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Instructions (HI-105)

Installation, Operation, and Maintenance of Three-Phase Padmounted Distribution Transformers 45 kVA through 10,000 kVA

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 damage to the equipment.

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

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

No one should 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 (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. Features presented herein may not be present in all equipment designs. Standard and optional features are subject to change without notice.

Although efforts have 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.

Questions regarding installation, operation, and maintenance of the equipment, particularly when encountering unusual or special circumstances that 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 three-phase compartmental padmounted distribution 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.

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 warning labels, and provides physical dimensions and weights. The nameplate provides electrical characteristics, winding connections, and weights. The wiring diagram provides details of any control, fan and alarm wiring that may have been supplied.

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.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW MAY CAUSE DEATH OR SERIOUS PERSONAL INJURY AND/OR 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.**

Transformers should be lifted in an upright position, allowing the transformer to tilt no more than 15° from vertical. Lifting cables should be no more than 20° from vertical. It is recommended that a spreader bar be used to keep the lifting cables nearly vertical to enable a safe lift and to reduce 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, 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 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" 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 packages that shipped separately from the transformer.

Fluid Level

The transformer is shipped from the factory with dielectric fluid filled to the proper level. Before energizing the transformer, verify proper fluid level by observing the fluid level gauge. The fluid level gauge pointer should be between the "High" and "Low" marks. For transformers supplied 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. Exercise caution when checking the fluid level using the fluid level plug, as the fluid may spill out and may be extremely hot. When checking the fluid level, bear in mind 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.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW MAY CAUSE DEATH OR SERIOUS PERSONAL INJURY AND/OR 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.**

Internal Inspection

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

Fluid Sampling

Sampling and testing of the fluid is not required unless there is indication that moisture or other contaminants have accidently entered the tank during transit. If moisture or contaminates 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.

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 tank.

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

SECTION 3: INSTALLATION

Lifting and Handling

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.

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° from vertical. It is recommended that a spreader bar be used to keep the lifting cables nearly vertical to enable a safe lift and to reduce 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 MAY CAUSE DEATH OR SERIOUS PERSONAL INJURY AND/OR 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, Skidding, and Rolling

The transformer tank base is 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. 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. The transformer should sit flush with the surface of the pad, so that there are no gaps that might compromise tamper resistance of the terminal compartment. The installed transformer should not tilt in any direction more than three degrees. Greater tilt may compromise insulation 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 (710 mm) from any obstruction and have adequate clearance to allow the terminal compartment doors to open fully. When installing transformers designed for indoor operation, adequate air inlets and outlets must be provided at the mounting location for proper cooling.

Avoid locating the transformer in corrosive areas. Remove any shipping braces and packing material that may have been installed at the factory.

Verifying Enclosure Integrity

Three-phase compartmental padmounted transformers are designed and constructed to be tamper resistant according to the requirements of IEEE Standard C57.12.28 or C57.12.29, as applicable, and therefore need not be located 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 of may void the warranty. Consult with the Howard Industries Transformer Division before making any modifications to the transformer.

⚠ DANGER

Do not make any modifications to the transformer that might compromise its tamper resistant construction. FAILURE TO FOLLOW THIS INSTRUCTION WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND DAMAGE TO THE EQUIPMENT.

Grounding

The transformer must be permanently grounded according to applicable local and national codes. Ground the transformer by using ground pads or nuts located at the base of the front panel in the terminal compartment. 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.

Transformers with a grounded wye high-voltage winding and a wye low-voltage 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.

⚠ DANGER

The transformer must be properly grounded at all times. FAILURE TO FOLLOW THIS INSTRUCTION WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND DAMAGE TO THE EQUIPMENT.

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 stress on the bushings.

High-Voltage Connections

Three-phase padmounted transformers with live-front construction are usually supplied with externally-clamped porcelain high-voltage bushings for connection to the high-voltage source. Bushings are supplied with tin-plated eye-bolt or spade terminals that are suitable for connection to both aluminum and copper conductors.

