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Instructions (HI-102)

Installation, Operation and Maintenance of Fluid-Filled Overhead Distribution Transformers

Howard Industries
Distribution Transformer Division

⚠ READ THIS IMPORTANT SAFETY INFORMATION

READ THIS ENTIRE INSTRUCTION MANUAL CAREFULLY AND BECOME FAMILIAR WITH THE EQUIPMENT AND ALL SAFETY-RELATED INFORMATION BEFORE PROCEEDING WITH INSTALLATION, OPERATION, OR MAINTENANCE ACTIVITIES.

Safe use of this equipment is dependent on proper installation, operation, and maintenance procedures. Follow all applicable local and national codes.

Do not attempt to service or perform maintenance activities on the equipment until it has been effectively de-energized, and all high-voltage and low-voltage bushing terminals have been properly grounded. Do not rely solely on fuse removal or switch position as conclusive indication that a transformer is de-energized. Be absolutely certain that a transformer is de-energized by checking for zero voltage on all terminals.

Only qualified personnel should install, maintain, and operate this equipment. Qualified personnel are those who are trained in the installation, maintenance, and operation of high-voltage equipment, trained in the proper use of personal protective equipment (PPE) and trained in appropriate first aid procedures. Refer to NFPA 70E.

Certain information in this manual is marked with the words DANGER, WARNING, or CAUTION, which indicate hazards as listed below.

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious personal injury, and could also result in damage to the equipment.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious personal injury, and could also result in damage to the equipment.

CAUTION indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate personal injury, and could also result in damage to the equipment.

These instructions are intended as a general guide for the installation, operation and maintenance of the equipment, when operated in “Usual Service Conditions” as defined in IEEE Standard C57.12.00.

Although every effort has been made to ensure accuracy and completeness, these instructions do not address every conceivable application or circumstance that might be encountered. Howard Industries makes no representation or warranty with respect to, and assumes no responsibility for the completeness, accuracy, sufficiency, or usefulness of, these instructions. Features presented herein may not be present in all equipment designs. Standard and optional features are subject to change without notice.

Questions regarding installation, operation, and maintenance of the equipment, particularly when encountering unusual or special circumstances which may not be sufficiently covered by these instructions, should be directed to the Howard Industries Transformer Division.

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SECTION 1: INTRODUCTION

This document is intended as a general guide for the installation, operation and maintenance of Howard Industries fluid-filled, overhead distribution transformers. Although every effort has been made to ensure accuracy and completeness, these instructions do not address every conceivable application or circumstance that might be encountered. Features presented herein may not be present in all transformer designs. Standard and optional features are subject to change without notice.

The instructions contained herein are applicable to transformers operated in usual conditions as specified in the "Usual Service Conditions" section of IEEE Standard C57.12.00. Questions regarding installation, operation, and maintenance (particularly when encountering unusual or special circumstances not sufficiently covered by these instructions) should be directed to the Howard Industries Transformer Division.

IT IS IMPORTANT TO READ AND COMPLY WITH ALL SAFETY INFORMATION AND WARNINGS DISPLAYED THROUGHOUT THESE INSTRUCTIONS BEFORE ATTEMPTING ANY INSTALLATION, OPERATION, OR MAINTENANCE ACTIVITIES.

SECTION 2: RECEIVING, HANDLING, AND STORAGE

Drawings and Documents

Locate all shipping papers, packing lists, specifications, and other pertinent information for use during inspection. Verify that the transformer is supplied with a nameplate, required warning labels, and terminal designation markings. Verify that the terminal designation markings are consistent with those on the nameplate. The transformer nameplate provides electrical characteristics, winding connections, and weights. Check the nameplate for verification of specification compliance, including voltage and kVA ratings, percent impedance, and other design characteristics. The transformer wiring diagram provides details of any control, fan and alarm wiring that may have been provided.

Lifting and Handling

Overhead transformers may be lifted by crane or hoist. Properly palletized transformers may also be lifted by a forklift truck. Refer to the transformer nameplate to determine the total weight of the assembled transformer and make sure that the lifting equipment, hooks, cables, slings and spreader bars are adequate to perform a safe lift. Do not use transformer bushings as handles, otherwise undue stress may damage the bushing and cause a fluid leak. Be aware that cooling radiators, if present, are made of relatively thin metal and can be easily damaged. Special care must be taken when handling transformers, if the ambient temperature is below minus 20°C (minus 4°F); otherwise, permanent damage to the transformer may result.

Lifting the transformer by crane or hoist is accomplished using the provided lifting lugs. Do not lift from any points other than the provided lifting lugs. Do not use holes in the lifting lugs for lifting. These holes are for tie-down purposes only and are not suitable for lifting. A spreader bar should be used to keep the lifting cables or slings nearly vertical, enabling a safe lift and reducing the likelihood of tank deformation or damage to painted surfaces. Transformers should be lifted in an upright position, allowing the transformer to tilt no more than 15 degrees from vertical. Lifting cables or straps should be no more than 20 degrees from vertical.

A forklift truck may also be used to lift overhead transformers that are securely mounted on a shipping pallet. Lifting forks must be of sufficient length to extend completely under the pallet. Do not attempt to lift an un-palletized transformer with a forklift truck.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Lifting equipment, including forklift trucks, cranes, hoists, cables, straps, lifting bolts, hoist rings and spreader bars, must be of adequate capacity to safely lift the completely assembled transformer.
- Keep unnecessary personnel clear while unloading and moving the transformer.

Initial Inspection

Although all transformers are carefully inspected and tested at the factory, a thorough receiving inspection should be conducted to detect any damage or loss that might have occurred during shipment. The receiving inspection should be completed upon receipt and before unloading from the truck. Note any damage or discrepancies on the bill of lading, file a claim with the carrier, and notify the Howard Industries Transformer Division prior to unloading the transformer and before attempting any repair.

The following checks should be performed:

1. Read the serial number on the transformer nameplate and make sure it matches the serial number listed on the shipping documents. Also, check the transformer nameplate for kVA rating, high-voltage rating, low-voltage rating, impedance and other design characteristics, and make sure they comply with the specifications.
2. Check shipping documents to make sure the shipment is complete, including all listed accessories and hardware. Be aware that

additional items may arrive on separate pallets. Claims for shortages or errors must be noted on the shipping documents and reported immediately to the Howard Industries Transformer Division. Failure to make a timely claim will constitute unqualified acceptance and a waiver of all such claims by the purchaser.

3. The tank vacuum/pressure gauge, if provided, may indicate a positive or negative reading when the transformer is received, depending on the relative temperatures of the fluid and ambient air. A rising or falling reading that varies over time with ambient temperature indicates that the transformer tank is sealed effectively. If the vacuum/pressure gauge shows a constant zero reading, this indicates the possibility of a tank leak. If this occurs, the tank should be checked carefully for leaks as indicated in the following step.
4. Check the tank for indication of fluid leaks, looking carefully at weld seams, bushings, gauges, valves and all other tank fittings. If suspicious indications are found, investigate thoroughly to determine if a leak does exist on the transformer. Indications of a leak can sometimes be residual fluid that was not cleaned completely during the filling process and not an actual leak. In many cases a small pinhole tank leak or leak from a bushing, gauge, valve or other fitting can be easily repaired on site. Refer to the "Maintenance and Repair" section for information about the repair of fluid leaks.
5. Check for external damage including dents or scratches on the tank walls and radiators, if present. Dents and scratches can often be repaired on site using simple touch-up procedures. If touch-up painting is performed, do not remove or obscure any warning labels, instructional labels or nameplates.
6. Check for broken, cracked, or damaged bushings, gauges, valves and other fittings and accessories.
7. Check for missing or damaged component parts and for packages that shipped separately from the transformer.

