Document 2.4.128, Revision 3
October, 2017

Instructions (HI-110)

Installation, Operation, and Maintenance of Secondary Network Transformers

Howard Industries
Distribution Transformer Division

READ THIS IMPORTANT SAFETY INFORMATION

Read these instructions carefully and become familiar with the equipment before proceeding with installation, operation, or maintenance activities. This equipment contains extremely hazardous voltages. To prevent death, serious personal injury, or equipment damage, all information in these instructions should be read and observed. Safe use of this equipment is dependent on proper installation, operation, and maintenance procedures.

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

- DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious personal injury and may 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 may also result in equipment damage.
- CAUTION indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate personal injury and may also result in damage to the equipment.

Personnel should not attempt to service this 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 (such as rubber gloves, safety glasses, protective clothing, hard hats, etc.) and trained in appropriate first aid procedures.

The instructions contained herein are intended to be a general guide for the installation, operation and maintenance of this equipment, when operated in “Usual Service Conditions” as defined in IEEE Standard C57.12.00. Although efforts have 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 equipment designs. Standard and optional features are subject to change without notice. Howard Industries makes no representation or warranty with respect to and assumes no responsibility for the completeness, accuracy, sufficiency, or usefulness of these instructions.

These instructions do not cover the installation, operation or maintenance of the secondary network protector or any other accessory equipment installed by the user. Users should refer to instructions provided by the manufacturer of such equipment.

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.

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SECTION 1: INTRODUCTION

This document is intended as a general guide for the installation, operation and maintenance of Howard Industries secondary network transformers. Although efforts have 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. Howard network transformers are designed in accordance with IEEE Standard C57.12.40, *Secondary Network Transformers, Subway and Vault Types (Liquid Immersed)- Requirements.*

The instructions contained herein are applicable to transformers operated in normal 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, INSTRUCTIONS 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, outline drawings, and other pertinent information for use during inspection. The transformer outline drawing indicates the location of nameplates and provides physical dimensions and weights. The nameplate provides electrical characteristics, winding connections, and weights. The wiring diagram provides details of any control and alarm wiring that might have been supplied.

Lifting and Handling

Lifting hooks are provided on the sides of the transformer tank near the tank cover. All four lifting hooks must be used simultaneously for lifting. The transformer must not be lifted from any points other than the provided lifting hooks. Do not use holes in the lifting hooks for lifting. These holes are for tie-down purposes only, and are not suitable for lifting. Do not use the cover-mounted lifting eyes for lifting the entire transformer, as these lifting eyes are suitable for lifting the cover plate only.

Transformers should be lifted in an upright position, allowing no more than 15 degrees of tilt from vertical. Lifting cables should be no more than 20 degrees from vertical. Spreader bars should be used to keep the lifting cables nearly vertical, enabling a safe lift and reducing the likelihood of tank deformation or damage to painted surfaces.

Lifting the transformer with a forklift is not recommended, since weight and balance can be problematic and radiator panels can be easily damaged. Refer to the transformer nameplate to determine the total weight of the assembled transformer. Special care must be taken when handling transformers when the ambient temperature is below minus 20°C (minus 4°F); otherwise, permanent damage to the transformer may result.

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 after 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.

⚠ WARNING

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

- **Use a crane, suitable lifting cables or straps, and a spreader bar to unload the transformer.**
- **Do not unload using a forklift. Keep unnecessary personnel clear while unloading and moving the transformer.**

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 bill of lading. Also, check the nameplate for kVA rating, primary voltage rating, secondary 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. Check the main tank, primary switch chamber and primary terminal chamber for indication of fluid leaks, looking carefully at weld seams, bushings, gauges, valves and all other main tank and chamber 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"* section for information about the repair of fluid leaks.
4. Check for external damage including dents or scratches on the main tank walls, radiators, primary switch chamber and primary terminal chamber. 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.
5. Check for broken, cracked, or damaged bushings, gauges, valves and other fittings and accessories.
6. Check for missing or damaged component parts that may have shipped separately from the transformer.

Fluid Levels

The transformer and primary switch chamber are shipped from the factory with insulating fluid filled to the proper level. When provided, the primary terminal chamber is also filled with fluid at the factory when the transformer is equipped with dead-front separable insulated bushings or bushing wells. Before energizing the transformer, verify proper fluid levels by observing the fluid level gauges. The fluid level gauge pointer should be between the "High" and "Low" mark, and point approximately at the 25°C mark.

A transformer found to have a low fluid level should be checked for potential leaks, repaired as necessary and filled to the proper level with the same type of liquid as specified on the transformer nameplate. If fluid must be added, refer to *"Filling with Fluid"* for instructions.

Internal Inspection

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

⚠ WARNING

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

- **Do not energize the transformer if the fluid level is low.**
- **Maintain proper fluid level while the transformer is energized.**

Fluid Sampling

Sampling and testing of the fluid is not required unless there is an indication that moisture or other contaminants have accidently entered the main tank, switch chamber, or terminal chamber during transit. If moisture or contaminants in the fluid are 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 can 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.

