INSTALLATION, OPERATION & MAINTENANCE

Pad-Mounted Zig-Zag Grounding Transformer

1 MVA • 34,500Y/19,920 V • 60 Hz

Mineral oil filled • ONAN • NEMA Type 4X wiring cabinet





Typical pad-mounted construction. Actual compartment contents and connections follow the approved equipment drawings.

Product 336090
MT-PML-GZ-3P-GMA-1MVA-LT-DF-Z6-XM-CZ-2Z6-M1
Read this manual before handling, installation, testing, operation, or maintenance. Work is restricted to qualified and authorized personnel.

Larson Electronics, LLC
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How to use this manual

This manual covers installation, operation, inspection, testing, and maintenance of the Larson Electronics 1 MVA, three-phase, pad-mounted zig-zag grounding transformer for product 336090. The specified insulating liquid is **mineral oil**. Keep this manual with the equipment records and make it available to qualified personnel.

APPLICATION
The transformer establishes a system neutral and a path for zero-sequence ground-fault current. It has no load-serving secondary winding. Do not apply distribution-transformer loading, secondary wiring, tap-changing, or fuse instructions to this unit.

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Controlling equipment information

Use the serial-number-specific approved drawings, wiring diagrams, nameplate, factory test report, and supplied component instructions together with this manual. If they disagree, stop the affected work and obtain written clarification from Larson Electronics. A typical illustration does not establish the shipped configuration, connection dimensions, torque, or component ratings.

Figures show typical equipment and component construction. Accessories described as optional are not installed unless identified on the approved equipment schedule. A right-hand cabinet historically labeled “LV” is an accessory or neutral compartment on this grounding transformer; it does not provide a low-voltage power output.

1 Safety and electrical isolation

DANGER
Hazardous voltage and arc flash can cause death or serious injury. Only qualified, authorized personnel trained in medium-voltage equipment, switching, grounding, and protective equipment may install, operate, test, or service this unit.

Read all instructions and safety labels before work. Follow the employer’s electrical safety program, applicable OSHA requirements, NFPA 70E practices, and utility operating rules. Determine shock and arc-flash boundaries and required PPE from the task and site assessment. The transformer does not replace personnel protection or safe work practices.

Establish an electrically safe work condition

1. Identify every source, including parallel bus ties, generation, induced voltage, auxiliary control power, and stored energy. Coordinate the outage with the system operator because disconnecting this transformer may remove the system grounding source.

2. Interrupt current with equipment rated for that duty. Isolate upstream sources and apply the site lockout/tagout procedure. A local switch indication or open handle does not establish isolation.

3. Verify absence of voltage at the work location using an appropriately rated detector. Verify the detector before and after testing. A capacitive test point indication alone is not proof that the circuit is de-energized.

4. Discharge stored energy and install temporary protective grounds under the approved procedure. Establish an equipotential work zone as applicable. Control the neutral, CT, and auxiliary circuits as well as the phase conductors.

5. Before return to service, inspect the work, account for tools and personnel, restore guards and covers, and remove grounds and lockout/tagout only under the authorized switching procedure.

Additional hazards

• Never open a CT secondary circuit while its primary can carry current. Use approved shorting provisions before disturbing CT wiring.

• Deadbreak connectors must be de-energized before mating or separating. They cannot interrupt load or fault current.

• Treat the neutral as a current-carrying conductor that can reach hazardous voltage during a ground fault. Never disconnect it on an energized system.

• Keep clear of pressure-relief discharge paths, hot liquid, suspended loads, and moving equipment. Do not open a pressurized tank or admit humid air into a tank under vacuum.

Signal words: DANGER identifies a hazard that will result in death or serious injury if not avoided. WARNING identifies a hazard that could do so. CAUTION addresses minor or moderate injury. NOTICE addresses equipment or property damage.

2 Equipment ratings and construction

Confirm the following configuration against the delivered nameplate and approved equipment schedule before installation. Electrical values are application data, not permission to perform a field withstand test or exceed a duty limit.

Item	Specified configuration / application data
Function and winding	Three-phase zig-zag grounding transformer; neutral brought out (Zn). No load-serving secondary. Radial feed.
Nominal system voltage	34,500 V line-to-line / 19,920 V line-to-neutral; 60 Hz.
Assigned capacity	1 MVA. This designation is not an available secondary load rating.
Grounding current duty	Listed neutral current: 120 A; verify its continuous-duty basis. Short-time current: 1,000 A for 10 seconds; verify the terminal/current basis and allowed repeat duty in the certified data.
Insulation	38 kV equipment class; 200 kV basic lightning impulse insulation level (BIL). Grounding-transformer technical data lists a 70 kV, 1-minute AC withstand test; use only the certified factory test basis.
Impedance	Zero-sequence impedance listed as 6.0 ohms per phase; X/R = 4. Confirm test basis, tolerance, and service conditions for the grounding study.
Cooling and liquid	ONAN: oil natural / air natural, self-cooled. Non-PCB mineral insulating oil. No fan-assisted increase in rating is authorized.
Temperature	65°C (117°F) winding temperature rise designation. This is not a top-liquid alarm or trip setting.
Service environment	Product application range: -40°F to +122°F (-40°C to +50°C); altitude up to approximately 3,300 ft (1,000 m). Actual assembly and accessory limits, cold-start capability, and the approved design govern.
Tank and enclosure	Sealed tank; NEMA Type 4X wiring cabinet; 316 stainless-steel tank, cabinet, and base; bell-green finish. Copper windings and grain-oriented steel core.
Primary connections	Dead-front arrangement; listed 900 A deadbreak connections, 38 kV class bushings; live-front H0 neutral bushing with four-hole spade connection. Confirm the delivered interfaces.
Switch and arresters	One two-position switch, listed 200 A / 38 kV; three surge arresters, one per phase, listed 36 kV rated / 29 kV MCOV. Verify installed component data.
Protective instrumentation	Three phase CTs and one neutral CT; listed ratio 300:5 A, 15 VA each. Liquid level, temperature, pressure/vacuum indication, pressure relief, rapid-pressure-rise protection, and four temperature sensors.

No tap changer, dual-voltage selector, delta-wye selector, internal overcurrent protection, or metering panel is specified. The approved layout includes a heater and accessory terminal boxes. External coordinated protection and a functioning trip source are required.

2.1 Physical arrangement and access

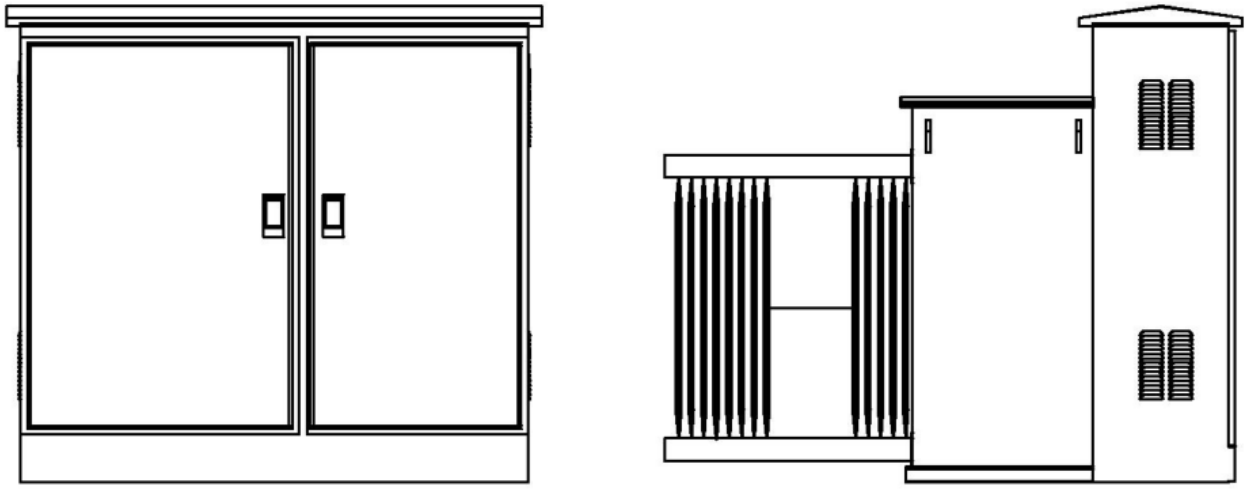


Figure 1. Typical front and side views of a compartmental grounding-transformer assembly. An adjoining resistor enclosure is configuration dependent; this outline is not a foundation or fabrication drawing.

Cabinet and tank

The approved layout on pages 37-39 identifies the live-front H0 neutral bushing, three phase CTs, one neutral CT, cabinet heater, and accessory terminal boxes. No neutral grounding resistor is shown in that equipment layout. The front compartments are air filled and separated by a steel barrier. Hinged doors, padlocking provisions, a penta-head entry fastener, and an interlock or release pin restrict access. Follow the installed door sequence; do not defeat the interlock. Close and secure both compartments after work.

Underground cables enter through the base. Keep covers, barriers, cable-entry seals, and rodent barriers in place. Seal openings with the specified compatible gasket or sealing system without blocking designed drainage. Preserve the enclosure rating when adding conduit or auxiliary wiring.

Identify equipment before work

• Locate the phase bushings, neutral terminal, tank ground bar, CT leads/shorting terminals, two-position switch, arresters, and cable supports from the approved drawing.

• Locate the liquid level and temperature indicators, pressure/vacuum gauge, pressure-relief device, rapid-pressure-rise relay, fill port, drain/sample valve, and gas-sampling connection.

• Read all component labels. Do not infer that a fourth primary connection is a spare phase terminal. Identify phase and neutral conductors from the winding diagram.

• Check installed clearances and the location of the center of gravity, lifting lugs, jacking points, and anchor holes. Do not scale the typical figures in this manual.

NOTICE
A hot stick may be stored on the high-voltage door. Its presence does not authorize energized work or operation of deadbreak connections. Confirm its voltage rating, inspection status, and suitability for the specific device.

2.2 Grounding function and neutral circuit

A zig-zag grounding transformer creates an accessible neutral on a three-phase system. Its interconnected windings provide a path for zero-sequence current. During balanced operation, current is primarily excitation current and any permitted unbalance current. During a ground fault, the grounding transformer and the connected neutral circuit carry fault current until protective equipment clears the fault.

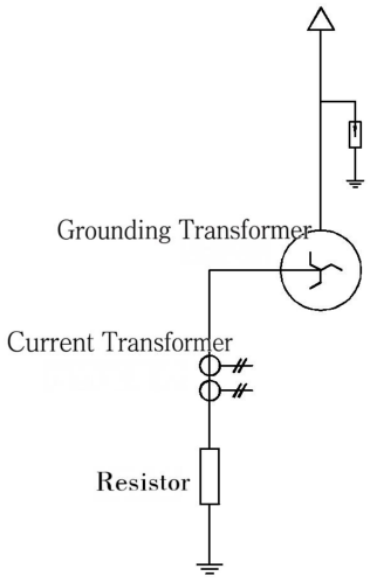


Figure 2. Typical resistance-grounded system diagram showing a grounding transformer, neutral current sensing, and a neutral grounding resistor. This is a functional illustration, not the wiring diagram for every installation.

