



# Instructions (HI-104)

Installation, Operation, and Maintenance of  
Single-Phase Pad-Mounted Compartmental-Type  
Distribution Transformers

(Note: For submersible transformers refer to Instructions HI-107.)



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.

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.

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.

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, single-phase, pad-mounted compartmental-type 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.

These instructions are applicable to single-phase, pad-mounted compartmental-type distribution transformers (including IEEE Type 1, IEEE Type 2 and other styles covered by IEEE Standards C57.12.25 and C57.12.38, and the Space-Saver™ style), which are designed as a single-door style with a one-piece flip-top hood, or the double-door style (sometimes called a “wardrobe-style” transformer), which is designed with two hinged access doors.

All transformer styles are designed for mounting outdoors on a concrete pad or other suitable surface. High-voltage and low-voltage cables enter the transformer terminal compartment from below ground through an opening in the mounting pad.

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. The transformer wiring diagram provides details of any control, fan and alarm wiring that may have been provided.

### Lifting and Handling

Lifting lugs or bosses are provided to lift the completely assembled transformer. All lifting lugs or bosses must be used simultaneously to provide a safe, balanced lift. The transformer must not be lifted from any points other than the provided lifting lugs or bosses. Do not use holes in the lifting hooks for lifting. These holes are for tie-down purposes only and are not suitable for lifting. Refer to the transformer nameplate to determine the total weight of the assembled transformer.

Lifting bosses, when provided, consist of 5/8"-11 threaded inserts. Lifting should be accomplished with user-installed lifting devices that have been fully engaged into the threaded inserts. Lifting devices, such as hoist rings, must be rated to safely support the weight of the completely assembled transformer. A spreader bar should be used to keep the lifting cables or straps 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.

Single-door style transformers may also be lifted with a forklift truck of adequate lifting capacity to safely handle the weight of the completely assembled transformer. Forks should be of sufficient length to

extend completely through the shipping pallet or runners. Transformers should be lifted with the tank (core/coil and fluid compartment) oriented toward the forklift truck, so that the transformer center of gravity is adequately supported. Lifting transformers from the terminal compartment side is not safe, as the transformer may tip and fall.

Lifting double-door style transformers with a forklift truck is not recommended, since weight and balance can be problematic, and radiator panels can be easily damaged.

Transformers should be handled with special care when the ambient temperature is below minus 20 °C (minus 4 °F); otherwise, permanent damage to the transformer may result.

### 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, components, and accessories are carefully inspected and tested prior to shipment from 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.



Before unloading the transformer, 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 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, when 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 during the manufacturing 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, radiators and terminal compartment. 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. If the transformer does not have a fluid level gauge or sight plug, the fluid level can be checked by removing the liquid level plug located at the 25°C mark. Prior to removing the fill plug, relieve tank pressure by operating the PRV, being careful to avoid any hot fluid that might be expelled from the valve. Exercise caution when checking the fluid level using the fluid level plug, as the fluid may spill out and may be extremely hot. When reinstalling the fill plug, apply a suitable sealing compound to the threads to ensure a proper seal. When checking the fluid level, be aware that the level will vary as a function of fluid temperature.

A transformer found to have a 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."*

 **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 energize the transformer if the fluid level is low.
- Maintain proper fluid level at all times while the transformer is energized.
- Exercise caution when checking the fluid level with the fluid level plug, as the fluid may spill and may be extremely hot.

Transformers should be stored on a firm level surface. They may also be stored in racks designed for that purpose. Transformers should not be stacked directly on top of one another, as this may damage the paint finish and cause cabinet misalignment.

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.

### **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 accidentally 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.



## SECTION 3: INSTALLATION

### Lifting and Handling

Lifting lugs or bosses are provided to lift the completely assembled transformer. All lifting lugs or bosses must be used simultaneously to provide a safe, balanced lift. The transformer must not be lifted from any points other than the provided lifting lugs or bosses. Do not use holes in the lifting hooks for lifting. These holes are for tie-down purposes only and are not suitable for lifting. Refer to the transformer nameplate to determine the total weight of the assembled transformer.

Lifting bosses, when provided, consist of 5/8"-11 threaded inserts. Lifting should be accomplished with user-installed 5/8"-11 lifting bolts that have been fully engaged into the threaded bosses and hoist rings. Do not lift with lifting bolts alone. Lifting bolts and hoist rings must be rated to safely support the weight of the completely assembled transformer. A spreader bar should be used to keep the lifting cables or straps 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.

Single-door style transformers may also be lifted with a forklift truck of adequate lifting capacity to safely handle the weight of the completely assembled transformer. Forks should be of sufficient length to extend completely through the shipping pallet or runners. Transformers should be lifted with the tank (core/coil and fluid compartment) oriented toward the forklift truck, so that the transformer center of gravity is adequately supported. Lifting transformers from the terminal compartment side is not safe, as the transformer may tip and fall.

Lifting double-door style transformers with a forklift truck is not recommended, since weight and balance can be problematic, and radiator panels can be easily damaged.

Transformers should be handled with special care when the ambient temperature is below minus 20 °C (minus 4 °F); otherwise, permanent damage to the transformer may result.

### 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.

### Jacking, Skidding and Rolling

Double-door style transformers are designed for jacking, skidding and rolling. Do not use radiator fins, bushings, valves, pipe fittings, gauges or sheet metal surfaces for jacking. Jacking must be done using the proper jacking provisions from two adjacent corners simultaneously to prevent warping of the tank bottom. When rolling, use an adequate number of rollers to distribute the transformer weight evenly. Refer to the transformer outline drawing for the total weight of the assembled 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 *General Requirements for Liquid-Immersed Distribution, Power and regulating Transformers*. 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

The transformer should be mounted on a level concrete foundation or other suitable surface, which is rated to support the weight of the completely

assembled transformer. The transformer should sit flush with the mounting surface, so that there are no gaps that might compromise tamper resistance of the terminal compartment or prevent the door from being properly secured in the closed position. The installed transformer should not tilt in any direction more than three degrees. Greater tilt may compromise insulating fluid coverage of live parts within the tank and may prevent insulating fluid from circulating properly through the cooling radiators. Improper circulation of insulating fluid may cause overheating and reduced transformer life.