If the transformer is to be stored for an extended period of time before being placed into service, it should be stored on a firm level surface. The gas space above the insulating fluid should be pressurized with dry nitrogen to a pressure of 2-3 PSIG. This will prevent a negative internal pressure that might draw moisture into the main tank, switch chamber, or terminal chamber. Prior to storage, be sure that the primary bushings or bushing wells are fitted with their protective dust covers, and the secondary throat shipping guard is installed.

The transformer should be inspected periodically while it is in storage. Ensure that an effective pressure seal is maintained, and check for leaks and corrosion. Any damage or defect should be repaired immediately.

SECTION 3: INSTALLATION

Lifting and Handling

Lifting hooks are provided near the top of the transformer tank for lifting. All four lifting hooks must be used simultaneously. The transformer must not be lifted from any points other than the provided lifting hooks. Do not use holes in the lifting hooks for lifting. These holes are for tie-down purposes only and are not suitable for lifting. Do not use the cover-mounted lifting eyes for lifting the entire transformer, as these lifting eyes are suitable for lifting the cover plate only.

Transformers should be lifted in an upright position, allowing the transformer to tilt no more than 15 degrees from vertical. Lifting cables should be no more than 20 degrees from vertical. Spreader bars should be used to keep the lifting cables nearly vertical, enabling a safe lift and reducing the likelihood of tank deformation or damage to painted surfaces.

Lifting the transformer with a forklift is not recommended, since weight and balance can be problematic and radiator panels can be easily damaged. Refer to the transformer nameplate to determine the total weight of the assembled transformer. Special care must be taken when handling transformers 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 MAY ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- **Use a crane, suitable lifting cables or straps, and a spreader bar to unload the transformer.**
- **Do not unload using a forklift.**
- **Keep unnecessary personnel clear while unloading and moving the transformer.**

Jacking

The transformer base is designed for jacking. Do not use radiator fins, bushings, valves, 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. Do not allow the jack to come into contact with panel radiators. 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. 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 of sufficient strength to support the weight of the completely assembled transformer including the network protector and any other attached accessories. The transformer should sit flush with the surface of the mounting surface, so that the transformer’s weight is evenly distributed. The installed transformer should not tilt in any direction more than three degrees. Greater tilt may compromise insulation fluid coverage of live parts and may prevent insulating fluid from circulating properly through the cooling radiators. Improper circulation of insulating fluid may cause overheating and result in reduced transformer life.

When network transformers are installed in vaults or compartments, it is necessary to provide adequate ventilation. The amount of air flow necessary will

depend on the transformer kVA, efficiency and load cycle. Forced ventilation may be required to adequately cool the transformer. Refer to the National Electric Code for recommended vault ventilation.

Before placing the transformer in service, remove any shipping braces and packing material that may have been attached at the factory.

Grounding

The transformer must be permanently grounded according to applicable local and national codes. Ground the transformer by using the grounding provisions located on the exterior surface of the main tank. Do not use hold-down bolts, pipe connections or any other fittings for ground connections. A proper low-resistance ground is critical for safe operation.

Transformers with a grounded-wye primary winding and a wye secondary winding are designed for electric distribution systems that have a grounded neutral. All windings designed for grounded neutral operation must be permanently and solidly grounded to the system neutral.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY AND MAY ALSO RESULT IN DAMAGE TO THE EQUIPMENT.
The transformer must be properly grounded at all times.

Primary and Secondary Connections

Before making primary and secondary connections, check to make sure that all mating connector surfaces are clean and smooth. Connections must be tightened appropriately to prevent overheating and possible subsequent failure of the connection. Refer to Table 5 for torque recommendations. Connections should be made with care to avoid placing undue stress on the bushings.

Primary Connections

Network transformers are supplied with a high-voltage entrance as specified by the user, usually consisting of dead-front bushings or wiping sleeves for connection to the high-voltage source. Dead-front bushings may be one-piece (integral) bushings or universal wells with or without factory-installed inserts. One-piece (integral) bushings and bushing inserts are designed to interface with insulated elbow connectors, and can be supplied for either load-break or non load-break operation.

When transformers are supplied with bushing wells only, inserts must be installed in the field before cable connections can be made. Bushing well inserts must be compatible with the universal bushing well. Do not use incompatible or improperly rated inserts, or equipment damage might occur. When installing bushings or cable accessories, follow the installation instructions provided by the equipment manufacturer.

Secondary Connections

Network transformers are normally supplied with provisions for connection to a network protector. These provisions consist of three externally-replaceable bushings bolted to the main tank within the secondary throat, three flexible connectors for electrical connection to the network protector, and a secondary neutral pad welded to the main tank. When a fully-insulated neutral bushing is provided, it must be effectively grounded to the system neutral for proper operation.