Neutral connection must follow the approved system design

Connect the neutral directly to the site grounding system only when the approved grounding study and wiring diagram specify solid grounding. If a neutral grounding resistor or other impedance is specified, connect it in the neutral path exactly as shown. Do not bypass the impedance with a parallel bond. A separate permanent tank/equipment grounding connection is always required.

Resistance grounding can limit ground-fault current and reduce transient overvoltage when properly designed. Performance depends on system capacitance, positive-, negative-, and zero-sequence impedances, resistor duty, source configuration, and protective clearing time. The approved equipment drawing exposes H0 but does not define an external neutral grounding circuit or show a resistor. Confirm the site connection before energization; no fixed overvoltage limit is guaranteed by this manual.

WARNING
Do not select solid grounding merely because a resistor is absent from a drawing or shipment. Do not energize until the neutral arrangement is established and the calculated current and clearing time are within the transformer and neutral-circuit ratings.

The 10-second withstand duration is a maximum short-time duty, not a relay delay recommendation. Include relay operating time, breaker clearing time, backup protection, and any automatic-reclosing duty in the protection study. Loss of the grounding source must trigger the response required by the system design.

3 Installation data and engineering verification

Complete this review before rigging, foundation construction, final cable preparation, or energization. Obtain missing serial-number-specific information from Larson Electronics. Keep the approved values in the equipment record on page 36.

Verify	Required basis / action
Neutral and protection	Approved one-line and wiring diagrams; direct or impedance grounding; grounding continuity; calculated neutral fault current; transformer continuous and short-time duty; clearing times, relay settings, and trip logic.
Liquid and fill quantity	Mineral oil grade, compatible seals, installed fill quantity, level-versus-temperature instructions, and liquid test report. Fill to the approved liquid level, never to a catalog gallon quantity alone.
Mass and geometry	Actual operating and shipping mass, center of gravity, lifting plan, outline, anchor pattern, pad opening, and access clearances. Published approximate values are not rigging or civil-design data.
Service conditions	Approved ambient/cold-start limits for the assembled transformer, sensors, switches, relays, and fluid. Verify applications above +104°F (+40°C) against the unit design because generic equipment conditions differ.
Mechanical environment	Project wind, seismic, flood, corrosion, and anchorage requirements. A generic seismic statement, pollution class, or wind-speed value does not establish site qualification.
Connections	Actual bushing/connector interface, voltage and current rating, BIL, insulation diameter range, conductor size, hardware, torque, and shield-bonding details.
CTs and controls	Ratio, polarity, burden, protection accuracy, shorting provisions, grounding point, contact ratings, control supply, sensor type, and approved alarm/trip setpoints.
Insulation and tests	Certified dielectric test levels and test connections; grounding-transformer acceptance criteria; reference winding resistance/impedance results; approved field-test limits.

Configuration limits

Use the delivered equipment documents to establish the insulation system rating; do not infer a winding operating limit from generic insulation-class wording. Confirm zero-sequence impedance units and whether each current value refers to neutral current or winding/line current. These distinctions affect both equipment selection and relay coordination.

NOTICE
Catalog quantities, weights, and dimensions may differ between product materials. Resolve discrepancies before using them for lifting, anchorage, cable installation, or liquid procurement. Do not average conflicting values or treat an approximate catalog value as a certified limit.

4 Receiving and acceptance inspection

Inspect before unloading

1. Compare the shipment with the packing list, bill of lading, purchase order, and approved equipment schedule. Confirm product identification, serial number, accessories, loose hardware, cable kits, and documentation.

2. Inspect the pallet, crate, tie-down locations, shock indicators if supplied, lifting lugs, base, tank, radiators, doors, and bushings for handling damage. A damaged pallet warrants a close examination of the tank and base.

3. Check for liquid leaks, cracked insulators, dents, displaced fittings, corrosion, damaged paint, missing plugs, broken seals, loose components, and damaged locks or interlocks.

4. Record liquid level, liquid temperature, pressure/vacuum indication, and any alarm or pressure-relief operation. Compare with the shipping record and ambient conditions.

5. Photograph damage and note it on the carrier’s delivery record. Notify the carrier and Larson Electronics promptly. Follow the purchase terms for freight claims. If significant damage affects safe unloading or serviceability, obtain instructions before moving or energizing the unit.

Inspect accessories and wiring

Check separately shipped parts and protected interfaces for moisture or contamination. Keep cable connector kits in clean, dry packaging until needed. Verify that the correct number of phase CTs, neutral CTs, arresters, gauges, and temperature sensors is present. Inspect low-voltage control and CT wiring for loose terminals, abrasion, incorrect labeling, and shipping restraints.

Do not open the tank for routine receipt inspection

The transformer is sealed. Routine core lifting or internal inspection is not required merely because the unit has arrived. If damage, leakage, moisture ingress, abnormal pressure, or a disturbed seal is found, stop and obtain an inspection/test plan. A sealed tank does not eliminate the need for the acceptance tests or liquid-condition checks required by the project.

> **WARNING**
> Do not energize a damaged, leaking, incompletely assembled, or unverified unit. A normal appearance alone does not confirm electrical integrity or correct neutral grounding.

Keep factory test reports, packing records, fluid identification, handling records, and receipt photographs with the permanent equipment file.

5 Handling, lifting, and transportation

WARNING
Use a qualified rigging plan based on the actual unit weight and center of gravity. Keep personnel clear of suspended loads. The tank and core assembly contain most of the mass; an adjoining accessory or resistor cabinet may be much lighter.

• Keep the transformer upright. Use only the designated lifting lugs and rated equipment. Do not lift, pull, or push on bushings, leads, valves, door handles, sheet metal, or radiator fins.

• Attach a separate sling leg to each required lifting lug. Do not loop one sling from lug to lug. Use spreader beams as needed to protect the enclosure and keep sling pull close to vertical.

• Use a maximum sling angle of 30 degrees from vertical unless a serial-number-specific approved lifting drawing requires a smaller angle. Do not increase this limit based on a generic sketch.

• Make a controlled trial lift to verify balance and rigging security. Adjust sling lengths only with the load safely supported. Keep doors closed and loose accessories secured.

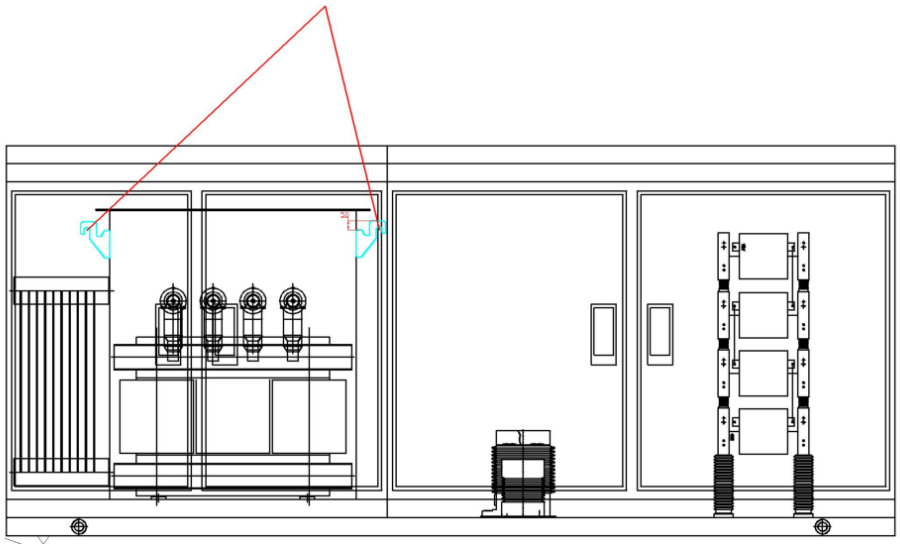


Figure 3. Typical grounding-transformer/resistor assembly showing lifting locations and unequal mass distribution. Sling lines are illustrative only; the approved lifting plan, designated lugs, and 30-degree maximum govern.

Forklift, rollers, and jacks

Use a forklift only when the shipping skid is designed for it and the forklift capacity is adequate at the actual load center. Keep the heavy tank toward the mast. Roll or skid only on a level, load-bearing route with weight distributed across the base. Jack at designated reinforced points using coordinated jacks and stable blocking; never jack under radiators, cabinets, or valves.

Secure truck loads at approved tie-down points. Protect components from strap loads and vibration. Adjust vehicle speed to road conditions. Do not use a generic transport slope allowance as permission to tilt the unit; obtain a route and restraint plan for grades or uneven ground.

6 Storage and preservation

Storage through 90 days

Store upright, fully supported on a level foundation capable of carrying the complete unit. Keep the insulating liquid at its shipping level and all tank openings sealed. Prefer the permanent pad when available. Protect the unit from standing water, salt spray, corrosive vapors, impact, and rapid temperature changes.

• Do not store the transformer on rollers, jacks, or temporary point supports. Do not rest removable radiators on the ground or expose their sealed openings to collected water.

• Keep doors closed, locked, and weather seals intact. Protect spare connectors and arresters in clean, dry packaging.

• Record the initial liquid level, pressure/vacuum, ambient temperature, and any visible leakage. Inspect periodically and after severe weather.

Storage beyond 90 days

Establish a documented inspection schedule. Monitor pressure trends, seals, liquid level, paint, cabinet dryness, rodent intrusion, and corrosion. Maintain the specified dry-gas blanket only when the delivered unit’s instructions call for it. Use dry nitrogen and a suitable regulator under an approved service procedure; do not apply a generic 2 psi or 3 psi storage setting to an unverified tank.

The approved layout includes a cabinet heater. Energize it from the specified protected auxiliary supply and verify their operation. Use and replace desiccant in air-filled spaces where appropriate. Keep desiccant and foreign material out of the liquid-filled tank.

Separate radiators and accessories

Keep removable radiator flanges capped and dry. Installation requires approved gaskets, torque, fluid handling, venting, and valve positions. Confirm that all required radiator valves are open before energization. Do not assume radiators were shipped separate or that field vacuum processing is permitted.

Return from storage

Repeat the receiving and pre-service inspections. After extended storage, perform the approved insulation, winding-connection/phase-relation, and other acceptance checks appropriate to a zig-zag transformer. Compare results with factory baselines, accounting for temperature and test configuration. Inspect and test control circuits and fluid as required by condition and the site maintenance program.

NOTICE
Mineral oil fluid requires a sound sealed system and controlled handling. Avoid unnecessary exposure to air and moisture. Investigate a pressure gauge that remains at zero through significant temperature changes, but do not condemn a unit from a single zero or negative reading.