Fluid Level

The transformer is shipped from the factory with insulating fluid filled to the proper level. Before energizing the transformer, verify proper fluid level by observing the fluid level gauge, if provided. The fluid level gauge pointer should be between the "High" and "Low" marks. For transformers provided with a fluid sight plug, the fluid level can be directly observed if it is within acceptable range.

When checking the fluid level, be aware that it is normal for the level to vary as a function of fluid temperature. A transformer found to have an unusually low fluid level should be checked for potential leaks and filled to the proper level with the same type of liquid as that specified on the transformer nameplate. Refer to *"Filling with Fluid."*

Internal Inspection

An internal inspection of the transformer tank is rarely necessary and is recommended only when there are obvious indications that the transformer has received severe impact damage during transit or when necessary to perform recommended pre-energization tests or inspections. Do not open the transformer tank without authorization from the Howard Industries Transformer Division. If the transformer tank must be opened, refer to *"Opening the Transformer Tank"* for instructions.

Fluid Sampling

Sampling and testing of the fluid is not required unless there is indication that moisture or other contaminants have accidently entered the tank during transit. If moisture or contaminants in the fluid is suspected, contact the Howard Industries Transformer Division immediately for instructions. If fluid sampling is required, refer to *"Sampling the Fluid"* for instructions.

Transformer Storage

Transformers may be temporarily stored if properly prepared. It is recommended that transformers be stored completely assembled. Prior to storage, transformers should be thoroughly inspected as described above in the *"Initial Inspection"* section. If the transformer is not completely assembled, separate components and accessories should be stored in a clean dry area in their original shipping

containers. Do not store the transformer in a corrosive environment.

Transformers may be stored in racks designed for that purpose. Transformers should not be stacked directly on top of one another, as this may damage the tank and bushings.

If the transformer is to be stored for an extended period of time before being placed into service, it should be stored on a firm level surface. It is recommended that the transformer be inspected periodically while it is in extended storage. Ensure that an effective pressure seal is maintained, and check for leaks and corrosion. Any damage or defects should be repaired immediately.

SECTION 3: INSTALLATION

Lifting and Handling

Overhead transformers may be lifted by crane or hoist. Properly palletized transformers may also be lifted by a forklift truck. Refer to the transformer nameplate to determine the total weight of the assembled transformer and make sure that the lifting equipment, hooks, cables, slings and spreader bars are adequate to perform a safe lift. Do not use transformer bushings as handles, otherwise undue stress may damage the bushing and cause a fluid leak. Be aware that cooling radiators, if present, are made of relatively thin metal and can be easily damaged. Special care must be taken when handling transformers, if the ambient temperature is below minus 20°C (minus 4°F); otherwise, permanent damage to the transformer may result.

Lifting the transformer by crane or hoist is accomplished using the provided lifting lugs. Do not lift from any points other than the provided lifting lugs. Do not use holes in the lifting lugs for lifting. These holes are for tie-down purposes only and are not suitable for lifting. A spreader bar should be used to keep the lifting cables or slings nearly vertical, enabling a safe lift and reducing the likelihood of tank deformation or damage to painted surfaces. Transformers should be lifted in an upright position, allowing the transformer to tilt no more than 15 degrees from vertical. Lifting cables or straps should be no more than 20 degrees from vertical.

A forklift truck may also be used to lift overhead transformers that are securely mounted on a shipping pallet. Lifting forks must be of sufficient length to extend completely under the pallet. Do not attempt to lift an un-palletized transformer with a forklift truck.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Lifting equipment, including forklift trucks, cranes, cables, straps, lifting bolts, hoist rings and spreader bars, must be of adequate capacity to safely lift the completely assembled transformer.
- Keep unnecessary personnel clear while unloading and moving the transformer.

Location and Mounting

Consult local and national codes to ensure that the installation meets all applicable requirements. Location of the transformer must permit it to operate in conditions that meet the requirements specified in the “Usual Service Conditions” section of IEEE Standard C57.12.00. Operation not meeting these service condition requirements will compromise transformer capacity and reliability, unless the transformer is designed specifically for operation in conditions other than usual service conditions. Contact the Howard Industries Transformer Division if additional information is needed about location and mounting issues not covered by these instructions

Overhead distribution transformers are not designed to be tamper resistant and must be installed in a location that is secure and accessible only by authorized personnel. Allow adequate electrical clearance between all live parts and between live parts and ground points. Ensure that cooling radiators are free of obstructions.

Hanger brackets are usually provided for direct pole mounting of the transformer. Pole capacity must be sufficient to support the weight of the transformer. The installed transformer should not tilt in any direction more than three degrees. Greater tilt may compromise the insulating fluid coverage of live parts within the tank and may prevent insulating fluid from circulating properly through the cooling radiators, if present. Improper circulation of insulating fluid may cause overheating and could result in reduced transformer life.

When specified by the user, base skids are provided for mounting the transformer on a solid, level surface, rather than on a pole. The factory may elect to provide skids for transformers whose weight exceeds the capability of pole-mounting brackets. The mounting surface must be rated to support the weight of the completely assembled transformer. Refer to the transformer nameplate for the weight of the transformer.

Grounding

The transformer must be permanently and effectively grounded according to applicable local and national codes. Ground the transformer by using the ground pads or nuts provided on the tank. Do not use hanger brackets or any other parts of the transformer for ground connections. A proper low-resistance ground connection is necessary for safe operation. Connect all available neutrals to the system neutrals.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

The transformer must be permanently and effectively grounded at all times.

High-Voltage and Low-Voltage Connections

The transformer nameplate illustrates the internal wiring and external identification of each bushing. The transformer must be connected and operated as indicated on the nameplate. High-voltage and low-voltage bushings are provided with terminals as specified by IEEE standards for overhead transformers, or as specified by the customer. Terminals are usually suitable for connection to either aluminum or copper conductors.

Before making high-voltage and low-voltage line connections, check to make sure that all mating connector surfaces are clean and smooth. Connections must be tightened adequately to prevent overheating and possible failure of the connection. Refer to the nominal torque guidelines contained in Table 3. Avoid excessive cantilever loads on bushings, otherwise bushing or gasket damage may result.

Reconfiguring the Internal Low-Voltage Connections

Unless otherwise specified by the user, overhead transformers with three low-voltage bushings are shipped from the factory with the internal low-voltage winding configured for the E/2E connection (for instance, 120/240 or 240/480 Volts). If the transformer must be reconfigured for operation at E Volts (for instance, 120 or 240 Volts), the transformer cover must be removed and the low-voltage leads reconnected in parallel. Connections must be tightened appropriately to prevent overheating and possible failure of the connection. Make sure the internal low-voltage leads are insulated and that they do not touch the tank, each other or any other surface. Refer to *"Opening the Transformer Tank"* for instructions.

External Surge Arresters

Some transformers are supplied with external surge arrester(s) mounted adjacent to the high-voltage bushing(s) and/or low-voltage-bushing(s). The arresters are temporarily rotated close to the tank wall at the factory to protect them during shipment, and in some cases foam packing material is used for additional protection.