Three-phase padmounted transformers with dead-front construction are supplied with universal bushing wells, one-piece (integral) bushings or universal bushing wells with 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 compatible with the universal bushing well. Do not use incompatible or improperly rated inserts, or equipment damage might occur. When installing inserts, follow the manufacturer's instructions accompanying the insert.

On transformers with dead-front construction, grounding caps must be installed on all unused high-voltage bushings before energizing.

Low-Voltage Connections

Three-phase padmounted transformers are normally supplied with externally-clamped molded low-voltage bushings, with or without spade terminals.

SECTION 4: INSPECTION AND TESTING BEFORE AND AFTER INITIAL ENERGIZATION

⚠ DANGER

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

- **Energize the transformer from a remote location.**
- **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.**
- **Be aware of dangerous voltages within the terminal compartment and avoid personal contact with live terminals.**
- **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.**
- **Current transformer (CT) leads must be connected to the metering load or shorted together and grounded to prevent dangerous voltages at the CT terminals.**

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. **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 supplied 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 contaminates that could influence the test results. Measured resistance should be 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 below the fluid level in the transformer tank. Refer to “Opening the Transformer Tank” for instructions.

3. **Tap Changer Setting**—Check the tap changer setting to ensure it is set to the proper position for the required voltage.

4. **Series/Multiple or Delta/Wye Switch Settings**—Check series/multiple and delta/wye 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.

5. **Grounding**—Check to ensure that the transformer tank is permanently 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 25° C mark.

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
   -0°C (32°F) for R-Temp fluid
   -10°C (14°F) for FR3 fluid

9. **Internal Fault Detector**—If the transformer is supplied 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 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 tank is sealed and should not be opened unless necessary. If the transformer tank must be opened, 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 DAMAGE TO THE EQUIPMENT.

- **Energize the transformer from a remote location.**
- **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.**
- **Be aware of dangerous voltages within the terminal compartment and avoid personal contact with live terminals.**
- **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.**
- **Current transformer (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 tank 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.
6. **Locking the Terminal Compartment**—Before leaving the installation site, make sure the terminal compartment is secure using the following procedure.
   - Lower the flip-top cover (if supplied) and engage the center-mounted cover security bolt
   - Close the primary compartment door and engage each security bolt.
   - Close the secondary compartment door and turn the handle to the closed position. Engage the secondary compartment door security bolt.
   - Install a suitable heavy-duty padlock.

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 three-phase padmounted 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.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS INJURY, AND 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.**
- **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 upstream source 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 when working with this equipment.**

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS INJURY, AND DAMAGE TO THE 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
  -0°C (32°F) for R-Temp fluid
  -10°C (14°F) for FR3 fluid

Many 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.

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 secondary voltage, core saturation may occur, resulting in a high noise level and high core loss.

⚠ DANGER

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

- **Do not operate a de-energized (no-load) tap changer unless the transformer is totally de-energized.**
- **Do not re-energize the transformer unless the tap changer handle is locked into position.**

The tap changer is operated by use of a rotating handle located inside the terminal compartment. 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 the transformer nameplate. A locking mechanism is normally 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 transformer is shipped from the factory with the tap changer in the rated voltage position, unless otherwise specified by the customer.

Series/Multiple or Delta/Wye Switch

Transformers designed with series/multiple windings (dual-voltage or triple-voltage transformers) are supplied with a de-energized series/multiple switch. Transformers with re-connectable delta/wye windings are supplied with a delta/wye switch. The presence of either of these switches will be indicated on the transformer nameplate.

The transformer must be completely de-energized before operating either of these switches. If the transformer is not de-energized before operating the switch, personal injury and permanent equipment damage will result. Unless otherwise specified, series/multiple transformers are shipped from the factory with the series/multiple switch in the highest voltage position.