SECTION 4: INSPECTION AND TESTING

⚠ DANGER

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

- **Do not energize the transformer using single-phase switches or fuses. Use only gang-operated three-phase switches to energize a three-phase transformer**
- **Do not energize the transformer if the primary switch handle is in the "GROUND" position**
- **Do not operate the transformer with any of the primary phases open.**
- **Only qualified personnel with appropriate equipment should measure transformer voltages.**
- **Wear personal protective equipment to prevent injury from potential arc-flash or contact with dangerous voltages.**
- **Make sure the transformer is properly 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.**
- **CT leads, if supplied, must be connected to a metering load or shorted together and grounded to prevent dangerous voltages at the CT terminals.**
- **Do not operate the tap switch while the transformer is energized from either the primary or secondary side.**

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.

1. **Continuity and Winding Resistance Test**
   Perform a continuity test to confirm continuity of all windings. Perform a winding resistance test and compare the measured values with factory test data. An increase of more than 10% may indicate a loose internal connection.

2. **Ratio Test**
   Using a transformer turns ratio (TTR) tester, perform a ratio test to verify the proper 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 verify 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.

3. **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. Insulation resistance should measure at least 1.0 GΩ.

   An insulation resistance test must not be performed on a wye-wye connected transformer with an Ho-Xo bushing without first disconnecting the internal connection between the primary and secondary neutrals. This connection can be found on a terminal

board located under oil in the transformer tank. Refer to "*Opening the Transformer Tank"* for instructions.

4. **Tap Changer Setting**
For transformers supplied with high-voltage taps, check the tap changer setting to ensure it is set to the proper position for the required voltage. The tap changer setting must not be changed while the transformer is energized. Unless otherwise specified, tapped transformers will be shipped from the factory with the tap switch set to the nominal position.

5. **Series/Multiple and Delta/Wye Switch Settings**
For transformers supplied with a delta/wye and/or series/multiple switch, check switch settings to make sure they are set to the correct position. If delta/wye or series/multiple connections are made using an internal terminal board instead of a switch, check to ensure that these connections are made properly according to the chart on the transformer nameplate. Refer to *"Opening the Transformer Tank"* for instructions. Neither the series/multiple nor delta/wye switch setting should be changed while the transformer is energized. Unless otherwise specified, transformers are shipped from the factory with series/multiple and delta/wye connections set to the highest voltage.

6. **Grounding**
Check to ensure that the transformer tank is permanently and effectively grounded.

7. **Bolted Connections**
Check all bolted connections for tightness, referring to nominal torque guidelines contained in Tables 3 through 6.

8. **Fluid Levels**
The transformer main tank and primary switch chamber are shipped from the factory with insulating fluid filled to the proper level, indicated by the 25°C mark on the fluid level gauge. Before energizing the transformer, verify proper fluid levels by observing the gauges. Be aware that fluid levels vary with fluid temperature. A transformer found to have a low fluid level should be checked for potential leaks, repaired as necessary and filled to the proper level with the same type of liquid as specified on the transformer nameplate. When wiping sleeve entrances are provided, the terminal chamber is shipped dry, unless otherwise specified by the customer.

9. **Fluid Temperature**
Before energizing the transformer, observe the fluid temperature gauge and make sure the temperature is no lower than the values listed below.

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

10. **Current Transformers**
If current transformers (CTs) are supplied, connect CT leads to a 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 the wiring of control and alarm circuits, if supplied, 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**
The transformer main tank is sealed and should not be opened unless necessary. If the transformer main tank must be opened, refer to "*Opening the Transformer Tank"* for instructions. Contact the Howard Industries Transformer Division prior to opening the tank.

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 MAY 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 MAY ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- **Do not energize the transformer using single-phase switches or fuses. Use only gang-operated three-phase switches to energize a three-phase transformer**
- **Do not operate the transformer with any of the primary phases open.**
- **Only qualified personnel with appropriate equipment should measure transformer voltages.**
- **Wear personal protective equipment to prevent injury from potential arc-flash or contact with dangerous voltages.**
- **Make sure the transformer is securely and effectively grounded at all times.**
- **CT leads must be connected to the metering load or shorted together and grounded to prevent dangerous voltages 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 voltages listed on the transformer nameplate.
2. **Checking for Leaks**
   Check the main tank, high-voltage switch chamber and terminal chamber to make sure there are no fluid leaks.
3. **Observing Operation**
   After the transformer is initially energized, visually inspect it occasionally for a few hours, to make sure that no abnormal conditions are observed.
4. **Checking Gauges**
   Observe the fluid level and fluid temperature gauges 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.

SECTION 5: OPERATION OF SWITCHING AND PROTECTIVE DEVICES

The following operating instructions and descriptions of switching and protective devices are intended to be a general guide for operation of Howard secondary network transformers in normal environments. Although efforts have 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 an accessory device.

