Installation, Accessories, and Maintenance Manual for Oil Immersed Network Transformers

ATTENTION!

Read and understand the information contained in this Instruction Manual before receiving/installing/operating/maintaining your Prolec GE SafeNET Network Transformer.

The product covered by this manual must be installed, operated and maintained exclusively by specialized and qualified personnel.

DISTRIBUTION DIVISION

Reception, Installation, Operation and Maintenance Manual for Oil Immersed Network Transformers.

Capacity	Nominal Voltage	Rated Current	Impedance

Serial Number	Shipping Date	Authorized Signature and Seal

LETTER OF GUARANTEE

Prolec GE USA, LLC guarantees the apparatus specified herein against any defect of Design, Construction, Material and Workmanship.

By this Warranty, we undertake to repair or replace, as necessary, Prolec GE manufactures, all equipment or part of which is found defective within twelve (12) months from the date of energization or eighteen (18) months from the date of shipment, whichever occurs first, and provided that we are given written notice upon discovery of the defect detailing the fault found referred to in the previous paragraph and the circumstances in which it occurred.

This being Warranty against design or manufacturing defects; Our commitment is void in case of improper installation, operation or maintenance, or carried out by unqualified personnel, as well as accidental or fortuitous circumstances, such as the lack of adequate protection of the equipment against over-currents, surges or overloads, atmospheric discharges, fires, mistreatment in transport or maneuver, in addition to not providing evidence of satisfactory results of tests carried out prior to energization, etc.

To maintain the validity of this Warranty, no modifications must be made to the design or characteristics of the equipment, without prior authorization from the factory.

The spare parts, components, consumables and accessories of the product covered by this Warranty, as well as further reports for its claim, can be obtained from the address shown below:

Prolec GE USA, LLC
7000 W. Bert Kouns Industrial Loop
Shreveport, LA 71129
Telephone: (318) 687-6600   Fax: (318) 683-5391

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1. INTRODUCTION

The Network Distribution Transformer covered by these instructions was shipped filled with the specified insulating liquid (GE Type II OIL, FR3™, or Silicone) and as completely assembled as possible unless directed otherwise by the purchaser's order or specification in effect on the date the order was placed. In the event moisture has accidentally entered the tank or compartments during transit, drying of the transformer after installation will not be required.

Copies of instruction leaflets referred to but not included in this text may be obtained by contacting the post sales department.

2. RECEIVING, HANDLING, AND STORAGE

2.1 Receiving

Immediately upon receipt of the equipment, examine the packages and parts for any damage that might have been sustained in transit. Check materials with the shipping memorandum for possible shortage. Record any damage or shortages (written details, pictures, video, etc.) that may have been sustained in transit. If damage, rough handling, or missing item is evident, file a damage claim with the transportation company immediately and promptly notify the Post Sales account manager.

The valves at the base of the tank have been sealed prior to shipment and should be intact when the transformer is received (seals are not broken). On some transformers, various secondary packaging is applied to some parts/features to protect them during shipment and this secondary packaging should be intact and the features should not be damaged.

If the outer coat of paint has been abraded during shipment or handling, sand the abraded area lightly, then clean thoroughly and apply several coats of touch-up paint with brush or spray gun allowing 16 hours drying time between coats. If the initial damage is such that bare metal or primer shows through, then refinish as described "Refinishing Underground Transformers in the Field".

2.2 Handling

Lugs are provided for lifting the complete transformer and, where necessary, additional facilities are supplied tor lifting the various parts. Lift transformers by means of the lugs provided, and use proper spreaders to obtain a vertical lift.

Jacking space is provided in the base of the transformer to facilitate lifting by means of jacks. The transformer must never be moved or lifted by placing jacks or tackle under the drain valve, radiator connections or other attachments.

If the transformer is supplied with specified removable boxes such as low voltage junction box, high voltage junction box, or bolted-on high voltage ground switch box, these boxes may be detached to facilitate placement of the transformer into the vault. Handling is facilitated using cranes, fork trucks, secondary pallets combined with fork trucks, or rolling devices/ techniques. Purchasers are responsible for these handling procedures and equipment.

> *Caution: Transformer must never be moved, lifted, jacked, or handled by any technique which places jacks or tackle onto or otherwise engages the drain valve, radiators (cooling panels), attachments, or any other transformer non-lifting attachments to accomplish the task.*

If a transformer is supplied with specified removable boxes such as low voltage junction box, high voltage junction box, or bolted-on high voltage ground switch box then these boxes can be detached to facilitate placement of the transformer into the vault. Purchasers are responsible for these handling procedures.

> *CAUTION: Most network distribution transformers are provisioned for a low voltage network protector supplied by others. The purchaser may mount the network protector prior to installation of the combined assembly into the transformer vault or assemble them after the lift in the vault. The transformer lifting lug design has accounted for the rated low voltage network protector size and weight as required in the transformer standards. All provisions and processes for a combined lift or other movement is the responsibility of the purchaser.*

2.3 Storage

It is advisable to completely assemble and set the liquid-filled transformer in its permanent location as soon as it is received, even though it is not to be placed in service for some time. Before storing a transformer, ensure the oil is at the proper level. Store renewal coils and insulation under oil in a container that can be sealed from the air. The storage room should be clean and dry, and when possible, without extreme temperature changes. Before a transformer is placed in service from storage, instructions given under "Inspection" should be observed, particularly with regard to moisture.

> *Caution: All other storage expectations should be specified during purchase along with special requirements that protect the transformer and its features in the anticipated environment. Before a transformer stored at a location other than its service location is placed in service, an oil sample should be taken and tested to confirm that no moisture has entered the tank or other boxes/compartments. Follow "Installation" recommendations.*

3. INSTALLATION

3.1 Foundation

The only foundation necessary for the installation of a network transformer is a level floor strong enough to support the weight.

3.2 Inspection

Sealed network transformers, shipped liquid (GE Type II or as specified) filled, are filled at the factory to the 25ºC liquid level. The liquid and gallons are listed on the transformer nameplate. The unit is ready to install.

Make an external inspection. Tighten any parts which may have worked loose, such as nuts, leads, etc. No internal inspection is required if there is no evidence of external damage during inspection.

If the transformer is to be installed at high altitude (3000 feet or more above sea level) and was not specified to have an initial gas space pressure, then open a fitting above the liquid level, either top sampling valve of filling plug on the cover, to equalize the internal & external pressures at approximately 25ºC before the transformer is placed in operation. Verify the 25ºC liquid level as entrained gases may leave the fluid. If a nitrogen gas was used to set the initial pressure as specified at the time of order, then the transformer was prepared for that condition and the altitude change. Test to that pressure and equalization should not be required, otherwise adjust the cap (initial) pressure by adding or subtracting nitrogen gas.

3.3 Internal Inspection

If a transformer must be opened for inspection outdoors on a damp or stormy day, clean off all adjacent surfaces of dust and debris, dry any adjacent surfaces so no moisture is present, and take proper precautions to prevent the entrance of moisture.

If internal damage is suspected or internal inspection desired, the following procedure is recommended.

1. Lower the liquid to the top of the core and carefully inspect the interior to see that damage has not occurred. It is not necessary to untank the transformer for inspection since inspection made through the liquid (using a weighted sealed-beam lamp) will show displaced or broken parts if damage enroute has occurred. To prevent scattering of the glass in case the lamp is accidentally broken, enclose the lamp in fine wire mesh before lowering it through the handhole into the tank. *CAUTION: Use a cord with approved synthetic rubber insulation for the lamp to prevent contamination of the oil.*
2. Examine the top of the core-coil assembly and tank cover interior surface for signs of moisture. If moisture is found inside the transformer, then arrangements should be made to dry the transformer. Use a drying method and equipment approved for the type of insulating fluid used in the transformer.
3. After Inspection replace the insulating liquid, adding it to the transformer through the standard (or specified) fill provisions found on the main cover or top of tank HV end (or side) wall. It is recommended that portable or

fixed equipment be used to heat and filter the oil into condition prior to it being added to the transformer. Fill slowly until the transformer liquid level reaches 25ºC (adjust setting depending on transformer temperature). Filling in this manner prevents the aeration of liquid, insulation, or coils below the level of the initial liquid filling, see section “Insulating Fluids”. *CAUTION: Check the insulating fluid type on the nameplate and use the correct replacement fluid. It is important that the transformer is level. The transformer must be allowed to vent/rest for 48 hours after being filled when vacuum is not used.*

3.4 Testing Insulating Liquid

Test a sample of oil taken from the bottom of the tank using the drain valve provided/specified. Remove an initial quantity (2 quarts maximum) to flush the drain valve. The dielectric strength is required to meet the ANSI standard for the insulating fluid in a transformer which is specified for both new and in service insulating fluid. If the dielectric strength is low, then the oil can be filtered to raise the dielectric strength. If the dielectric strength is low as defined in the standard, moisture levels are above standard recommendations, or free water droplets are visible in the sample for the fluid, then core and coils require a filtered drying cycle to remove moisture, see section “Insulating Fluids”.

3.5 Connections

Do not change connections on a transformer that is under excitation, or make any connections except those authorized by the diagram or nameplate accompanying the transformer.

Tap leads are normally connected to a tap changer for de-energized operation. The tap changer is covered and typically located on the main tank cover. A hot stick handle is located under the tap changer cover. When specified a separate handle is provided mounted to the tap changer cover or adjacent to it on the main cover.

Regardless of the floor or foundation on which the transformer is placed, ground the tank permanently and effectively by connecting to the grounding lug at the bottom of the tank, unless prevented by special operating conditions. A good, permanent, low-resistance ground is essential for adequate protection. A poor ground may be worse than no ground at all since it gives a false feeling of safety to those working on or near the equipment, and may result in loss of life or damage to the apparatus.

When a transformer is specially designed for use on a system having a solidly grounded neutral, be sure that the neutral lead, as indicated on the name plate, is permanently and solidly grounded without resistance.

Line connections must not bring any strain on the terminals which will cause the joints or contacts to become loose, or bring undue strain on the bushing porcelains.

3.6 Pressure Test

Pressure test all sealed transformers before placing them in service. This is done by first subjecting the tanks to an internal pressure of 5 PSIG (pounds per square inch) when the installation is completed, using dry compressed air or dry nitrogen introduced through the pressure test fitting. When this pressure has been attained, shut off the supply and allow the transformer to stand for 12 hours. Observe the pressure reading during this period, and examine the tank and fittings for leaks. If the pressure holds constant, the joints are satisfactory. Leaks above the liquid level can be located by applying a solution of soap and glycerin to all gasketed joints, pipe fittings, and cable connections.

3.7 Vault Ventilation

When large, self-cooled network transformers are installed in vaults or compartments, it is necessary to ventilate the compartments thoroughly. Recommended practice would place cool air inlets in or near the floor and outlets in or near the roof. The following is a guide only, not an encompassing technical paper, for use by the purchaser’s technical staff/ consultants to begin design of the transformer ventilation. Many utilities have their own developed standards for vault sizes provisioned with either natural or forced ventilation.

The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. In general, provide about 20 square feet each of inlet and outlet opening for each 1000 kVA of transformer capacity. If the transformer will be required to operate for considerable periods at continuous full load, the areas of openings should be increased to about 40 square feet per 1000 kVA of transformer capacity.

Arrange the air inlets and outlets so that they are permanently open. Do not use as ventilators, windows or doors which may be opened or closed by attendants, because of the danger of excessive heating in case they are inadvertently left closed during periods of heavy load or high temperature.