7 Site, foundation, and enclosure installation

Location and access

Choose a location protected from flooding, vehicle impact, unauthorized access, and corrosive contamination. Provide working space, cable access, door swing, switching clearance, and emergency access suitable for the voltage and task. Follow the adopted electrical code, utility rules, fire protection requirements, and the authority having jurisdiction.

Provide at least 36 inches of unobstructed space around cooling surfaces as an initial layout consideration, or more where required by the approved installation. This is not the electrical working clearance for 34.5 kV equipment. Determine all electrical clearances separately from the applicable code and site design.

Indoor installations

Have the responsible engineer confirm indoor suitability, ventilation, heat rejection, liquid containment, fire protection, and any required vault or separation. Mineral oil is combustible; do not treat it as a high-fire-point ester liquid. Size ventilation from the certified heat losses and room conditions; a generic vent area per kVA is not an adequate design for a grounding transformer. Do not disable fire dampers or fire-rated features to improve ventilation.

Foundation and mounting

1. Verify the approved outline and anchor pattern before pouring the pad or setting conduits. The foundation must support the actual operating mass and applicable wind/seismic loads.

2. Set the unit level and fully support the base. In-service tilt must not exceed 2 degrees, and the approved design may require closer leveling. Do not use the transport condition as an operating allowance.

3. Anchor at the designated points with the specified hardware and torque. Do not drill the tank or use the enclosure sheet metal as an anchor point.

4. Seal unacceptable base gaps with the approved permanent method to preserve cabinet security. Keep drainage paths open and prevent water from entering conduits or compartments.

5. Support cables independently and allow for settlement, thermal movement, and freeze/thaw movement without loading bushings. Restore barriers, covers, interlocks, and locks.

> **WARNING**
> A NEMA Type 4X cabinet is not a submersible enclosure or an arc-resistant enclosure. Keep water out of the cable compartment and keep all personnel clear during energization and switching.

8 Equipment grounding and neutral connection

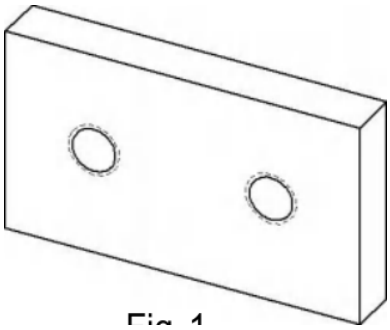


Figure 4. Typical tank ground pad.



Figure 5. Typical welded ground boss.

Permanent equipment grounding

Before making other electrical connections, connect the tank ground bar to the engineered site grounding grid using the specified conductors and lugs. Bond doors, barriers, cable shields, connector grounding tabs, arrester grounds, and accessory enclosures as shown. The equipment grounding circuit remains solidly bonded even when the neutral is impedance grounded.

Clean contact surfaces by the approved method without compromising corrosion protection. Use conductors and connectors compatible with their terminal materials. Apply the specified joint compound when required and tighten with a calibrated torque tool. Record torque and verify continuity. Do not use the liquid tank, hinges alone, or an incidental conduit contact as the sole required bonding path.

Grounding-transformer neutral

1. Identify the live-front H0 neutral terminal from the winding diagram and terminal markings. H1, H2, and H3 are phase terminals. H0 can carry hazardous voltage during a ground fault; do not treat its cabinet as a safe low-voltage compartment. Do not use H0 to supply single-phase loads.

2. Route the neutral through the specified CT and, where required, the grounding resistor/reactor. Keep cable forces off spade terminals, CTs, and resistor elements.

3. If a resistor is part of the design, verify its resistance, voltage, current/time rating, insulation, connections, ventilation, enclosure bond, and monitoring. Field-bolt shipped-loose cable terminals using the supplied approved hardware and torque.

4. If direct grounding is specified, verify that the design accounts for available fault current and the transformer’s neutral and short-time limits. Do not add an impedance or a parallel neutral bond without engineering authorization.

5. Verify that the complete neutral path is continuous and all permanent grounding connections are complete before phase energization.

WARNING
Opening the neutral or grounding transformer circuit can leave the system ungrounded. A connection around a required resistor can defeat current limiting. Both conditions can change protective relay behavior and create hazardous voltages.

9 Medium-voltage connections

DANGER
Isolate, test for absence of voltage, discharge, and ground all associated equipment before installing or servicing deadbreak cable connectors or arresters. Never mate or separate a deadbreak interface while energized.

Verify the connection system

The equipment schedule lists 38 kV class bushings; the field-installation list identifies four 35 kV class, 900 A deadbreak connectors with 200 kV BIL. Verify the exact matched system. The separately identified H0 live-front bushing is not a deadbreak interface. Match the installed connector interface, continuous-current and fault ratings, BIL, conductor size/material, cable insulation diameter, insulation level, and accessories. A nominal voltage or current label alone does not establish interchangeability.

Use the installation sheet supplied for the exact connector kit. Do not use 15/25 kV, 200 A loadbreak-elbow stripback lengths, probe torque, loadmake instructions, or 600 A connector dimensions on an unverified 900 A system. If the correct kit instructions are missing, obtain them before cutting the cable.

Preparation and installation sequence

1. Confirm phase identification, cable routing, and terminal assignment against the approved diagram. Provide cable slack and support without violating the cable’s minimum bend radius.

2. Inspect bushings and connectors for cracks, tracking, moisture, contaminants, and interface damage. Replace damaged parts; do not attempt to conceal defects with grease.

3. Prepare cable shields, insulation, and conductors to the exact kit dimensions. Avoid nicking conductors, insulation, or concentric neutral wires. Keep conductive residue off insulating surfaces.

4. Use the supplied or approved cleaner and lubricant. Clean and dry all mating surfaces; apply a thin, even lubricant film only where specified. Do not apply unapproved chemicals or grease to threaded electrical joints.

5. Install the compression or shear-bolt connector with the specified tooling, dies, sequence, and torque. Assemble studs, insulating plugs, and caps to the kit instructions.

6. Bond cable shields and connector drain tabs as designed, verify seating, check torque records, and fit correctly rated grounded insulating caps to unused service interfaces. Shipping caps are not energized-service caps.

If a connector has been closed onto a fault or shows evidence of arcing, keep the circuit isolated and replace damaged mating components under the approved repair procedure. Do not repeatedly reclose to diagnose a fault.

9.1 Cable preparation and interface care

The following illustrations identify common workmanship requirements. They do not prescribe stripback dimensions, connector rating, or torque for the installed kit.

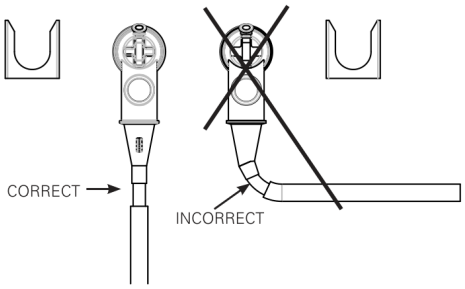


Figure 6. Train the cable straight into the connector; avoid side loading.

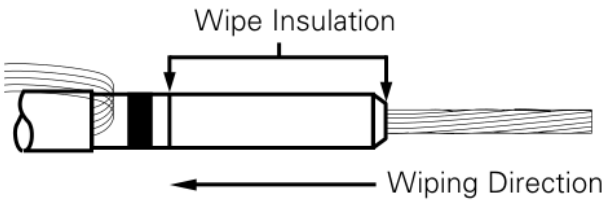


Figure 7. Clean insulation toward the shield without spreading conductive residue.

Prepare a clean, controlled work area

Keep connector kits covered until needed. Provide good lighting, lint-free wipes, approved cable cleaner and silicone lubricant, cable stripping tools, crimp/shear-bolt tools, calibrated torque tools, and required PPE. Inspect tools before use. Support the cable while working so its weight cannot rotate or damage the bushing.

Shield and insulation workmanship

Remove the jacket and semiconductive shield without scoring the underlying layers. Keep concentric neutral or shield wires long enough for the specified grounding connection. Use the supplied shield adapter, mastic, jacket seal, and tape system when required. Do not improvise the seal layers or use a generic cable dimension from a different voltage class.

Remove conductive particles from exposed insulation. Use cleaner on the wipe rather than flooding the cable. Follow the kit’s bevel or chamfer instruction; do not pencil the insulation unless that kit specifically requires it. Inspect the surface before applying lubricant or sliding on an adapter.



Figure 8. Typical cable-adapter seating. Keep the adapter straight and at its specified reference mark.



Figure 9. Incorrect adapter alignment or a bulge requires correction before assembly.

NOTICE
Stop if the insulation diameter, conductor construction, or cable size is outside the connector kit range. A connector that can be forced onto a cable is not necessarily a compatible connector.

9.2 Connector assembly and final checks

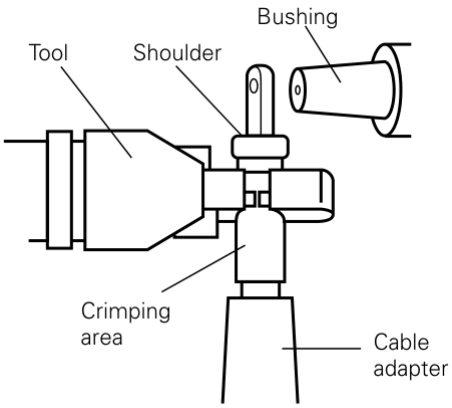


Figure 10. Typical compression connection. Use the kit-specific tool and die schedule.

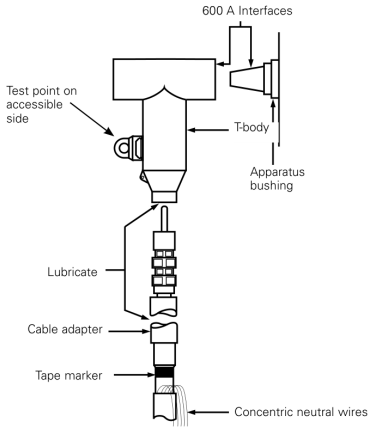


Figure 11. Typical T-body assembly. The illustrated interface is representative only.

Connector and T-body assembly

Fully seat the conductor in the lug and orient the connection to minimize strain. For aluminum conductors, use the specified cleaning and oxide-inhibiting method. Complete all crimps or shear-bolt operations in the required sequence. Remove excess compound from insulating surfaces. Do not substitute generic crimp spacing or torque.

Clean and lubricate the approved mating interfaces. Position the adapter and connector body without disturbing the reference location. Use the correct stud and insulating plug; hand-start threads to avoid cross-threading, then tighten by the kit procedure. Never apply force that can rotate a tank bushing or compromise its seal.

Checks before energization

• Verify full seating and the specified torque with a calibrated tool. Check for cable side loads, adapter bulges, loose plugs, damaged caps, or exposed energized interfaces.

• Connect shield and drain-wire grounds, leaving only the movement allowance required by the design. These small grounding tabs do not replace the main tank bond or the grounding-transformer neutral connection.

• Clean, lubricate as specified, and seat insulating caps. Restore test-point caps and any jacket seals.