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

⚠ WARNING

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

- **Do not operate load-break equipment if a fault condition is suspected.**
- **Do not operate a no-load tap changer, series/multiple switch, or delta/wye switch while a transformer is energized.**
- **Use a live-line tool (hot stick or shotgun stick) to operate transformer load-break equipment.**
- **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, and then proceed to ground all primary and secondary transformer terminals following industry accepted safe grounding practices. Place the network protector in the "OPEN" position. Then operate the primary disconnect switch, moving the handle to the "GROUND" position.**
- **Follow industry accepted safety practices and utilize personal protective equipment (PPE) when working with this equipment.**
- **Do not operate fluid-immersed load-break switching devices when the insulating fluid temperature is below the following limits:**

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

Tap Changer

The de-energized (no-load) 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 raise or lower 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 different from rated voltage, core saturation may result, producing high excitation current, high core loss and a high noise level.

⚠ WARNING

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

- **Do not operate a de-energized tap changer unless the transformer is completely de-energized.**
- **Do not re-energize the transformer unless the tap changer handle is locked into position.**

The de-energized tap changer is located on the main tank cover, protected by a 2-inch pipe cap. The tap changer can be rotated by means of a special wrench that must be inserted into the operating mechanism. When the tap changer is not in use, the protective cap must be installed. Apply a suitable sealant to the threads of the coupling before installing the cap.

Never operate a de-energized tap changer while the transformer is energized. Tap changers normally have five or seven tap positions, as indicated on the tap changer dial plate and on the transformer nameplate. A locking mechanism is provided to lock the tap changer into position and prevent accidental operation. Do not re-energize the transformer until the tap changer is firmly locked into a tap position. The wrench is keyed, so that it can be removed only when the tap changer is properly placed into one of the tap positions.

Unless otherwise specified, transformers supplied with tap changers will be shipped from the factory with the switch set to the nominal position.

Series/Multiple or Delta/Wye Switch

Transformers designed with series/multiple windings (dual-voltage or triple-voltage) or re-connectable delta/wye windings are provided with a de-energized series/multiple or delta/wye switch, as indicated on the transformer nameplate. The series/multiple or delta/wye switch is usually located on the main tank cover, protected by a 2-inch pipe cap. The switch can be rotated by means of a special wrench that must be inserted into the operating mechanism. When the switch is not in use, the protective cap must be installed. Apply a suitable sealant to the threads of the coupling before installing the cap.

Never operate a de-energized series/multiple or delta/wye switch while the transformer is energized. A locking mechanism is provided to lock the switch into position and prevent accidental operation. Do not re-energize the transformer until the switch is firmly locked into the desired position. The wrench is keyed, so that it can be removed only when the tap changer is properly placed into position.

Unless otherwise specified, transformers are shipped from the factory with series/multiple and delta/wye connections set to the highest voltage.

⚠ WARNING

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

- **Do not operate a series/multiple or delta/wye switch unless the transformer is totally de-energized.**
- **Do not re-energize the transformer unless the series/multiple or delta/wye switch handle is locked into position.**

Primary Disconnect and Grounding Switch

Network transformers are normally supplied with a three-position primary disconnect switch (sometimes called a “network switch”), which is housed in a fluid-filled chamber welded to the main tank below the primary terminal chamber. Primary switches can be designed as a non-interrupting switch suitable only for completely de-energized operation, or designed to interrupt magnetizing current only (Sometimes called a “mag-break switch.”). An external, pad-lockable switch operating handle is provided with a mechanical latching mechanism to prevent accidental movement of the switch.

Three-position switches are designed with an operating sequence of OPEN, CLOSED, and GROUND. In the OPEN position the primary feeder is disconnected from the transformer and from ground. In the CLOSED position the primary feeder is connected to the transformer. In the GROUND position the primary feeder is solidly grounded, while the transformer is disconnected and not grounded by the grounding switch.

Unless otherwise specified, network transformers are shipped from the factory with the primary disconnect and grounding switch set to the CLOSED position. Contact the Howard Industries Transformer Division to inquire about other switch configurations and options that may be available.

Three-Position Non-Interrupting Primary Disconnect and Grounding Switch

The non-interrupting switch is suitable for use only when the transformer is totally de-energized. An electrical interlock is normally provided to prevent operation of the switch while the transformer is energized from either the high-voltage or low-voltage side.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW COULD RESULT IN DEATH OR SERIOUS PERSONAL INJURY AND MAY ALSO RESULT IN DAMAGE TO THE EQUIPMENT.
Although the electrical interlock system should prevent unsafe operation of the primary switch, the operator should verify that the transformer is disconnected from the primary feeder and that the network protector is in the OPEN position.

Before attempting to operate the non-interrupting primary switch, verify that the transformer is not energized from either the high-voltage or low-voltage side. Use the following procedure to move the switch from the OPEN to the CLOSED position.

1. Operate the blocking toggle pin.
2. Pull the mechanical locking pin on the handle.
3. Rotate the handle until the mechanical locking pin engages in the CLOSED position.

Use the following procedure to move the switch from the CLOSED to the GROUND position.

1. Operate the blocking toggle pin.
2. Pull the mechanical locking pin on the handle.
3. Rotate the handle until the mechanical locking pin engages in the GROUND position.