Before placing the transformer in service, all packing material must be removed, and the arrester(s) must be rotated to the proper operating position. This can be done by loosening the arrester bracket pivot nut and rotating the arrester, so that it is perpendicular to the tank. The arrester bracket pivot nut must then be re-tightened to the torque recommended in Table 1. Refer to the photo on the cover of this manual for an example of a properly positioned arrester.

SECTION 4: INSPECTION AND TESTING

Pre-Energization Inspection and Tests

After the transformer has been installed, but before it is energized, the following tests and checks should be performed at a minimum to ensure that the transformer is ready to be energized. The transformer should not be energized without successfully completing these tests and checks.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

Be aware of dangerous voltages and avoid personal contact with live terminals.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Only qualified personnel with appropriate equipment should measure transformer voltages.
- Wear personal protective equipment (PPE) to prevent injury from potential arc-flash or contact with dangerous voltages.
- Make sure the transformer is securely and effectively grounded at all times.
- Current transformer (CT) leads, if present, must be connected to a metering load or shorted together and grounded to prevent dangerous voltages at the CT terminals.
- After successful completion of the recommended tests and checks, energize the transformer from a remote location.

1. **Ratio Test**—Using a transformer turns ratio tester (TTR), perform a ratio test to verify the primary-to-secondary winding ratio. The measured value should be within 0.5% of the voltage ratio indicated on the transformer nameplate. If the transformer is provided with high-voltage taps (or low-voltage taps on step-up/step-down transformers having low-voltage ratings above 600 Volts), measure the ratio at each tap position to ensure that each of the ratios is correct.

   When internal low-voltage windings have been reconfigured by the user as described above in *"Reconfiguring the Low-Voltage Internal Connections"*, the ratio test will confirm that the transformer has the correct output voltage and polarity. Follow the instructions and safety precautions provided by the TTR equipment manufacturer. For additional information about ratio testing, refer to IEEE Standard C57.12.90.

2. **Insulation Resistance Tes**t—Perform a 1,000-Volt insulation test (Megger test) to measure the resistance of the insulation between windings and from each winding to ground. Follow the instructions and safety precautions provided by the test equipment manufacturer. Prior to the test, bushings must be thoroughly cleaned with denatured alcohol to remove any moisture or contaminants that could influence the test results. Measured resistance should be at least 1.0 GΩ.

3. **Multiple-Voltage Switch Setting**—On transformers provided with a multiple-voltage switch, check the switch setting to make sure it is set to the correct position and that the locking screw, if provided, is engaged. When specified, the multiple-voltage switch may be mounted internally and accessibly only after removing the transformer cover or, if provided, the handhole cover. Before removing the cover or handhole cover, refer to *"Opening the Transformer Tank"* for instructions.

4. **Tap Switch Setting**—On transformers provided with taps, check the tap switch setting to ensure it is set to the proper position for the required voltage, and that the locking screw, if provided, is engaged. When specified, the tap switch may be mounted internally and accessible only after removing the transformer cover or, if provided, the handhole cover. For transformers provided with both taps and multiple-voltage windings, make sure the tap switch is in the position indicated on the nameplate when the multiple-

voltage switch is in the parallel position. Before removing the cover or handhole cover, refer to *"Opening the Transformer Tank"* for instructions.

5. **Grounding**—Check to ensure that the transformer tank is securely and effectively grounded. The transformer tank ground pad or nut is located on the tank.
6. **Bolted Connections**—Check all bolted connections for tightness, referring to nominal torque guidelines contained in Tables 1 through 4.
7. **Fluid Level**—Check to make sure the fluid level is correct as indicated by the fluid level gauge or sight plug, if provided. Be aware that fluid temperature and orientation of the transformer tank will cause the fluid level to vary. Transformers are filled to a level that corresponds to a fluid temperature of 25°C. The actual fluid level will increase with increasing temperature. The fluid level indication will also vary when the transformers is not installed in a level orientation.
8. **Fluid Temperature**—Observe the fluid temperature gauge and make sure the temperature is no lower than indicated below before the unit is energized.

   -20°C (-4°F) for conventional transformer oil and silicone fluid
   0°C (32°F) for R-Temp fluid
   -10°C (14°F) for FR3™ fluid
9. **Internal Fault Detector**—If the transformer is provided with an Internal Fault Detector (IFD), remove the orange shipping lock after the transformer is installed and before it is placed into service.
10. **Current Transformers**—If current transformers (CT's) are present, connect CT leads to the metering load. If CT leads are not connected to a metering load, they must be shorted together and grounded before the transformer is energized.
11. **Accessory Wiring**—Check wiring of control and alarm circuits, if provided, to make sure there are no loose connections and no damage to wire insulation.
12. **Tank Finish**—Check all painted surfaces to make sure that there is no damage or corrosion.
13. **Internal Inspection**—Transformer tanks are sealed at the factory and should not be opened unless necessary. If the transformer tank must be accessed, refer to *"Opening the Transformer Tank" for instructions.*

Post-Energization Inspection and Tests
After the transformer is energized, the following tests and inspections should be performed.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

Be aware of dangerous voltages within the terminal compartment and avoid personal contact with live terminals.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Energize the transformer from a remote location.
- Only qualified personnel with appropriate equipment should measure transformer voltages.
- Wear personal protective equipment (PPE) to prevent injury from potential arc-flash or contact with dangerous voltages.
- Make sure the transformer is securely and effectively grounded at all times.
- Current transformer (CT) leads must be connected to a metering load or shorted together and grounded to prevent dangerous voltage at the CT terminals.

1. **Verifying Correct Voltage**—Before supplying voltage from the transformer to the load, verify that the secondary voltages are correct. Using a suitable AC voltmeter, measure the voltage of the secondary windings and make sure they agree with the secondary voltages listed on the transformer nameplate.

2. **Checking for Leaks**—Check the tank to make sure there are no fluid leaks.
3. **Observing Operation**—After the transformer is initially energized, visually inspect it to make sure that no abnormal conditions are observed.
4. **Checking Gauges**—Observe the fluid level and fluid temperature gauges (if provided) to confirm the proper fluid level and temperature.
5. **Audible Sound**—It is normal for transformers to emit an audible humming sound, which is primarily caused by alternating magnetic flux in the transformer core. Amplitude and harmonic content of the sound is influenced by transformer size, the energizing voltage level and sinusoidal purity, load conditions and acoustic conditions at the installation site. Refer to NEMA Standards Publication TR1, *Transformers, Regulators and Reactors*, and IEEE Standard C57.12.90, *IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers*, for more information about design sound levels and factory sound testing. Unusual sounds should be investigated, as this might indicate a potential problem.

SECTION 5: OPERATION OF SWITCHING AND PROTECTIVE DEVICES

The following operating instructions and descriptions of switching and fusing devices are intended to be a general guide for operation of Howard Industries fluid-filled overhead distribution transformers in normal environments. Although every effort has been made to ensure accuracy and completeness, these instructions and descriptions do not address every conceivable application or circumstance that might be encountered. Personnel should read and comply with any safety and instructional labels that accompany an accessory device.

