nuts, bolts, and other parts of the transformer enclosure that might come loose and cause noise. Tighten them as required.
8. Check the different parts of the coils and core of the transformer. They might become noisy if shifted or dislodged during the shipment and installation procedures. If some part gets dislodged, torquing bolts and coil support blocks may be used to reduce the noise.

Factory Testing

The information below is meant to be used as a guideline for transformer testing. For more details, please refer to IEE/ANSI C57.12.90-2006 and ANSI/ NETA ATS-2009.

Routine Tests

Ratio Test

The transformer turn ratio measures the relationship between its two windings. It is obtained by taking the ratio of the number of high-voltage winding turns to the number of low-voltage winding turns.

NOTE:

The ratio test device can also test transformer phase polarity, sequence, and relation.

Winding Resistance

Measuring the Winding resistance is a fundamentally important task because it allows us to calculate the I^2R component of conductor losses. These values are needed to calculate the total temperature of a winding through the temperature rise test

Excitation Current and Losses

Excitation (no-load) current is the current required to excite the transformer through any given winding when all other windings are left open-circuited. Generally, it is expressed as a percentage of the rated current of the winding under the measure.

Excitation (no-load) losses are transformer losses that are caused due to the flow of excitation current through the transformer windings. These losses include dielectric losses, core losses, and the two types of conductor losses that exist due to the flow of excitation currents in the winding and the flow of circulating currents in parallel windings, respectively. The Core losses of the transformer core are the primary contributors to the total excitation losses of a transformer. These losses are a function of the applied voltage magnitude and frequency. Excitation losses also vary with temperature and waveforms, which means that the no-load loss measurements show noticeable variations when different test voltage waveforms are used.

Load Losses and Impedance Voltage

The losses of a transformer that specifically vary with the incident load as it is supplied by the transformer are known as load losses. These losses include the I^2R losses that arise when the load current flows through the windings and the stray losses that are caused by the flow of induced eddy currents in the tank walls, windings, core clamps, magnetic shields, and other conducting parts due to the action of the leakage flux.

If the two specified transformer windings are connected for their rated voltage operations, and we short-circuit one of them and apply voltage on the other, then the transformer impedance voltage will be the amount of voltage required to cause the rated current to circulate through the windings. Impedance voltage is typically expressed per unit or as a percentage of the rated voltage for the winding under-measure.

Dielectric Strength Test

The dielectric Test of the transformer is a measure of the insulation quality between turns, mainline, and earth, and between line-end and earth. Generally, this Test is performed in two steps: The separately-applied-voltage withstand (Hi-Pot) Test and the Induced-voltage withstand Test.

Design Tests

Insulation Power Factor Test

The insulation power factor is a parameter used to judge the quality of the transformer insulation. It is obtained by taking the ratio between the power (watts) dissipated within the insulation and the effective power (volt-amperes). Effective power is the product of the effective voltage and current values obtained by testing the transformer response with sinusoidal voltages and controlled conditions.

Insulation Resistance Test

The insulation resistance test is conducted to find the total insulation resistance between individual windings and between individual windings and ground. Its value may be measured in units of megohm or calculated from measured values of applied voltage and leakage current.

Temperature Rise Test

The temperature-rise Test is used to determine the operating temperature rise above ambient for the transformer windings. The winding rises are determined by comparing winding resistances at room temperature with winding temperatures after full current is run through the windings. The measurement results for a given winding or terminal pair give us the average temperature and the average temperature rise for the each winding. These values do not refer to the temperature values for any specific point on the winding, nor do they refer to the arithmetic average of the measurement results from different terminal pairs.

Lightning Impulse Test

Lightning impulse tests are used to test the dielectric strength of the transformer insulation by applying different voltage waveforms (impulses) on the transformer windings without supplying the transformer with excitation voltage or current. In this Test, a reduced full wave, full wave, two chopped waves, and two full waves are applied individually to each bushing. There is minimal delay between the final two impulses to prevent the insulation from regaining some of its dielectric strength that could potentially obscure a failure before the final impulse.