Three-Position Mag-Break Primary Disconnect and Grounding Switch

The mag-break switch is designed to operate when only magnetizing current is present and is prevented from operating while the network protector is in the closed position. The switch is equipped with an electric interlock system, which permits operation of the switch according to the parameters listed in Table 1 below. The interlock system requires a source of power that is independent of the associated network transformer and an auxiliary contact on the network protector. The interlock system will lock if it looses its independent power source.

Table 1: Mag-Break Primary Switch Operation

Primary Feeder Status	Network Protector Position	Switch Operation
De-energized	OPEN	Switch may be operated to any position
De-energized	CLOSED	Switch cannot be operated
Energized	OPEN	Switch may operate between CLOSED and OPEN positions. Switch cannot operate between CLOSED and GROUND positions.
Energized	CLOSED	Switch cannot be operated.

Operation of the three-position mag-break switch is similar to that of the three-position non-interrupting switch. Before attempting to operate the mag-break switch, verify that the network protector is in the open position.

⚠ WARNING

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

Although the electrical interlock system should prevent unsafe operation of the primary switch, the operator should verify that the transformer is disconnected from the primary feeder and that the network protector is in the open position.

Sequential Grounding Provisions

When specified, the three-position primary disconnect and grounding switch can be supplied with two additional positions to allow for sequential grounding of the primary feeders. Typical switch operation is described in Table 2 below; however, other user-specified switch characteristics are available. Markings on the switch handle indicate switch position. The switch may be operated in either a clockwise or counterclockwise direction.

Table 2: Sequential Grounding Switch Operation

Switch Position	Primary Feeder Connections		
	A Phase	B Phase	C Phase
A	Grounded	Open	Open
AB	Grounded	Grounded	Open
GROUND	Grounded	Grounded	Grounded
OPEN	Open	Open	Open
CLOSED	Closed	Closed	Closed

Phase Sequence Identification Provisions

Optional phase sequence identification provisions (also known as “phasing tubes”) are provided when specified to allow determination of the phase sequence of incoming primary feeders. Phasing tubes are located on the switch chamber cover and are positioned to allow phasing probes to be inserted and make electrical contact with live portions of the switch bushings. Pipe plugs or caps are provided to seal phasing tubes when not in use.

Network Protector

Howard network transformers are usually supplied with network protector mounting provisions designed according to user specifications. These provisions typically consist of a secondary throat with mounting holes, guide pins and gasket. A steel shipping guard is installed over the secondary throat to protect the secondary bushings, connectors and throat flange from damage during shipment and storage.

The network protector should be installed, operated and maintained by the user according to the instructions provided by the network protector manufacturer.

Other Switching and Protective Devices

Contact the Howard Industries Transformer Division for information related to any other switching or protection options not discussed in these instructions.

SECTION 6: ACCESSORIES

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

Diagrammatic Nameplate

The transformer nameplate is supplied on each transformer and provides a circuit diagram and certain physical and electrical information in accordance with IEEE Standard C57.12.00.

Fluid Level Gauge

Fluid level gauges are magnetic dial-type devices that indicate internal fluid levels. One gauge is welded to the transformer main tank above the primary terminal chamber at the 25°C fluid level. A second gauge is welded on the side of the primary switch chamber at the 25°C fluid level.

If a gauge reads "LOW," the cause of the low reading should be investigated and corrected. A low fluid level in the main tank could cause overheating of the transformer and could compromise the insulation system. A low fluid level in the primary switch chamber could compromise the insulation system of the primary switch.

Fluid level gauges can be supplied with optional switch contacts, which can be used to provide a remote indication of low fluid level.

⚠ WARNING

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

- **Do not energize the transformer if the fluid level is low.**
- **Maintain proper fluid level while the transformer is energized.**

Fluid Temperature Gauge

The fluid temperature gauge is a dial-type bi-metal device that indicates the fluid temperature at the top of the fluid column in the main tank. The temperature gauge is mounted above the primary terminal chamber in a dry leak-proof well, permitting removal of the gauge without exposure to the tank fluid.

The gauge is furnished with a red drag-hand pointer that indicates the maximum temperature measured. 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. Fluid temperature gauges may also be supplied with switch contacts, which can be used to provide a remote indication of low or high temperature.

During normal operation the fluid temperature gauge should read less than the sum of the ambient temperature and the rated temperature rise (normally 85°C). Refer to IEEE Standard C57.91 for loading recommendations.

Filler Plug and Upper Filter Press Connection

The filler plug and upper filter press connection is located on the main tank cover, consisting of 1-inch NPT opening with protective plug.

Combination Drain and Bottom Filter Valve

The combination drain and bottom filter valve is provided to permit draining, filtering and sampling of the insulating fluid for testing purposes. Two valves are typically provided, one located on the main transformer tank and another on the primary switch chamber. Refer to *"Sampling and Testing the Fluid," "Removing or Lowering the Fluid,"* and *"Filling with Fluid"* for instructions.