The transformer should be located at least 24 inches from any obstruction and have adequate clearance to allow the terminal compartment hood or doors to open fully. Avoid locating the transformer in corrosive areas. Remove any shipping braces and packing material that may have been installed at the factory. Hold-down cleats or brackets should be used to securely fasten the transformer to the mounting surface.

#### Verifying Enclosure Integrity

Howard single-phase compartmental-type pad-mounted transformers are designed and constructed to be tamper resistant according to the requirements of IEEE Standard C57.12.28 Pad-Mounted Equipment—Enclosure Security, or C57.12.29 Pad-Mounted Equipment—Enclosure Security for Coastal Environments, as applicable, and therefore need not be installed in a restricted area. Do not modify the tank or terminal compartment in such a way that it will compromise tamper resistance. If for any reason modifications must be made to the tank or terminal compartment that compromise tamper resistance, the transformer must then be located in a restricted area. Such modifications may void the warranty. Consult with the Howard Industries Transformer Division before making any modifications to the transformer.

Refer to Section 6 for important information about lockup and verification of enclosure security.

#### Grounding

The transformer must be permanently grounded according to applicable local and national codes. Ground the transformer by using ground pads or nuts located inside the terminal compartment at the base of the front panel. Do not use hold-down bolts, pipe connections or any other fittings for ground connections. A proper low-resistance ground connection is necessary for safe operation.

In addition to proper tank grounding as stated above, transformers designed for use on a grounded-wye system must also have all winding neutrals securely and effectively grounded to the system neutral.

### **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 properly grounded at all times.

#### High-Voltage and Low-Voltage Connections

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 appropriately to prevent overheating and possible failure of the connection. Refer to the nominal torque guidelines contained in Table 3. Connections should be made with care to avoid placing undue cantilever stress on the bushings.

#### High-Voltage Terminals

Dead-front transformers are designed to use the separable insulated high-voltage connector system defined in IEEE Standard 386. These dead-front transformers come equipped with universal bushing wells only, one-piece (integral) bushings or universal bushing wells with factory-installed bushing inserts. Either loadbreak-rated or non-loadbreak-rated bushings can be provided as specified by the user.

When transformers are provided with universal bushing wells only, bushing inserts must be installed in the field by the user before cable connections can be made. Bushing well inserts must be compatible

### **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 modify the transformer in any way that might compromise its tamper-resistant construction.

with the universal bushing wells. Do not use incompatible or improperly rated bushing inserts, or equipment damage could occur. When installing inserts, follow the manufacturer's instructions accompanying the inserts. Insulated dead-end caps or plugs must be installed on all unused high-voltage bushings before energizing. Shipping dust caps must never be used in place of insulated dead-end caps or plugs.

Live-front transformers are equipped with high-voltage bushings having tin-plated eye-bolt or spade terminals that are suitable for connection with either aluminum or copper conductors to the high-voltage source.

### **Low-Voltage Terminals**

Single-phase pad-mounted transformers are usually provided with externally-clamped, molded, low-voltage bushings, with or without NEMA standard spade terminals. When threaded terminals are installed, a backup nut should be installed and tightened against the terminal to ensure an adequate connection that will not loosen or overheat. Secondary line leads should be securely attached to the terminals to ensure a low-resistance connection.

Space-Saver™ style transformers may be provided with a block-mounted, wire-lead, low-voltage termination instead of molded bushings. These wire leads are designed to be crimp-connected to the load leads.

## SECTION 4: INSPECTION AND TESTING BEFORE AND AFTER INITIAL ENERGIZATION

### 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. Do not energize the transformer without performing 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 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.**

- 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.
- Insulated dead-end caps or plugs must be installed on all unused dead-front high-voltage bushings. Dust caps must not be used in place of insulated dead-end caps or plugs.
- Current transformer (CT) leads must be connected to a metering load or shorted together and grounded to prevent dangerous voltage 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, measure the ratio at each tap position to ensure that each of the ratios is correct. 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 Test**—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 G $\Omega$ .
3. **Tap Changer Setting**—On transformers provided with taps, check the tap changer setting to ensure it is set to the proper position for the required voltage.
4. **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.
5. **Grounding**—Check to ensure that the transformer tank is securely and effectively grounded. The transformer tank ground pad is located inside the terminal compartment near the bottom of 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 the transformer does not have a fluid level gauge or sight plug, the fluid level can be checked by temporarily removing the

liquid-level plug located at the 20 °C mark. Prior to removing the plug, relieve tank pressure by operating the pressure relief valve, being careful to avoid any hot fluid that might be expelled from the valve. When reinstalling the plug, apply an appropriate thread sealing compound to prevent a fluid leak. 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 natural ester fluid
9. **Internal Fault Detector**—If the transformer is provided with an Internal Fault Detector (IFD), remove the red shipping lock after installation and before placing the transformer into service.
10. **Current Transformers**—If current transformers (CTs) 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. **Tools**—Check to make sure that all tools and equipment are accounted for.
14. **Internal Inspection**— Transformer tanks are sealed at the factory and should not be opened unless necessary. Single-door style transformer tanks are fully welded and are not accessible except through bushing openings. Double-door style transformer tanks are accessible through a bolted handhole located on the tank cover. 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.
- Insulated dead-end caps or plugs must be installed on all unused dead-front high-voltage bushings. Dust caps must not be used in place of insulated dead-end caps or plugs.
- 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 voltage is correct. Using a suitable AC voltmeter, measure the voltage of the secondary windings and make sure they



agree with the secondary voltage 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 periodically, 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 TR-1 *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.