Audible Sound Level Test

The transformer core is the primary source of audible sounds within the transformer's body. From there, this sound travels through the dielectric fluid and the structural supports to the outer transformer shell and other solid transformer surfaces. Here, the vibrations radiate as an airborne sound and can be heard as noise. The frequency spectrum of this audible noise is primarily a combination of the even harmonics of the fundamental power frequency. Thus, for a 60Hz power system, the audible sound is made up of 120, 240, 360, and 480 Hertz frequencies, and so on. This sound spectrum also contains the combined sounds from the mechanical cooling system for the dielectric fluid: from the broadband fan, the fan blade passage frequency, and its harmonics. In some cases, the transformer windings may also become a source of sound and noise under rated load conditions. However, these sounds and noise have a different makeup which is not discussed here.

Accessories

Some accessories are considered required or normal and some accessories are optional; additional equipment may be installed on a single-phase overhead transformer. They include a variety of switches, pressure relief devices, and gauges. Accessories are mostly installed at the factory before shipment of the transformer and do not require fieldwork to become operable. Always install attachments and accessories by following the relevant manufacturer's instructions and ensure that all connectors are rated correctly.

Liquid level gauge

Liquid level indicators help aid transformer operators and workers in systematically inspecting the transformer, even in loaded conditions. This device consists of three components:

- A floating arm that moves vertically with the oil level inside the tank.
- An indicating pointer outside the tank that is separated from the float arm physically due to the liquid-tight construction of the tank,
- A magnetic coupling mechanism between the above components allows the pointer to move in response to the position of the float arm, even with the liquid-tight separation between them.

The liquid level gauge may use one or two Single-Pole Double-Throw (SPDT) alarm contacts to give a remote indication when the liquid levels become very low. More information on the wiring and contact ratings can be found on the schematics that are furnished with the transformer.

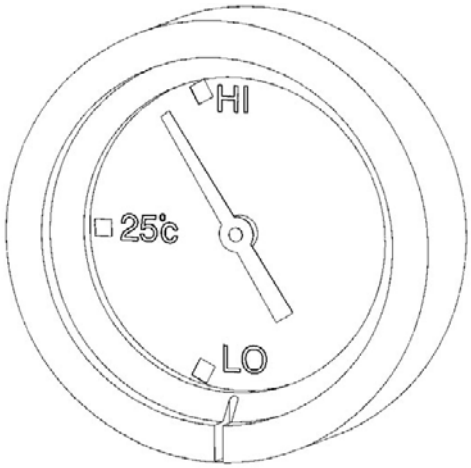

Figure. Liquid Level Gauge

Liquid Temperature Gauge

Liquid temperature gauges help indicate the top liquid temperature inside the tank in units of degrees Celsius. The device consists of a temperature-sensitive element that can be mounted in a leak-proof well. The well allows the transformer operators to remove the thermometer without lowering the transformer oil level. An additional red pointer in the device is used to show the highest temperature that was recorded since the last reset. The maximum indicator can be reset by turning the knob in the dial's center. The thermometer may use two Single Pole Double Throw (SPDT) contacts to energize a high-temperature alarm or a fan circuit. More information on the wiring and contact ratings can be found on the schematics that are furnished with the transformer.

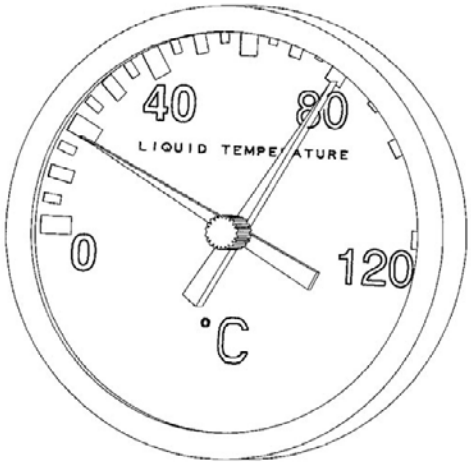

Figure. Liquid Temperature gauge

Pressure Vacuum Gauge

Pressure vacuum gauges help indicate whether the gas space in the tank is under negative or positive pressure. The tank pressure can vary with the transformer temperature and loading conditions. For example, the pressure may be negative for a de-energized transformer and a transformer operating under light loading and low ambient temperature conditions.

CAUTION:

The transformer unit should be checked for possible leaks in its seal if the indicator stays at zero, even when the loading conditions are varied.