Terminal Chamber Vent and Level Plug

The terminal chamber vent and level plug is located on the terminal chamber cover at the 25°C fluid (or compound) level, which can be used to vent the chamber and check the fluid (or compound) level.

Air Test Provision

The air test provision is located on the primary switch chamber above the 85°C fluid level. The provision consists of a 0.5-inch NPT opening with protective plug, which can be used for testing the air inside the switch chamber.

Automatic Pressure Relief Valve and Pressure Relief Device

The automatic pressure relief valve (PRV) is designed to relieve excessive tank pressures that might occur during operation of the transformer. The standard subway-type PRV consists of a self-resealing, spring-loaded diaphragm and is normally located above the fluid level on the side of the transformer main tank. The PRV can be operated manually by pulling on the pull-ring with a live-line tool. An optional high flow-rate pressure relief device (PRD) is supplied when specified, and mounted on the transformer main tank cover. The high flow-rate PRD can be supplied with optional switch contacts, which can be used to provide a remote indication of valve activation.

When gas pressure in the tank exceeds the PRV's or PRD's specified limit, the gas pressure will cause the valve to open, venting the excess pressure. After the internal pressure decreases below the PRV or PRD reseal rating, the valve will automatically close and reseal the transformer.

⚠WARNING

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

- **The cause of PRV or PRD activation should always be investigated, since pressure venting indicates a potential problem inside the transformer.**
- **Personnel should wear eye and skin protective equipment when using the PRV to relieve tank pressure. Hot fluid may be expelled.**
- **Do not attempt to disassemble a PRD. Internal components may be under high spring pressure, creating a potential hazard from flying objects.**

Primary Entrance

The primary entrance is located on the top of the terminal chamber and is provided for connection to the primary feeders. The primary entrance typically consists of separable insulated connectors, wiping sleeves or potheads, as specified by the user.

When separable insulated connectors are provided, they may consist of universal bushing wells only, universal busing wells with factory-installed bushing inserts, or one-piece bushings. In the case of separable insulated connectors, a single chamber is provided to house the terminals and primary switch, unless a separate terminal chamber is specified by the user. When a separate terminal chamber is provided, it is filled with fluid at the factory and need not be opened in the field. Installation of bushing inserts and primary feeder cables should be carried out in accordance with instructions provided by the bushing manufacturer.

When wiping sleeves or potheads are provided, primary feeder connections will be made inside the terminal chamber. In this case, terminal chambers are shipped dry, and must be filled with the proper insulating fluid or compound after connections are made and the chamber cover has been properly installed. Refer to the cable manufacturer's instructions for proper method of cable connection, use of stress cones and selection of insulating fluid or compound. When filling with compound, voids must be prevented, otherwise partial discharge issues and cable failure could result. Consult compound manufacturer for recommended filling temperature and technique.

High-Voltage Bushings

Externally-removable high-voltage bushings are installed between the main tank and the primary switch chamber. These bushings can be removed and replaced through the switch chamber. When replacing bushings, new gaskets should be used.

When a separate terminal chamber is provided, externally-removable bushings are also installed between the primary switch chamber and the terminal chamber. These bushings can be removed and replaced from the terminal chamber. When replacing these bushings, new gaskets should be used.

Secondary Bushings

Three externally-removable secondary bushings are bolted to the main tank wall inside the secondary throat. Each is fitted with a flexible connector for connection to a network protector. The low-voltage neutral connection consists of a blade welded to the main tank or, when specified by the user, a fully-insulated bushing.

Current Transformers

Optional current transformers (CT's) are supplied when specified, to allow remote measurement of secondary phase currents. When provided, CT's are mounted inside the main tank, immersed in insulating fluid. CT leads are brought out to an external junction box mounted on the main tank.

Transformers are shipped from the factory with CT leads shorted together and grounded. If the CT's are not connected to a metering load by the user, 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 MAY ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

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

Other Accessory Devices

Network transformers may be supplied with accessory devices not discussed in these instructions. In such cases, contact the Howard Industries Transformer Division for information.

SECTION 7: MAINTENANCE

⚠ WARNING

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

The transformer must be de-energized before performing any maintenance work.

Transformers should be inspected periodically while in service, with the frequency of inspection 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 PRVs, PRDs, temperature gauges, fluid level gauges and drain valves typically require no maintenance, except replacement in the event of damage. Gauges should be checked periodically to make sure they are operating properly.

When performing periodic maintenance, the checks described below should be made at a minimum.

Periodic Inspection

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

Inspection and Maintenance Checklist

While observing safe working practices, perform the following checks.