⚠ DANGER

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

- **Do not operate a de-energized 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.**

Load-Break Switch

One or more rotary under-oil load-break switches may be supplied on the transformer and located in the high-voltage compartment. These switches can be either two-position (ON-OFF) switches or three- or four-position sectionalizing switches. Switch positions are marked on the transformer front panel and shown on the nameplate diagram. Rotary 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 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- or four-position 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 MAY RESULT IN MINOR OR MODERATE PERSONAL INJURY, AND /OR 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 position.**

Fuses

A blown fuse may indicate a faulted transformer. Do not replace a blown fuse unless the cause of the fuse operation has been identified and corrected. Fuses should be applied according to the fuse rating. Replacement fuses should have the proper rating and operating characteristics. Refer to the circuit diagram on the transformer nameplate for the location of fuses.

⚠ DANGER

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

- **De-energize the transformer before replacing fuses.**
- **Do not energize or de-energize a three-phase transformer using single-phase switches or fuses. Use only gang-operated three-phase switches to energize or de-energize a three-phase transformer.**
- **Do not operate the transformer with any phases open.**
- **Only qualified personnel with appropriate measurement devices should measure the voltages on the transformer.**

Internal Weak-Link Cartridge Fuse

A weak-link cartridge fuse is an internal, fluid-immersed expulsion fuse. These fuses are installed under fluid inside the transformer tank on mounting blocks located above the core and coil assembly. These fuses can be replaced in a de-energized transformer by removing the tank hand-hole cover.

1. Make sure the transformer tank is properly grounded.
2. Remove the tank hand-hole cover. Refer to “Opening the Transformer Tank” for instructions.
3. Identify the fuse block assembly.
4. Remove leads attached to each end of the cartridge fuse, being careful not to drop any nuts or washers into the tank.
5. Replace the fuse and reconnect leads to their original positions using the washers and nuts removed in step 4.
6. Re-install the tank hand-hole cover. Refer to “Opening the Transformer Tank” for instructions.

Bay-O-Net Fuse

A Bay-O-Net is a fluid-immersed, draw-out, dead-front, single-pole 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. Bay-O-Net devices (one device per phase) are normally located in the high-voltage 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.

A Bay-O-Net expulsion fuse device 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.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND 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 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.**
- **Operate the pressure relief device to vent pressure in the transformer tank before unlatching a Bay-O-Net device to prevent hot oil from being expelled during fuse removal.**

The following procedure should be used to operate a Bay-O-Net fuse device. Open both compartment doors and engage the prop rods on each door to latch them in the open position. On transformers supplied with a hinged terminal compartment cover, disengage the center security bolt and raise the cover until the support arm latches in place.

Remove Fuse Holder—The following procedure should be used to draw the fuse holder out of the Bay-O-Net housing.

1. Vent the transformer by operating the pressure relief valve. Keep the valve open until the sound of air venting can no longer be heard.
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° 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 device 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 dead-break dry-well canister is a fluid-tight, single-pole, 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. Dry-well canisters (one per phase) are mounted on the transformer front panel in the high-voltage section of the terminal compartment.

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.

⚠ DANGER

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

- **Do not operate a dead-break canister fuse device while the transformer is energized.**
- **When replacing a blown current-limiting fuse, the transformer should be re-energized from a remote location.**

The following describes proper operation of the dead-break canister device.

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 equivalent 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
Internal partial-range (backup) current-limiting fuses (one fuse per phase or two parallel fuses per phase) are connected in series with low current interrupting devices, such as weak-link cartridge fuses or Bay-O-Net expulsion fuses. Partial-range current-limiting fuses are designed to clear low impedance (high current) faults, while expulsion fuses are designed to clear a high impedance fault or overload. When properly applied, partial-range current-limiting fuses 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 S&C Arc-Strangler (one per phase) is a 200 Ampere, air-insulated, load-break, single-pole device that is designed to be operated with a live-line tool (hot stick or shotgun stick). The Arc-Strangler device may include a full-range current-limiting fuse on the switch blade or a clip-style current-limiting fuse.

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.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS INJURY, AND 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 devices 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
S&C fused switches should be operated according to instruction provided by S&C. S&C tools should be used to operate an S&C fused switch.