• Use only voltage-indicating devices intended for the installed test point. The point is not a calibrated voltage-measurement or phasing connection unless specifically rated for that purpose.

WARNING
Do not use a “no voltage” capacitive test-point indication as the sole basis for touching a connector. Follow the site absence-of-voltage and protective-grounding procedure.

Multi-tap separable splices, feedthrough assemblies, and live-front terminations require the correct separately approved kit and application instructions. They are not implied by the radial-feed configuration of this unit.

10 Current transformers and secondary circuits

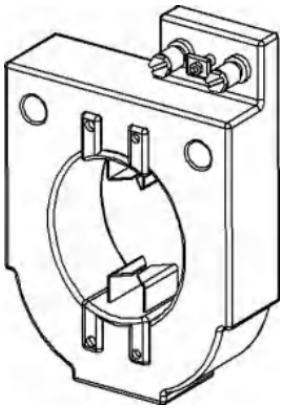


Figure 12. Typical bushing-mounted CT.

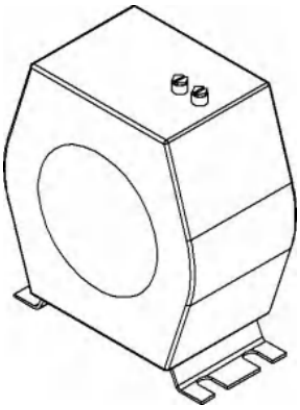


Figure 13. Typical internal CT construction.

The configuration lists one CT per phase and one CT for neutral current, each with a 300:5 A ratio and 15 VA burden designation. Confirm ratio, polarity marks, secondary connections, accuracy, and short-time capability from the installed CT data. International protection class 5P20, if shown on the supplied data, does not establish an interchangeable IEEE C-class; use the certified performance for the relay study.

DANGER
An open CT secondary can develop dangerous voltage. Never disconnect a CT lead, relay, meter, or test instrument while primary current can flow unless the approved CT shorting arrangement is already established.

Wiring and grounding

1. Verify each CT location and polarity against the approved protection schematic. Confirm the neutral conductor passes through the correct sensing path and that parallel paths do not bypass the intended measurement.

2. Use designated shorting/test terminal blocks. Keep unused CT secondaries in the approved shorted condition. Never short a voltage-transformer or power-supply circuit by analogy.

3. Ground each CT secondary circuit at the single point specified in the control design. Avoid additional grounds that can create circulating currents or measurement errors.

4. Check terminal tightness, conductor identification, insulation, continuity, relay inputs, and total burden including lead resistance. Protect CT circuits from accidental opening.

5. Test ratio, polarity, continuity, and the complete relay/trip path under an approved commissioning procedure. Restore every shorting link and test switch to its documented service position.

The 300:5 ratio means 300 A primary corresponds to 5 A secondary under rated conditions. It does not make 300 A an allowable continuous grounding-transformer neutral current. Do not substitute CT ratings for the transformer’s duty ratings.

No watt-hour meter or metering panel is specified. If added by approved design, use compatible CT circuits and preserve the protection functions.

10.1 Control wiring and protective functions

Protection must operate an external device capable of clearing the available fault. A local switch, gauge contact, pressure-relief valve, or CT alone does not interrupt a fault. Verify the control power source, relay settings, breaker trip circuit, backup protection, and indications before energization.

Function	Required commissioning check
Neutral/ground overcurrent	Verify pickup and total clearing time against continuous and short-time transformer duty and the system grounding study. Include all operating source configurations.
Phase protection	Verify the design covers internal faults and abnormal phase conditions without defeating required grounding availability.
Rapid-pressure-rise relay	Prove the alarm/trip logic and seal-in/reset function, where provided, by the approved non-damaging test method.
Pressure-relief contact	Verify indication or trip response. Do not assume device actuation alone de-energizes the transformer.
Liquid level and temperature	Verify contact ratings, wiring, setpoints, annunciation, and required shutdown response.
Winding/core temperature	Confirm all four sensor channels, sensor type, display scaling, alarms, and failed-sensor behavior.
Neutral path / resistor monitoring	Where provided, verify continuity supervision, alarm, and system shutdown logic.
Control power failure	Verify the response to loss of auxiliary power or trip supply. Prevent operation with essential protection unavailable.

Terminations and testing

Use the terminal numbers and contact logic on the approved wiring diagram. Separate power, CT, sensor, and communication wiring as specified. Maintain shield and grounding practices appropriate to the circuit. Seal conduit entries and protect wiring from heat, sharp edges, moisture, and door movement.

Isolate electronic devices, arresters, CT circuits, and sensitive accessories as required before insulation testing. Do not apply a megohmmeter or withstand voltage across relay electronics, sensor inputs, or gauge contacts without an approved test instruction.

NOTICE
Alarm and trip settings are engineering values. Do not copy a generic temperature, pressure, or current setting from a sample gauge. Record approved settings and changes in the equipment file.

11 Liquid level, temperature, and pressure gauges



Figure 14. Liquid level indicator.



Figure 15. Top-liquid temperature indicator.

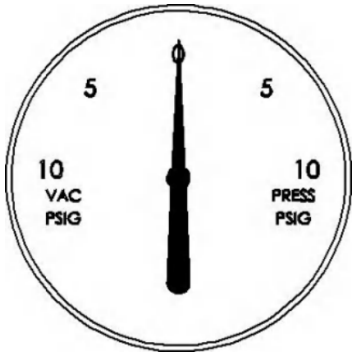


Figure 16. Pressure/vacuum gauge.

Liquid level

A float inside the tank is magnetically coupled to an external pointer, maintaining a sealed separation. Interpret the reading with liquid temperature and the gauge reference marks. A +25°C mark is a reference condition, not a fixed level for every temperature. A sustained decline, low-level alarm, or reading below the approved range requires investigation before continued operation.

Top-liquid temperature

The indicating pointer displays liquid temperature near the top of the liquid column. A maximum pointer, if fitted, retains the highest reading until reset. Record it before resetting. Pointer colors and adjustment methods vary; use the installed gauge legend. The sensing element may be in a sealed well, but removal is permitted only by the component's approved service procedure.

The 65°C winding-rise designation is not a maximum top-liquid temperature and must not be added to ambient temperature to create a gauge alarm setting. Use the approved thermal design and alarm/trip values. Change contacts only with authorization, then test and document their operation.

Pressure/vacuum

Headspace pressure normally changes with liquid and ambient temperature. A moderate negative reading during cool conditions can be normal. A sustained zero reading through changing temperatures may indicate a leak or a faulty gauge. Investigate trends, leakage, seals, and device condition rather than relying on one reading.

Do not add nitrogen or adjust a regulator using a generic pressure value. Use the tank's approved pressure range and service procedure. High/low contacts, where installed, require the specified control supply and annunciation/trip logic.

WARNING
Do not loosen a gauge, plug, bushing, cover, or valve to check pressure. Release positive pressure only through the designated device under the approved de-energized service procedure.

11.1 Pressure relief and rapid-pressure-rise protection

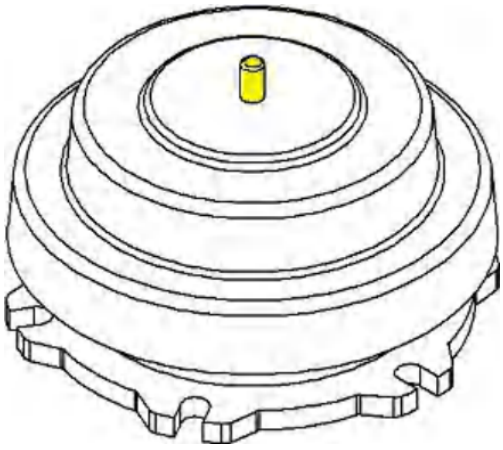


Figure 17. Typical automatic pressure-relief device.

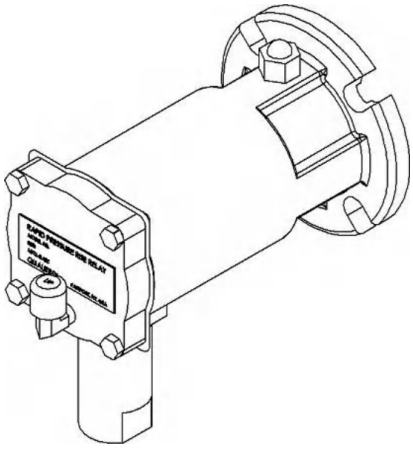


Figure 18. Typical rapid-pressure-rise relay.

Pressure-relief device (PRD)

The PRD opens mechanically when pressure reaches its designed release level and reseals after pressure falls. An operated indicator may remain visible until reset. An auxiliary contact may provide alarm or trip indication. Use the actual device setting; a typical value from another transformer is not a tank-pressure limit.

Keep the discharge path clear and directed away from personnel. Do not block, clamp, paint shut, adjust, or defeat the device. A PRD reduces pressure but cannot guarantee prevention of tank rupture, fire, or injury during an internal fault.

Rapid-pressure-rise relay (RPRR)

The RPRR responds to the rate of pressure increase. It is a detection device, not a vent. Its contact changes state to initiate the specified alarm/trip circuit. A seal-in relay, if installed, retains the indication or trip until the authorized reset sequence is completed.

Response to an operation

1. Keep personnel clear and notify the system operator. Follow the protection scheme to isolate the affected equipment from a safe upstream point.

2. Do not re-energize merely because a PRD resealed or an indicator can be reset. Record relay targets, fault current, fault duration, temperature, pressure, and visible evidence.

3. Inspect for liquid discharge, leakage, tank distortion, external faults, and control malfunctions. Obtain the required electrical and mineral-oil liquid tests.

4. Reset indicators or seal-in relays only after the cause is understood, corrective action is complete, and return to service is authorized.

WARNING
A pressure event can indicate an internal fault. Do not approach a bulging tank, escaping gas, hot liquid, smoke, or fire. Follow the site emergency response plan.

11.2 Fill, drain, sampling, and gas connections

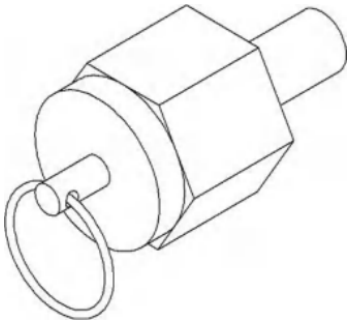


Figure 19. Typical small pressure-relief/vent valve.

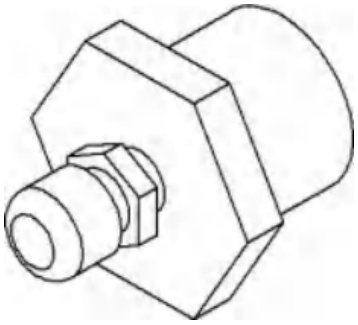


Figure 20. Typical fill plug and gas connection.