**Locking the Terminal Compartment**—Before leaving the installation site, make sure the terminal compartment is secure. Follow the procedures "Standard Single-Door Terminal Compartment," "Hi-Lift Single-Door Terminal Compartment," or "Double-Door Terminal Compartment" section, as applicable.



## 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 single-phase pad-mounted 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 might accompany any 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.**

- Do not operate load-break equipment if a fault condition is suspected.
- Use a live-line tool (hot stick or shotgun stick) to operate transformer load-break equipment. Do not attempt to operate by hand any device that is designed to be operated with a live-line tool.
- After operating transformer loadbreak equipment, check that voltages at transformer terminals are the expected values. Checking voltages verifies that loadbreak equipment operated properly and that electrical circuit conditions are as expected.
- 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 load-break fusing and 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 natural ester fluid

### Hot-Stick Operable Devices

Some devices such as draw-out expulsion fuses, dry-well canister fuses, dead-front high-voltage elbow terminations, rotary load-break 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.

### Tap Changer

The de-energized tap changer may be used to adjust the voltage ratio of a transformer while it is de-energized. It is intended to allow adjustment of the output (secondary) voltage to the rated value. Do not use the tap changer to alter the output voltage to any voltage other than that indicated on the transformer nameplate. If the tap changer is set to provide an output voltage other than the rated secondary voltage, improper transformer operation could 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 tap changer unless the transformer is totally de-energized.
- Do not re-energize the transformer unless the tap changer handle or cap is secured in the desired position.

Tap changers usually have five or seven tap positions as indicated on the tap changer dial plate and the transformer nameplate. A locking screw is provided on the operating handle to lock the tap changer into position and prevent accidental operation. Prior to operating the tap changer on a de-energized transformer, disengage the locking screw and then rotate the handle to the desired tap position. Never operate a tap changer while the transformer is energized. Do not re-energize the transformer until the tap changer is set to the desired tap position, and the locking screw has been engaged.

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

### Multiple-Voltage Switch

Transformers designed with multiple high-voltage windings (dual-voltage or triple-voltage transformers) are provided with a de-energized multiple-voltage switch. The switch, if provided, will be indicated on the transformer nameplate.

The transformer must be completely de-energized before operating the multiple-voltage switch. Unless otherwise specified, multiple-voltage transformers 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 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.

### Load-Break Switch

The optional rotary load-break switch is located inside the terminal compartment. The switch can be designed as a two-position ON-OFF switch, or a three- or four-position sectionalizing switch. Switch positions are marked on the transformer front panel and shown on the nameplate diagram. Load-break switches are designed to be operated with a live-line tool (hot stick or shotgun stick) and should not be operated by hand.

The two-position load-break switch is operated by inserting the live-line tool into the operating handle and rotating the switch to either the ON or OFF position. The three-position or four-position load-break switch is operated by inserting the live-line tool

in the index plate and moving the plate over the peg between its present setting and the next setting. The index plate prevents the switch from switching more than one position at a time. The live-line tool is then inserted into the switch operating handle and turned until the switch snaps into the next position. Repeat this procedure until the switch is in the desired position. Do not stop and reverse direction of the switch before it has changed position, as this will damage the switch mechanism.

 **CAUTION**

**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 load-break switch by hand. Operate only using a live-line tool (hot stick or shotgun stick).
- Do not stop and reverse direction of the load-break switch before it has changed positions.

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

### Internal Weak-Link Fuse

An internal weak-link fuse (also called a cartridge fuse) is a fluid-immersed expulsion fuse, which is designed to isolate the transformer from the distribution system in the event of an internal fault on the load side of the fuse. On single-door style transformers the fuse can usually be accessed by removing one of the high-voltage bushings. On double-door style transformers, the fuse is accessible through the cover-mounted handhole. Refer to the transformer nameplate for the fuse location. When accessing the fuse, observe the precautions discussed in *“Opening the Transformer Tank.”*

 **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.

On single-door style transformers the fuse can be usually be inspected and replaced through the front panel using the following procedure.

1. Make sure that the transformer is completely de-energized and that the tank and all primary and secondary terminals are securely and effectively grounded.
2. Vent the tank by operating the pressure relief valve, being careful to avoid contact with any hot fluid that might be expelled from the PRV.
3. Tilt the transformer to the rear, so that the internal fluid level drops below the bushing opening. Alternatively, the fluid level can be lowered to replace the fuse Refer to “Removing or Lowering the Fluid.”
4. Remove the bushing clamping hardware and remove the bushing and fuse, taking care to avoid stress on the high-voltage coil lead.
5. Unbolt the fuse and replace it with a new fuse of the appropriate rating. Tighten the fuse mounting fasteners according to the recommended torque values in Table 4.
6. Clean the bushing mounting surface and inspect the bushing gasket. Replace the gasket if damaged.
7. Insert the fuse and bushing into the mounting hole and install mounting hardware. Tighten mounting fasteners according to the recommended torque guidelines in Table 4.

8. Level the transformer, re-attach hold-down cleats or brackets if previously removed, and check to make sure the bushing is not leaking fluid.
9. Energize the transformer from a remote location and check for proper operation.

On double-door style transformers the fuse can be inspected and replaced through the cover-mounted handhole using the following procedure.

1. Make sure that the transformer is completely de-energized and that the tank and all primary and secondary terminals are securely and effectively grounded.
2. Vent the tank by operating the pressure relief valve, being careful to avoid any hot fluid that might be expelled from the PRV.
3. Remove the tank hand-hole cover.
4. Identify the fuse block assembly.
5. Remove leads attached to each end of the cartridge fuse, being careful not to drop any nuts or washers into the tank.
6. Unbolt the fuse and replace it with a new fuse of the appropriate rating. Tighten the fuse mounting fasteners according to the recommended torque values in Table 4.
7. Re-install the tank hand-hole cover. Refer to *“Opening the Transformer Tank”* for instructions.