Vacuum Fault Interrupter
The vacuum fault interrupter (VFI) transformer is equipped with a three-phase molded vacuum interrupter mounted in the high-voltage section of the terminal compartment. This device is capable of making, carrying and automatically interrupting currents through 12,500 Amperes (symmetrical) at distribution system voltages of 5 kV to 38 kV.

The device combines vacuum interrupters, programmable electronic control, trip-free mechanism and universal molded elbow connection interfaces. The control is field programmable with a wide range of time-current characteristic curves and trip settings and is SCADA capable. The molded vacuum interrupter should be operated and maintained according to the VFI manufacturer's instructions provided with the device.

Surge Arresters

Surge arresters can be used in three-phase padmounted transformer installations to protect the transformer and underground cable from damage due to voltage surges.

⚠ DANGER

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW WILL RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND 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.**

Surge arresters should be installed only on systems where the power frequency voltage at the arrester does not exceed the published maximum continuous operating voltage (MCOV) values.

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

Internal MOV Arresters

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

Disconnect fluid-immersed MOV surge arresters before performing impulse, induced-potential or applied-potential tests; otherwise, the arresters may be damaged. Reconnect surge arresters after testing and before placing the transformer into service.

Optional arrester disconnectors provide a means to disconnect the fluid-immersed MOV arrester grounds for transformer testing without entering the transformer tank. Individual disconnectors are provided for each MOV arrester. Two different styles of disconnectors 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 arresters using the following procedure for the disconnector on each phase.

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 arresters by operating the disconnectors as described below.
   For the CPS disconnector (identified by a black plastic external cap):
   a. Unscrew the black disconnector cap from the shaft.
   b. Re-attach the small diameter end of the disconnector 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 disconnector (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 arresters 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 arresters by operating the disconnectors as described below.
   For the CPS disconnector:
   a. Pull the disconnector handle and shaft fully away from transformer.

b. Unscrew the disconnector cap and re-attach it with the large diameter end toward the transformer. Rotate the handle clockwise to tighten.

For the ECI disconnector:

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.

If arrester disconnectors are not provided, the fluid-immersed MOV arresters must be manually disconnected before testing by opening the transformer tank.

MOV arresters 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. Remove the tank cover. Refer to "Opening the Transformer Tank" for instructions.
5. Locate the disconnect points to which the arrester line leads are attached.
6. Disconnect the three arrester leads from their junction points and isolate the lead ends at least six inches from each other and from any other part of the transformer.
7. It is now safe to perform impulse, induced-potential or applied-potential tests.

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

1. Reconnect each of the three arrester leads to their junction points.
2. Re-install the tank cover. Refer to "Opening the Transformer Tank" for instructions.

Molded-Case Circuit Breakers

Molded-case circuit breakers use an automatic trip system to help protect the transformer and connected equipment from damage caused by overloads and short circuits. Molded-case circuit breakers should be operated and maintained according to instructions provided by the breaker manufacturer.

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 devices are designed to be operated with a live-line tool (hot stick or shotgun stick). Do not attempt to operate by hand any device that is designed to be operated with a live-line tool. Use the live-line tool properly according to the instructions provided by the live-line tool manufacturer.

Other Switching and Fusing Devices

Transformers may be supplied 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.

SECTION 6: OPERATION OF BUSHINGS, GAUGES AND OTHER ACCESSORY DEVICES

Many 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.

The transformer nameplate, supplied on each transformer according to IEEE Standard C57.12.00, provides a circuit diagram and certain physical and electrical information.

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.

Pressure-vacuum gauges can be supplied with optional switch contacts, which can be used to provide remote alarm of positive or negative pressure.

⚠ WARNING

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. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN DEATH, SEVERE PERSONAL INJURY AND/OR DAMAGE TO THE EQUIPMENT.

Fluid Level Gauge and Sight Plug

The fluid level gauge is a dial-type device that indicates the fluid level inside the transformer tank. The gauge is mounted on the 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.

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

Transformers may also be supplied with a sight plug, which provides direct observation of the fluid level.