1. Inspect for dents or other damage to metal surfaces and make the necessary repairs
2. Inspect the paint finish for damage, corrosion or weathering that exposes the primer coat or bare metal. Repair any paint damage that might be found. Refer to *"Exterior Paint Finish"* for instructions.
3. Inspect thoroughly for evidence of fluid leaks, including main tank, switch chamber, terminal chamber, radiators, bushings, gauges, switches, valves and all other accessories. Check fluid level gauges or sight glasses to determine fluid levels in all compartments. If a leak is suspected, perform a pressure test according to the instructions in "*Pre-energization Inspection and Tests*." Add fluid as necessary to ensure that the proper fluid level is maintained. Repair as necessary. Fluid leaks must be repaired immediately to prevent serious damage to the transformer and danger to personnel. Refer to "*Fluid Leaks*" for instructions.
4. Visually check all gaskets for cracking or other signs of deterioration. 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, being careful not to overtighten.
5. Maintain a clean and unobstructed area around the transformer, including sufficient clearance around radiators to ensure adequate cooling of the transformer.
6. Inspect the base of the transformer main tank and make sure that there is no accumulated dirt or other debris that might promote corrosion.
7. Check bushings, gauges, valves, switches and all other accessories for proper operation, and repair or replace any defective devices.

8. Check all fasteners for signs of corrosion and replace as necessary.
9. Check fluid temperature gauges, including the maximum temperature drag hand (if present) to determine whether the fluid temperature has exceeded the design limit. Any such indication should be investigated to determine and correct the cause.
10. Check torque values on all ground connections and tighten as necessary. Refer to torque guidelines contained in Table 6.
11. Replace any damaged or unreadable nameplates, instructional labels and safety labels.
12. If it is suspected that water or other contaminants may have entered the main tank, switch chamber or terminal chamber, the fluid or compound 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 transformer 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 silicone fluid or seed-based fluid (such as Envirotemp FR3), contact the Howard Industries Transformer Division for testing recommendations.
13. Lubricate external parts of the primary disconnect and grounding switch at least annually.
14. Exercise the primary disconnect and grounding switch at least annually.

Electrical Testing

The following electrical tests should 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 MAY 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 MAY ALSO RESULT IN DAMAGE TO THE EQUIPMENT.

- **Do not energize the transformer using single-phase switches or fuses. Use only gang-operated three-phase switches to energize a three-phase transformer**
- **Do not operate the transformer with any of the primary phases open.**
- **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.**
- **CT leads must be connected to the metering load or shorted together and grounded to prevent dangerous voltages at the CT terminals.**

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 (This test cannot be performed on a transformer having a secondary neutral that is solidly grounded.)
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 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 lease two coats of high-quality touchup paint should be applied to the damaged area. Touch-up paint is available in aerosol cans 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. In addition to the presence of fluid residue, a low reading on the fluid level gauge is further indication of a possible fluid leak. Fluid leaks should be repaired as soon as possible to prevent moisture contamination of the insulating fluid and to prevent internal flashover due to low fluid level.

⚠ WARNING

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

- **Do not energize the transformer if the fluid level is low.**
- **Maintain proper fluid level while the transformer is energized.**

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 during the oil-filling process. In some cases silicone lubricant used to install high-voltage bushing inserts can spread to the tank surface, giving a false indication of a fluid leak.

To verify that a fluid leak exists, clean the suspected leak area with an appropriate solvent to completely remove the fluid and observe the area for reappearance of fluid. Pressurize the tank with dry air or dry 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 examine the tank and fittings 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.

Bushing leaks can sometimes be corrected by tightening the bushing clamp bolts. Do not exceed the recommended torque values listed in Table 4 to prevent the possibility of bushing or gasket damage.

Audible Sound Level

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

Refer to NEMA Standards Publication 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.

Other Accessory Devices

Other accessories 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 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 Liquid*s for recommended sampling procedures. Also refer to any sampling recommendations supplied by the fluid test equipment manufacturer.

It is recommended that a fluid sample be drawn annually and tested for dielectric strength. Dielectric strength should measure at least 26 kV.

Filtering the Fluid

Insulating fluids such as mineral oil, R-Temp or seed-based fluids can be filtered using a filter press system. A filter press can remove particle contaminants as well as small amounts of moisture. Follow the operating instructions provided by the filter press system manufacturer.

Continue to filter the fluid until the dielectric test result is 26kV or better. 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.

1. De-energize the transformer and make sure the tank, bushings, and terminals are effectively grounded.
2. If cover removal is required, remove cover as outlined in the *"Opening the Transformer Tank"* section.
3. Use a clean, dry temporary storage container to contain the fluid.
4. Use clean pumps and hoses that have not been contaminated by different types of fluids. Hoses must be designed for handling the particular fluid in the transformer (As an example, rubber hoses should not be used with mineral oil.).
5. Connect the pump intake line to the drain valve at the bottom of the transformer tank.
6. Place the pump discharge line nozzle at the bottom of storage container.
7. Pump slowly and do not allow the fluid to splash into the container, as this will introduce air and moisture into the fluid.
8. Do not lower the insulating fluid below top of core/coil clamp pan unless absolutely necessary. Exposing coils may allow moisture to contaminate coil insulation.

Filling with Fluid

When refilling 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 refilling is complete, allow 24 hours for dissipation of air bubbles before energizing the transformer. Trapped air bubbles can reduce the insulating value of the fluid and cause an internal flash-over.