If forced ventilation is used, supply about 5000 cubic feet of air per minute for each 1000 kVA of transformer capacity, and conduct the incoming air directly to the transformers so that it will flow up through and around the radiating members of the tank. If this cannot be done, and the air is merely moved through the room, provide about 10000 cubic feet per minute for each 1000 kVA.

CAUTION: Do not allow the temperature of the room in which the transformer is installed to exceed the temperature of the air entering the room by more than 5°C. The entering air should come from the outside, or at least from a source not much warmer than the outside air.

4. ACCESSORIES

4.1 Thermometers

The thermometers normally supplied on network transformers are mounted in a sealed well. The sealed well permits removal of the thermometer without lowering the level of the liquid in the transformer tank.

Each thermometer is equipped with a maximum reading hand. The maximum reading hand can be reset by removing the permanent magnet attached to the side of the case and wiping it across the face of the dial glass so as to make the maximum reading hand rest against the instantaneous indicating hand.

4.2 Tap Changers

CAUTION: The tap changer must not be operated while the transformer is excited. Serious personal injury or damage to the transformer may result if this is attempted.

Tap changers furnished with network transformers are usually of the "drum" type. A change in voltage with a drum-type tap changer is made by a partial turn of the operating abaft. The tap-changer shaft is terminated in a hex shaped head directly under a two-inch pipe plug in the transformer cover or casing. A small pointer is attached to the hex head, and an indicating plate which shows the tap-changer position is mounted below the pointer on the sealed tap changer glad. See Figure 1.

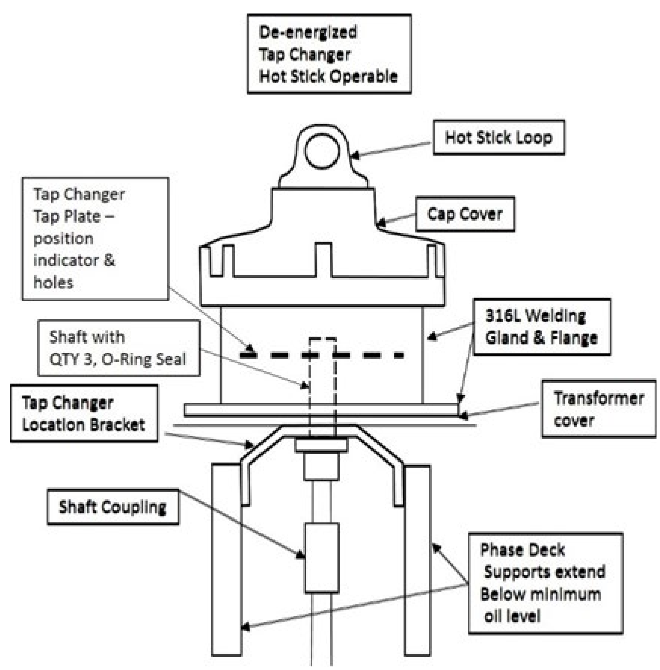


Figure 1. Outline of Tap-Changer Drive, Cover Mounted

To operate the tap changer, remove the pipe plug and insert a socket wrench to turn the hex head to the desired position hole designated on the fixed nameplate. The operator can tell by the "feel" of the wrench when the tap changer moves from one position to the next. After removing the wrench, check the position of the tap changer by observing the pointer position through the pipe-plug hole.

Indicating marks on stationary and rotating parts of all tap changers must be in alignment when the tap changers are on the first position. Check for and remove debris from inside the tap changer gland and complete the purchaser's safety check list, then reseal the tap changer cap.

4.3 Bushings

Externally removable high-voltage bushings, as shown in Figure 2, are used between the switch case and the transformer tank. The bushing can be removed through the switch case by unscrewing the terminal block which carries the switch contacts, and then removing the clamp bolts and clamp. The porcelain can then be removed and the stud will remain attach to the transformer leads inside the tank.

> *CAUTION: the switch chamber fluid must be drained completely then the transformer fluid must be drained until the liquid is below the transformer high voltage bushing opening. Transformer fluids must be handled by approved processes including the disposal of any fluids or cleaning equipment/accessories, see section "Insulating Fluids".*

The high voltage bushing can be removed through the switch box chamber after the chamber cover has been removed, then by unscrewing the nuts holding the leads from the switch frame to the bushing stud on all the switch chamber HV (high voltage) bushings. Follow the switch removal process to remove the HV Disconnecting & Ground Switch hardware and frame. Once the switch frame is removed then remove the bushing clamp bolts and bushing clamp on the bushing(s) that are to be removed. The concrete polymer bushing can then be removed and the top stud will remain attached to the transformer. To remove the high voltage bushing, then disconnect the phase lead from the top bushing stud.

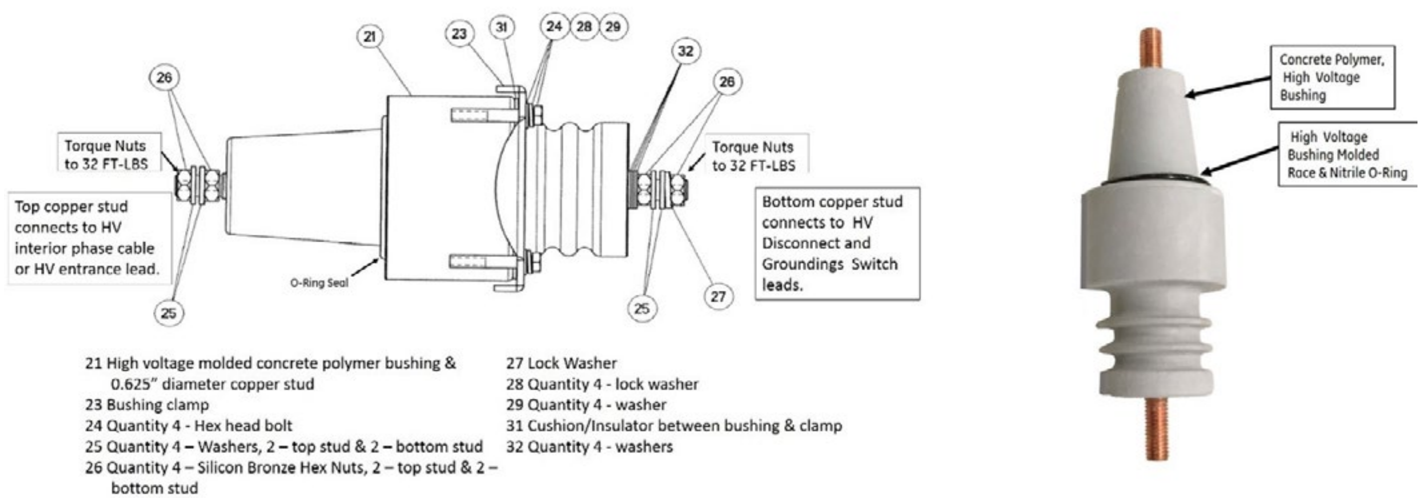


Figure 2. Externally Removable High-Voltage Bushings

When specified some units have terminal chambers which has three concrete polymer HV bushing between the Terminal chamber and Switch chamber. These HV Bushings are removed in a very similar manner as the removable HV bushings between the Switch chamber and the transformer. They can be removed in the same way except that the top of the HV bushing is connected to the HV entrance or HV line bushing (this is typically a non-removable ESNA type apparatus bushing). The connection to the HV line bushing is also secured with nuts to the bushing stud so that the HV concrete polymer bushing is removable. See Figure 02 above.

Network transformers are equipped with removable LV (low voltage) bushing between the transformer and the LV Network Protector or Junction Box. These come in several forms as follows:

- Standard removable “welded” LV bushings for connection to the LV network protector or a LV junction box for direct connection to a LV bus distribution bar. CAUTION: Requires equipment and training to repair these LV bushings. Statistically the LV bushings remain in place without removal during service life. Aside from occasional cleaning these bushings rarely require removal.
- When specified removable “bolt-on” gasket sealed LV bushings for connection to the LV network protector or a LV junction box for direct connection to site LV distribution.
- When specified non-removable welded LV bushings located on the transformer cover or transformer side/end wall.
- Figure 03 and Picture 03, shows LV Throat with the welded bushings for the small (2000 ampere maximum) LV throat and large (3000 ampere maximum) LV throat.

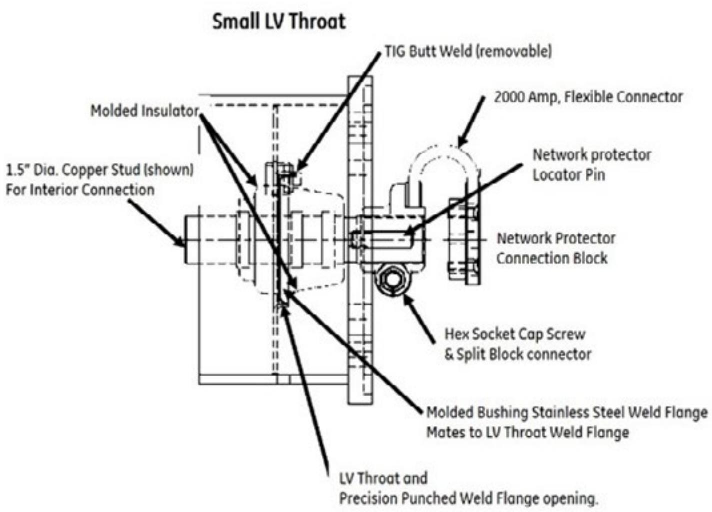


Figure 3a. Small Low-Voltage Bushing

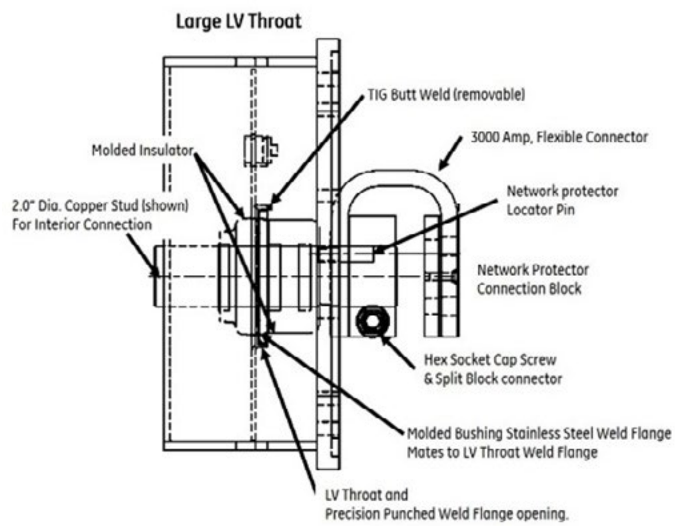


Figure 3b. Large Low-Voltage Bushing

Figure 3. Low-Voltage Bushing (Externally Removable)

A "spark plug" style LV bushing is used in the switch chamber to connect to up to (4) interlock lead spring connections in the main tank. These are small porcelain bushings that can be removed, if the seal fails or porcelain cracks. These interlock bushings are screwed into switch chamber fittings and once they are 100% into the fitting electric/mechanical contact is made on a spring contact mechanism internal to tank. The interlock LV bushing brings power to the solenoids transformers in the HV switch chamber. Also, the interlock LV bushing completes the neutral circuit from the switch chamber solenoids to ground or to the neutral bar for transformer that have an isolated neutral, See Figure 04 and Picture 04. These bushings are self-connecting as the internal connection is spring loaded, therefore no internal transformer lead connection is attached to the LV bushing.