Fluid Temperature Gauge

The fluid temperature gauge is a dial-type bi-metal instrument that indicates the fluid temperature at the top of the fluid column in degrees centigrade. 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. Fluid level gauges may also be supplied with switch contacts, which can be used to provide a remote alarm indication of low or high temperature, or to energize a fan control circuit.

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

Drain Valve and Sampling Device

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

terminal compartment at the bottom of the front panel. Refer to "Sampling and Testing the Fluid" and "Draining and Filling the Tank" for the fluid sampling and draining procedures.

Automatic Pressure Relief Device

The automatic pressure relief device (PRD) is designed to relieve excessive tank pressure that might occur during operation of the transformer. The device consists of a self-resealing, spring-loaded diaphragm. Some PRD types also include a re-settable visual flag to indicate that the valve has operated. PRD's are usually mounted on the front panel inside the terminal compartment; however some high flow-rate PRD's are designed to be mounted externally on the tank cover and enclosed in a tamper-resistant housing.

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

Some PRD's can be supplied with optional switch contacts, which can be used to provide a remote alarm of valve activation.

⚠ WARNING

The cause of PRD activation should always be investigated, since pressure venting may indicate a potential problem inside the transformer. FAILURE TO FOLLOW THIS INSTRUCTION MAY RESULT IN DEATH, SEVERE PERSONAL INJURY AND/OR DAMAGE TO THE EQUIPMENT.

Internal Fault Detector

The Internal Fault Detector (IFD) is a mechanical sensor that activates when sudden pressure from an internal arcing fault occurs inside the transformer. If an internal fault occurs, the IFD releases a visible, non-resettable orange signal flag. This signal flag alerts crews that the transformer is faulted and should not be re-energized.

⚠ WARNING

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

- **Do not re-energize a transformer if the IFD has operated.**
- **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.**
- **Transformers should always be re-energized according to the user's standard safety procedures.**

The IFD also includes a standard pressure relief device that is integrated into the sensor to relieve excessive tank pressures that might occur during normal operation of the transformer.

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.

High-Voltage Bushings

Three-phase padmounted transformers with live-front construction are normally supplied with externally-clamped porcelain high-voltage bushings for connection to the high-voltage source. Bushings are usually supplied with tin-plated eye-bolt terminals that are suitable for connection to both aluminum and copper conductors.

Three-phase padmounted transformers with dead-front construction are supplied with universal bushing wells, one-piece (integral) bushings or universal bushing wells with factory-installed inserts. One-piece bushings and bushing inserts are designed to interface with insulated elbow connectors, and can be supplied as either load-break or non load-break devices.

When transformers are supplied with bushing wells only, inserts must be installed in the field before cable connections can be made. High-voltage terminations may be configured for radial (three terminations) or loop feed (six terminations).

⚠ WARNING

Do not exceed the cantilever load rating of a low-voltage or high-voltage bushing. FAILURE TO FOLLOW THIS INSTRUCTION MAY RESULT IN DEATH OR SEVERE PERSONAL INJURY, AND/OR DAMAGE TO THE EQUIPMENT.

Low-Voltage Bushings

Three-phase padmounted transformers are normally supplied with externally-clamped molded low-voltage bushings, with or without spade terminals.

Current Transformers

Molded current transformers (CTs) 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 CTs are not connected to a metering load, they must remain shorted and grounded to avoid hazardous voltage at the CT secondary terminations.

⚠ WARNING

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. FAILURE TO FOLLOW THIS INSTRUCTION MAY RESULT IN DEATH OR SERIOUS PERSONAL INJURY, AND/OR DAMAGE TO THE EQUIPMENT.

Accessory Brackets

Accessory brackets (parking stands) are provided on dead-front transformers and are located inside the terminal compartment near the high-voltage bushings. These brackets are used as mounting locations for portable feed-throughs, insulated standoff bushings and other similar devices.

Flip-Top Terminal Compartment Cover

The transformer may be equipped with a flip-top terminal compartment cover, which can be raised to facilitate operation of Bay-O-Net fuses 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.