### Bay-O-Net Fuse

The optional Bay-O-Net is a fluid-immersed, draw-out, dead-front fused disconnect device that is rated for load-break operation. It is designed to be operated with a live-line tool (hot stick or shotgun stick) and should not be operated by hand. The Bay-O-Net device is located in the terminal compartment near the high-voltage bushings. The Bay-O-Net is available as an expulsion fuse device or as a full-range current-limiting fuse device. Personnel should read and follow the instructions provided by the Bay-O-Net device manufacturer for proper operating procedures and safety information.

The Bay-o-Net is designed to provide protection for the transformer and the distribution system, and can be used as a disconnect device within the ratings specified by the device manufacturer. The Bay-O-Net does not provide a visible disconnect and should not be relied on as the sole indication that the transformer is de-energized.

When the Bay-O-Net is provided as an expulsion fuse device, it is equipped with a series-connected fluid-immersed isolation link, or if specified by the customer, a series-connected partial-range current-limiting fuse. Isolation links and partial-range current-limiting fuses are designed to blow in the event of an internal transformer fault. A transformer with a blown isolation link or partial-range current-limiting fuse cannot be re-energized and must be removed from service.

## WARNING

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

- Bay-O-Net fuse devices are not recommended for fault closing. The Bay-O-Net device should not be used to re-energize a transformer that is suspected to be faulted.
- Operate the pressure relief valve to vent pressure in the transformer tank before unlatching a Bay-O-Net device to prevent hot oil from being expelled during fuse removal. Be careful to avoid hot fluid that might be expelled from the PRV.
- Operate the Bay-O-Net device with a live-line tool (hot stick or shotgun stick). Never operate the Bay-O-Net device by hand.
- After replacing a blown fuse, the transformer should be re-energized from a remote location.
- Never rely on Bay-O-Net removal as the sole indication that the transformer is de-energized.

The following procedures are intended as a general guide for operation of the Bay-O-Net device. Personnel should also read and follow the instructions provided by the Bay-O-Net device manufacturer for proper operating procedures and safety information. On single-door style transformers open the flip-top hood and secure it in the open position. On double-door style transformers open both compartment doors and engage the prop rods on each door to latch them in the open position.

**Remove Fuse Holder**—The following procedure should be used to withdraw the fuse holder from the Bay-O-Net housing.

1. Vent the transformer by operating the PRV. Keep the valve open until the sound of air venting can no longer be heard. Be careful to avoid contact with any hot oil that might be expelled from the PRV.
2. Stand to one side of the Bay-O-Net device being operated.
3. Attach a live-line tool to the holder eye.
4. Twist the live-line tool to unlock the fuse holder.
5. Rotate the holder 90 degrees clockwise in the housing to break the seal between the gasket and the housing.
6. Firmly and quickly pull the fuse holder out about 8 to 10 inches to open the circuit. Wait a few seconds while the fluid drains back into the tank, and then completely withdraw the fuse holder. Wipe the fuse holder and cartridge to remove excess fluid.
7. If fluid continues to flow from the Bay-O-Net device, operate the pressure relief valve again to vent pressure from the tank.

**Replace Fuse Link**—Replace the fuse according to the manufacturer's instructions included with the replacement fuse.

**Re-Insert Fuse Holder**—Re-insert the fuse holder using the following procedure.

1. Using a live-line tool attached to the eye of the fuse holder, re-insert the holder firmly into the Bay-O-Net housing.
2. Twist the locking handle, latching it to the shoulder of the Bay-O-Net housing. Make sure that the metal washer is positioned tightly on the end of the Bay-O-Net housing.
3. Inspect the fuse holder carefully to make sure it is fully seated and latched properly.

### **Dead-Break Dry-Well Canister Fuse**

The optional dead-break dry-well canister is a fluid-tight current-limiting fuse holder. It is designed to be operated with a live-line tool (hot stick or shotgun stick) and should not be operated by hand. The dry-well canister is mounted on the transformer front panel near the high-voltage bushings.

Dead-break dry-well canisters are not designed to break load and must only be operated when the transformer is de-energized. When specified, dry-well canisters are mechanically interlocked with a load-break switch to prevent removal of the fuses while the transformer is 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 operate a dead-break canister fuse device while the transformer is energized.
- After replacing a blown current-limiting fuse, the transformer should be re-energized from a remote location.

The following procedures are intended as a general guide for operation of the canister fuse device. Personnel should also read and follow the instructions provided by the canister fuse device manufacturer for proper operating procedures and safety information.

**Remove Fuse Holder**—The following procedures should be used to remove the fuse holder.

1. Make sure the transformer is de-energized.
2. Attach a live-line tool to the hook eye.
3. Quickly pull the fuse holder assembly completely from the housing.

**Replace Fuse**—The fuse should be replaced using the following procedure.

1. Unscrew the fuse from the fuse holder.
2. Replace with new fuse of the appropriate rating and characteristics.
3. Tightly screw the new fuse onto the fuse holder.

**Re-Insert Fuse Holder**—Re-insert the fuse holder using the following procedure.

1. Attach a live-line tool to the hook eye.
2. Insert the fuse holder into the housing.
3. Push the fuse holder in firmly until the dust cap seats against the housing and grounding clip.



### Internal Partial-Range Current-Limiting Fuse

The optional internal partial-range (backup) current-limiting fuse is connected in series with a low-current interrupting device, such as a weak-link cartridge fuse or a Bay-O-Net expulsion fuse. The partial-range current-limiting fuse is designed to clear low impedance (high current) faults, while expulsion fuses are designed 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 blown, the transformer should be considered faulted and removed from service.