Some of the accessory devices described below are optional and may not be present in any particular transformer design. The inclusion of particular accessory devices in any transformer design is governed by industry standards and by individual customer specifications.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Use a live-line tool (hot stick or shotgun stick) to operate devices designed to be operated by a live-line tool.
- Before servicing the transformer, always de-energize the transformer from a remote location and then proceed to ground all primary and secondary transformer terminals following industry-accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.
- Follow industry-accepted safety practices. Utilize personal protective equipment (PPE) when working with this equipment.
- Do not operate fluid-immersed switching devices when the insulating fluid temperature is below the following limits:

  -20°C (-4°F) for conventional transformer oil and silicone fluid
  0°C (32°F) for R-Temp fluid
  -10°C (14°F) for FR3™ fluid

Hot-Stick Operable Devices

Some devices such as low-voltage circuit breakers, tap switches, multiple-voltage switches and automatic pressure relief devices are designed to be operated with a live-line tool (hot stick or shotgun stick). Do not attempt to operate by hand any device that is designed to be operated with a live-line tool. Inspect, test and operate the live-line tool according to the instructions provided by the live-line tool manufacturer.

Taps and Multiple-Voltage Windings

Transformers with low-voltage ratings of 600 Volts or less can be provided with either high-voltage taps or

multiple high-voltage windings. Although not recommended, these transformers also can be designed with both high-voltage taps and multiple high-voltage windings. When both are provided, extreme care must be taken to ensure that the tap switch setting is in the position shown on the nameplate when the multiple-voltage switch is in the parallel position. Failure to set the tap switch in the correct position could result in an unsafe condition.

Step-up/step-down transformers (transformers with a low-voltage rating of more than 600 Volts) can be provided with high-voltage and/or low-voltage taps, or with multiple high-voltage and/or low-voltage windings.

Tap switches and multiple-voltage switches are suitable for de-energized operation only. Never operate a tap switch or multiple-voltage switch while the transformer is energized. These switches are typically provided with an external operating handle, but when specified can be designed for internal operation and accessed by removing the transformer cover or, if provided, the handhole cover. Before removing the transformer cover or handhole cover, refer to *"Opening the Transformer Tank"* for instructions.

To operate the tap switch or multiple-voltage switch on a de-energized transformer, first disengage the locking screw, if provided, and then rotate the switch handle to the desired position as indicated on the switch dial plate or switch body and on the transformer nameplate. After verifying that the switch is set to the desired position, re-engage the locking screw, if provided, to prevent accidental operation of the switch.

Tap Switch

The de-energized tap switch may be used to adjust the voltage ratio of a transformer. It is intended to allow adjustment of the output (secondary) voltage to the rated value. Tap switches usually have five or seven tap positions as indicated on the switch dial plate or switch body and on the transformer nameplate. Do not use the tap switch to raise or lower the output voltage to any other than the rated voltage indicated on the transformer nameplate. If the tap switch is set to provide an output voltage different from rated secondary voltage, improper transformer operation will occur.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Do not operate a de-energized multiple-voltage switch unless the transformer is completely de-energized.
- Do not re-energize the transformer unless the multiple-voltage switch handle or cap is secured in the desired position.

The transformer is usually shipped from the factory with the tap switch set to the rated voltage position, unless otherwise specified. Always check the tap switch position to make sure it is set correctly.

Multiple-Voltage Switch

The de-energized multiple-voltage switch is used to allow operation of the transformer on multiple system voltages. Switch positions and available ratings are shown on the transformer nameplate. Unless otherwise specified, transformers with multiple-voltage windings are shipped from the factory with the multiple-voltage switch set to the highest voltage position.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN MINOR OR MODERATE PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Do not operate a de-energized multiple-voltage switch unless the transformer is completely de-energized.
- Do not re-energize the transformer unless the multiple-voltage switch handle or cap is secured in the desired position.

Fuses

A blown fuse may indicate a faulted transformer. Do not replace a blown fuse unless the cause of the fuse operation has been identified and corrected. Fuses should be applied according to the fuse rating.

Replacement fuses should have the proper rating and operating characteristics. Refer to the circuit diagram on the transformer nameplate for the location of fuses.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Do not replace a blown fuse unless the cause of the fuse operation has been identified and corrected.
- De-energize the transformer and ground all terminals before replacing fuses.
- Only qualified personnel with appropriate measurement devices should measure the voltages on the transformer.

Internal Weak-Link Fuse

The optional internal weak-link fuse is a fluid-immersed expulsion fuse that is designed to isolate the transformer from the distribution system in the event of an overload or an internal transformer fault on the load side of the fuse. The fuse is mounted at the bottom of the high-voltage bushing or in some cases on a terminal block located on the multiple-voltage switch or between the high-voltage bushing and the high-voltage coil. The presence of a weak-link fuse, if provided, will be indicated on the transformer nameplate.

Fuses can be accessed by removing the transformer cover or, if a handhole is provided, by removing the handhole cover. When accessing the fuse, observe the precautions and instructions discussed in *"Opening the Transformer Tank."*

Partial-Range Current-Limiting Fuse

The optional partial-range current-limiting fuse is designed to limit the energy released by a low-impedance (high-current) internal fault and reduce the likelihood of violent transformer failure. A weak-link expulsion fuse is normally installed in series with the partial-range current-limiting fuse. The purpose of the weak-link expulsion fuse is to clear a high-impedance fault or overload. When properly applied, the partial-range current-limiting fuse will operate only for internal transformer faults. When a partial-range current-limiting fuse has operated, the transformer should be considered faulted and removed from service. The presence of a partial-range current limiting fuse, if provided, will be indicated on the transformer nameplate.

Surge Arrester

The optional surge arrester is used to protect the transformer from damage due to over-voltage transients (such as lightning surges), which propagate through the distribution system. Surge arresters may be provided as an externally-mounted device or as an internal fluid-immersed device. The surge arrester should be installed only on systems where the power frequency voltage at the arrester does not exceed the arrester's published maximum continuous operating voltage (MCOV) value.

External Surge Arrester

The external arrester line-lead and tank grounding connections should be checked to ensure they are tight before placing the transformer in service. Refer to Table 3 for torque guidelines.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- De-energize the transformer from a remote location and make sure all transformer terminals and bushings have zero voltage before connecting or servicing surge arresters.
- Disconnect all surge arresters before performing impulse, induced-potential or applied-potential tests.

Disconnect the external surge arrester line-lead before performing impulse, induced-potential or applied-potential tests; otherwise, the arrester may be damaged. Reconnect the surge arrester after testing and before placing the transformer back into service.

Internal Surge Arrester

The optional internal metal-oxide-varister (MOV)

surge arrester is designed to be fluid immersed and mounted inside the transformer tank. It is recommended that the fluid-immersed MOV arrester not be exposed to an average fluid temperature exceeding 90°C (194°F) or a maximum fluid temperature exceeding 125°C (257°F).

Disconnect the fluid-immersed MOV surge arrester before performing impulse, induced-potential or applied-potential tests; otherwise, the arrester may be damaged. Reconnect the surge arrester after testing and before placing the transformer back into service. Refer to *"Opening the Transformer Tank"* for instructions.

Low-Voltage Circuit Breaker

The optional fluid-immersed, low-voltage circuit breaker uses an automatic trip system to help protect the transformer from damage caused by overloads and short circuits. The presence of a low-voltage circuit breaker will be indicated on the transformer nameplate. The circuit breaker coordinates with an internal protective link or internal current-limiting fuse, so that the breaker operates first for overloads and faults on the load side of the transformer.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Do not rely solely on the circuit breaker to de-energize the transformer secondary. Always ground the secondary terminals before performing work.
- Even with the circuit breaker in the OPEN position, there may be sufficient capacitive coupling to cause a shock hazard at ungrounded secondary terminals.
- Use a live-line tool (hot stick or shotgun stick) to operate the low-voltage circuit breaker. Never operate the breaker by hand.