Door Handle, Security Bolt and Padlock

Three-phase compartmental padmounted 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 a door handle with interlocking penta-head security bolt and padlock provisions. To ensure enclosure integrity and prevent unauthorized entry, the handle should be latched, the security bolt should be fully engaged and a suitable heavy-duty padlock should be installed.

Lift-Off Door Hinges

Lift-off door hinges are provided, so that the primary and secondary compartment doors can be removed. The door design prevents their removal while in the closed position.

Other Accessory Devices

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

The transformer must be de-energized before performing any maintenance work. FAILURE TO FOLLOW THIS INSTRUCTION MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH, AND/OR DAMAGE TO THE EQUIPMENT.

These instructions are intended as a general guide for the maintenance of Howard three-phase compartmental padmounted distribution transformers, when used in typical applications and operated in normal environments. Although efforts have been made to ensure accuracy and completeness, these instructions do not address every conceivable application or circumstance that might be encountered.

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

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

Periodic Inspection

The transformer's terminal compartment interior, all exterior surfaces 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.

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW MAY RESULT IN DEATH OR SEVERE PERSONAL INJURY, AND /OR DAMAGE TO THE EQUIPMENT.

- **De-energize transformer from a remote location before opening cabinet to perform inspection or maintenance.**
- **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.**

⚠ WARNING

FAILURE TO FOLLOW THE INSTRUCTIONS BELOW MAY RESULT IN DEATH OR SEVERE PERSONAL INJURY, AND /OR DAMAGE TO THE EQUIPMENT.

- **De-energize transformer from a remote location before opening cabinet to perform inspection or maintenance.**
- **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.**

Inspection Checklist

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

1. Inspect for dents or other damage to metal surfaces and make the necessary repairs
2. Inspect the cabinet for evidence of tampering and immediately repair any damage to ensure cabinet integrity and prevent unauthorized entry.
3. 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.
4. Inspect thoroughly for evidence of fluid leaks, including tank, radiators, bushings, gauges, switches, valves, fuse holders and all other accessories. Check the fluid level gauge or sight glass 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 can indicate zero occasionally, but normally indicates a slight positive or negative pressure, dependent on fluid and ambient temperatures). 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 life. Refer to “Fluid Leaks” for instructions.
5. 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.
6. Maintain a clean and unobstructed area around the transformer, including sufficient clearance around radiator panels, to ensure adequate cooling of the transformer.
7. 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.
8. Inspect the base of the terminal compartment and make sure that it is sitting level and flat on the surface of the pad with no gaps that might compromise tamper-resistance.
9. Check bushings, gauges, switches, fuse holders and all other accessories for proper operation and repair or replace any defective devices.
10. Check all fasteners for signs of corrosion and replace as necessary.
11. Check the fluid temperature gauge, including the maximum temperature drag hand (if supplied) to determine whether the fluid temperature has exceeded the design limit. Any such indication should be investigated to determine and correct the cause.
12. Check the torque values on all electrical connections, including the ground

Inspection Checklist (cont.)

connections and tighten as necessary (Refer to torque guidelines contained in Tables 1 through 4).

13. Replace any damaged or unreadable nameplates, instructional labels, and safety labels.

14. If it is suspected that water or other contaminates 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 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.

Electrical Tests

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

⚠ DANGER

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

- **Energize the transformer from a remote location.**
- **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.**
- **Be aware of dangerous voltages within the terminal compartment and avoid personal contact with live terminals.**
- **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 must be connected to the metering load or shorted together and grounded to prevent dangerous voltages at the CT terminals.**

Electrical Tests (cont.)

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 contaminates. At lease two coats of a 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 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. 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 MAY RESULT IN DEATH OR SEVERE PERSONAL INJURY, AND /OR DAMAGE TO THE EQUIPMENT.