When replacing bushings with gaskets use new gaskets installed in accordance with section "Gaskets and Gasket Procedures".

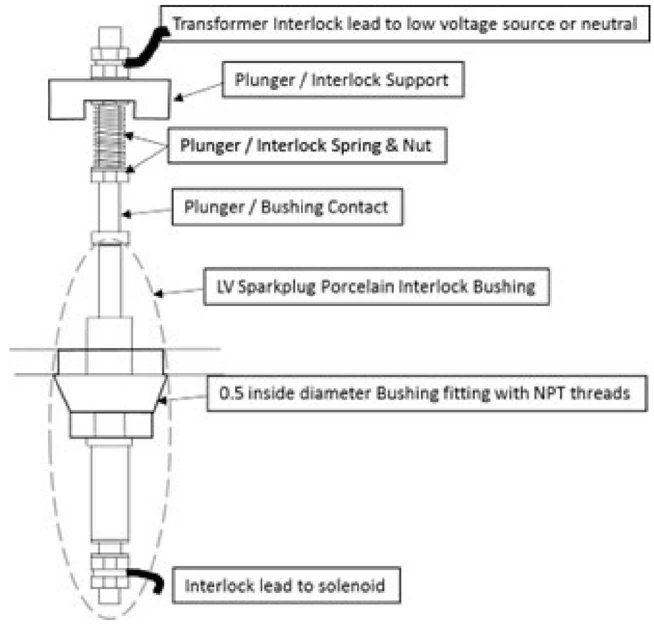


Figure 4. Interlock "Spark Plug" LV Bushing

5. MAINTENANCE

5.1 Filling Transformers

If it is necessary to refill a transformer with oil, proceed as follows:

1. Make sure that all joints are tight.
2. Open all air vents. In order to prevent aeration of the oil, fill the transformer through the drain valve by means of a filter press. Continue the pumping until the oil level reaches the 25°C mark on the gage. If a transformer is to be filled without running the oil through a filter press and tests on the oil are satisfactory, fill the transformer by straining the oil through two or more thicknesses of muslin or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. New set of cloths must be used for each transformer.
3. If transformer must be open outdoors on damp or stormy day take proper care to prevent the entrance of moisture into the transformer.

CAUTION: Opening a transformer outdoors is risky and should only be done for minor issues/repairs only and as a last resort. Low Voltage Networks systems are designed (unit removal) to allow purchaser to do service in a proper repair environment without risk of customer outage.

5.2 Periodic Inspection

Since moisture may be absorbed by the transformer, test the oil after the first few days of operation. It is also recommended Since moisture may be absorbed by the transformer fluid and insulation, test the liquid after the first few days of operation. It is also recommended that liquid samples be drawn and tested on a regular schedule. For complete information refer to section "Insulating Fluids".

The condition of the external surfaces should be examined at regular intervals. Weathering will attack the external surfaces of the transformer and components. When this condition warrants then the transformer should be refurbished by cleaning these external surfaces and applying new coats of primer and top coat. The recommended original paint suppliers offer equipment and techniques for this and many purchasers take advantage of this equipment and expertise in their maintenance programs.

See section, “Refinishing Transformers – Epoxy paint: Zinc Rich Primer and Top Coat”.

Specified sensors can also include a host of new devices that are rapidily improving the data on in service network transformers. The sensors include but are not limited to:

- Temperature sensors
- Pressure sensors
- Liquid Level sensors
- Dissolved Gas Monitors
- Special Moisture and Hydrogen sensors

These sensors provide tracking data to improve the conditional accessment of the transformer and provide a a digital footprint that can be tracked.

5.3 Filtering and Drying Transformer Oil

The transformer oil drier and filter covered by Instructions GEH-754 is recommended for drying and filtering GE transil oil. The oil is treated in a filter press by being forced through a number of layers of filter paper which remove all moisture and solid matter held in the oil. By this method, 850 to 1200 gallons of oil can be treated in one hour, depending on the size of the filter press.

5.4 Drying a Network Transformer

The short-circuit method is recommended for drying a network transformer. This method consists of heating the windings, while under oil, by circulating current in them and removing the moisture by ventilation. For complete information, refer to Instructions GEI-28005, “Drying Oil-Immersed Transformers”.

5.5 Gaskets

Two different types of gasket material may be used on Prolec GE Network Transformers. Nitrile rubber is recommended as it has excellent history with the all available transformer fluids and it comes in many forms. Hard cork is used on some flat surfaces or where specified when 10-C mineral oil is specified for the insulating fluid. Cork is not recommended in either Silicone or FR3 insulting fluids. For complete imformation, refer to section “Gaskets and Gasket Procedures”.

5.6 Pipe Fittings

When assembling pipe fittings, clean the threads thoroughly to remove all oil, grease, old compound, and dirt. Apply a coating of GE compound No. A15A11A to the threads and screw the mating parts tightly in place.

5.7 Welded Covers

Welded covers are most easily removed by an oxyacetylene torch. For information, refer to Instructions section “Removing and Reweld ing Covers”.

5.8 Refinishing

Should it become necessary to refinish a transformer after it has been placed in service, refer to section, “Refinishing Underground Transformers in the Field”.

6. RENEWAL PARTS

Whenever ordering supply or renewal parts, or asking for information regarding a particaular transformer, always state the serial number and rating. The serial number, in addition to being on the nameplate, will be found stamped on the top core frame, the top band of the tank, and also on the cover directly above the number on the tank band. A pciture of the nameplate can save a lot of time. A clear description of the components and any drawings/sketches that show the circuits in use or other parts required will greatly facilitate the filling of the order. This sketch must always state which side of the transformer is shown.

Any additional information as to the electrical or mechanical construction, operation or installation of a particular transformer can be obtained through your Prolec GE sales representative or GE account manager, mentioning the serial number and rating.

7. GASKETS AND GASKETING PROCEDURES

Three different types of gaskets may be used on Prolec GE Network Transformers. These include:

1. Hard composition cork
2. Nitrile rubber

Each of these types of gasket has its own field of application and best results will be obtained if the procedures outlined for each are adhered to.

7.1 Hard Composition Cork Gaskets

Composition cork gaskets will not hold liquid unless treated or coated; that is, the liquid will seep very slowly through the cork and flow along the joint. For this reason, a suitable compound is essential with composition cork gaskets.

When necessary to apply a replacement cork gasket, proceed as follows:

1. Remove all traces of the old gasket material and cementing compound adhering to the gasket surfaces.
2. Brush the gasket surfaces which are to be joined, and all surfaces including the edges of the gasket itself, with a generous coat of GE compound No. A15A11A.
3. Suspend the gasket in the air until it is perfectly dry for handling. Such drying usually requires less than 4 hours. (If necessary, a small amount of talc may be sprinkled over the dry compound as an added precaution against sticking when handling.)
4. The sealing compound is of the proper consistency as supplied in the can. If the compound has been exposed to the air and has thickened, thin it with denatured alcohol.
5. All surfaces should now he given a second coat of the compound. Bolt or clamp the gasket surfaces together immediately with uniform pressure at all points until they are reasonably tight. Give a second tightening after 4 hours.

Extra gasket material and compound may be obtained from your Prolec GE sales representative or GE account manager.

7.2 Nitrile-Rubber Gaskets

Nitrile-rubber gaskets are made from a special grade of oil-resistant rubber. Although they require no adhesive to make a liquid-tight seal, adhesive GE A50P68 may he applied as a thin film in a few places when required to hold a gasket on a vertical surface. Also, a small amount of this adhesive is required to make a scarfed joint in a gasket.

> *CAUTION: Before applying a nitrile gasket to any surface, make sure the gasket and the surfaces involved are cleaned of all rust, water, grease, insulating liquid, loose paint, scale, or any other foreign material.*

Place the gasket in the proper location. As stops and retainers are used on most gasketed joints, it is essential that gaskets of proper width and thickness are used so that correct compression can be maintained, as specified.

Tighten the bolts, drawing each down in small increments. Proceed around the bolt circle several times until the metal stops are reached, or if no stops are provided, until the gasket is compressed to at least ¾ but not more than ⅔ of its original thickness. No subsequent tightening of the bolts is necessary.

The resilience of nitrile rubber makes possible the reuse of the gaskets in forming a seal if the gasket has not been damaged.

Store spare nitrile-rubber gaskets flat and in a dark place away from high temperatures, such as those caused by steam radiators. Gaskets should he purchased to size from your Prolec GE sales representative or GE account manager. If made up by the customer and joints are required, they should be of the scarfed type made up as follows:

1. Scarf at an angle equal to the rate of 1 inch of length to each 1/4 inch of thickness. Surfaces must be flat and make a neat fit.
2. Clean the surfaces carefully with Solvatone. Do not touch the surfaces with the fingers after cleaning. To the clean scarfed surfaces apply a smooth, even coat of GE A50P68 adhesive. Allow to air dry for 7 minutes. During that time the adhesive should have developed a firm, aggressive tack, but should not lift off the rubber surfaces.
3. Bring the surfaces together and roll under pressure to displace all air. Do not distort the shape of the gasket excessively. Joints can be cured immediately or any time within a week. To cure the joint, place the gasket in a heated press or vulcanizer and clamp together. Apply only enough pressure to insure a joint of uniform contact. Avoid excessive distortion of the gasket.
4. Cure the joint in the press for 35 minutes at 130°C or 20 minutes at 150°C. Do not heat over 160°C.
5. Remove the gasket at the end of the curing cycle and dip in cold water if needed immediately.

A properly prepared joint is sufficiently strong to withstand sharp bending, twisting and elongation of 100%. There should be no gap or projections at either end of the scarf and the adhesion should be uniformly good. Extra gasket material and adhesive may be obtained from your Prolec GE sales representative or GE account manager.

8. NETWORK TRANSFORMER SWITCHES

8.1 Three-Position Rotary Disconnecting and Grounding Switch

8.1.1 Installation

The three-position rotary disconnecting and grounding switch, Figure 5, is contained in a one-compartment switch box or switch chamber of a two-compartment switch box. This is normally welded to the high voltage end or the side of the transformer tank, and is seperated from the transformer by high voltage apparatus bushings.

Cables are terminated onto high voltage apparatus bushings mounted on the cover or front of a single chamber switch box. The single chamber switch box is complete and the chamber cover does not need removal since all connections are external.

Some customers require a terminal chamber that provides a separate chamber for mechanical cable terminations and these cables enter the terminal chamber via wipe sleeves, pot heads, etc. Terminal chamber can be above (normal top cable drop) or below the switch chamber (infrequent bottom floor cable entrance).

If there is a terminal chamber on the top or bottom of the switch chamber as part of the switch box, remove the terminal chamber cover to make or break cable connections.

CAUTION: The terminal chamber is normally shipped dry (unless specified otherwise), then filled by the purchaser after terminating cables. If liquid filled, follow the procedures for draining liquid from the terminal chamber prior to removing the cover. Observe the procedures, see "Insulating Fluids", to fill the terminal chamber.