### S&C Arc-Strangler

The optional S&C Arc-Strangler is a 200 Ampere, air-insulated, load-break device that is designed to be operated with a live-line tool (hot stick or shotgun stick) and should never be operated by hand. The Arc-Strangler device may include a full-range current-limiting fuse on the switch blade or a clip-style current-limiting fuse.

The following procedures are intended as a general guide for operation of the Arc Strangler device. Personnel should also read and follow the instructions provided by S&C for proper operating procedures and safety information. To operate the switch, insert the live-line tool in the operating hook and pull forward, swinging the Arc-Strangler open. To remove the Arc-Strangler, insert the live-line tool in the hinge opening and lift up.

## WARNING

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

- Arc-Strangler devices are not recommended for fault closing. Arc-Strangler devices should not be used to re-energize a transformer that is suspected to be faulted.
- Operate Arc-Strangler device with a live-line tool (hot stick or shotgun stick). Never operate by hand.
- After replacing a blown fuse, the transformer should be re-energized from a remote location.

### S&C Fused Switch

The optional S&C fused switch should be operated according to instructions provided by S&C. S&C tools should be used to operate an S&C fused switch.

### Surge Arrester

The optional surge arrester is used to protect the transformer and underground cable from damage due to voltage surges. A 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.

## 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 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.

### Internal MOV Surge Arrester

The 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 oil temperature exceeding 90°C (194°F) and a maximum oil 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 into service.



An optional arrester disconnecter provides a means to disconnect the fluid-immersed MOV arrester ground for transformer testing without entering the transformer tank. Two different styles of disconnecters are available, one manufactured by ERMCO Components Inc. (ECI) and one manufactured by Cooper Power Systems (CPS). These two styles operate differently as indicated below.

Before testing the transformer, disconnect the arrester using the following procedure.

1. Make sure the transformer tank is properly grounded.
2. De-energize the transformer from a remote location.
3. Ground all bushings and terminals.
4. Disconnect the MOV arrester by operating the disconnecter as described below.

For the CPS disconnecter (identified by an external black plastic cap):

- a. Unscrew the black disconnecter cap from the shaft.
- b. Re-attach the small diameter end of the disconnecter cap to the shaft.
- c. Push the handle and shaft toward transformer until the shaft flange is flush to the sealing gland.

For the ECI disconnecter (identified by a 7/16" square brass metal head):

- a. Unscrew the 7/16" square metal head until the thread disengages.
- b. Pull the shaft out to its full extent (approximately 2").

5. It is now safe to perform impulse, induced-potential or applied-potential tests.

After testing the transformer, reconnect the MOV arrester using the following procedure.

1. Make sure the tank is properly grounded.
2. De-energize the transformer from a remote location.
3. Ground all bushings and terminals.
4. Reconnect the MOV arrester by operating the disconnecter as described below.

For the CPS disconnecter:

- a. Pull the disconnecter handle and shaft fully away from transformer.
- b. Unscrew the black disconnecter cap and re-attach it with the large diameter end toward the transformer. Rotate the cap clockwise to tighten.
- c. Reinstall the black cap.

For the ECI disconnecter:

- a. Push the shaft inward until the threads engage.
- b. Tighten the 7/16" square head according to the torque guidelines listed in Table 4.

On double-door style transformers the arrester disconnecter may not be provided, and the fluid-immersed MOV arrester must be manually disconnected before testing by opening the transformer tank. Refer to "Opening the Transformer Tank" for instructions.

The MOV arrester can be manually disconnected using the following procedure.

1. Make sure that tank is properly grounded.
2. De-energize the transformer from a remote location.
3. Ground all bushings and terminals.
4. Relieve pressure inside the tank by operating the pressure relief valve, being careful to avoid any hot fluid that might be expelled from the valve.
5. Remove the tank cover.
6. Locate the disconnect point to which the arrester line lead is attached.
7. Disconnect the arrester lead from its junction point and isolate the lead end at least six inches from any other part of the transformer.
8. It is now safe to perform impulse, induced-potential or applied-potential tests.

The following procedure should be followed to manually reconnect the arrester lead.

1. Reconnect the arrester lead to its junction point using the hardware previously removed.
2. Re-install the tank cover.

### Low-Voltage Circuit Breaker

The optional low-voltage circuit breaker is mounted inside the tank and is fluid immersed. The 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.

## **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 the secondary terminals.
- Operate the low-voltage circuit breaker with a live-line tool (hot stick or shotgun stick). Never operate by hand.

The circuit breaker is a thermal trip device provided for transformer protection. It 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 secondary is de-energized. The circuit breaker operating handle is located in the terminal compartment near the low-voltage bushings 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 an optional emergency overload capability. The emergency overload lever is located adjacent to the main 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.

### 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 that 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 S340-34-1.

The operating handle is located in the terminal compartment 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.

### Other Switching and Fusing Devices

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

## **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.

## SECTION 6: OPERATION OF TERMINAL COMPARTMENT, 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 draw-out expulsion fuses, dry-well canister fuses, dead-front high-voltage elbow terminations, rotary load-break 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 front panel in the terminal compartment 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 DEATH OR SERIOUS 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 optional fluid level gauge is a dial-type device that indicates the fluid level inside the transformer tank. The gauge is mounted on the front panel in the terminal compartment at the normal 25 °C fluid level.

If the gauge reads “LOW,” 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. Transformers may also be provided with an optional sight plug instead of a gauge to allow direct observation of the fluid level.

### Fluid Temperature Gauge

The optional 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 front panel in a dry leak-proof well, permitting removal of the gauge without exposure to the tank fluid.

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 level 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 (usually 85 °C rise). Refer to IEEE Standard C57.91 Guide for Loading Mineral-Oil-Immersed Transformers for loading recommendations.