Normally the transformer will operate in the positive pressure range, depending on the transformer loading conditions. If the pressure is negative, this is not a cause for concern, provided that the pressure vacuum gauge does not indicate a leak by remaining on zero for any length of time. Generally, a transformer can operate safely in pressures ranging from -2 to +6 psig.

The transformer may use pressure vacuum switches and two Single Pole Double Throw (SPDT) contacts to generate an alarm in case of excess negative or positive pressures inside the tank. More information on the wiring and contact ratings can be found on the schematics that are furnished with the transformer.

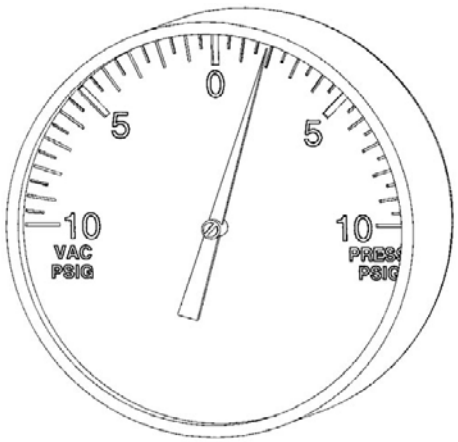

Figure. Pressure Vacuum Gauge

Pressure Relief Device

Some three-phase grounding transformer units may come equipped with cover-mounted pressure relief devices (PRD) or standard faceplate-mounted pressure relief valves (PRV) for improved protection against pressure accumulation inside the transformer tank. A cover-mounted PRD device comprises a spring-loaded, self-resetting diaphragm and a mechanical operation indicator. If the pressure inside the tank increases beyond the set value of the PRD, then the diaphragm gets lifted by the gas pressure, allowing the gas to escape quickly, and resetting it back to its original position, and resealing the transformer. The mechanical indicator protrudes vertically and must be manually reset for subsequent operations.

The PRD may use Single Pole Double Throw (SPDT) alarm contacts to remotely signal to indicate the activation of the device. More information on the wiring and contact ratings can be found on the schematics that are furnished with the transformer.

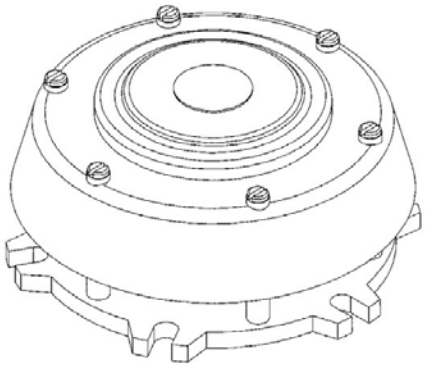

Figure. Pressure Relief Device

Handling insulating fluid

Mineral Oil-Filled Transformers

It is a type of non-PCB insulating fluid (less than 1 ppm). Additional guidelines for testing and handling this insulating oil can be found in the IEEE Std C57.106™ standard, "Guide for Acceptance and Maintenance of Insulating Oil in Equipment".

Envirotemp™ FR3™ Fluid-Filled Transformers

It is a type of non-PCB insulating fluid (less than 1 ppm) with a high fire point. Additional guidelines for testing and handling this insulating fluid can be found in the IEEE Std C57.147 standard, "Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers".

Steps to Lower the Level of Insulating Fluid

1. Prepare a dry and clean storage container so it can be used to receive the collected fluid.
2. Use hoses and pumps that have not been in contact with dissimilar fluids and hence will not contaminate the fluid. Use a metallic or a non-rubber hose to pump out the insulating oil because oil can damage a rubber hose by dissolving the sulfur in it.
3. Place the pump intake line inside the tank and the output line nozzle on the bottom of the receiving container.
4. Make sure the fluid does not splash into the container because doing so could introduce moisture and air bubbles into the collected fluid

Steps to Restore the Level of Insulating Fluid

1. Pump the fluid from the bottom of the temporary storage tank. Prevent the intake line from sucking in the air along with the fluid.
2. Direct the fluid stream parallel to the core clamp along its upper surface. This will help in preventing the aeration of the fluid at the outflow.
3. Pump the fluid out of the storage tank slowly until the transformer tank fluid reaches the required 25°C level, as indicated by a stamp on the tank wall.
4. Give sufficient rest time to the fluid after refiling to allow any unwanted gas bubbles to dissipate from the fluid. Energize the transformer after this rest period.