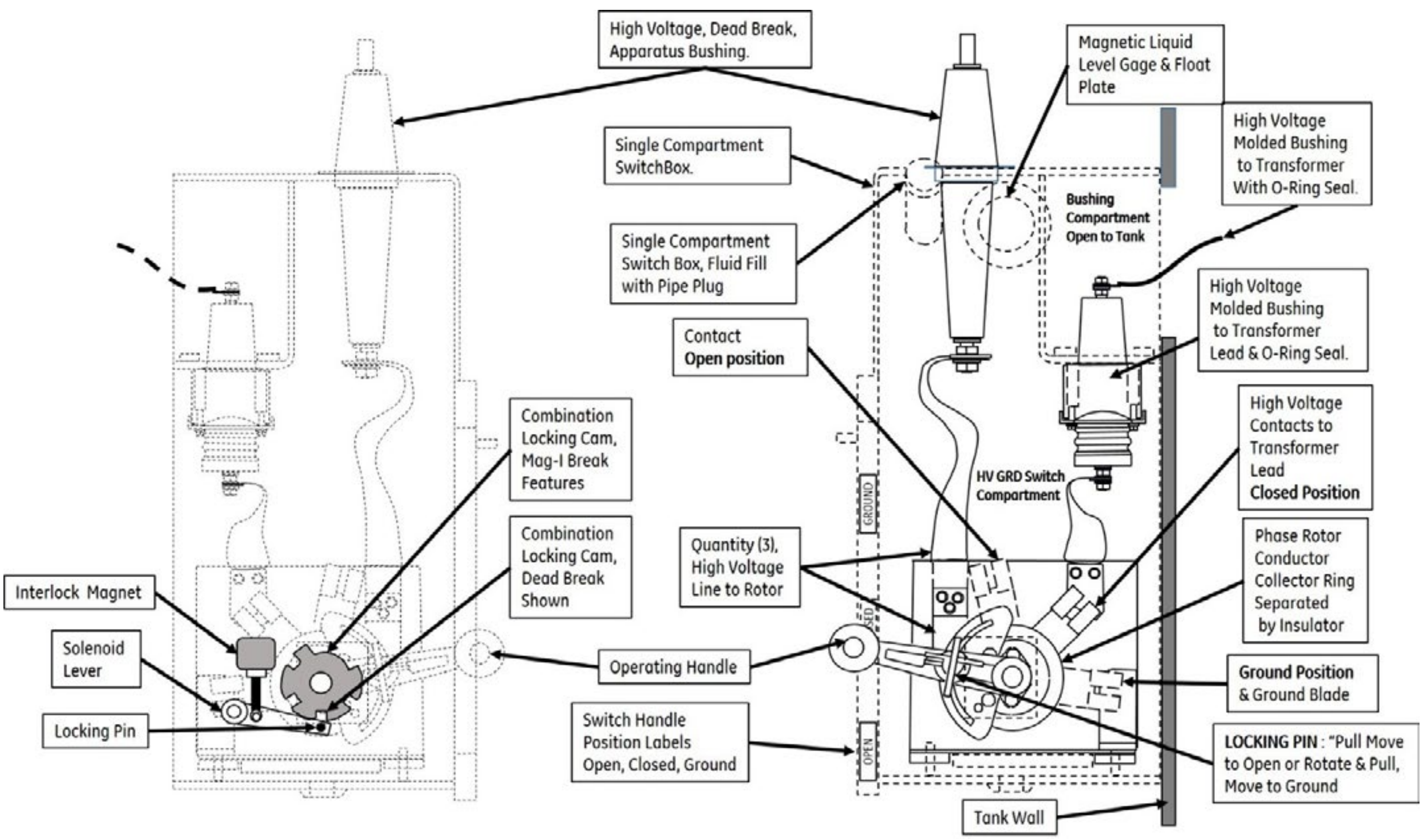


Figure 5. Three-Position Rotary Disconnecting and Grounding Switch

The terminal chamber is separated from the switch chamber by high voltage apparatus bushings (same bushings as the shown between tank and switch chamber). The switch chamber cover and insulating fluid is not disturbed to make cable connection or to check connection integrity. Make up cable connections, phase out the cables, and replace the terminal chamber cover. Then fill the terminal chamber with cable insulating fluid or compound as was specified and now indicated on the transformer nameplate. Additional instructions related to each type of fluid or compound, see “Insulating Fluids”.

8.1.2 Operation

The three positions of the switch are OPEN, CLOSED, and GROUND.

- In the OPEN position, the high-voltage cable terminals are disconnected from the transformer and from ground.
- In the CLOSED position, the high-voltage cable terminals are connected to the transformer terminals.
- In the GROUND position, the high-voltage cables are short-circuited and solidly grounded to the switch case, but the transformer terminals are not grounded.

*CAUTION: These disconnecting and grounding switches must not be used to interrupt the transformer load current. To operate the switch, make sure the **POWER IS OFF**. It is recommended that equipment stethoscope be used to insure a transformer is not energized. The switch is equipped with an electric interlock which will prevent operation of the switch when the transformer is energized from either the high voltage or low voltage side. Follow all utility or site required procedures to validate that the transformer is not energized.*

Disconnecting switches must not be used to interrupt load current, and can be used to interrupt transformer exciting current only when designed for that purpose. See “Three-Position Switch for Interrupting Exciting Current”.

To close the switch from the OPEN position, pull the latch on the operating handle (Figure 6) and move the handle to the CLOSED position. The handle will strike the stop pin in the CLOSED position and the spring-operated latch will drop into the slot provided for it. The switch handle insures that you have reached the closed position but will not allow movement from OPEN position to GROUND position in one motion.

The handle can be locked in any position by a padlock inserted in the holes provided for it in the latch and handle casting. See Figure 07.

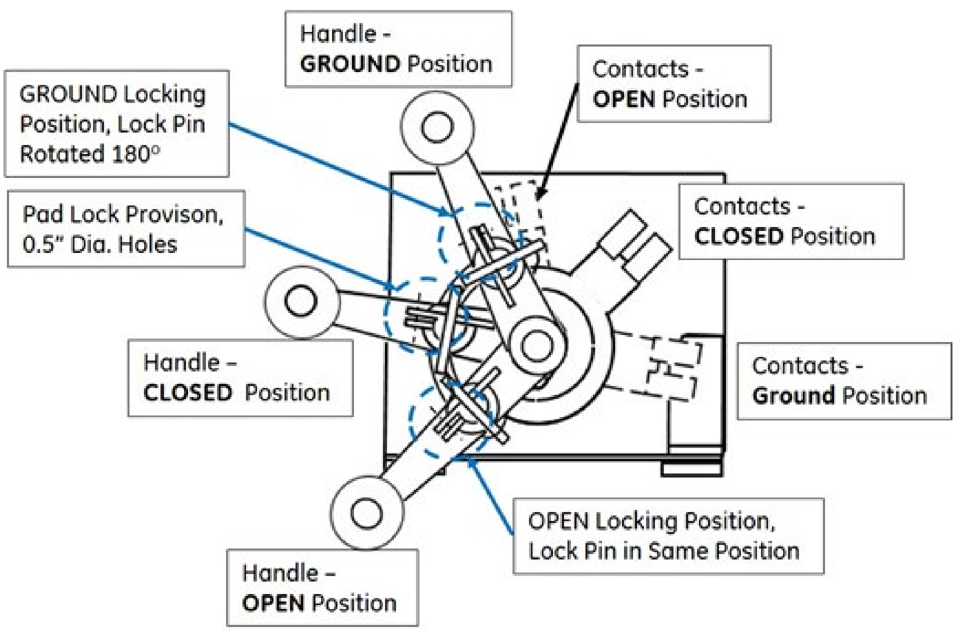


Figure 6. Three-Position Disconnecting & Ground Switch Positions

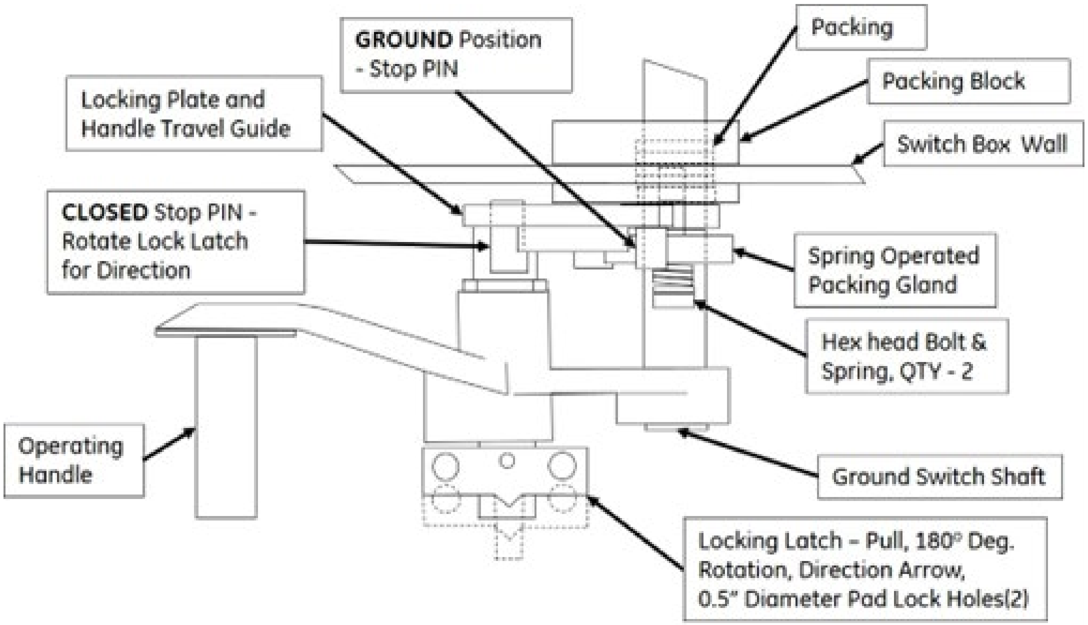


Figure 7. Three-Position Disconnecting and Ground Switch Handle

To proceed to the GROUND position, rotate the latch 180° so that the arrow on the latch points in the direction the handle is to move. Then pull out the latch and move the handle to the GROUND position. The latch cannot be rotated when it is pulled out. The function of the latch and stop pin is to compel the operator to hold the switch in the CLOSED position while turning and pulling out the latch. This gives the electric interlock time to operate if the high-voltage cable is energized and thus protects the operator.

If necessary, the switch can be removed from the switch chamber as follows:

1. Remove the taper pins holding the switch rotor to the handle shaft and switch handle.
2. Loosen the bolts on the handle packing gland. This handle and shaft can then be withdrawn and the switch assembly can be removed. The older switches have a switch rotor that can be removed.
3. The present switch is a frame switch and connections to high voltage apparatus bushings must be removed at each bushing stud. The interlock components are mounted on the switch frame, remove Interlock wiring connections at the interlock bushings keeping track of their connection positions. The frame has a switch shaft mounting plate, remove the 2 bolts at this plate. The frame is also connected to 2 screws the position the switch, remove the top nut and hardware on these screws. Now the switch frame including the rotor can be removed.
4. To replace the switch, reverse the above procedure, see that the rotor is pinned securely to the switch handle shaft and check the contact alignment with the position of the operating handle.

8.2 Three-Position Switch for Interrupting Exciting Current

The three-position switch with OPEN, CLOSED, and GROUND positions is sometimes provided with auxiliary quick-break contacts so that the switch can be used to interrupt transformer exciting current.

8.2.1 Operation

The operation of the switch is similar to that of the three-position disconnecting switch without quick-break contacts The exception being that the electric interlock, which is connected to the transformer winding, prevents operation from the CLOSED to GROUND positions when the transformer is energized, but permits operation from CLOSED to OPEN; or OPEN to CLOSED. The interlock is shown at “A” in Figures 8 and 9. The “A” coil in both circuits is energized when the transformer is energized.