1. Every storage container or tote of transformer fluid should be visually inspected and tested for

⚠ WARNING

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

- **Release internal pressure before opening the tank. Personnel should wear eye and skin protective equipment when using the pressure relief valve to relieve tank presure. Hot fluid may be expelled.**
- **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 outside the tank to ensure the safety of the person inside the tank.**

water and other possible contaminants before proceeding with the filling process

2. Pump from the bottom of the storage container. To prevent bubbles in the fluid, do not allow air to enter the pump intake.
3. Place the discharge hose at the bottom of the transformer tank below the fluid surface to prevent aeration and the introduction of bubbles.
4. Pump and fill the transformer tank slowly. Fill the tank to fill line marked on inside of the transformer tank. If the fill line mark cannot be viewed, use the indication on the fluid level gauge (if supplied) or fill to the bottom of the fill plug on the other side of the transformer tank.

Opening the Transformer Tank

Transformer tanks are shipped sealed and should not be opened unless necessary. If it is necessary to open the tank, follow the instructions below and observe all safety warnings.

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. Either of the above could contaminate the insulating fluid and cause a transformer failure. The tank opening should be protected against entry of foreign matter.

If it is necessary to remove some fluid from the tank to allow for inspection or other work, the transformer must be re-filled with fluid after work is completed. 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.
The following procedure should be used to remove the bolted hand-hole cover.

1. Thoroughly clean the hand hole 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, being careful to avoid hot fluid that could be expelled from the valve.
3. Remove 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.

The following procedure should be used to reinstall the hand-hole cover.

1. Replace the gasket, if damaged.
2. Re-install the hand-hole cover. Re-install fasteners according to the torque recommendations in Table 3. After tightening all fasteners, re-torque each one to ensure proper torque.
3. Pressurize the headspace to 3-4 PSIG and check for fluid leaks. This pressure should be maintained for at least four hours.

When the internal inspection is complete, reseal the tank and re-fill with fluid (if any was removed prior to inspection). The gas space should be filled with dry air or dry nitrogen to 2 PSIG. Contact the Howard Industries Transformer Division, if any internal damage is found during the internal inspection.

Torque Guidelines

Tables 3 through 6 below contain recommended torque values for tightening various connections on the transformer. Connections with gaskets or those involving rubber components (such as high-voltage busing inserts) will normally relax after initial tightening. Nominal torque values listed below include an allowance for normal relaxation.

Do not over-tighten any connection; otherwise, gaskets may split due to over-compression, and components may break. Fluid leaks may 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 manufacturer's recommended torque values for any user-supplied devices.

Table 3: Torque Guidelines for External Cabinet Fasteners

Fastener Type	Nominal Torque (in-lbs)	Torque Range (in-lbs)
Secondary throat shipping guard bolts	80	70-90
Hand-hole cover bolts	190	170-210
Terminal and switch chamber cover bolts	350	300-400

Table 4: Torque Guidelines for External Bushing Mounting Hardware

Bushing Type	Nominal Torque[1] (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 well, molded Tri-Clamp (without clamp ring), 3/8" mounting studs	60	40-80
High-voltage bushing well, molded (with clamp ring), 3/8" mounting studs	120	90-150

Notes:

[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 5: Torque Guidelines for External Bushing Terminal Connections

Terminal Type	Nominal Torque[2] (in-lbs)	Torque Range (in-lbs)
High-voltage molded bushing insert [1]	180	156-204
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

Notes:

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

[2] When checking tightness of gasketed components and molded busing inserts, 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 or bushing insert may cause the component to crack or the gasket to become over-compressed.

Table 6: Torque Guidelines for Accessories

Component	Nominal Torque[1] (in-lbs)	Torque Range (in-lbs)
Fluid level sight glass	600	480-720
Fill plug	960	900-1020
Drain plug	960	900-1020
Drain valve	600	480-720
Automatic pressure relief device, ¼" NPT	180	160-200
Automatic pressure relief device, cover-mounted	300	250-350
Ground connector	160	140-180

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

Additional Maintenance Instructions

These instructions are intended to be a general guide for the maintenance of Howard secondary network transformers, when used in typical applications and operated in usual environments as described in IEEE Standard C57.12.00. Although efforts have been made to ensure accuracy and completeness, these instructions do not address every conceivable application or circumstance that might be encountered.

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 (particularly when encountering unusual or special circumstances not sufficiently covered by these instructions) should be directed to the Howard Industries Transformer Division.

Repair Parts

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

Warranty Claims

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

Transformer Disposal

Comply with all local, state and federal regulations when disposing of any insulating 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.

HI-110
Instructions for Installation, Operation and Maintenance of Secondary Network Transformers

Document 2.4.128, Revision 3, October, 2017

Laurel, Mississippi
Telephone: 601-425-3151
Fax: 601-649-8090
Email: mkt@howard.com
Web: howardtransformers.com