The circuit breaker operating handle is located on the side of the transformer tank and is designed to be operated with a live-line tool (hot stick), as follows.

- –To open the circuit breaker, rotate the handle so that the pointer is at the OPEN ("O") position.
- –To close the circuit breaker, rotate the handle, so that the pointer is at the CLOSED ("C") position.
- –To reset the circuit breaker after it has tripped, rotate the handle, so that the pointer is at the RESET ("R") position. Then rotate the handle, so that the pointer is at the CLOSED ("C") position.

The circuit breaker may be provided with optional emergency overload capability. The emergency overload lever is located adjacent to the operating handle. To provide continued service during an overload situation, rotate the emergency overload lever to temporarily raise the breaker trip setting. Rotation of the lever is variable, so that more or less overload capability can be selected. Overload operation should be minimized to prevent excessive loss of transformer life. When shipped from the factory, the emergency overload lever is secured with a meter seal to prevent accidental operation.

When specified, the circuit breaker can be provided with an overload signal light. Illumination of the signal light indicates that the transformer has been heavily overloaded. The signal light remains illuminated until the breaker handle is rotated to the RESET ("R") position.

The circuit breaker is not intended as a disconnect device for routine transformer operation. The circuit breaker does not provide a visible disconnect and should not be relied on as the sole indication that the transformer secondary terminals are de-energized.

Magnex Interrupter

The optional Magnex Interrupter is an over-current protective device and load-break switch, which is internally mounted under oil and connected into the high-voltage circuit of the transformer. The interrupter coordinates with an internal protective link or internal current-limiting fuse, so the interrupter operates first for overloads or faults on the load side of the transformer. The presence of a Magnex Interrupter will be indicated on the transformer nameplate. The following procedures are intended as a

general guide for operation of the Magnex Interrupter. Personnel should read and follow Cooper Power Systems Magnex Interrupter Installation Instructions S240-34-1.

The operating handle is located on the side of the transformer tank and is designed to be operated with a live-line tool (hot stick), as follows.

- –To open the interrupter, rotate the handle upward in a counterclockwise direction, until the spring-loaded contacts open and the handle is in the OPEN position.
- –To close the interrupter, rotate the handle downward in a clockwise direction, until the handle is against the physical stop in the CLOSED position. When in the CLOSED position, the interrupter will operate automatically due to an over-current condition or rise in oil temperature.
- –To reset the interrupter after it has tripped, rotate the handle upward in a counterclockwise direction to the OPEN position, and then downward in a clockwise direction, until the handle is against the physical stop in the CLOSED position.

An optional trip indicator is available, consisting of an indicator lens which appears orange when the interrupter is in the TRIPPED position.

Some Magnex Interrupters are supplied with an optional emergency overload setting. The emergency overload will allow approximately 30% overload before tripping. Using a live-line tool (hot stick), operate the emergency overload as follows.

- –To enable emergency overload, rotate the handle upward in a counterclockwise direction, until the handle is in the OPEN position. Next, turn the emergency overload lever counterclockwise to the EO position. Then rotate the handle downward in a clockwise direction, until the handle is in the CLOSED position.
- –To disable emergency overload, rotate the handle upward in a counterclockwise direction, until the handle is in the OPEN position. Next, turn the emergency overload lever clockwise to the NORMAL position. Then rotate the handle downward in a clockwise direction, until the handle is in the CLOSED position.

The Magnex Interrupter does not provide a visible disconnect and should not be relied on as the sole indication that the transformer secondary terminals are de-energized.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Do not rely solely on the Magnex interrupter to de-energize the transformer secondary. Always ground the secondary terminals before performing work.
- Operate the Magnex Interrupter with a live-line tool (hot stick or shotgun stick). Never operate by hand.
- Do not operate the Magnex Interrupter if there is evidence of tank distress or leaking.
- The handle must be rotated fully against the stop in the CLOSED position.

Other Switching and Protective Devices

Overhead transformers may be provided with switching and protective devices not discussed in these instructions. In such cases, contact the Howard Industries Transformer Division or the device manufacturer for instructions.

SECTION 6: OPERATION OF BUSHINGS, GAUGES AND ACCESSORY DEVICES

Some of the devices described below are optional and may not be present in any particular transformer design. The inclusion of particular accessory devices in any transformer design is governed by industry standards and by individual user specifications.

Hot-Stick Operable Devices

Some devices such as low-voltage circuit breakers, switches and automatic pressure relief valves are designed to be operated with a live-line tool (hot stick or shotgun stick). Do not attempt to operate by hand any device that is designed to be operated with a live-line tool. Inspect, test and operate the live-line tool according to the instructions provided by the live-line tool manufacturer.

Pressure-Vacuum Gauge

The pressure-vacuum gauge is a dial-type instrument that indicates the pressure in the tank gas space relative to atmospheric pressure. The gauge is mounted on the transformer tank above the fluid level. Pressure in the tank will normally vary as a function of transformer and ambient temperatures. If the transformer is lightly loaded or de-energized during times of low ambient temperature, the gauge may indicate a negative pressure.

The pressure-vacuum gauge may be provided with optional switch contacts, which can be used to provide a remote alarm.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN MINOR OR MODERATE PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

If the pressure-vacuum gauge constantly reads zero under varying load and ambient conditions, the transformer should be checked for a possible tank leak. A leak will allow moisture and air to enter the transformer tank, which could degrade the paper insulation and insulating fluid. Left unrepaired, a leak could limit transformer life or cause a violent failure.

Fluid Level Gauge and Sight Plug

The fluid level gauge is a dial-type device that indicates the fluid level inside the transformer tank. The gauge is mounted on the transformer tank at the normal 25°C fluid level. Transformers may be provided with a fluid sight plug instead of a fluid level gauge to allow direct observation of the fluid level. The top fluid level should be visible in the sight plug.

If the gauge or sigh plug indicates a low fluid level, the cause of the low reading should be investigated and corrected. A low fluid level can cause overheating of the transformer and can compromise the insulation system. The fluid level gauge may be provided with optional switch contacts, which can be used to provide a remote alarm of low fluid level.

Be aware that fluid temperature and orientation of the transformer tank will cause the fluid level to vary. Transformers are filled to a level that corresponds to a fluid temperature of 25°C. The actual fluid level will increase with increasing temperature. The fluid level indication will also vary when the transformer is not installed in a level orientation.

Fluid Temperature Gauge

The fluid temperature gauge is a dial-type bi-metal instrument that indicates the fluid temperature at the top of the fluid column. The temperature gauge is mounted on the transformer tank near the top of the fluid column.

The gauge may be furnished with a red drag-hand pointer that indicates the maximum temperature reached since it was last reset. The drag-hand can be reset by rotating the magnet at the center of the dial or, on some types, by pressing a reset button. The fluid temperature gauge may also be provided with switch contacts, which can be used to provide a remote alarm, or to energize a fan control circuit.

During normal operation the fluid temperature gauge should read less than the sum of the ambient temperature and the rated temperature rise (normally a sum of 85°C). Refer to IEEE Standard C57.91, *IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators*, for loading recommendations.