This type of disconnecting and grounding switch is provided with a second electric interlock to prevent using the switch interrupt the load current. The second electric interlock is shown at “B” in Figure 8 and Figure 9. In this type of circuit shown by Figure 8, the “B” coil is energized when the main contacts of the network protector are open. The “B” coil shown in Figure 9 is energized when the main contacts are closed.

The “B” electric interlock must be connected to the low voltage grid. This is accomplished by connecting the auxiliary switch on the network protector to the spark plug type bushing provided for that purpose and located in the low voltage transformer throat adjacent to one of the low voltage bushings.

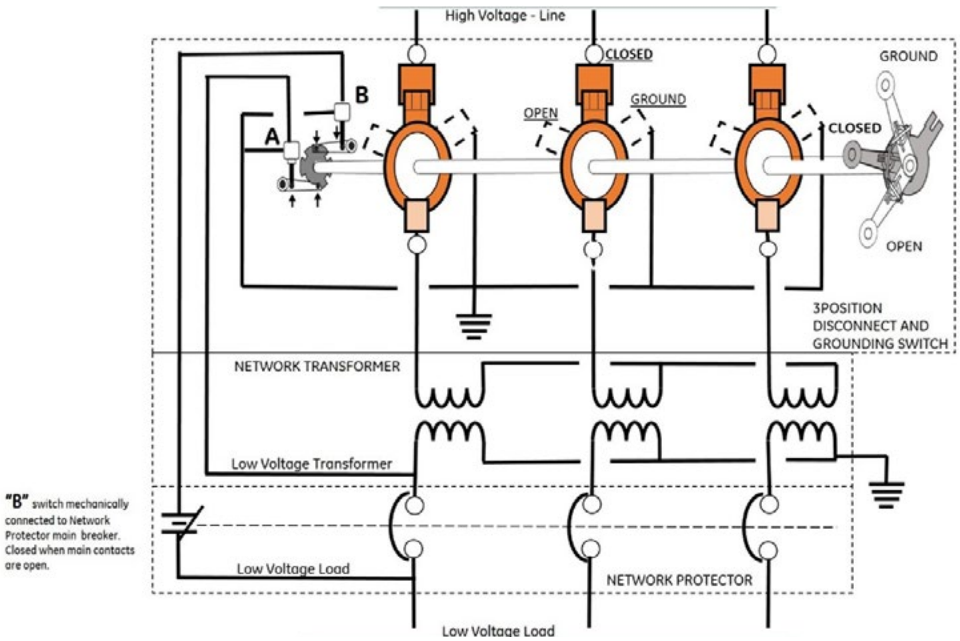


Figure 8. "A" Solenoid, Energized Lock & "B" Solenoid, De-Energized Lock

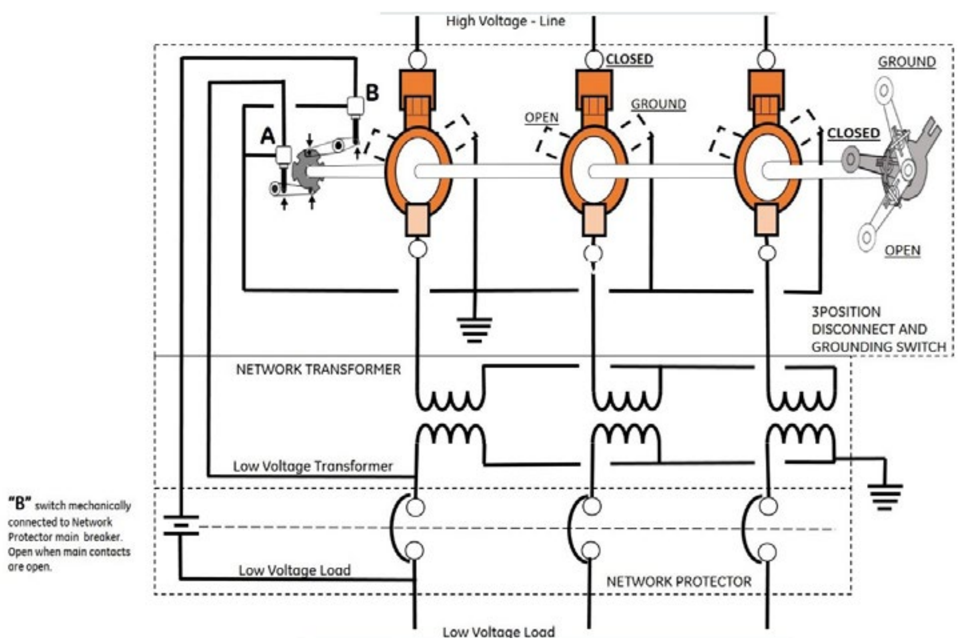


Figure 9. "A" Solenoid, Energized Lock & "B" Solenoid, Energized Lock

Network distribution transformers and their associated equipment, in-service in utility grid systems, have variations that impact the features offered in the network disconnecting and grounding switch, which include:

- Phasing Tubes.
- Phase Sequence Grounding from left to right facing switch chamber cover and a phasing plate on the handle.
- Phase Sequence Grounding from right to left facing switch chamber cover and a phasing plate on the handle.
- Energized/De-energized interlock operation per the ANSI/IEEE C57-12.40 standards.
- Non-Standard Energized/De-energized interlock operation.
- Dead Break Switches with multiple interlock solenoids.
- Interrupting Exciting Current Switch (MAGI break or Quick Break) with additional solenoids.
- “Buffalo Style” Dead Break Disconnect and Grounding Switch (Handle on opposite side of the switch box).

The purchaser’s order or specification identify these frequently requested features. These requirements are made to order using standard disconnecting and grounding switch components, feature specific parts, and the correct interlock/transformer wiring configurations.

8.3 Two-Position Internal Grounding Switch

The grounding switch is occasionally mounted inside the transformer tank and may be attached to the core and coil assembly, as shown in Fig. 10. The operating handle is located on the side of the tank or on the cover, and a packing gland is provided on the operating shaft, which is part of the handle assembly.

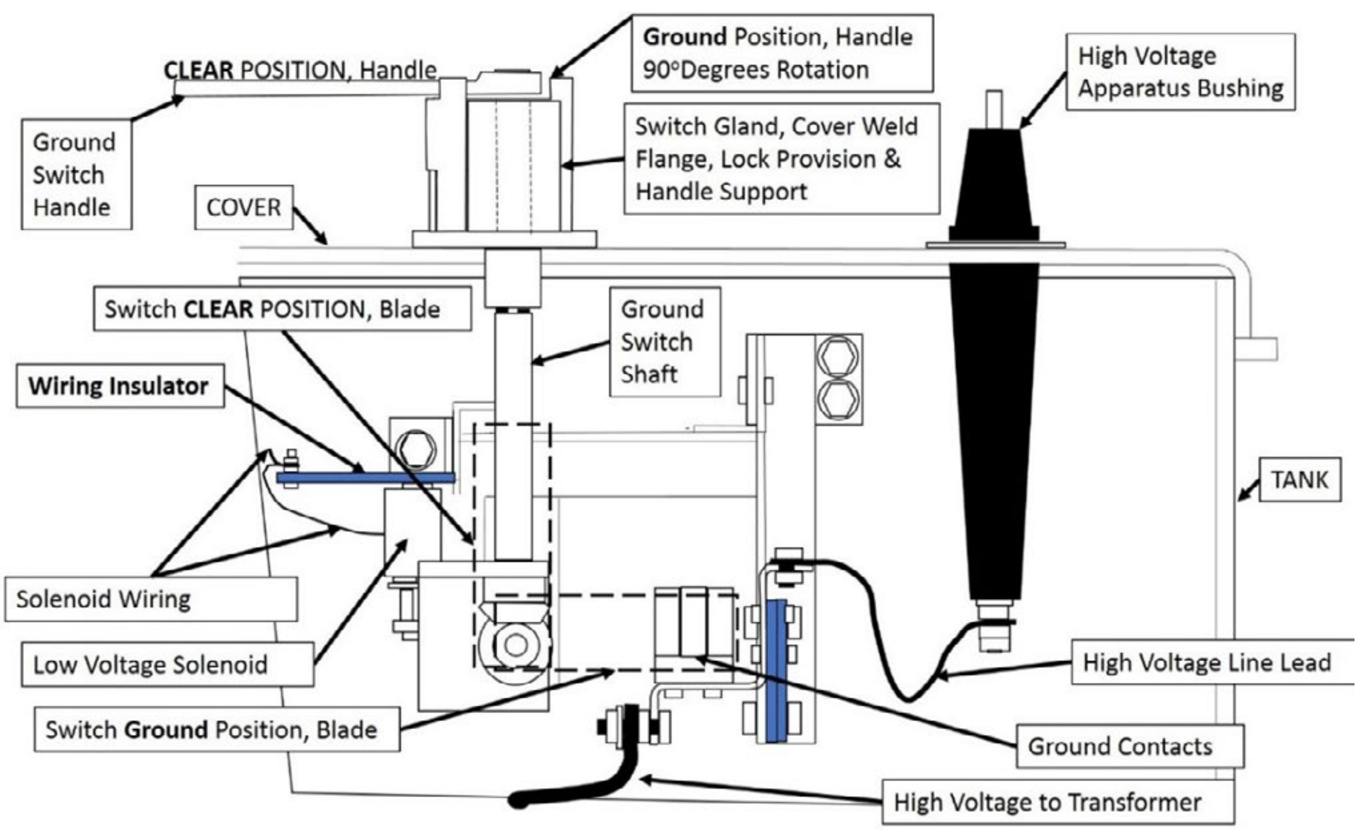


Figure 10. Two-Position Internal Grounding Switch

The switch assembly is bolted to the transformer tank walls and can be removed whenever the cover is removed for service during un-tank operations. A handle hole in the cover provides access to the switch and its electric interlock.

When the switch and transformer interior are returned to the tank after being removed for any reason, the switch positions must be lined up with the switch handle. The switch frame mounting can be easily adjusted to align the switch positions with the switch handle positions.

The Two-Position Internal Grounding switch has a CLEAR position and GROUND position. The electric solenoid prevents switch handle and ground blade movement when transformer is energized.

> *CAUTION: To operate the switch make sure the power is off. It is recommended that equipment stethoscope be used to insure a transformer is not energized. The switch is equipped with an electric interlock which will prevent operation of the switch when the transformer is energized from either the high voltage or low voltage side. Follow all utility or site required procedures to validate that the transformer is not energized.*

The Two-Position Internal Grounding switch is not in the circuit when in the CLEAR position. The handle is locked and a GROUNDED condition is prevented. Once the transformer is de-energized and the utility safety procedures confirm that the transformer is de-energized then the switch may be placed into the GROUND position.

> *CAUTION: The electric interlock is present to prevent injury when transformer is energized. Do not attempt to override the interlock. Excess force is not required to go from the CLEAR position to the GROUND position when the transformer is de-energized.*

The switch is normally provided with an electric interlock, which prevents operation of the switch when the transformer is energized. The interlock coil is connected to the low-voltage winding of the transformer so that the interlock coil is energized and the handle is locked when the transformer is energized.

8.4 Packing Glands

Pressure-tight packing glands are furnished with all switch-handle shafts which project through the tank wall or cover. Figure 11 shows a switch-handle packing gland. There is a support through which the shaft passes, in which the opening has been enlarged to receive the packing. The packing is wrapped around the shaft in a spiral, and the gland is forced down against the packing by means of screws provided for the purpose, until the gland is pressure tight. It is often necessary to cut the packing in several pieces and force each piece in separately so the threads on the screws catch.