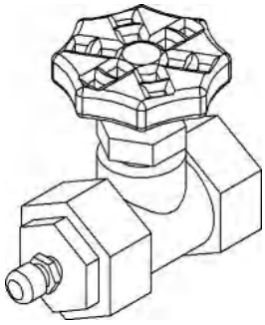


Figure 21. Alternate fill-valve arrangement.

Small pressure-relief valve

Where installed, this valve relieves gradual thermal pressure changes and provides a controlled means of releasing positive headspace pressure. It is distinct from the fault-pressure-relief device. Do not substitute the slow vent for the PRD or assume their operating settings are the same.

Fill and gas-sampling connection

The configuration provides a front-compartment fill port with a removable plug and a gas-sampling connection. Confirm the installed fitting sizes and instructions. Use the approved closed-transfer method for mineral oil and dry nitrogen when required. Do not use compressed shop air, oxygen, or an unregulated gas cylinder.

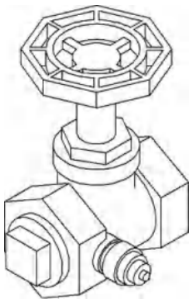


Figure 22. Typical drain valve with a separate liquid-sampling port.

Drain and liquid-sampling valve

Use the designated sampling port for representative samples when practical. Capture all flushed liquid in a compatible container. Keep drain plugs/caps secured after service, close the valve, and inspect for leaks. Protect the valve from accidental operation and impact.

WARNING
Before opening the liquid system, isolate the transformer and establish zero gauge pressure by the approved method. If the tank is under vacuum, do not pull a vent open to admit moist air; obtain the specified dry-gas equalization procedure. Avoid skin contact with hot liquid.

Do not open the tank during precipitation, fog, condensation, or other conditions that allow moisture ingress. Keep ports open only as long as necessary. Section 15 covers fluid handling and sampling.

11.3 Temperature monitoring and cooling

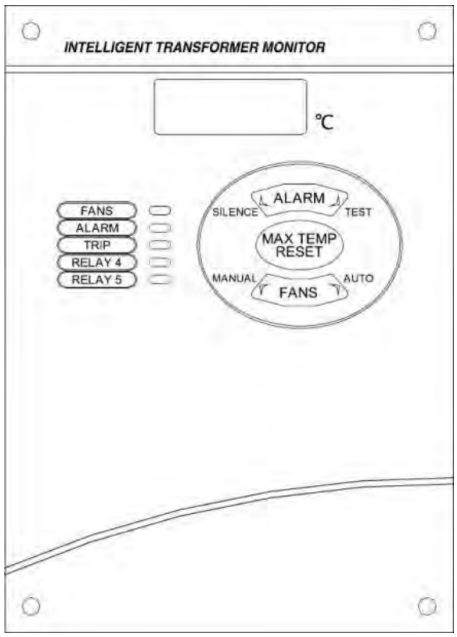


Figure 23. Typical temperature monitor; display layout and controls vary with the installed equipment.

Winding and core sensors

Four sensors are specified: one at each phase coil and one at the core. The approved layout includes the sensor indicator, an external monitoring terminal box, and an accessory heater. Confirm the actual sensor technology, heater supply, and wiring before connecting instruments. Sensor leads pass through sealed fittings; do not disturb these seals or substitute incompatible input modules. Label each channel by its physical location.

Compare readings with ambient and top-liquid temperature during commissioning and routine inspections. Investigate implausible, fixed, erratic, or sharply divergent values. A failed sensor can defeat a protection function; follow the approved loss-of-sensor response. Test alarms and trips without heating the transformer beyond its rated limits.

ONAN cooling

Heat moves through the insulating liquid by natural circulation and leaves the tank/radiators by natural air circulation. Keep cooling surfaces clean and unobstructed. Maintain the liquid level and correct radiator valve positions where valves are fitted. Do not cover the tank or use it as a shelf.

The specified unit is self-cooled. Adding fans does not automatically authorize a 25 percent capacity increase, a higher neutral current, or a longer fault duration. Any change in cooling equipment or duty requires written engineering approval and revised equipment ratings.

NOTICE
Mineral oil does not provide a high-fire-point natural-ester classification. Do not apply a generic 120 percent loading claim to this grounding transformer. Continuous unbalance current, short-time ground-fault current, and temperature limits remain controlling.

12 Two-position switch and surge arresters



Figure 24. Typical two-position switch operating handle.

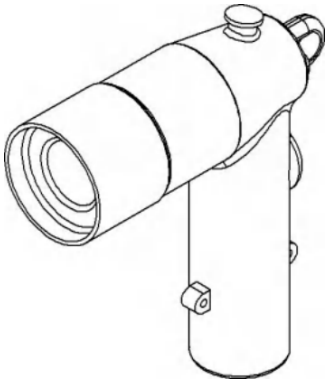


Figure 25. Typical separable surge-arrester construction.

Switch operation

The specified switch is a two-position oil-immersed device listed at 200 A and 38 kV. Identify its actual OPEN/CLOSED positions and switching ratings from its label and approved diagram. A spring mechanism provides rapid contact motion. Operate with the specified live-line tool and PPE under the authorized switching procedure.

• Do not operate a switch when an internal fault is suspected or use it to interrupt a fault unless explicitly rated for that fault duty.

• Plan switching so the connected system is not left without its required grounding source. Coordinate any alternate grounding source before isolation.

• Operate to a definite position without stopping between positions. Verify the resulting circuit condition by the approved indication and voltage checks.

• An OPEN position does not make the entire cabinet safe; incoming cables and other sources may remain energized. Establish isolation upstream before hands-on work.

Surge arresters

Three arresters, one per phase, are listed at 36 kV rated voltage and 29 kV maximum continuous operating voltage (MCOV). Confirm their suitability for the actual system grounding and temporary overvoltages. Arresters conduct surge energy to ground and return to low leakage after the surge; they are not fault-interrupting devices.

Keep arrester ground connections short and routed as designed. Inspect for cracks, tracking, loose bonds, contamination, and failed indicators where present. Install separable arresters only with the correct clean, dry, lubricated interface and with all associated equipment de-energized.

NOTICE
Disconnect and isolate arresters before transformer impulse or applied-voltage tests as required by the approved test plan. Use correctly rated insulating caps on exposed interfaces. Reconnect all arresters and grounds and verify their condition before energization.

13 Pre-energization inspection and acceptance tests

Use qualified test personnel and a written plan appropriate to the zig-zag winding and installed accessories. Apply the project acceptance specification and relevant ANSI/NETA guidance. The factory dielectric values are not automatic field-test settings.

Inspection / test	Acceptance basis
Documents and configuration	Approved nameplate, one-line, connection diagram, neutral design, equipment schedule, factory report, and protection settings agree.
Mechanical condition	No unresolved shipping/storage damage; secure anchors, intact seals, correct liquid level, clear cooling surfaces, operable locks and barriers.
Grounding and neutral continuity	Low-resistance permanent bonding and continuous intended neutral path; no unintended resistor bypass or missing bond.
Cable and interface checks	Correct phases, ratings, clearances, shield bonds, support, seating, and documented torque. Cable tests separated from transformer/accessories as required.
Winding tests	Resistance, insulation condition, phase relation, and zig-zag connection verification by the approved method; compare with factory baseline and temperature-corrected criteria.
Zero-sequence impedance	Verify certified data and, where required, test using the approved grounding-transformer configuration. A conventional secondary short-circuit test is not interchangeable.
CTs, sensors, and controls	Correct polarity, ratio, burden, continuity, secondary grounding and shorting positions; all sensor channels and contacts function.
Protection and trip path	End-to-end trip/annunciation checks; external clearing device and control supply available; primary and backup clearing within duty ratings.
Fluid and tank condition	Mineral oil identity confirmed; no leaks or abnormal pressure trends; baseline/condition tests completed as required.

Test precautions

Maintain barriers around test areas. Isolate sensitive electronics and surge arresters where required. Do not megger across connected CT relay inputs or sensors. After DC winding-resistance tests, discharge stored energy and apply the approved demagnetization/restoration procedure. After dielectric tests, discharge and ground the tested circuits before handling.

Do not lift the core or open the tank for routine acceptance. If abnormal results or signs of contamination exist, obtain a diagnostic plan and written disposition. Record test equipment, connections, temperatures, measured values, acceptance criteria, and corrective actions.

WARNING
Do not energize with unresolved test failures, uncertain neutral grounding, incomplete protection, low liquid, incorrect cable interfaces, or an open CT secondary.

13.1 Energization and controlled shutdown

Before energization

1. Complete the checklist on page 35. Confirm acceptable test results and documented resolution of installation discrepancies.

2. Verify mineral oil level, closed fill/drain valves, secured plugs, normal device indications, clear cooling surfaces, and correct radiator valve positions if provided.

3. Verify the neutral path, equipment bonds, CT circuit service positions, surge arresters, control power, alarms, trip circuits, and the specified switch position.

4. Account for tools, temporary leads, test equipment, and personnel. Remove temporary grounds only under the authorized clearance procedure; keep all permanent grounds and neutral connections intact.

5. Close and lock doors, restore covers and barriers, clear the area, and notify the system operator. Use the approved upstream energization point.

Initial energization

Energize under the approved switching order with protection active. Observe from a safe location. Confirm the expected voltages, phase condition, neutral current, temperature trends, and alarm status through installed instrumentation. A grounding transformer may be lightly excited in normal operation; this does not eliminate the possibility of a ground fault at any time.

Record initial readings and recheck after conditions stabilize under the site commissioning plan. If abnormal sound, excessive current, rapid temperature rise, leakage, pressure operation, smoke, or protection pickup occurs, isolate remotely and investigate. Do not repeatedly energize to see whether the condition clears.

Shutdown

Coordinate shutdown with the system operator and provide the required alternate grounding arrangement or de-energize the affected system. Interrupt and isolate using rated equipment. Apply lockout/tagout, absence-of-voltage verification, and protective grounding before access. Do not disconnect the neutral first as a means of switching the transformer.

Return after a fault or protective trip

Record current magnitude, duration, relay targets, and breaker operation. Evaluate the transformer, resistor if fitted, connections, CTs, arresters, and liquid condition. Confirm the available repeat-duty/cooling requirements. Return to service only after the fault cause is corrected and engineering/operations authorization is recorded.

NOTICE
Do not routinely vent a sound sealed tank before each energization. Venting is a controlled service operation for positive pressure when required by the approved procedure, not a substitute for checking the liquid and tank condition.

14 Operating limits and routine observation

Rated operation

Operate only at the approved voltage, frequency, cooling condition, ambient limits, and continuous neutral-current duty. Do not use the 1 MVA designation as a load capacity or derive a neutral-current limit from it. The system study and certified nameplate establish the permissible duty.

Do not intentionally operate above rated voltage or below rated frequency without written approval. Excessive volts per hertz can overexcite the core. A generic 0.5 percent overvoltage allowance is not an operating control range. Phase loss, abnormal unbalance, and persistent neutral current require investigation; they are not assumed harmless.