NOTE:

Some of the insulating fluid may get lost in the pumps and lines, and it may become necessary to compensate for this loss by using a reserve supply to add extra fluid to the storage container. This extra fluid also prevents air from entering the replacement fluid at the intake.

Contaminated Insulating Fluid

If there is evidence of moisture and contaminants inside the transformer tank and the insulating fluid, a fluid sample should be collected from the bottom of the tank for analysis. If the tests confirm the presence of moisture in the fluid, the transformer should be dried out. You can contact your MPS representative for special instructions to initiate the dry-out and other decontamination processes

NOTE:

Take the required samples of the transformer insulating fluid from the bottom of the tank when the transformer is running warmer than its surrounding air. This will help you avoid any moisture condensation on the fluid.

Take a clean and dry bottle to collect the samples. Rinse this bottle three (3) times with the fluid whose samples are needed. Ensure that the collected test samples of the fluid adequately represent the fluid inside the transformer.

Allow the fluid to settle for some time before taking the test samples. The settling period could vary between several hours and several days, depending on the size of the transformer and the temperature of the fluid. For example, cold insulating fluids and fluids within large transformers take longer to settle.

Disposal of Transformer

Transformers and their insulating fluids should be disposed of by following relevant state and federal regulations and standards on the disposal of oil-filled electrical equipment.

Maintenance

Exterior maintenance

Inspect all the exposed transformer surfaces periodically to look for evidence of damage, battered metal, tampering, etc. Any dents and deformities on these surfaces should be repaired at once. Weathered and scratched paints and protective coatings should be reapplied promptly. The transformer area should be kept clean of dirt and grease. No equipment or tools should be stored on or against the transformer.

Inspect the different plugs and switches. Look around the tank-wall gaskets, seals, etc., for evidence of seepage and leaks of the insulation fluid. If leaks are found, the seal or gasket in the tank wall may need replacing. This process may require the tank to be opened and the insulating fluid lowered to an appropriate level.

Internal inspection

Internal defects and damage can be found through internal inspections to help prevent improper transformer operations.

You should inspect for:

1. Moisture on the underside of the cover.
2. Shifted, loose, and damaged parts. For example, fuse holders, bushings, etc.
3. Loose and broken connections.
4. Contaminations in the insulating fluid. For example, sediment in the bottom of the tank, air bubbles and dust particles suspended in the fluid, etc.

NOTE:

In case a transformer unit has been stored outdoors for a long period, samples of its insulating fluid should be collected and checked for moisture content

CAUTION:

The moisture in a transformer's insulation can greatly affect its life. Excess moisture in the transformer insulation fluid can accelerate the insulation's breakdown, eventually leading to equipment failure. Therefore, if the seal is broken upon inspection, regardless of the cause, the transformer should be resealed carefully to prevent moisture from entering the transformer.

Security

Inspection and maintenance of a transformer should be planned and executed carefully to avoid any possible security risk to human life and equipment. Therefore, a series of recommended procedures and steps must be followed to realize inspection and maintenance works. The most basic rule of security is disconnecting all electric power sources from the transformer and grounding all its terminals. Follow these three instructions to safely disconnect a transformer.

a) Disconnect the electric circuits from the primary and secondary terminals of the grounding transformer.

b) Make sure that the disconnection means (the disconnecting device) is in an open position. If fuses are used to disconnect the transformer, then the fuses should be retired after operations and placed in a location that is not easily accessible so that they are not accidentally reinstalled by an unaware technician.

c) Use the transformer bushings to ground the primary and secondary transformer windings. This will help discharge any capacitively stored energy within the transformer. Retire these connection cables to the ground until the maintenance work is finished.

Some inspection and maintenance work must be performed inside the transformer tank. In these cases, the tank should first be prepared by operating the pressure relief valves to relieve the internal pressure of the tank before any work can begin. Once the work is finished, the tank should be carefully inspected to make sure no tool is left inside it by mistake. Re-energize the transformer again only after making sure that everything is clear.