Drain Valve and Sampling Device

The drain valve and sampling device permit draining the transformer fluid and sampling the fluid for testing purposes. The valve is located near the bottom of the transformer tank. Refer to *"Sampling and Testing the Fluid"* and *"Draining and Filling the Tank"* for the fluid sampling and draining procedures.

Automatic Pressure Relief Valve

The automatic pressure relief valve (PRV) is designed to relieve excessive tank pressure that might occur during operation of the transformer. The valve consists of a self-resealing, spring-loaded diaphragm. Some PRV types may include a re-settable visual flag to indicate that the valve has operated.

When pressure in the tank exceeds the PRV's specified limit, the pressure will cause the valve to open, venting the excess pressure. After the internal pressure decreases below the PRV reseal rating, the valve will automatically close and reseal the transformer. For PRV's equipped with a visual indicating flag, the flag must be manually reset.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN MINOR OR MODERATE PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

The cause of PRV activation should always be investigated, since pressure venting may indicate a potential problem inside the transformer.

Internal Fault Detector

The Internal Fault Detector (IFD) is a mechanical sensor that activates when sudden pressure from an internal arcing fault occurs inside the transformer. If an internal fault occurs, the IFD releases a visible, non-resettable orange signal flag. This signal flag alerts crews that the transformer is faulted and should not be re-energized. Be aware that the IFD provides only a visual indication that a fault has occurred. It is not an electrical disconnect device.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Do not re-energize a transformer if the IFD has operated.
- Do not attempt to reset the orange signal flag.
- Always assume that a transformer might be faulted, even if the IFD has not operated.
- Never rely solely on the IFD as an indicator of transformer condition.
- The IFD is a visual indicator only, and should not be relied on as an electrical disconnect device.

The IFD also includes a standard pressure relief valve that is integrated into the sensor to relieve excessive tank pressures that might occur during normal operation of the transformer. Refer to information elsewhere in these instructions regarding operation of an automatic pressure relief valve.

The IFD incorporates a removable shipping lock for use during transportation and storage. The shipping lock must be removed after the transformer is installed. Re-install the shipping lock if the transformer must be relocated. Always transport IFD-equipped transformers with the shipping lock installed to prevent accidental operation.

Bushings and Terminals

Tin-plated eye-bolt or spade terminals are provided as specified by IEEE standards and are suitable for connection to either aluminum or copper conductors. High-voltage and low-voltage connections should be made as indicated on the transformer nameplate.

Clean and properly tighten all terminal connections to ensure a low-resistance connection and prevent overheating. Refer to torque guidelines contained in Table 3. Ensure that there is sufficient electrical clearance between all live parts, including both phase-to-phase and phase-to-ground clearances.

Line connections should be made without placing excessive cantilever load on the bushings. Excessive loading may cause bushing or gasket damage.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN MINOR OR MODERATE PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

Do not place excessive cantilever load on a low-voltage or high-voltage bushing.

High-Voltage Bushings

Internally-clamped cover-mounted porcelain bushings are typically supplied for connection to the high-voltage source. Insulated terminal caps may be provided as an option to prevent wildlife from making contact with live high-voltage terminals.

Low-Voltage Bushings

Internally-clamped, sidewall-mounted bushings are typically supplied for connection to the secondary load. These may be constructed of either molded plastic or porcelain.

Other Accessory Devices

Transformers may be provided with other accessory devices not discussed in these instructions. In such cases, contact the Howard Industries Transformer Division or the device manufacturer for information.

SECTION 7: MAINTENANCE AND REPAIR

These instructions are intended as a general guide for the maintenance and repair of Howard Industries fluid-filled overhead distribution transformers, when used in typical applications and operated in normal environments. Although every effort has been made to ensure accuracy and completeness, these instructions do not address every conceivable application or circumstance that might be encountered.

Transformers should be inspected periodically while in service, with the frequency determined by service conditions. Transformers operating in unusual service conditions should be inspected more frequently. Refer to IEEE Standard C57.12.00 for a discussion of usual and unusual service conditions.

Accessories such as pressure relief valves, temperature gauges, fluid level gauges, pressure-vacuum gauges and drain valves typically require no maintenance, except replacement in the event of damage. Gauges, if present, should be checked periodically to make sure they are operating properly.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- De-energize transformer from a remote location before performing any inspection or maintenance work.
- Make sure all transformer terminals and bushings have zero voltage.
- Make sure that the transformer is properly grounded.
- Fluid leaks should be repaired as soon as they are discovered.

Periodic Inspection

All exterior surfaces and the transformer surroundings should be inspected periodically. Inspection frequency should be governed by operating conditions at the installation site. More severe conditions indicate the need for more frequent inspection.

Inspection Checklist

While observing the safety instructions above, perform the following checks.

1. Inspect for dents or other damage to metal surfaces and make necessary repairs.
2. Inspect the paint finish for damage, corrosion or weathering that exposes the primer coat or bare metal. Repair any paint damage that might be found. Refer to *"Exterior Paint Finish"* for instructions.
3. Inspect thoroughly for evidence of fluid leaks, including tank, radiators, bushings, gauges, switches, valves and all other accessories and fittings. Check the fluid level and add fluid as necessary to ensure that the proper fluid level is maintained. Refer to *"Filling with Fluid."* Fluid leaks must be repaired immediately to prevent serious damage to the transformer and danger to life. Refer to *"Fluid Leaks"* for instructions.
4. Visually check all gaskets for cracking or other signs of deterioration, and replace as necessary. When replacing a gasket, carefully clean mating surfaces to remove any rust, dirt, transformer fluid, old gasket material, or other contamination that might prevent a good seal. Use an appropriate gasket cement when installing new gaskets. Do not reuse old gaskets.
5. Maintain a clean and unobstructed area around the transformer, including sufficient clearance around radiator panels, if present, to ensure adequate cooling of the transformer.
6. Check bushings, valves, gauges, switches and all other accessories for proper operation, and repair or replace any defective devices.
7. Check all fasteners for signs of corrosion and replace as necessary.
8. Check the fluid temperature gauge, if present, including the maximum temperature drag hand, if provided, to determine whether the fluid temperature has exceeded the design limit. Any such indication should be investigated to determine and correct the cause. Reset the drag hand.
9. Check to make sure the fluid level is correct as indicated by the fluid level gauge or sight plug,

if provided. Be aware that fluid temperature and orientation of the transformer tank will cause the fluid level to vary. Transformers are filled to a level that corresponds to a fluid temperature of 25°C. The actual fluid level will increase with increasing temperature. The fluid level indication will also vary when the transformer is not installed in a level orientation. If the fluid level is low, add fluid according to the instructions in the *"Filling with Fluid"* section.

10. Check the torque values on all electrical connections, including ground connections, and tighten as necessary. Refer to the torque guidelines contained in Tables 1 through 4.
11. Replace any damaged or unreadable nameplates, instructional labels, and safety labels.
12. If it is suspected that water or other contaminants may have entered the tank, the fluid should be tested to determine its condition. For transformers filled with conventional transformer oil, Refer to IEEE Standard C57.106, "*Guide for Acceptance and Maintenance of "Insulating Oil in Equipment*." For transformers filled with less-flammable high molecular weight hydrocarbon insulating fluid (such as R-Temp), refer to IEEE Standard C57.212, "*Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluids in Transformers*." For transformers filled with seed-based fluids (such as Envirotemp FR3™) refer to IEEE Standard C57.147, "*Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers"* for information. For transformers filled with silicone fluid, contact the Howard Industries Transformer Division for information.