### Drain Valve and Sampling Device

The optional drain valve and sampling device permits draining the transformer fluid and sampling the fluid for testing purposes. The valve is located in the ter-

minal compartment at the bottom of the front panel. Refer to “*Sampling and Testing the Fluid*” for the fluid sampling.

### Automatic Pressure Relief Valve

The automatic pressure relief valve (PRV) is designed to relieve excessive tank pressure that might occur during normal 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 gas pressure in the tank exceeds the PRV’s specified limit, the gas 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. When specified, PRV’s are provided with optional switch contacts, which can be used to provide a remote alarm.

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

### Internal Fault Detector

The optional 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 is not a disconnect device. It provides only a visual indication that an internal fault has occurred. Personnel should read and follow the instructions provided by the IFD device manufacturer for proper operating procedures and safety information.

## 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. It is not an electrical disconnect device, and should not be relied on as such.

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. The valve can be operated manually using the pull-ring.

The IFD incorporates a removable shipping lock for transportation and storage. The shipping lock must be removed after transformer installation. Always transport IFD-equipped transformers with the shipping lock installed to prevent accidental operation of the device.

### High-Voltage Bushings

Single-phase pad-mounted transformers with dead-front construction are provided with externally-clamped universal bushing wells only, one-piece (integral) bushings or universal bushing wells with factory-installed bushing inserts. One-piece bushings and bushing inserts are designed to interface with separable insulated elbow connectors, and can be provided as either load-break or non load-break devices. When transformers are provided with bushing wells only, inserts must be installed by the user before cable connections can be made. High-voltage terminations may be configured for radial feed (one termination) or loop feed (two terminations).

Single-phase pad-mounted transformers with



live-front construction are usually provided with externally-clamped porcelain high-voltage bushings for connection to the high-voltage source. Bushings are usually provided with tin-plated eye-bolt terminals that are suitable for connection to either aluminum or copper conductors.

 **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 place excessive cantilever load on a low-voltage or high-voltage bushing.

### Low-Voltage Bushings

Single-phase pad-mounted transformers are usually provided with externally-clamped molded low-voltage bushings, with or without spade terminals. When threaded terminals are installed, a backup nut should be installed and tightened against the terminal to ensure an adequate connection that will not loosen or overheat. Secondary line leads should be securely attached to the terminal to ensure a low-resistance connection and prevent overheating.

Space-Saver™ transformers may be provided with block-mounted wire-lead low-voltage leads. These should be crimped to the secondary line leads using the appropriate crimp connectors and crimping tool. Follow instructions provided by the crimping tool manufacturer.

### Current Transformers

Optional current transformers (CT's) are designed to be mounted around each low-voltage line terminal for metering applications. Transformers are shipped from the factory with CT leads shorted together and grounded. If the CT's are not connected to a metering load, they must remain shorted and grounded to avoid hazardous voltage at the CT secondary terminations.

 **WARNING**

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

CT leads must be connected to a metering load or short-circuited and grounded before the transformer is energized to avoid hazardous voltage at the CT terminals.

### Accessory Brackets

An accessory bracket (parking stand) is provided on dead-front construction, located inside the terminal compartment near the high-voltage bushings. This bracket is used as a mounting location for portable feed-through bushings, insulated standoff bushings and other similar accessory devices. Follow accessory manufacturer's instructions for mounting and using any accessory devices.

### Terminal Compartment

Single-phase pad-mounted compartmental-type transformers are designed and constructed to be tamper resistant according to the requirements of IEEE Standards C57.12.28 or C57.12.29, as applicable, and as such are provided with an enclosed terminal compartment, a penta-head security bolt and provision for a padlock. Standard penta-head sockets can be obtained from Snap-On Company (P/N B2191) or from other tool distributors.

### Standard Single-Door Terminal Compartment

The standard single-door style pad-mounted transformer is designed with a terminal compartment consisting of hinged, lift-up hood and base sill. The hood can be opened after removing the padlock and disengaging the penta-head security bolt. The hood can be completely removed when in the fully-open position.

Before leaving the installation site, make sure the terminal compartment is closed and secure, using the following procedure.

1. Close the lift-up hood.
2. Fully engage the penta-head security bolt.
3. Install a suitable heavy-duty padlock.



4. Carefully check the transformer to make sure the cabinet is secure and tamper proof. Make sure the transformer and sill are sitting flush on the mounting pad with no gaps that might allow entry of a foreign object into the terminal compartment.

#### **Hi-Lift™ Single-Door Terminal Compartment**

The optional Hi-Lift™ single-door style pad-mounted transformer is designed with the latch handle and padlock provisions located on the front surface of the lift-up hood, rather than on the base sill. The hood can be opened after removing the padlock, disengaging the penta-head security bolt, and rotating the latch handle fully outward. An interlock mechanism prevents the latch handle from closing while the lift-up hood is in the open position. The hood can be completely removed when in the fully-open position.

Before leaving the installation site, make sure the terminal compartment is closed and secure, using the following procedure.

1. Make sure the transformer and sill are sitting flush on the mounting pad with no gaps that might allow entry of a foreign object into the terminal compartment.
2. Make sure the transformer sill has been secured to the pad with cleats or other satisfactory method.
3. Close the lift-up hood.
4. Observe the sides of the terminal compartment to make sure that the lift-up hood rests squarely on the sill with no gaps. Proper fit-up is necessary for securing the lift-up hood in the closed position.
5. Rotate the latch handle fully inward.
6. Fully engage the penta-head security bolt.
7. Install a suitable heavy-duty padlock.
8. Carefully check the transformer to make sure the cabinet is secure and tamper proof. Grasp the bottom edge of the lift-up hood and pull upward briskly to make sure the hood is securely latched.