Documentation of the inspections and repair work is an essential component of every well-designed transformer maintenance program.

To make your preventive maintenance procedure more effective, you should prepare the following:

- An Equipment Log, to note down the serial number, location, nameplate, and other basic transformer information.
- A Repairs Log to keep track of the different maintenance and repair work performed on the transformer. This is an essential diagnosis register that can help eliminate future difficulties.
- An Inspection Revision List to note down the lists of points that need to be revised and the dates and frequency of when they come into effect.

These logs are very important for streamlining preventive maintenance programs, as they allow inspection knowledge to be documented and be available for future tasks.

The instructions in this manual are intended for technicians, but they should not be considered a substitute for their proper training and experience in handling this product securely. Additionally, the maintenance procedures outlined in this section are not intended to replace the client's existing maintenance practices.

When a protection relay operates and causes an alarm, it is important to investigate the cause of the problem that initiated the response from the relay and alarm devices. It is essential to identify the relay that operated and the protection device that caused it to operate. It should be investigated fully, along with other abnormal symptom conditions that may also exist, like excessive and abnormal sounds, low or high oil levels, etc.

Maintenance Procedures

The transformer unit is a static device whose operation conditions may exceed the specified normal operating standards. Depending on the duration and intensity of these abnormal conditions, the useful service life of the transformer can deteriorate at an accelerated rate. This section provides practical procedures and steps to take to maintain and service a transformer device to help increase the service life of the transformer device.

WARNING:

Only competent technicians should perform the transformer maintenance operations described in this manual. These technicians should be familiar with the pertinent practices for securing dangerous electrical equipment.

Exterior Maintenance

Items to be Inspected	Points to be Checked	Remedial Actions	Frequency
Exterior Surfaces	Inspect the exterior surfaces for signs of damage, battered metal, gouges, tampering, etc. Check damages that could allow wires and other metallic devices to enter the transformer body.	Promptly repair any damages found on the exterior surface.	Yearly
Paint or Protective Coatings	Inspect for scratches or weathering.	Any damage to the paint or protective coatings should be touched up immediately.	Yearly
Tank Leaks	Inspect the transformer tank for leakages.	Promptly repair any damages found on the exterior source.	Yearly
General Location	Check the surrounding area of the transformer device for stored materials, equipment, tools, or debris.	Remove anything found lying on, against, or near the transformer.	Yearly
General Location	Walk around the transformer unit and listen for noises other than a smooth humming sound. There should not be any intermittent rattling noise.	If found, abnormal noises should be promptly reported and investigated.	Yearly
Pad	Inspect the tilt angle of the pad support. It should be such that it does not cause the transformer to tilt more than 2°from the horizontal.	Repair the pad support immediately if it is compromised or out of level greater than 2°.	Yearly
Nameplates	Inspect the transformer nameplates and decals for abnormal or unexpected fading.	Contact your MPS representative to order a replacement nameplate or decals as required.	Yearly
Unusual Odors	Inspect the vicinity of the transformer device for smells of fluid or burning. Such smells are indicative of an undetected leakage under the base. The concrete around the transformer base should also be inspected for signs of oil spots.	If found, the abnormal odors should be promptly reported and investigated.	Yearly

Interior Maintenance

Items to be Inspected	Points to be Checked	Remedial Actions	Frequency
Gauges and Controls	Check the operations of these devices.	Repair or replace an equipment or device if it does not operate as expected. No damaged or defective equipment should be operated during the transformer service.	Yearly
Equipment Leaks	Inspect fuse mountings, switches, and drain cocks. and plugs. Search tank-wall seals, gaskets, and similar equipment for signs of insulating liquid seepage.	Make all possible repairs if a device is found to be damaged. Replace seals and gaskets in the tank wall after opening the tank and lowering the liquid to an appropriate level. Refer to the Insulating Liquid Maintenance section for instructions on opening the transformer tank, draining the insulating liquid, and refiling it after the work.	Yearly
Tank Pressure	Check the vacuum/pressure gauge and ensure it does not remain at zero for an extended period. Preferably, the given unit should not cycle between positive and negative pressures daily. If any of the readings are observed to be lower than -2 psig, or greater than +7 psig, then the reading should be taken as an indication of an unwanted condition that should be corrected promptly.	The vacuum/pressure gauge remaining at zero for an extended period indicates that the transformer tank is not air-tight and that air is leaking out and into the tank. In such a case, a leak test should be performed to make the required repairs. To perform this Test, add nitrogen to the airspace and monitor the area for a minimum period of 12 hours and observe for signs of loss of pressure. If any pressure loss occurs, locate the leak, and repair it immediately.	Yearly