Fault current and repeat duty

The listed short-time duty is 1,000 A for 10 seconds on the verified current basis. Do not extrapolate a different current/time combination, assume repeated faults are acceptable, or use the withstand duration as the normal clearing delay. Protection must keep every credible event within the approved thermal and mechanical limits, including backup clearing and reclosing.

Temperature and environment

Trend top-liquid, winding, and core temperatures against neutral current and ambient conditions. Use approved alarms and trips. Keep cooling surfaces clear. The mineral oil grade and assembled equipment determine cold-start behavior after a cold soak; verify the approved low-temperature procedure before energization outside the established conditions.

Observe	Action
Stable normal readings	Record neutral current, temperatures, level, pressure/vacuum, switch position, and alarm status at the site-defined interval.
Rising neutral current or unbalance	Check the connected system and relay indications. Reduce exposure or isolate as required by the protection plan.
Low liquid / persistent leakage	Investigate promptly; isolate if liquid is below the approved minimum or dielectric integrity is uncertain.
Pressure event / smoke / severe noise	Keep clear, isolate from a safe upstream location, and use the emergency response procedure.
Loss of neutral continuity or protection	Apply the system design response. Do not continue operation without the required grounding or protection.

Avoid approaching the unit solely to obtain a reading when an abnormal electrical or pressure condition is suspected. Use remote instrumentation where provided.

15 Preventive maintenance program

Set maintenance intervals from equipment condition, service criticality, environment, operating history, and the applicable maintenance program. The following is a starting schedule; shorten intervals after faults, leaks, flooding, salt exposure, severe weather, or unusual temperature/current trends.

When	Work
At commissioning	Establish photographs, baseline electrical tests, fluid test results, approved settings, torque records, and normal operating readings.
Routine operator rounds	Read available instruments safely; check alarms, unusual sound/odor, visible leakage, blocked cooling, security, and evidence of tampering. Record trends.
Periodic exterior inspection	Check coating, corrosion, foundation settlement, anchors, door seals, labels, vegetation, debris, cable-entry seals, and drainage. Repair defects promptly.
At least annually, unless the approved program specifies otherwise	Review trends and protection events; obtain a representative mineral oil condition sample and DGA as appropriate; inspect external condition and plan the outage tasks needed.
Planned de-energized outage	Inspect/clean bushings and interfaces; check bonds, neutral path, CT/control wiring, mechanical operation, and alarm/trip functions. Verify critical joints by the approved method.
After a fault, pressure operation, flood, impact, or suspected moisture ingress	Isolate as needed and perform an engineering-directed inspection, electrical tests, fluid diagnostics, and protection review before return to service.

Cleaning and inspection

De-energize before cleaning or touching internal components. Clean insulators with compatible materials and inspect for cracks, tracking, or carbon deposits. Replace damaged components. Remove cooling-surface debris and dirt at the base without driving water into seals or electrical interfaces.

Inspect terminals for overheating and looseness. Use specified torque; do not tighten indiscriminately or transfer wrench force into a bushing. Check cable support, neutral connections, shield grounds, and contact corrosion. Preserve stainless-steel surfaces and use the approved coating repair system.

Replacement parts

Order through Larson Electronics using the serial number, nameplate data, component identification, and photographs. Match electrical ratings, interface, material compatibility, and mineral oil seals. Do not substitute a component solely because it fits mechanically.

15.1 Mineral oil liquid handling

Use only the approved non-PCB mineral insulating oil grade identified for this transformer, meeting the specified ASTM D3487 requirements. Verify the required inhibitor/type designation; do not substitute solely on viscosity or appearance. Keep the liquid clean and dry, use dedicated compatible hoses and containers, and limit exposure to air. Do not mix in silicone liquid, natural or synthetic ester, or an unapproved mineral-oil grade. Confirm compatibility and performance before adding any different liquid.

Before opening the liquid system

1. Isolate, lock out, verify absence of voltage, and ground the equipment. Allow safe temperature conditions. Prepare containment, PPE, clean tools, and the liquid safety data sheet.

2. Record liquid level, temperature, and pressure. Relieve positive pressure through the designated service device. If the tank is under vacuum, use the approved dry-gas procedure; do not draw ambient air into the tank.

3. Clean the area around the port. Avoid rain, fog, condensation, windblown dust, and unnecessary open time. Use a closed transfer method when available.

Adding or replacing liquid

Investigate and repair the reason for low level before topping up. Add the correct liquid through the designated fill connection using the approved filtration/transfer process. Avoid entrained air, splashing, and contamination. Set the level according to the specified temperature reference, leaving the required expansion space.

Do not determine the final level by adding a catalog number of gallons. Confirm the actual capacity and temperature-corrected fill level. Confirm all liquid-contact materials and gaskets are compatible with the approved fluid.

After draining, topping up, or filling, reseal the system, restore the specified gas space, inspect for leaks, and allow the required settling/de-aeration time. The required time depends on the work and fluid condition; obtain it from the approved service procedure. Confirm liquid level and required test results before energization.

WARNING
Do not apply vacuum processing or tank pressure beyond the unit’s approved structural limits. A sealed tank is not automatically rated for full vacuum. Large-volume filling, drying, and internal repairs require a transformer service procedure.

Spills and end-of-life handling

Mineral oil provides dielectric insulation and cooling and is combustible. Do not release oil to soil, drains, or surface water. Contain spills, protect personnel, and use approved collection and disposal practices. Follow the liquid SDS and site environmental requirements.

15.2 Liquid sampling and condition assessment

Sampling plan

Obtain baseline samples when required by the acceptance plan and establish a condition-based program, normally including an annual review/sample. Sealed construction does not make periodic diagnostic testing unnecessary. Sample sooner after a pressure event, overheating, moisture entry, bushing damage, an unusual fault, or a significant leak.

1. Use a laboratory experienced with mineral oil transformers. Specify the actual fluid type, transformer serial number, sampling point, operating history, and requested tests.

2. Follow the approved de-energized sampling procedure unless a separately authorized engineered procedure permits sampling in service. Control temperature, pressure, access, and electrical exposure.

3. Clean the sample port and flush the specified amount into a waste container. Use the laboratory's clean, dry containers and airtight gas-analysis sampling equipment.

4. Avoid air bubbles and moisture. Fill, seal, label, and ship samples as instructed by the laboratory. Record liquid/ambient temperature, current, pressure, level, date, and sampler.

5. Close and secure the valve and cap, clean any spill, check for leakage, and confirm the liquid level remains acceptable.

Tests and interpretation

The test plan may include dielectric breakdown, moisture, acidity, visual condition, and dissolved-gas analysis (DGA). Select methods and limits appropriate to mineral oil. Trend results and investigate rates of change; use mineral-oil interpretation criteria appropriate to the equipment, oil condition, and test method.

Use the approved mineral-oil and transformer criteria, including applicable IEEE C57.106 guidance for oil acceptance and maintenance. Use an experienced laboratory for DGA interpretation. A single sample is not a complete diagnosis. Combine liquid results with current history, temperatures, protection events, electrical tests, and physical condition.

Corrective action

Do not energize equipment with unresolved evidence of moisture ingress, internal fault, inadequate dielectric condition, or an unacceptable liquid level. Determine whether further sampling, leak repair, dehydration, filtration, or component replacement is required. Document all added liquid and processing activities.

NOTICE
Mineral oil fluid properties and limits depend on the actual formulation and test method. Use the approved fluid specification and SDS, not generic property values from a different product, to make service decisions.

16 Troubleshooting and abnormal conditions

The actions below begin with safe observation. Any hands-on inspection requires the isolation procedure on page 3. Do not use repeated switching, bypassed protection, or an open neutral as a diagnostic method.

Condition	Possible issue / required response
High neutral current or ground relay pickup	System ground fault, abnormal unbalance, incorrect CT wiring, or grounding configuration error. Review relay records and the system study; isolate when required.
No expected neutral current indication	Open CT circuit, incorrect CT ratio/polarity, relay issue, or a broken/bypassed neutral sensing path. Treat possible loss of grounding as urgent; verify de-energized.
High liquid, winding, or core temperature	Excessive neutral duty, overexcitation, inadequate airflow, low liquid, sensor error, or internal fault. Compare channels and operating conditions; follow approved trip limits.
Low level or visible leak	Seal, bushing, valve, weld, or fitting defect. Isolate if level/insulation is unsafe; repair and test before refilling/return.
Pressure gauge stays at zero	Possible gas-space leak or faulty gauge. Compare temperature history and inspect seals; one zero reading is not conclusive.
Persistent unexpected vacuum or high pressure	Temperature effect, gas/level issue, blocked device, or abnormal internal condition. Do not vent a vacuum to ambient; obtain an approved diagnostic procedure.
PRD or rapid-pressure-rise operation	Possible internal fault or abnormal pressure event. Isolate, record evidence, inspect, and test. Do not simply reset and reclose.
Tracking, cracking, or arcing at interface	Contamination, moisture, damage, poor seating, wrong kit, or loose connection. Replace defective components and correct the cause while isolated.
Control or sensor failure	Loss of auxiliary supply, loose wiring, incorrect input type, or device failure. Restore required protection before service.
Unusual vibration or sound	Loose hardware, overexcitation, fault, phase abnormality, or core/winding issue. Evaluate from a safe location; isolate for severe or unexplained changes.

Information for service assistance

Provide Larson Electronics with the serial number, nameplate photograph, approved drawing references, operating voltage/frequency, neutral current, temperatures, pressure/level readings, relay event records, fault duration, liquid test results, and photographs of observed damage. Preserve failed parts and event evidence when safe to do so.

17 Factory tests and technical records

The factory test report establishes the tests actually performed and the acceptance criteria for this serial-numbered grounding transformer. Descriptions below explain common test functions; they are not instructions to reproduce factory tests in the field.

Test	Purpose / grounding-transformer application
Winding resistance	Checks winding continuity and connection condition; supports loss and temperature calculations. Compare using the correct phase path and temperature correction.
Connection, polarity, and phase relation	Verifies the intended zig-zag interconnection and neutral. Conventional primary-to-secondary ratio procedures require adaptation because no load-serving secondary is provided.
Excitation and no-load loss	Assesses excitation/core behavior at the specified voltage, frequency, waveform, and test arrangement.
Zero-sequence impedance / loss	Establishes the grounding circuit’s behavior at the specified current and connection. Preserve the current basis and impedance units in the report.
Insulation resistance / power factor	Assesses insulation condition under a defined setup. Correct interpretation depends on winding connections, liquid type, temperature, and isolated accessories.
Applied and induced voltage withstand	Checks insulation under the approved factory test plan. The listed 70 kV, 1-minute value is not a field-testing instruction.
Lightning impulse	Checks the specified impulse insulation level. Use the certified test method and results; do not infer field impulse requirements from the BIL alone.
Temperature rise / short-time duty	Verifies thermal performance for the designated continuous and short-time grounding duties. Winding rise differs from top-liquid temperature and local hot-spot temperature.
Pressure integrity	Checks the sealed tank and fittings by the approved pressure method. Do not exceed the structural pressure/vacuum limits in service.
Audible sound	Assesses sound under specified test conditions. Transformer core sound commonly includes multiples of twice the power frequency.