The amount of packing necessary for any particular transformer can be obtained from your Prolec GE sales representative or GE account manager.

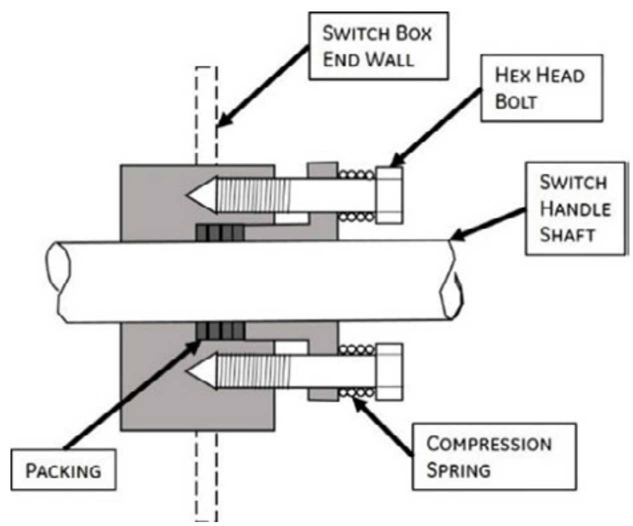


Figure 11. Switch-Handle Packing Gland

8.5 O-ring Seals

Pressure tight O-ring seals (gas tight, quantity 3) are furnished for the welding gland housed shaft found in all 2 Positioned Internal Grounding switches, Tap Changers, and some 3 Positioned Disconnecting & Grounding switches. These can be mounted on the tank cover, the tank wall, and the 3 Positioned Disconnecting & Grounding switch is mounted on the switch box side wall.

9. CABLE CONNECTIONS

9.1 Junction Boxes

When a transformer is equipped with junction box or boxes for making cable connections to the terminals of any winding of the transformer, the transformer terminals are brought into the junction box through pressure tight bushings. On a new transformer (a junction box is typically shipped separately), mount the junction box to the provided transformer flange or low voltage throat as specified. Refer to the instructions found in the section “Gaskets and Gasket Procedures”.

The junction box can be specified to use any of several GE approved insulation fluids that are for use in Network Transformers or acceptable practice for low voltage service:

- GE Type II mineral oil, this should match the transformer.
- Cargill FR3™ fluid, this should match the transformer.

When specified by the purchaser the junction box can be insulted with:

- Insulating compound
- Air (under 1000 volts)

A junction box can be operated dry when the circuit voltage is below 1000 volts, and should be filled with the appropriate insulating fluid when the circuit voltage is above 1000 volts.

A low voltage junction box, below 1000 volts, will have a bolted or welded entrance bushings located on the top, end or bottom of the junction box as specified. A junction box cover is normally specified. Remove the cover and connect to the transformer terminals. Cable connections are made external to the junction box. If the box is to be filled with insulating fluid, choose the specified fluid and fill the box with clean dry fluid to the 25C level on the gage, or until it runs out the bottom liquid level indicator plug if there is no gage. *CAUTION: Pressure test the junction boxes before apply voltage to the transformer.*

Boxes with potheads for circuit voltages above 1000 volts should be filled with insulating fluid that matches the transformer fluid. Boxes with wiping sleeves or types of cable entrance in which the cable insulation contacts the filling material, should be filled with compound unless the purchaser specified otherwise.

To make cable connections in a junction box:

- Make certain box is empty (normal condition no fluid or packing materials).
- If box is filled with insulating fluid, remove the liquid through the drain plug or valve in the bottom of the box into clean, dry, and properly labeled containers. Then remove the junction-box cover.
- If there are potheads on the box, remove them and attach cables to the potheads and fill with compound or cable oil in accordance with instructions furnished by the pothead manufacturer.
- If there are wiping sleeves, prepare cable ends and attached the sleeves in accordance with the instructions under “Wiping Sleeve Cable Connection” found in the section “Cable Connections associated with a Terminal Chamber”.
- Attached the assembled cable and pothead, or wiping sleeve, to the junction box, and connect the cable terminals or pothead terminals to the transformer terminals in the junction box.

Prepare the gasket surface and replace the junction box gasket and cover as described in the section "Gaskets and Gasket Procedures". If the box is to be filled with insulating fluid, choose the specified fluid and fill the box with clean dry fluid to the 25C level on the gage, or until it runs out the bottom liquid level indicator plug if there is no gage.

For compound filling refer to instructions under section "Cable Connections associated with a Terminal Chamber". *CAUTION: Pressure test the junction boxes before apply voltage to the transformer.*

9.2 Single Compartment Switch Box - High Voltage

When a transformer is equipped with a single compartment switch box comprising a switch chamber and high voltage entrance, the transformer terminals are brought into the switch chamber through pressure tight concrete polymer high voltage bushings. The bushing stud(s) are connected to the output contact of the HV switch frame. HV entrance bushings are connected to the bushing stud on welded or bolted bushings on the switch chamber cover or switch chamber front plate above the switch chamber cover.

The high voltage switch chamber can be specified to use any of several Prolec GE approved insulation fluids that are for use in Network Transformers:

- GE Type II mineral oil, this should match the transformer and be confirmed on nameplate or a purchaser's specification.
- Cargill FR3™ high fire point fluid, this should match the transformer.
- Silicone high fire point fluid, this should match the transformer.

Based on the purchaser(s) specification high voltage bushings on the switch camber entrance are ANSI/IEEE 386 standard dead break or load break bushings. The load break HV bushings are available rated for 200 amp service. The dead break bushings are available for 200 amp and 600 amp service, see Table 1.

Table 1. Switch Box Mounted Entrance - High Voltage Bushing Details

Switch Chamber Cover Mounted & Front Plate Mounted	200A Load-Break	200A Dead-Break	600A Dead-Break
Bushing Conductor Diameter	0.375		0.5
kV BIL max	≤ 150	≤ 150	≤ 200
Shank Length (below cover top surface)	9.5 in	9.5 in	9.5 in - 12 in
Shank Length (behind front plate exterior surface)	Side Mounted Short Shank	Side Mounted Short Shank	Side Mounted Short Shank

Based on the purchaser(s) specification high voltage bushings on the tank cover HV entrance are ANSI/IEEE 386 standard dead break or load break bushings. The load HV bushings are available rated for 200amp service. The dead break bushings are available for 200amp and 600amp service, see Table 2:

Table 2. Tank Mounted Entrance - High Voltage Bushing Ratings

Tank Cover Mounted Tank End Wall Mounted	200A Load-Break	200A Dead-Break	600A Dead-Break
Bushing Conductor Diameter	0.375	0.375	0.5
kV BIL max	≤ 150	≤ 150	≤ 200
Shank Length (below cover top surface)	9.5 in - 15 in	9.5 in - 15 in	9.5 in - 12 in
Shank Length (behind tank wall exterior surface)	Side Mounted Short Shank	Side Mounted Short Shank	Side Mounted Short Shank

Load break bushings are available in several forms:

- Welded bushing-well to weld flange with or without tabs
- Bolt-on bushing-well to weld flange with or without tabs
- With bushing inserts
- Capped without bushing inserts
- Available on the switch chamber HV entrance on cover
- Available on the switch chamber HV entrance on switch box front plate
- Optional on the tank cover (HV end) without switch box & switch chamber
- Optional on the tank HV end wall without switch box & switch chamber

Dead break bushings are available in several forms:

- Welded bushing
- Bolt-on bushing
- Capped for weather protection.
- Available on the switch chamber HV entrance cover
- Available on the switch chamber HV entrance front plate.
- Optional on the tank cover (HV end) without switch box & switch chamber.
- Optional on the tank HV end wall without switch box & switch chamber.

The HV Bushing manufacturers make all the supporting cable product to complete the connections and they can be contacted for the appropriate instructions for those products. The bushings are clean, protected with caps, and shipping covers (depending on the design and/or purchaser(s) specification) when the units are shipped.

Note: Load Break Bushing Inserts, Missing Ground (Drain) Wires. CAUTION: Without the drain-wire, it is possible to build up charge on the insert. This charge may discharge gradually over time to the well or elbow in which case there may be erosion/tracking. The charge may also discharge rapidly if contacted by a grounded item. In this case, bodily injury or equipment damage may occur.

When working in dead-front transformers or switchgear, be aware that this potential hazard may exist. If an outage is necessary to perform other work in such equipment where drain-wires are not connected to the bushing inserts, then add the drain-wires before re-energizing the equipment.

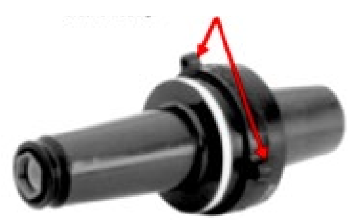


Figure 12a. Load Break Bushing Insert

Figure 12b. Integral Load Break Bushing Insert

Bushing drain-wire requirement only applies to transformers or switchgear with bushing inserts, see Picture 06. Bushing inserts are field replaceable and screw into bushing wells installed in the equipment. If the equipment has integral bushings, then the drain-wires are not needed, see Picture 07. Integral bushings are one-piece, non-field replaceable.
Provided, that the load break elbow or insulating cap has their ground-tabs connected to ground with a drain-wire, the exposure to this static discharge hazard is minimal.

The bushing-well is bonded to the transformer wall, cover, or switch box cover/front plate; the bushing-well clamp is bonded in the same way; and the elbow connector cuff covers most of the bushing insert, then the area of exposure for an ungrounded bushing insert.