Interior Maintenance

Items to be Inspected	Points to be Checked	Remedial Actions	Frequency
Dielectric Fluid Level	Check the dielectric fluid level gauge. The notation of the gauge has the expected fluid level calibrated against an average internal fluid temperature of 25 °C. If the gauge shows a level above this zone, then the fluid level is normal when operating at full operational temperature. Such a reading does not indicate the transformer is operating at a temperature above the nameplate-rated value.	Check the transformer for leaks if the dielectric fluid level falls below the nominal level. If found, repair the leaks immediately and fill the tank with the oil needed to bring the fluid level to the nominal operating levels.	Yearly
Fluid Temperature	Check the liquid temperature gauge to note down the elevated temperature of the fluid. If a drag hand exists, reset it, and compare the elevated temperature value to those of similar transformer units. The maximum top-fluid temperature measured by the drag hand is determined by the maximum loading on the hottest day. A typical maximum reading can be calculated by subtracting 10 °C from the nameplate-rated temperature rise value and adding the maximum ambient peak for the given area. Example: 65 - 10 + 40 = 95 °C. Similar units at the same location should be within 3 °C of each other.	If the temperature value is elevated compared to similar transformers, the unit should be serviced immediately to identify the cause for the elevated value.	Yearly
Cable Connections	Check for signs of overheating by looking for discolored spades (paddles) and loose connections. The tin plating on a terminal will have a rainbow-like coloring if the particular terminal is exposed to over-temperature conditions.	Find the loose connections and tighten them immediately. A qualified technician should immediately address any observed damage and discolorations on the device.	Yearly
Bushings	Inspect the condition of the LV and HV bushings. Observe these bushings for signs of breakages, dirt accumulation, heat damage, general damage, and flashovers. It should be noted that the excess dielectric grease from separable dead-front connectors can liquefy under heat and appear like an internal fluid leak.	Clean the bushings immediately to get rid of the dirt. A qualified technician should address any observed damage to the device immediately.	Yearly
Cubicle Padlock	Check all cubicles and ensure that all of them are locked.	If any locks are missing, replace them immediately.	Yearly
LV Bushing Cantilever	Check for stiff cable conductors and excessive cable weights that may put downward or upward pressure on the bushings due to pad settling.	Adjust the conductor or cable position immediately to eliminate pressure.	Yearly
Pressure Relief Valve	Check their operation and look for signs of dirt and debris accumulation on the device.	Replace the device if it is damaged. Clean the device if it is dirty or clogged with debris.	Yearly
Lightning Arresters	Check for signs of breakage and damage on the device. Check the ground connection for tightness and intactness.	Replace any arresters that are damaged. Any loose ground connection should be secured and tightened.	Yearly

Dissolved Gas Analysis

Items to be Inspected	Points to be Checked	Remedial Actions	Frequency
Oil and DGA Samples	Collect oil samples from the transformer and send them to a third-party testing laboratory to check for their characteristics. For dissolved gas analysis (DGA) samples, request a DGA sampling kit from a third-party testing laboratory. Following the instructions, properly fill the syringe and return it to the lab for analysis.	Compare the results of the dissolved gas analysis tests to the baseline composition standards. Check the dissolved gas levels for abrupt changes. If any abrupt changes are found, investigate them immediately.	Yearly

Important Note for The Interpretation of The Temperature Values:

A transformer unit is generally designed to operate at full capacity (100% of its load rating) without interruptions and with an ambient temperature average of 30°C (as indicated on the transformer nameplate). The hottest spot on a transformer winding is generally 15°C higher than its oil temperature.

Spare Parts

MMPS has expertise in manufacturing custom transformers and only makes a limited number of units based on a single design. MPS also makes replacement parts on a case-by-case basis. If a unit needs a replacement part, the customer should contact the MPS factory and provide all the unit's nameplate data.