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

If a fluid leak is suspected, investigate thoroughly to determine if an actual leak does exist on the transformer. False indications of a leak can occur as a result of residual fluid that was not sufficiently cleaned after the transformer was filled with fluid. In 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 fluid level gauge and a constant zero reading on the 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 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. Welding on radiator panels is not recommended due to the thinner gauge material. Very small pin-hole leaks can sometimes be repaired using an epoxy patch kit designed to repair oil leaks.

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

Audible Sound Level

It is normal for transformers to emit an audible humming sound, which is primarily caused by alternating magnetic flux in the transformer core. Amplitude and harmonic content of the sound is influenced by transformer size, the energizing

voltage level and sinusoidal purity, load conditions and acoustic conditions at the installation site. Unusual sounds should be investigated, as this might indicate a potential problem.

Refer to NEMA Standards Publication 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.

Molded-Case Circuit Breakers

Molded-case circuit breakers are sealed devices requiring minimal maintenance. Refer to inspection and maintenance instructions provided by the breaker manufacturer. Test sets are available from breaker manufacturers that can be used to test and calibrate breakers.

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 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 contaminates as well as small amounts of moisture. Follow the operating instructions provided by the filter press system manufacturer.

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

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

Removing or Lowering the Fluid

Should it be necessary to remove or lower the insulating fluid, the following procedure should be used.

1. De-energize the transformer and make sure the tank, bushings, and terminals are effectively grounded.
2. If cover removal is required, remove the 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 the top of the core/coil clamp pan. 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 insulation value of the fluid and cause a flash-over.

1. Pump from the bottom of temporary storage container. To prevent bubbles in the fluid, do not allow air to enter the pump intake.
2. Place the discharge hose at the bottom of the transformer tank below the fluid surface to prevent aeration and the introduction of bubbles.
3. Pump and 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 supplied) 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 MAY RESULT IN DEATH OR SEVERE PERSONAL INJURY, AND/OR DAMAGE TO THE EQUIPMENT.

- **Before servicing the transformer, ALWAYS de-energize the transformer from a remote upstream source 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 before opening the tank.**
- **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 hand-hole 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. 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 of or inside the transformer while it is open unless they have emptied all pockets and checked for loose objects that might fall into the tank. All tools should be accounted for after work is completed. It is recommended that any tools used on top of the transformer or inside the tank be attached with safety cords to prevent them from being lost inside the transformer.

Personnel must not stand directly on any electrical insulation. Clean drop cloths should be used under working areas in the transformer to prevent objects from dropping into the core/coil assembly.
The following procedure should be used to remove the 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.
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.
5. Remove the gasket from the hand-hole flange.

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

1. Place the gasket in its original position. If the gasket is damaged, it should be replaced.

2. Re-install the hand-hole cover. Re-install fasteners according to the torque recommendations in Table 1. 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.

Torque Guidelines

Tables 1 through 4 below contain recommended torque values for tightening various connections on the transformer. Connections with gaskets and 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 the manufacturer's recommended torque values for any customer-supplied devices.

Table 1: Torque Guidelines for External Cabinet Fasteners

Fastener Type	Nominal Torque (in-lbs)	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 Torque① (in-lbs)	Torque Range (in-lbs)
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 Torque② (in-lbs)	Torque Range (in-lbs)
High-voltage molded bushing insert ①	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 Torque① (in-lbs)	Torque Range (in-lbs)
Bay-O-Net fuse cartridge end plug	70	60-80
Bay-O-Net fuse holder-to-cartridge connection	70	60-80
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 device, panel-mounted, 1/4" NPT	180	160-200
Automatic pressure relief device, cover-mounted	300	250-350
Neutral strap fastener (at ground pad)	160	140-180
Series/multiple, delta/wye or tap switch mounting nut	120	96-144
MOV arrester disconnector mounting nut (ECI brand)	120	96-144
Ground connector	160	140-180
Rotary load-break switch (Central Moloney brand)	1200	1100-1300
Rotary load-break switch (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 (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.

NOTES

HI-105
Instructions for Installation, Operation and Maintenance of Three-Phase Padmounted Distribution Transformers, 45 kVA through 10,000 kVA

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