Electrical Tests

The following electrical tests can be used to determine the condition of the transformer. Comply with instructions and precautions provided by the test equipment manufacturer. Contact the Howard Industries Transformer Division for further information.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

Be aware of dangerous voltages and avoid personal contact with live terminals.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- De-energize the transformer and ground all transformer terminals.
- Only qualified personnel with appropriate equipment should perform these tests.
- Wear personal protective equipment (PPE) to prevent injury from potential arc flash or contact with dangerous voltages.
- Make sure the transformer tank is properly grounded at all times.
- After testing is complete and the transformer has been reconnected to the line leads, energize the transformer from a remote location.

1. Insulation Resistance Test—Refer to *"Insulation Resistance Test"* for instructions.
2. Ratio Test—Refer to *"Ratio Test"* for instructions.
3. Insulation Power Factor Test—Refer to *"Insulation Power Factor Test"* for instructions.
4. Fluid Quality Tests—Moisture content, power factor, dielectric strength and dissolved gas analysis.

Exterior Paint Finish

Any damage to the exterior paint finish that exposes the primer coat or bare metal should be repaired immediately in order to prevent corrosion. Areas to be repaired should be thoroughly clean and dry. The surface should be sanded to remove rust, loose

paint flakes and other debris. The surface should then be cleaned with a suitable solvent to remove any oil, grease or other contaminants. At least two coats of a high-quality touch-up paint should be applied to the damaged area. Bare metal should receive a primer coat before applying the final finish. Touch-up paint is available from the Howard Industries Transformer Division.

Fluid Leaks

Check the tank for indication of fluid leaks, looking carefully at weld seams, bushings and all tank fittings. Fluid leaks should be repaired as soon as possible to prevent moisture contamination of the insulating fluid and to prevent internal flashover due to low fluid level.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- De-energize transformer from a remote location before performing any inspection or maintenance work.
- Make sure all transformer terminals and bushings have zero voltage.
- Make sure that the transformer is properly grounded.
- Fluid leaks should be repaired as soon as they are discovered.

If a fluid leak is suspected, investigate thoroughly to determine if an actual leak does exist on the transformer. False indications of a leak can occur as a result of residual fluid that was not sufficiently cleaned after the transformer was filled with fluid.

In addition to the presence of fluid residue, a low reading on the fluid level gauge, if present, and a constant zero reading on the pressure/vacuum gauge, if present, (which does not vary over time as a function of transformer loading and ambient temperature) are also indications of a possible fluid leak.

To verify that a fluid leak does exist, clean the suspected leak area with an appropriate solvent to completely remove the fluid and observe the area for reappearance of fluid. To accelerate the test, pressurize the tank with dry air or dry nitrogen through the PRV fitting to a pressure of 3-4 PSIG. Let the tank stand under pressure for one to two hours, then inspect for leaks. Leaks above the fluid level can be detected by applying soap solution prior to the pressure test.

In many cases a small pin-hole tank leak or leak from a bushing, gauge, valve or other fitting can be repaired on site. Pin-hole and weld seam leaks can usually be repaired by welding on a de-energized transformer. Welding on radiator panels is not recommended due to the thinner gauge material used. Very small pin-hole leaks can sometimes be repaired using an epoxy patch kit designed to repair oil leaks.

Bushing leaks can sometimes be corrected by tightening the bushing clamp bolts. Do not exceed the recommended torque values listed in Table 2 to prevent the possibility of bushing or gasket damage.

Audible Sound Level

It is normal for transformers to emit an audible humming sound, which is primarily caused by alternating magnetic flux in the transformer core. Amplitude and harmonic content of the sound is influenced by transformer size, the energizing voltage level and sinusoidal purity, load conditions and acoustic conditions at the installation site. Unusual sounds should be investigated, as this might indicate a potential problem.

Refer to NEMA Standards Publication TR1, *Transformers, Regulators and Reactors*, and IEEE Standard C57.12.90, *IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers* for more information about design sound levels and factory sound testing.

Low-Voltage Circuit Breaker

The low-voltage circuit breaker, if present, is accessible by removing the transformer cover or handhole cover. The link to the operating handle can be adjusted if necessary for proper operation. Defective breakers should be replaced. Refer to *"Opening the Transformer Tank"* for instructions.

Magnex™ Interrupter

The Magnex™ interrupter and protective link, if present, are accessible by removing the transformer cover or handhole cover. Interrupters do not normally require field adjustment. Defective interrupters should be replaced. Refer to *"Opening the Transformer Tank"* for instructions.

Other Accessory Devices

Other accessory devices, such as a gauges and valves, typically require no maintenance except for replacement in the event of malfunction or damage.

Insulating Fluid

For transformers filled with mineral oil, refer to IEEE Standard C57.106 *Guide for Acceptance and Maintenance of Insulating Oil in Equipment* for additional guidelines that should be observed when testing or handling insulating fluid. For transformers filled with natural ester fluids (such as Envirotemp FR3™), refer to IEEE Standard C57.147 *Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers* for information. For transformers filled with silicone fluid, contact the Howard Industries Transformer Division for information.

Sampling the Fluid

Before sampling the insulating fluid, de-energize the transformer and make sure all bushings and terminals are effectively grounded. Samples should be drawn from the bottom of the tank. Refer to ASTM D923, *Standard Practices for Sampling Electrical Insulating Liquids* for recommended sampling procedures. Also, refer to the sampling recommendations provided by the manufacturer of the fluid test equipment.

Filtering the Fluid

The insulating fluid can be filtered using a filter press system. A filter press can remove particle contaminants as well as small amounts of moisture. Follow the operating instructions provided by the filter press system manufacturer. Continue to filter the fluid until the dielectric test result is 26kV or greater.

When filtering any particular type of insulating fluid, make sure the filter press system is not contaminated with any other type of fluid. Contamination of the fluid may alter its chemical or physical characteristics and could reduce its fire point.

Removing or Lowering the Fluid

Should it be necessary to remove or lower the insulating fluid, the following procedure should be used. Use clean pumps and hoses that have not been contaminated by different types of fluids. Hoses must be designed for handling the particular fluid in the transformer (As an example, rubber hoses should not be used with mineral oil.).

1. De-energize the transformer, and make sure the tank and all terminals are effectively grounded.
2. Remove the cover or handhole cover, if provided, as outlined in the *"Opening the Transformer Tank"* section.
3. Use a clean, dry temporary storage container to contain the fluid.
4. Place the pump discharge hose nozzle at the bottom of storage container.
5. Pump slowly, and do not allow the fluid to splash into the container, as this could introduce air and moisture into the fluid.
6. Do not lower the insulating fluid below the top of the core/coil clamp pan. Exposing coils could allow moisture to contaminate coil insulation.

Filling with Fluid

When refilling the transformer with insulating fluid, fill with the same type of fluid, following the procedure outlined below. Do not mix different types of fluids. Care should be taken to avoid introduction of air bubbles during the filling process. After refilling is complete, allow 24 hours for dissipation of air bubbles before energizing the transformer. Trapped air bubbles can reduce the insulation value of the fluid and cause an internal flash-over.