### **WARNING**

**FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY.**

- Do not depress the unpainted interlock lever located inside the lift-up hood, as this will prevent the lift-up hood from being secured in the closed position.
- Follow instructions on all warning and informational labels posted inside the terminal compartment.
- Before leaving the transformer, carefully check the security of the lift-up hood to make sure it is properly secured in the closed position and cannot be opened.

#### **Double-Door Terminal Compartment**

The double-door style pad-mounted transformer is designed with a terminal compartment consisting of a terminal compartment cover, two hinged doors and a base sill. The secondary-side door can be opened by removing the padlock, disengaging the penta-head security bolt and rotating the door handle. The primary-side door may be fastened with one or more security bolts, which must be disengaged to open the door. Latch rods located at the bottom of each door can be used to secure doors in the open position.

The double-door style pad-mounted transformer may also be equipped with a flip-top terminal compartment cover, which can be raised to facilitate operation of the optional Bay-O-Net fuse and to provide clearance for pulling cables into the terminal compartment. To open the cover, disengage the center security bolt and rotate the cover upward. A latch is provided to secure the cover in the open position.

Lift-off door hinges are provided on double-door style pad-mounted transformers, so that the compartment doors can be removed when in the open position.

Before leaving the installation site, make sure the terminal compartment is closed and secure, using the following procedure.

1. Close the flip-top cover, if present.
2. Close the primary compartment door and engage

each security bolt.

3. Close the secondary compartment door and turn the handle to the closed position. Fully engage the secondary compartment door security bolt.
4. Install a suitable heavy-duty padlock.
5. Carefully check the transformer to make sure the cabinet appears to be secure and tamper proof. Make sure the transformer and sill are sitting flush on the mounting pad with no gaps that might allow entry of a foreign object into the terminal compartment.

#### **Other Accessory Devices**

Transformers may be provided with accessory devices not discussed in these instructions. In such cases contact the Howard Industries Transformer Division if additional information is needed.

## SECTION 7: MAINTENANCE AND REPAIR

These instructions are intended as a general guide for the maintenance of Howard single-phase pad-mounted 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.

### **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**

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 malfunction or damage. Gauges should be checked periodically to make sure they are operating properly.

### **Inspection Checklist**

Observing the safety instructions above, open the terminal compartment and perform the following checks.

1. De-energize the transformer and ground all

terminals

2. Inspect for dents or other damage to metal surfaces and make the necessary repairs.
3. Inspect the cabinet for evidence of tampering and immediately repair any damage to ensure cabinet integrity and prevent unauthorized entry.
4. 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.
5. Inspect all surfaces thoroughly for evidence of fluid leaks, including tank, radiators, bushings, gauges, switches, valves, fuse holders and all other accessories and fittings. Check the fluid level gauge or sight glass (if either of these is present) to determine the fluid level. Check the pressure-vacuum gauge (if present) for a zero reading, which indicates the possibility of a tank leak. The pressure-vacuum gauge may indicate zero occasionally, but normally indicates a slight positive or negative pressure, as a function of fluid and ambient temperatures. Perform a pressure test according to the instructions in the “Pre-Energization Inspection and Tests” section. Add fluid as necessary to ensure that the proper fluid level is maintained. Repair as necessary. Fluid leaks should be repaired immediately to prevent serious damage to the transformer and an unsafe operating condition. Refer to “Fluid Leaks” for instructions.
6. 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 appropriate gasket cement when installing new gaskets. Do not reuse old gaskets. Six months after replacing a gasket, check and re-tighten, if necessary.
7. Maintain a clean and unobstructed area around the transformer, including sufficient clearance around radiator panels, to ensure adequate cooling of the transformer.
8. Inspect the base of the transformer tank and terminal compartment and make sure that there

is no accumulated dirt or other debris that might promote corrosion.

9. Inspect the base of the terminal compartment and make sure that it is sitting level and flat on the mounting pad with no gaps that might compromise tamper-resistance.
10. Check bushings, gauges, switches, fuse holders, valves and all other accessories for proper operation and repair or replace any defective devices.
11. Check all fasteners for signs of corrosion and replace as necessary.
12. 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. If the fluid level is low, add fluid according to the instructions in the “Filling with Fluid” section.
13. 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.
14. Check the torque values on all electrical connections, including all ground connections and tighten as necessary. Refer to the torque guidelines contained in Tables 1 through 4.
15. Replace any damaged or unreadable nameplates, instructional labels, and safety labels.
16. 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 natural ester fluid (such as Envirotemp FR3), refer to IEEE Standard C57.147 Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers. For transformers filled with silicone fluid, contact the Howard Industries Transformer Division for testing recommendations.

### Electrical Tests

The following electrical tests can be used to determine the condition of the transformer. Follow the instructions and precautions provided by the test equipment manufacturer. Contact the Howard Industries Transformer Division to discuss any of these tests.

## 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. Turns Ratio Test. Refer to “*Ratio Test*” for instructions.
3. Insulation Power Factor Test.
4. Fluid quality tests, such as 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 high-quality touchup 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 and at tank fittings, such as bushings, gauges, plugs and valves. 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.

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 some cases silicone lubricant used to install high-voltage bushing inserts can flow onto the front panel, giving a false indication of a fluid leak.

In addition to the presence of fluid residue, a low reading on the optional fluid level gauge and a constant zero reading on the optional pressure/vacuum gauge (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 nitrogen through the pressure test 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 to all welds, joints, pipe fittings, and cable connections.

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 panel-type radiators is not recommended due to the thin gauge material used in its construction. Very small pin-hole leaks can sometimes be repaired using an epoxy patch kit designed to repair fluid 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

## 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.



sounds should be investigated, as this might indicate a potential problem.

Refer to NEMA Standards Publication TR-1 *Transformers, Regulators and Reactors*, and IEEE Standard C57.12.90 *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 is inaccessible (except in the double-door style transformer) and typically requires no maintenance.