Keep complete records

Retain factory reports, certified drawings, CT/component data, liquid identification, acceptance results, relay settings, trip tests, fluid additions, repair history, and all subsequent condition trends. Document the basis for every configuration or duty change.

The approved equipment schedule lists approximately 1,300 W no-load loss and marks conventional voltage-ratio and load-loss tests as not applicable because no load-serving secondary is provided. Generic distribution-transformer efficiency percentages and DOE efficiency claims do not establish an operating limit or certification for this grounding application. Use the certified losses for heat-rejection design and the applicable procurement requirements for compliance.

18 U.S. installation and technical references

Apply the editions adopted by the authority having jurisdiction and specified by the project. These references guide installation, safety, testing, and maintenance; listing them does not certify the complete unit to every standard.

Reference	Application
NFPA 70 (NEC)	Installation requirements, including grounding/bonding, transformers, and equipment over 1,000 V as applicable. Utility-controlled installations may instead fall under the applicable NESC/utility rules.
NFPA 70E; OSHA electrical rules	Qualified-person work practices, electrical risk assessment, isolation, and protection. Apply OSHA 29 CFR 1910.269 for covered utility work and Subpart S where applicable.
NFPA 70B; ANSI/NETA ATS and MTS	Maintenance program and condition assessment; acceptance and maintenance test specifications appropriate to the installed equipment.
IEEE C57.32	Neutral grounding devices, including grounding transformers. Use the project-specified approved requirements. The 2015 edition and its 2020 amendment are listed by IEEE as inactive-reserved; verify the applicable contractual edition.
IEEE C57.12.28 / C57.12.29	Pad-mounted enclosure integrity and the applicable environmental/enclosure requirements when specified.
IEEE 386; IEEE C62.11 / C62.22	Separable connector systems and surge-arrester requirements/application, within their respective scopes and actual component ratings.
ASTM D3487; IEEE C57.106	Mineral oil liquid specification and guidance for its acceptance and maintenance.
IEEE C57.12.00 / C57.12.90	General liquid-immersed transformer requirements/test code. Their scope excludes grounding transformers; use only specifically adopted applicable methods under the grounding-transformer specification.
IEEE C57.12.34; NEMA TR 1	Pad-mounted distribution-transformer construction and general transformer reference material, only where expressly applicable to this unit.

International component classifications are not automatically equivalent to an American rating. Do not replace a CT accuracy class, connector interface, creepage requirement, or test level with a U.S. designation without supporting qualification data.

Reference access

NFPA: nfpa.org/codes-and-standards • OSHA: osha.gov/laws-regs
IEEE: standards.ieee.org • ASTM: store.astm.org • NETA: netaworld.org/standards

Appendix A Accessory identification

SCOPE
The items on pages 32-34 identify other pad-mounted transformer components. They are not operating equipment on this grounding-transformer configuration unless specifically listed in its approved equipment schedule.

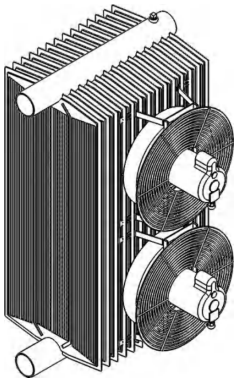


Figure A1. Forced-air cooling fans.

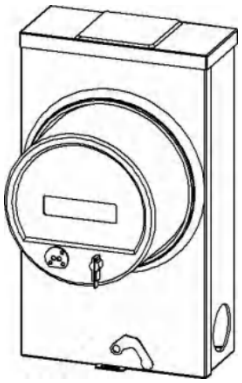


Figure A2. Meter socket and watt-hour meter.

Fans and metering: Fans may be used on separately rated forced-air designs. They do not increase this ONAN unit's duty. Meters require their own approved circuit and CT application. Keep all CT secondary safety requirements in force.

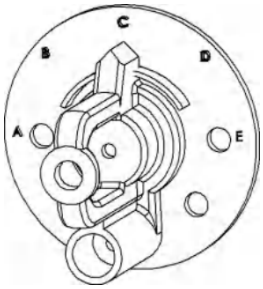


Figure A3. Typical de-energized tap-selector mechanism.

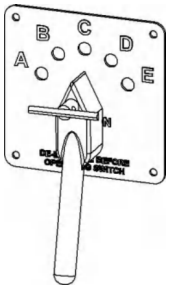


Figure A4. Alternate tap-selector handle.

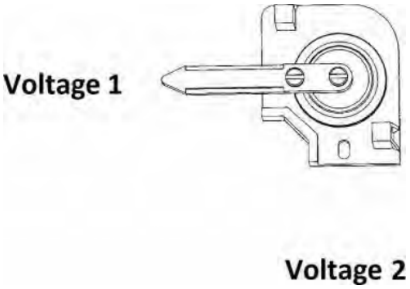


Figure A5. Dual-voltage selector.

Tap and voltage selectors: No tap changer or dual-voltage selector is specified for this unit. On equipment that has them, operate only de-energized, isolated, and grounded, using the equipment's exact nameplate positions. Generic 2.5 percent tap increments are not applicable here.

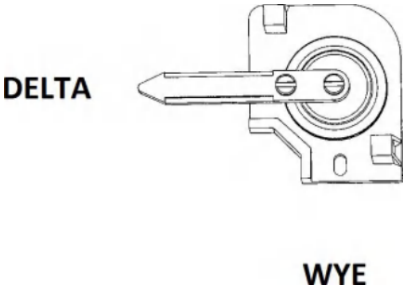


Figure A6. Delta-wye selector.

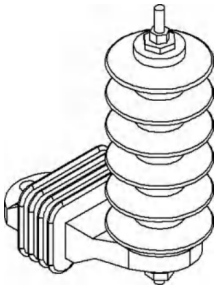


Figure A7. Typical live-front surge arrester.

Connection selectors and live-front parts: No delta-wye reconnection is authorized for the zig-zag winding. A live-front arrester illustration does not permit substitution for the installed dead-front assembly.

Appendix A Switching and fuse identification

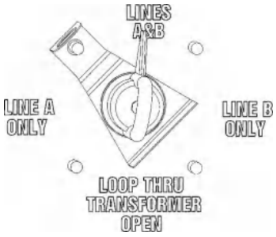


Figure A8. Four-position sectionalizing switch, T-blade arrangement.

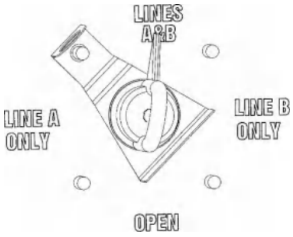


Figure A9. Four-position sectionalizing switch, V-blade arrangement.

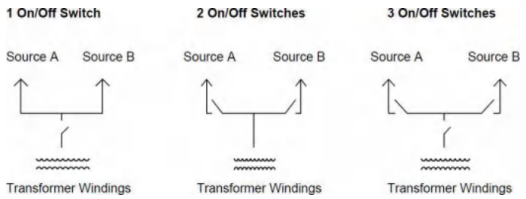


Figure A10. Typical multiple two-position switch arrangements used in other pad-mounted designs. The present unit is specified as radial feed with one two-position switch.

Four-position and multiple-switch loop-feed arrangements require their own approved operating sequence. They are not interchangeable with the specified two-position grounding-transformer switch. Never connect different phases or parallel sources through an unapproved switching configuration.

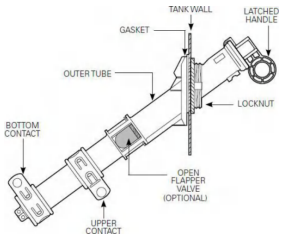


Figure A11. Typical expulsion-fuse holder assembly.

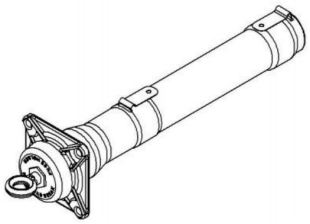


Figure A12. Typical dry-well current-limiting fuse enclosure.

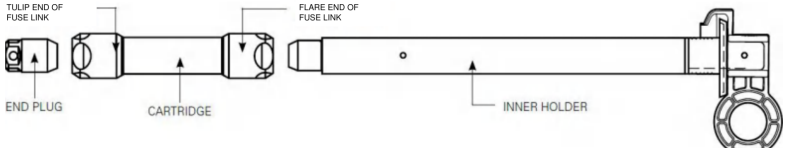


Figure A13. Typical removable fuse-holder components, shown for identification only.

No internal overcurrent protection or fuse assembly is specified for this unit. Use the external protection in the approved design. Do not import fuse ratings, replacement sequences, or live fuse-withdrawal instructions from another transformer.

If an approved variation includes fuses, obtain its exact fuse schedule and component instructions. Isolate upstream, verify absence of voltage, ground as required, and safely control tank pressure before replacement. Investigate the fault before installing a new fuse. Dry-well fuses must remain free from insulating liquid.

WARNING
Never use a fuse or separable connector to close onto a known or suspected fault. Never remove a fuse holder from a pressurized tank.

Appendix B Connector identification and compatibility



Figure B1. Typical deadbreak T-body connector. Appearance alone does not establish voltage class, current rating, interface dimensions, or compatibility.

Connection type	Meaning for this installation
Specified 900 A deadbreak system	Install and service de-energized. Match the actual bushing interface and the exact kit instructions. Verify voltage class, BIL, cable range, and fault duty.
200 A, 15/25 kV loadbreak elbow	A different system. Its stripback dimensions, probe torque, and energized loadmake/loadbreak procedures do not apply to the specified grounding transformer.
600 A deadbreak connector example	Common construction features can aid identification, but its stud, plug torque, cable dimensions, and conductor-code table must not be applied to the 900 A kit without verified compatibility.
Parking stand / insulating cap	Use the correct rated, grounded accessory and support bracket. A dust cap or shipping cap is not an insulating service cap.

When instructions or parts do not match

Stop cable preparation or assembly and contact Larson Electronics with the bushing and connector identification, cable construction and insulation diameter, conductor size, and photographs. Obtain a complete matched assembly and its instructions. Do not make an adapter by mixing unrelated interfaces or substitute hardware by visual similarity.

Preserve the component installation sheet, torque values, crimp tooling record, and cable-kit identification in the equipment file. The safety and workmanship requirements in Section 9 apply to every approved connector assembly.

NOTICE
Correct fit, cleanliness, lubrication, torque, shielding, and grounding are all required. None of these checks compensates for a connector with the wrong electrical rating or interface.

Commissioning checklist

Complete before first energization and after major repairs. Mark each item Complete, Not Applicable, or Hold, with supporting records. Resolve every Hold before energization.