9.2 Terminal Chambers

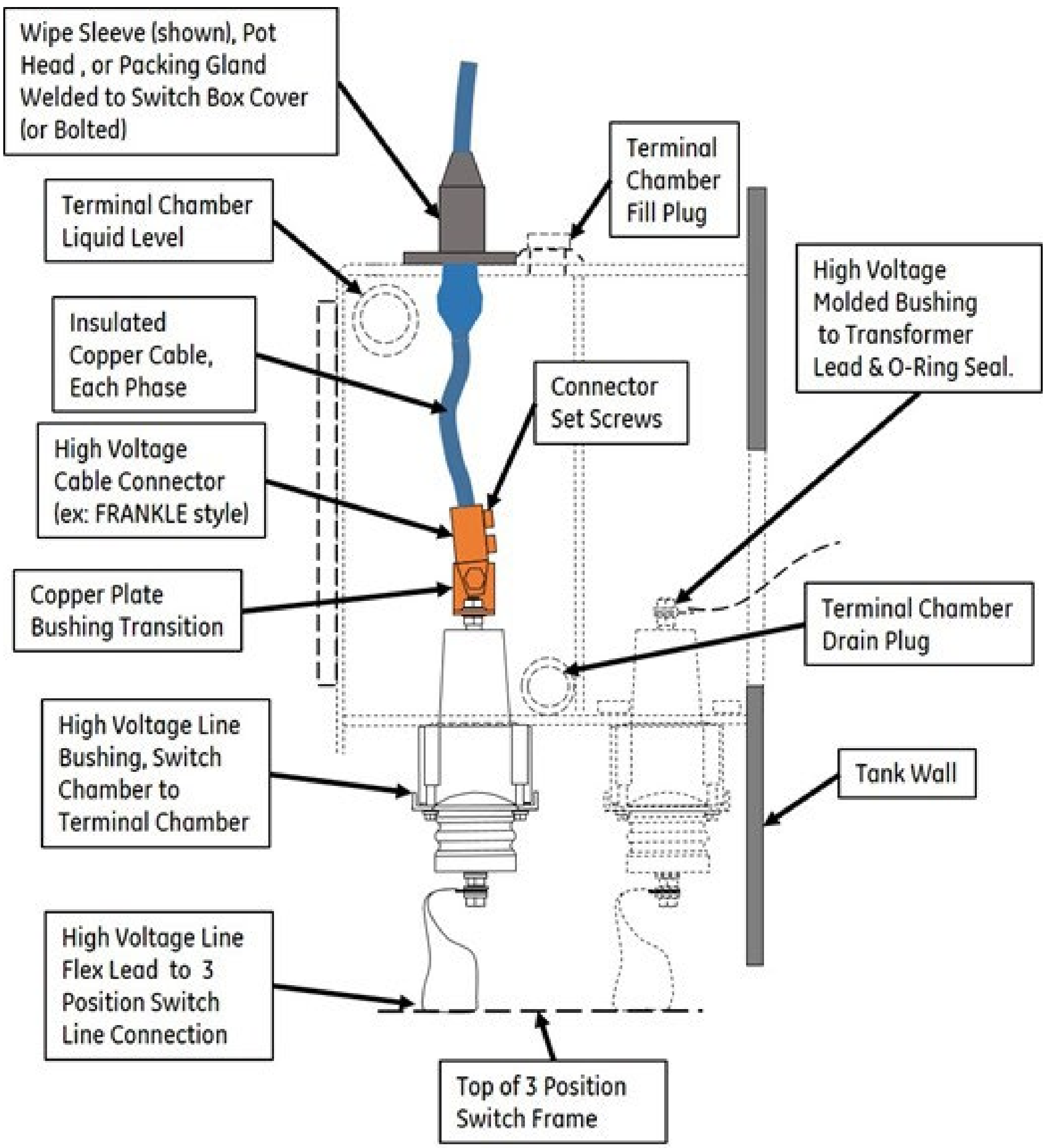


Figure 13. Terminal Chamber

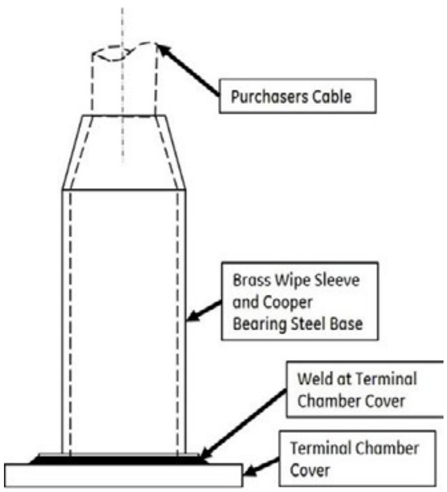


Figure 14. Wiping Sleeve

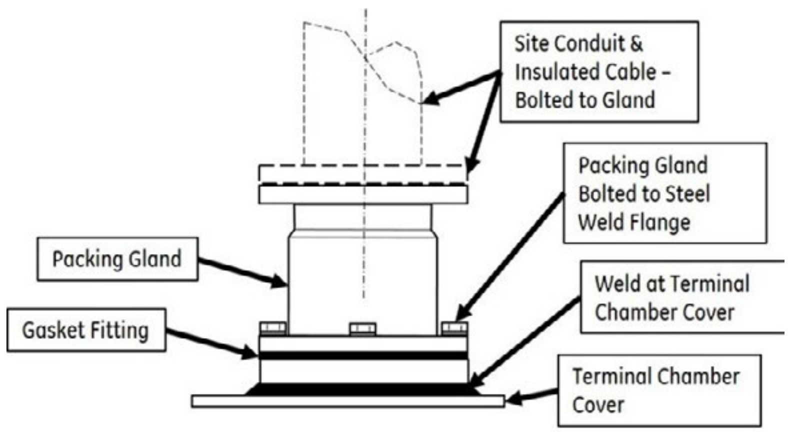


Figure 15. Cable Packing Gland

Terminal chambers are cable entrance compartments attached to switch cases or junction boxes. Terminals from the switch or the transformer are brought into the terminal chambers through pressure-tight bushings.

Cables are normally brought into a terminal chamber through wipe sleeve, see Figure 13 and 14, flanged stuffing-box/packing glands, see Figure 15, and Angled Wipe Sleeve, see Figure 16, or other miscellaneous clamp type connections.

To connect paper-insulated or varnished-cambric insulated cable to a terminal chamber, proceed as follows. Remove the terminal-chamber cover. Prepare the cable ends as described under "Wiping-Sleeve Cable Connection", and attach wiping sleeves and the prepared cable ends to the terminal chamber. Connect the cable terminals to the terminal-chamber bushings. Tape the bare terminals with three half-lap wraps of varnished-cambric tape, brushing each layer with cable oil. Extend the tape one and one-half inches beyond the penciled portion of the cable insulations, and one and one-half inches over the end of the porcelain insulator.

Prepare the gasket surfaces and replace the terminal chamber cover as described in section "Gaskets and Gasketing Procedures."

CAUTION: Pressure test the terminal chamber before applying voltage to the transformer.

Top-connected terminal chambers for paper-insulated or varnish-cambric-insulated cables should be filled with cable oil heated to l00°C. Bottom-connected terminal chambers for paper or varnish-cambric insulated cables should be filled with an oil-insoluble resin compound to prevent loss of compound by migration into the cable insulation. Follow the compound manufacturer's application and pouring recommendations. A pipe plug is provided in the top of the terminal chamber for filling. On some top-connected terminal chambers with large, tapered wiping sleeves, a pipe plug may be provided in the body of the wiping sleeve for filling and venting the terminal chamber and the wiping sleeve (see Fig. 17).

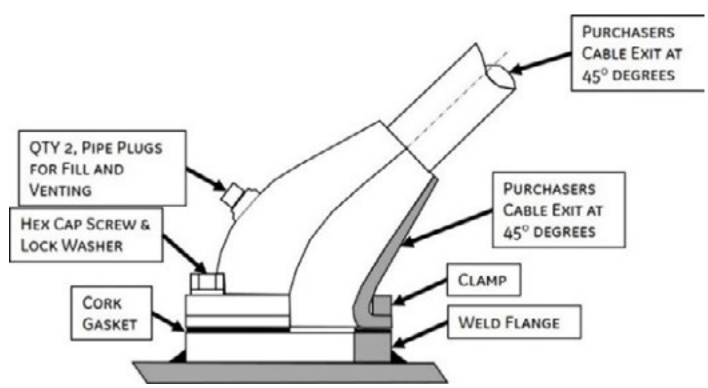


Figure 16. Wiping Sleeve (45° Angle)

Terminal chambers for rubber or other coated cable that is compatible with insulation fluids or compound may be used terminal chambers with the approved liquid or compound.

Do not use rubber-covered cables in oil or silicone. It is recommended that the cable or compound manufacturer be consulted for specific recommendations as to proper choice of compound, pouring temperature, use of stress cones on shielded cables, etc. For further assistance, contact your Prolec GE sales representative or GE account manager.

9.3 Wiping-Sleeve Cable Connection

Single-conductor, lead-covered, paper-insulated, or varnished-cambric-insulated cable can be connected to a top or bottom connected terminal chamber or junction box as follows: (Refer to Figure 17, which shows a typical top-connected terminal chamber with wiping sleeve for single-conductor cable).

1. Remove the wiping sleeve.
2. Remove the terminals from the bushings.
3. If the tapered end of the wiping sleeve is smaller than the outside diameter of the cable, cut off the end of the wiping sleeve to fit the cable used.
4. Slip the wiping sleeve over the end of-the cable.
5. Strip the lead sheath from the end of the cable to point, which is located at the level shown.
6. Bell the end of the lead sheath as indicated.
7. Remove sufficient insulation from the end of the terminals; the attach the terminals.
8. Pencil the paper insulation as indicated at bushing terminal.
9. "Boil out" the paper insulation.
10. Build a bumper by wrapping a cone of varnished cambric tape treated with cable oil, to a diameter of about 4 times the thickness of the paper insulation, plus the bare diameter of the conductor.
11. Apply one layer of copper mesh tape with a 0.067(1/16) inch starting at the maximum diameter of the bumper and extending to a point beneath the bell in the lead sheath. The lower edge of the copper mesh tape should extend at least 1.0 inch below the underside of the terminal chamber top plate as shown.
12. Dress the end of the lead sheath down on the copper tape, and solder the sheath to the copper. The copper should be bound down to the bumper with varnished cambric tape, and the tape should extend from the lead sheath to the end of the bumper.
13. Many chambers now use terminal connectors on the bushing stud, insulate over the connector. Build up the penciled portion of the insulated bare conductor and transformer terminal with varnished cambric tape treated with a thorough application of cable oil between each layer.
14. Locate the wiping sleeve on the cable so that the gasket surface of the wiping sleeve is the correct distance from the end of the cable. This distance can be obtained by direct measurement. Make the wiped joint between the sleeve and the cable sheath.
15. Attach the sleeve and cable to the terminal chamber or junction box.

Refer to the section “Insulating Fluids” for information pertinent to filling with insulating fluid or insulating compound.

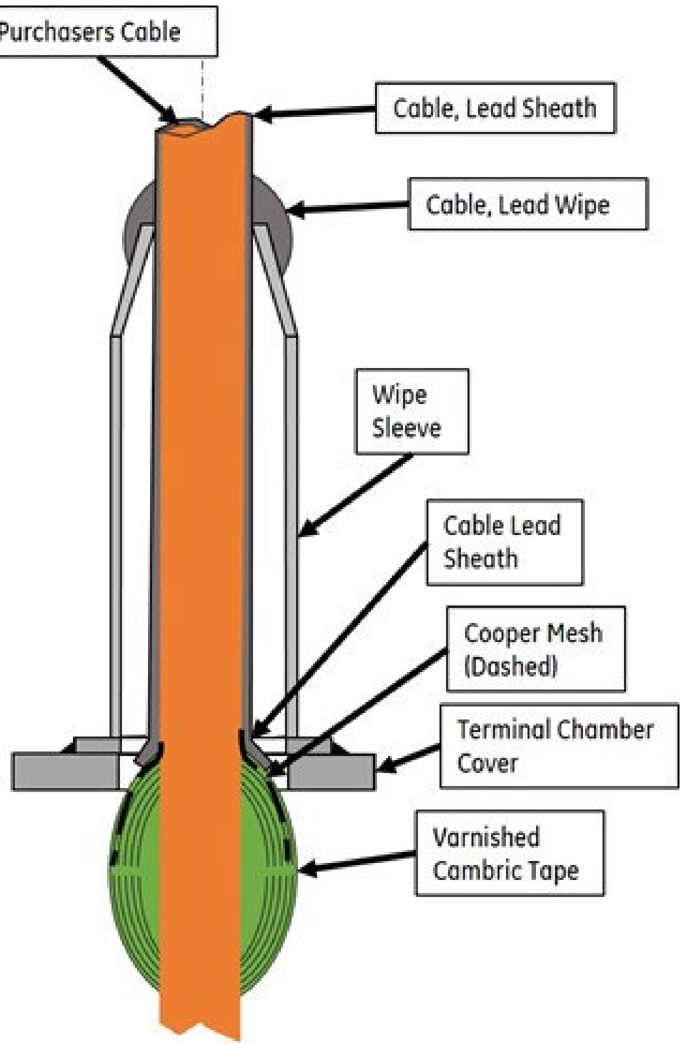


Figure 17. Top-connected Terminal Chamber

Three-conductor, lead-covered cable can be connected to top or bottom-connected terminal chambers or junction boxes in the same manner as single-conductor cable. The bushing terminals shown in Figure 18 are located on the arc of a circle having a radius (A), so that all three cables can be cut to the same length. Both straight wiping sleeves (Fig. 14) or angle wiping sleeves (Fig. 16) are attached to the cable in the same manner.