### **Magnex Interrupter**

The Magnex Interrupter typically requires no maintenance except for replacement in the event of malfunction or damage.

### **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.

### **Sampling and Testing the Fluid**

Before sampling the insulating fluid, de-energize the transformer from a remote location 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 any 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 results satisfy the requirements of IEEE Standard C57.106 for mineral oil, IEEE Standard C57.147 for natural ester fluids and IEEE Standard C57.212 for transformers filled with less-flammable high molecular weight hydrocarbon insulating fluid (such as R-Temp). 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 other 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. If cover removal is required, follow the procedure outlined in the “Opening the Transformer Tank” section.
3. Connect the pump inlet hose to the drain valve at the base of the transformer tank. In the case of a double-door style transformer, the inlet hose can be inserted through the cover-mounted handhole and placed at the bottom of the tank.
4. Use a clean, dry temporary storage container to contain the fluid.
5. Place the pump discharge hose nozzle at the bottom of storage container.
6. Pump slowly, and do not allow the fluid to splash into the container, as this will introduce air and moisture into the fluid.
7. Do not lower the insulating fluid below the top of the core/coil clamp pan, as exposing coils could allow moisture to contaminate coil insulation.

### **Filling with Fluid**

When filling the transformer with insulating fluid, fill with the same type of fluid. Do not mix different types of fluids. Care should be taken to avoid introduction of air bubbles during the filling process. After filling 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. Connect the pump discharge hose to the drain valve at the base of the transformer tank to prevent aeration and the introduction of bubbles.



In the case of a double-door style transformer, the discharge hose can be inserted through the cover-mounted handhole and placed at the bottom of the tank.

4. Fill the transformer tank slowly. Fill with fluid to fill line marked inside the transformer tank on the interior surface of the front panel. If the fill line cannot be viewed, use the indication on the fluid level gauge or sight plug (if provided) or fill to the bottom of the fill plug.

### 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.

## 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 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.
- 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.
- Never allow anyone to enter the transformer tank until an analysis of the air inside the tank indicates at least 19.5% oxygen.
- Whenever someone is inside the tank, a person should be stationed near the handhole to ensure the safety of the person inside the tank.

Transformer tanks 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.

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. Should it be 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 “Removing or Lowering the Fluid” and “Filling with Fluid.”

Personnel should not be permitted on top 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.

When working on a double-door style transformer, the following procedure should be used to remove the handhole cover.

1. Thoroughly clean the handhole cover. Remove all moisture, dirt, and grease to avoid contaminating the transformer tank.
2. Relieve internal tank pressure by manually operating the pressure relief valve, taking care to avoid any hot oil that might be expelled.
3. Remove and retain cover fasteners.
4. Gently pry the cover upward, making sure that the cover gasket does not fall into the tank. Lift the cover vertically to prevent damage to cover, bolts, and gasket.
5. Remove the gasket from the handhole flange.

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

1. Place the gasket in its original position. If the gasket is damaged, it should be replaced.
2. Re-install the handhole cover. Re-install fasten-

ers according to the torque recommendations in Table 1. After tightening all fasteners, re-torque each one to ensure proper torque.

- Pressurize the headspace to 3-4 PSIG and check for fluid leaks. This pressure should be maintained for at least four hours, followed by another leak check.

### Torque Guidelines

Tables 1 through 4 below contain recommended torque values for tightening various connections on the transformer. Be aware that connections with gaskets and those involving rubber components (such as high-voltage bushing inserts) will normally relax after initial tightening.

Do not over-tighten any connection; otherwise, gaskets might 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 Cabinet Fasteners**

Fastener Type	Nominal Torque	Torque Range (in-lbs)
Penta-head security bolt	100	80-120
3/8" bolt	550	500-600
Hand-hole cover bolt	190	170-210

**Table 2: Torque Guidelines for External Bushing Mounting Hardware**

Mounting Type	Nominal Torque <sup>①</sup> (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 Bushing Terminal Connections**

Terminal Type	Nominal Torque <sup>②</sup> (in-lbs)	Torque Range
High-voltage molded bushing insert <sup>①</sup>	180	170-190
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

① Apply silicone grease before installation according to the insert manufacturer's instructions.

② 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 Torque <sup>①</sup> (in-lbs)	Torque Range
Bay-O-Net fuse cartridge end plug	70	60-80
Bay-O-Net fuse holder-to-cartridge connection	70	60-80
Bushing-mounted weak-link fuse mounting bolts	150	140-160
Dry-well fuse canister clamp	60	40-80
Fluid-level sight plug	600	480-720
Fill plug	960	900-1020
Drain plug	960	900-1020
Drain valve	600	480-720
Automatic pressure relief valve, 1/4" NPT	180	160-200
Automatic pressure relief valve, 1/2" NPT	180	170-190
Neutral strap fastener (at ground pad)	160	140-180
Series/multiple, delta/wye or tap switch mounting nut	120	96-144
MOV arrester disconnect nut (ECI brand)	120	96-144
Ground connector	160	140-180
Rotary load-break switch mount (Central Moloney brand)	1200	1100-1300
Rotary load-break switch mount (Cooper Power brand)	600	480-720
Rotary load-break switch handle, Allen screw	55	45-65

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 transformers. 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 for all circumstances.

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

**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 transformer cover or hand-hole cover, and then completely purging the interior with pure air or an inert gas such as nitrogen.

To avoid death from suffocation, never allow anyone to enter the interior of a transformer tank unless an analysis of the air in the tank shows at least 19.5% oxygen content. Whenever anyone is in the tank a person should be stationed at the manhole outside the tank to ensure the safety of the person inside.



**HI-104**

**Instructions for the Installation, Operation, and Maintenance  
of Single-Phase Pad-mounted Distribution Transformers**

**(Note: For submersible transformers refer to Instructions HI-107.)**

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