Check	Status / record
Equipment serial number and approved drawings verified	
Mineral oil grade and correct liquid level verified	
Actual mass, foundation, anchorage, and clearances verified	
Receipt/storage damage resolved; tank and seals sound	
Ambient and cold-start conditions within approved limits	
Tank, doors, shields, arresters, and accessories bonded	
Neutral path matches approved grounding study and diagram	
Neutral continuous duty and 1,000 A / 10 s basis confirmed	
Calculated fault current and total clearing time acceptable	
Required resistor/impedance installed, tested, and not bypassed	
Correct phase sequence, terminal identification, and cable kit	
Connector seating, support, grounding, and torque recorded	
Unused interfaces have properly rated insulating caps	
CT ratio, polarity, burden, grounds, and shorting links correct	
Switch and arrester ratings/positions verified	
Gauges, four sensor channels, and contacts checked	
Alarm, trip, control-power, and backup protection tests passed	
Acceptance electrical/fluid tests accepted and recorded	
Valves/plugs secure; required radiator valves open	
Tools, test leads, and temporary grounds accounted for	
Covers/barriers installed; doors secured; area clear	
Authorized switching order and operator notification complete	

Equipment serial no.: _____ Site: _____

Authorized commissioning acceptance: _____ Date: _____

Equipment and service record

Equipment identification	Record
Serial number / location	
Approved outline / wiring / one-line drawing references	
Grounding study / relay-settings record	
Mineral oil grade / installed quantity	
Continuous neutral current / short-time duty basis	
Actual weight / pressure limits / cold-start limits	
Connector kit / interface / installation sheet	
CT data / control supply / alarm and trip settings	
Commissioning date / factory report reference	

Operating inspection log

Date / time	Neutral A / temperatures	Level / pressure / alarms	Action / initials

Maintenance and event log

Date	Work, fault event, test results, or liquid added	Record / authorization

Keep detailed results, fault current and duration, laboratory reports, torque records, settings changes, parts replaced, and return-to-service authorization with this log.

Larson Electronics service assistance

Larson Electronics, LLC
9419 E US Highway 175, Kemp, TX 75143
Phone: 1-800-369-6671 • International: 1-903-270-1187
Email: sales@larsonelectronics.com
Website: www.larsonelectronics.com

Provide the serial number and nameplate information when requesting technical assistance or replacement parts.

Appendix C Approved equipment layout

Overall dimensions shown on the approved equipment drawing are **90.6 in. wide × 88.6 in. deep × 74.8 in. high**. The compartment depth is 40 in. These views retain the approved drawing dimensions and item numbers; use the component key on page 39.

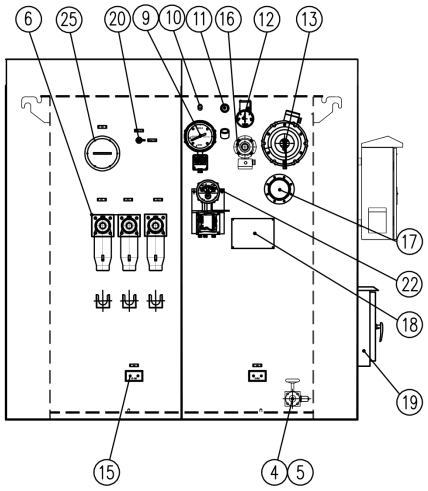


Figure C1. Front compartment and device locations.

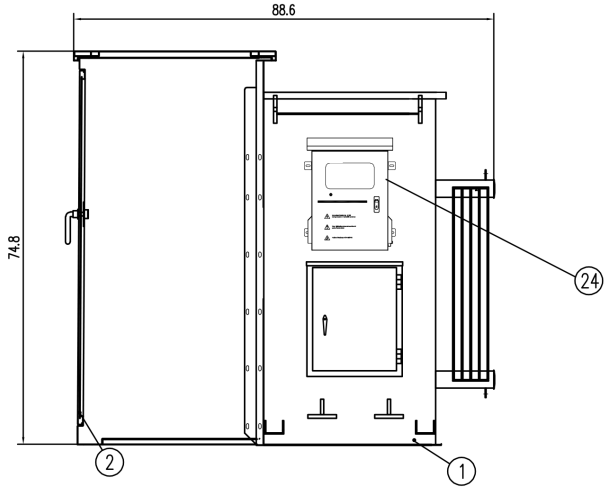


Figure C2. Side elevation and cooling surfaces.

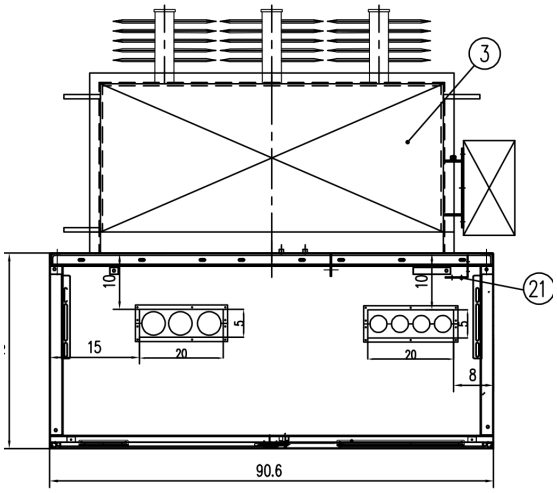


Figure C3. Plan view and bottom-entry arrangement.

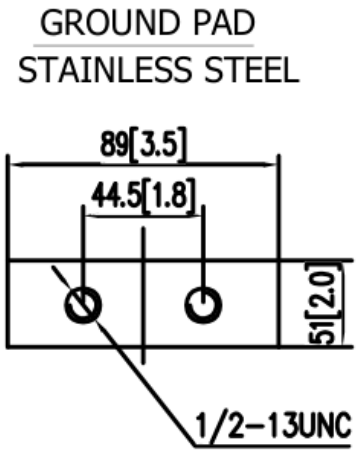


Figure C4. Ground-pad detail. Millimeters are shown with inch equivalents in brackets; thread is 1/2-13 UNC.

The drawing lists an approximate total weight of 13,450 lb. Verify actual shipped mass, center of gravity, lifting points, anchor details, and site loads before rigging or foundation work. The separately listed 6,173 lb dry weight and 2,866 lb oil weight do not reconcile with the 13,450 lb total; obtain the verified actual mass before lifting.

NOTICE
The approved equipment schedule lists approximately 373 US gallons of mineral oil and 2,866 lb of liquid. Confirm the actual quantity and grade on the delivered unit. Use the temperature-corrected level as the fill criterion, not the approximate volume alone.

Appendix C Winding and field-installed accessories

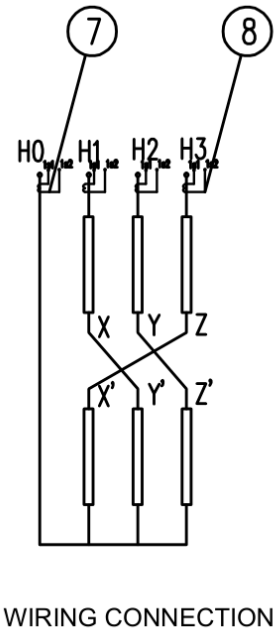


Figure C5. Approved zig-zag winding connection and CT locations.

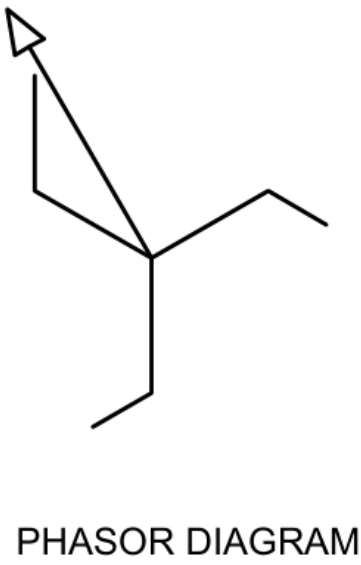


Figure C6. Approved phasor representation.

Terminal identification: H1, H2, and H3 connect to the three system phases. H0 is the brought-out neutral. Item 7 is the neutral CT; item 8 identifies the phase CTs. Internal X/Y/Z winding connections are factory connections and must not be changed in the field.

This winding diagram does not show a complete external ground grid, neutral bond, resistor, protection relay, or trip circuit. Connect H0 only according to the approved site grounding design. Do not infer a resistor value or an automatic direct bond from the internal winding sketch.

Field-installed accessory	Quantity	Identification
Deadbreak cable connectors	4	35 kV class, 900 A, 200 kV BIL; match the actual bushing interface and supplied kit instructions.
Surge arresters	3	36 kV class; 29 kV MCOV; one per phase.

Inspect separately packaged accessories on receipt and before installation. Confirm terminal assignment for all four supplied connectors; do not infer that the quantity defines a fourth phase or the H0 live-front interface. Torque, cable preparation dimensions, and contact wiring must come from the supplied component instructions and approved installation documents.

WARNING
The H0 neutral connection is live-front. Maintain its designed barrier, spacing, and access control. Isolate the associated system before working on H0, its CT, or the neutral grounding conductor.

Appendix C Installed component key

Item numbers correspond to Figures C1-C6. Component identification is functional; order replacements through Larson Electronics using the serial number and installed component markings.

Item	Component	Qty.	Application / detail
1	Main tank	1	316 stainless steel
2	Front compartment	1	316 stainless steel
3	Cover plate	1	316 stainless steel
4	Drain valve	1	Use the approved drain/sample procedure.
5	Insulating liquid	-	Mineral oil; verify actual grade and fill.
6	High-voltage bushing assembly	4	900 A deadbreak designation in the equipment key; verify individual terminal functions.
7	Neutral CT	1	300:5 A; 15 VA; associated with H0.
8	Phase CTs	3	300:5 A; 15 VA; one per phase.
9	Liquid level indicator	1	Verify high/low contacts and reference level.
10	Gas-sampling valve	1	Schrader-type connection.
11	Liquid fill plug	1	Keep sealed except during authorized service.
12	Pressure indicator	1	Pressure/vacuum indication with contacts.
13	Pressure-relief device	1	Automatic mechanical relief.
14	Top-liquid thermometer	1	Verify approved alarm/trip settings.
15	Ground pads	2	Stainless-steel tank grounding points.
16	Rapid-pressure-rise relay	1	Verify alarm/trip and reset logic.
17	CT terminal box	1	Maintain CT shorting and grounding provisions.
18	Nameplate	1	Verify serial-specific ratings and connections.
19	Accessory terminal box	1	Use the approved terminal wiring diagram.
20	Loadbreak switch	1	Two-position device.
21	Cabinet heater	1	Confirm supply voltage and protective circuit.
22	Temperature indicator	1	Four sensors: three coils and core.
23	Finish	-	Bell-green exterior coating.
24	Temperature-monitoring terminal box	1	Winding and core monitoring.
25	H0 neutral bushing	1	Porcelain, live-front neutral connection.

Ground-pad material, contact ratings, individual interface assignments, and any departures between the delivered unit and the drawing must be confirmed before replacement or connection. The approved equipment key does not supply a complete auxiliary wiring diagram.