1. Every storage container of transformer fluid used in the filling process should be visually inspected and tested for water and other possible contaminants before proceeding with the filling process.
2. Pump from the bottom of storage container. To prevent bubbles in the fluid, do not allow air to enter the pump intake.
3. Place discharge hose at the bottom of the transformer tank to prevent aeration and the introduction of bubbles.
4. Pump and fill the transformer tank slowly.

Fill with fluid to fill line marked inside the transformer tank.

Opening the Transformer Tank

Transformer tanks are shipped sealed and should not be opened unless necessary. If it is necessary to open the tank, follow the instructions below and observe all safety warnings. Before removing the transformer cover or handhole cover, de-energize the transformer and relieve internal pressure by operating the pressure relief valve, taking care to avoid any hot fluid that could be expelled from the PRV.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND COULD ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- Before servicing the transformer, always de-energize the transformer and then proceed to ground all primary and secondary transformer terminals following industry-accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.
- Release internal pressure by operating the PRV with a live-line tool before opening the tank. Be careful to avoid any hot oil that might be expelled from the PRV.

To prevent contamination of the transformer, do not open the transformer tank in an unprotected area during inclement weather or where the air may contain dirt or other particles. Any of these situations could contaminate the insulating fluid and cause a transformer failure. The tank opening should be protected against entry of foreign matter. If it is necessary to remove some fluid from the tank to allow for inspection or other work, the transformer must be re-filled with fluid after work is completed. Refer to the instructions In *"Removing or Lowering the Fluid"* and *"Filling with Fluid."* The transformer tank should not remain open for more than two hours. If work is interrupted, the tank should be resealed, evacuated, and filled with dry air or nitrogen.

Personnel should not be permitted on top of or inside the transformer while it is open, unless they have emptied all pockets and checked for loose objects that might fall into the tank. All tools should be accounted for after work is completed. It is recommended that any tools used on top of the transformer or inside the tank be attached with safety cords to prevent them from being lost inside the transformer.

Personnel must not stand directly on any electrical insulation. Clean drop cloths should be used under working areas in the transformer to prevent objects from dropping into the core/coil assembly.

The following procedure should be used to re-install the handhole cover.

1. Place the cover gasket in its original position. If the gasket is damaged, it should be replaced.
2. Re-install the handhole cover. Re-install and tighten the cover bolt according to the torque recommendations in Table 1.
3. To ensure a proper cover seal, pressurize the headspace to 3-4 PSIG and check for leaks.

Torque Guidelines

Tables 1 through 4 below contain recommended torque values for tightening various connections on the transformer. Connections with gaskets will normally relax after initial tightening. Nominal torque values listed below include an allowance for gasket relaxation.

Do not over-tighten any connection; otherwise, gaskets could split due to over-compression, and components might break. Fluid leaks could result if tank-mounted components are over tightened. Check with the Howard Industries Transformer Division for recommended torque values for any devices or connections not listed below. Use the manufacturer's recommended torque values for any user-provided devices.

Table 1: Torque Guidelines for External Fasteners

Fastener Type	Nominal Torque (in-lbs)	Torque Range (in-lbs)
3/8" bolt	240	220-260
Hand-hole cover bolt	144	129-158
Fastener Type Cover band bolt	180	170-185
Surge arrester mounting bolts and pivot nut	280	252-308

Table 2: Torque Guidelines for External Bushing Mounting Hardware

Bushing Type	Nominal Torque① (in-lbs)	Torque Range
Low-voltage bushing, molded Tri-Clamp (without clamp ring), 3/8" mounting studs	60	40-80
Low-voltage bushing, molded (with clamp ring), 3/8" mounting studs	120	90-150
Low-voltage bushing, porcelain (with clamp ring), 1/2" mounting studs	80	70-90
High-voltage bushing, molded Tri-Clamp (without clamp ring), 3/8" mounting studs	60	40-80
High-voltage bushing, molded (with clamp ring), 3/8" mounting studs	120	90-150
High-voltage bushing, porcelain	80	70-90

① When checking tightness of gasketed components, the measured torque will normally be less than the nominal torque listed in the table above due to relaxation of the gasket material. Additional tightening of bushing mounting hardware may cause the component to crack or the gasket to become over-compressed.

Table 3: Torque Guidelines for External Terminal Connections

Terminal Type	Nominal Torque① (in-lbs)	Torque Range
High-voltage porcelain bushing eye-bolt	210	180-240
High-voltage porcelain bushing end cap	168	156-180
Low-voltage bushing, 5/8" jam nut	600	480-720
Low-voltage bushing, 1" jam nut	600	480-720
Low-voltage bushing, 1-1/4" jam nut	720	600-840
External surge arrester line lead	180	162-198
External surge arrester ground lead	180	162-198

① When checking tightness of gasketed components, the measured torque will normally be less than the nominal torque listed in the table above due to relaxation of the gasket material. Additional tightening of bushing mounting hardware may cause the component to crack or the gasket to become over-compressed.

Table 4: Torque Guidelines for Accessories

Component	Nominal Torque① (in-lbs)	Torque Range (in-lbs)
Bushing-mounted weak-link fuse mounting bolts	85	80-90
Fluid-level sight plug	960	900-1020
Fill plug	960	900-1020
Drain plug	960	900-1020
Drain valve	600	480-720
Automatic pressure relief device, 1/4" NPT	180	160-200
Automatic pressure relief device, 1/2" NPT	360	324-396
Neutral strap fastener (at ground pad)	160	140-180
Series/multiple, delta/wye or tap switch mounting nut	120	96-144
Ground connector	160	140-180

① When checking tightness of gasketed components, the measured torque will normally be less than the nominal torque listed in the table above due to relaxation of the gasket material. Additional tightening of bushing mounting

hardware may cause the component to crack or the gasket to become over-compressed.

Additional Maintenance Instructions

Features and accessory devices discussed herein may not be present in all transformer designs. Some features or accessory devices may be present on a transformer, but not discussed in these instructions. Howard Industries does not represent that these instructions are complete, sufficient, accurate or useful in all circumstances.

Questions regarding installation, operation, and maintenance (particularly when encountering unusual or special circumstances not sufficiently covered by these instructions) should be directed to the Howard Industries Transformer Division.

Repair Parts

Repair parts can be ordered from the Howard Industries Transformer Division. A description of the part and the transformer serial number will be required to ensure that the correct part has been ordered.

Warranty Claims

The Howard Industries Transformer Division should be notified immediately when problems are discovered during the warranty period. All warranty repairs must be made or approved by the Howard Industries Transformer Division.

Transformer Disposal

Comply with all local, state and federal regulations when disposing of any transformer fluid. Fluid type and volume can be determined by referring to the transformer nameplate. Contact Howard Industries to obtain the appropriate fluid Safety Data Sheet (SDS). The SDS identifies fluid composition and properties, and describes important safety, handling and storage, ecological, regulatory, disposal and other pertinent information.

⚠WARNING ⚠

Improper disposal of a transformer could result in personal injury or death and could be hazardous to the environment.

Before the transformer tank can be safely cut with a grinder or torch, any potentially explosive gasses must be removed from the tank interior. This can be done by first operating the pressure relief device to slowly bring the tank interior to atmospheric pressure, removing the regulator cover or hand-hole cover, and then completely purging the interior with pure air or an inert gas such as nitrogen.

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Instructions for the Installation, Operation, and Maintenance of Fluid-Filled Overhead Distribution Transformers

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