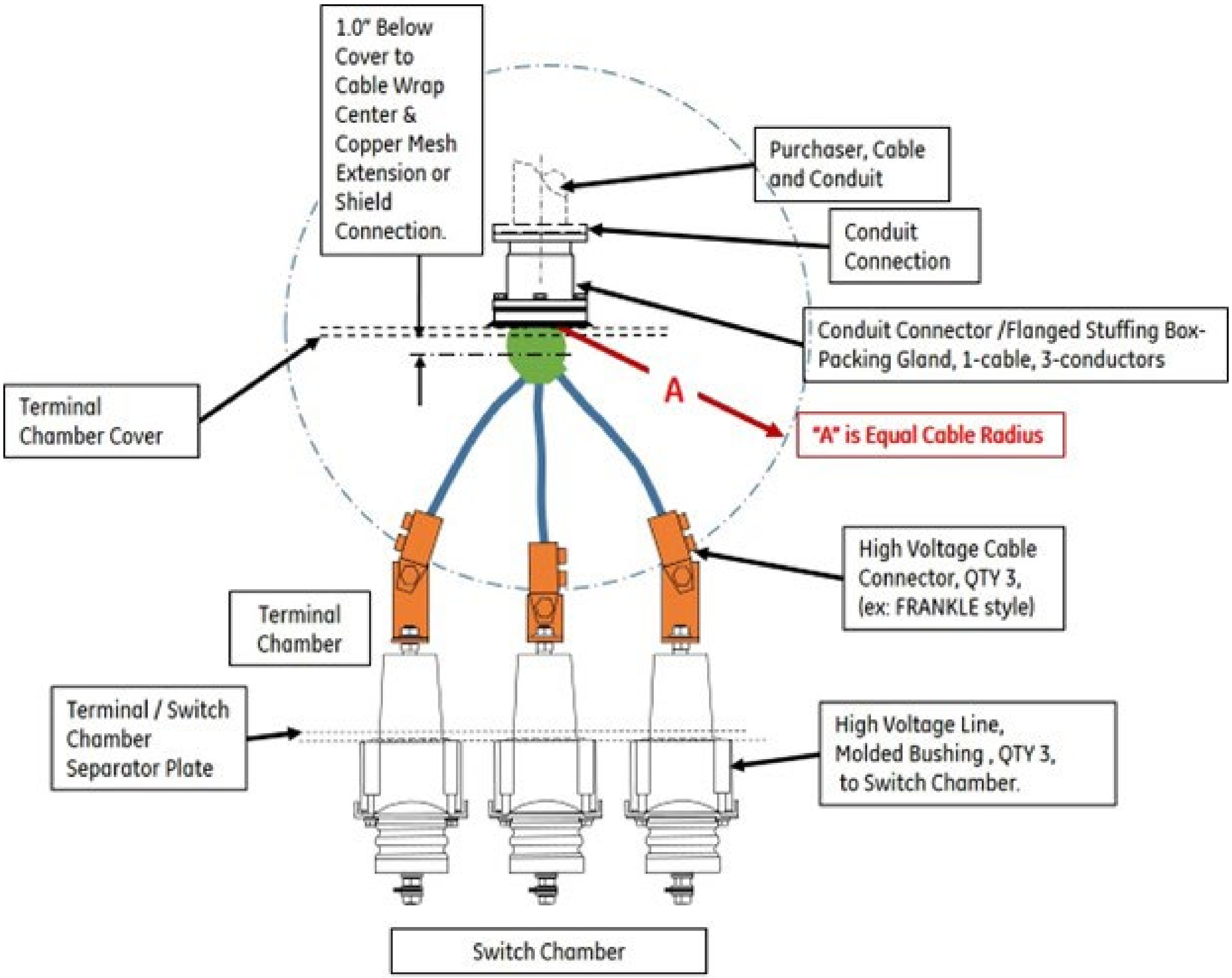


Figure 18. Conduit Cable Gland, 3 Conductor, 1 Cable, Equal Conductor Length

CAUTION: These instructions are offered, but do not supersede the purchaser's (Utility or Electrical contractor) developed procedures for cable terminations in insulting fluids or insulting compounds. Special attention should be directed at material compatibility with insulating fluid or compound for anything used in a terminal chamber or junction box.

9.4 Compression Glands and Miscellaneous Cable Connections

One type of compression gland or packing gland is shown in Figure 15. Rubber-covered cables are usually brought into dry (air-filled), or asphaltic-type compound-filled terminal chambers through this type of gland.

If the terminal chamber or junction box is to be filled with compound, refer to sections "Insulating Fluids" for information pertinent to fill with compound.

A suggested procedure for preparing cable ends when connecting shielded rubber covered cables to terminal chambers having FRANKLE style connectors on the terminal chamber bushing studs is as follows:
Because of the wide variety of shielded, rubber in sulated cables available, it is recommended that the cable manufacturer be consulted as to the best method of terminating the cable and for minimum recommended insulating distances.

1. Remove the terminal chamber cover and the compression gland packing nut and packing.
2. Make reference marks as shown in Figure 18. Dimension "A" is a function of the height of the terminal chamber and the compression gland used. It should be arrived at by temporarily assembling a piece of cable in the compression gland and terminal chamber and marking it just below the rubber bushing in the gland.
3. Assemble the compression gland packing nut and packing on the cable and push it back out of the way.
4. Clear the end of cable down to the bare strands for a distance of 1 ½ inches from the end. Clean the strands and sweat the cable to the bayonet connector. Fill the strands with solder.
5. Remove rubber jacket, metallic shield, and all traces of semi-conducting tape (Figure 16). Pencil insulation at the bushing terminal connection for 3/4 inch.
6. Fill between shoulder of insulation and bayonet connector with dry varnished cambric or rubber tape. Build up the lowest part first to avoid wrinkled tapes.
7. Apply two of the ½ lap wraps of tape to 1/4 inch over the connector at bushing terminal.
8. Build the stress cone with tape, Figure 16 and 17. Remove the rubber jacket ½ inch back. Solder copper mesh tape to the cable ground shield. Use the mesh tape extend the ground to the maximum diameter of the stress cone. Solder the copper mesh tape back on the previous wraps. Allow sufficient tape for extension back along the cable toward the top of the terminal chamber and subsequent connection to ground terminal.
9. Apply two ½ lap wraps of tape over the stress relief cone and cable down to the bayonet connector. Bring the copper mesh out to the ground connection.

Assemble the stuffing gland in place; then prepare the gasket surfaces and replace the terminal chamber cover as described in a supplementary leaflet "Gaskets and Gasketing Procedures." Pressure test the terminal chamber.

When cable terminations other than those manufactured by Prolec GE are used in conjunction with the equipment covered by these instruc tions, refer to the manufacturer's instructions covering the particular device.

Caution: These instructions are offered, but do not supersede the purchaser's developed procedures for cable terminations in insulting fluids or insulting compounds. Special attention should be directed at material compatibility with insulating fluid or compound for anything used in a terminal chamber or junction box.

10. FIELD REPLACEMENT OF WELDED SEAL LOW VOLTAGE EPOXY BUSHINGS

The low voltage bushings located in the low voltage throat are a standard offering as a welded removable bushing. These LV Bushings are molded epoxy insulated defined as:

- 2000 Ampere with 1.50-inch diameter threaded copper stud.
- 3000 Ampere with 2.00-inch diameter threaded copper stud.

The studs and a bushing adapter flange are permanently cast into the epoxy insulator. The bushing adapter mates to a tank adapter, then they are arc welded to form the permanent seal for the assembly.

CAUTION: On liquid filled units, welding adjacent to an insulation fluid atmosphere can be hazardous. Lower the liquid level in the transformer at least 6.0inch to 8.0inch below the level of the bushings being careful not to expose items below the top surface of the core and coil clamping. Follow all the recommendations in these instructions for properly handling the insulating fluids, see section "Insulating Fluids". Follow all local, state, and federal technical regulations *and standards. Once the fluid is removed, then fill the space with dry nitrogen, first purge the unit gases in the air space and second to flow slowly to keep the transformer protected.*

10.1 Welding Process Description & Materials

Weld processes is a tungsten inert gas shield arc welding (T.I.G). The welding process is an all position weld of the replacement bushings. The power is control by a foot operated switch providing 10 to 30 amperes to a D.C. (electrode negative) electrode. The welding torch is a miniature straight pencil type with collet and nozzle. A thoriated tungsten electrode is 0.040inch diameter. Pure argon with a flow meter control for adjustment from 6 to 10 cubic foot per hour is the gas supply.

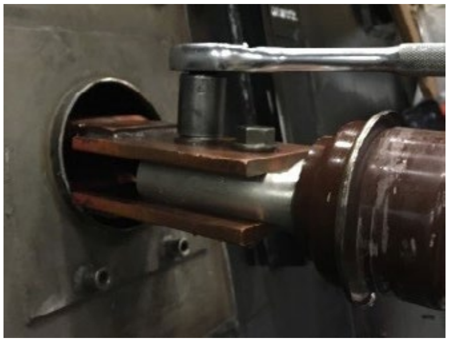
Miscellaneous materials required include:

- Carbon Block for arc starting.
- No.6 shade for welding helmet.
- Diagonal cutting pliers.
- Long nose pliers.
- Flat mill files.
- Small rotary wire brush.
- Rotary files with portable electric drill
- Extension welding cables and gas hose.
- Short length of filler wire (0.045 dia., 18-8 stainless steel).
- Heat sinks, see Pictures15 & 16
- Clean rags and solvent.
- Grinder (either electric or air driven).

10.2 Replacing a Welded LV Epoxy Bushing Assembly

Clean up the area removing all debris and prepare the area for grinding to minimize debris or debris build up from the process. Remove most of the existing TIG butt weld between the 2 flanges (Bushing and Throat) using a cup sized grinding disk or rotary in a portable electric drill, Picture 09. Do not remove more material than 0.050 inch.

CAUTION: Do not create an uneven surface on the flanges and do not damage the bushings.

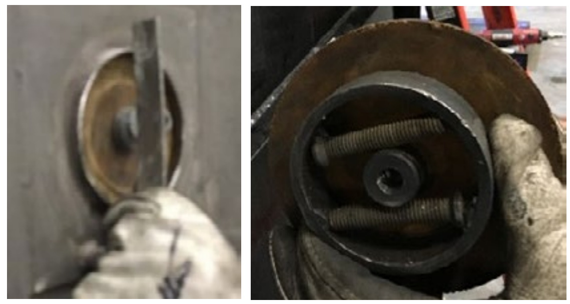


When the joint line, between the flanges, can be seen around the weld periphery, use a cold chisel and hammer on the bushing flange and break it lose from the LV throat flange, Picture 10.

Caution: Do not deform, thin, or gouge the LV throat flange that is to be reused. Clean up the area removing all debris and prepare the area for removal of the bushing.

Remove the bushing by pulling the bushing through the LV throat flange, Picture 11. Break the internal connection to the bushing being careful to maintain control of all hardware. If the hand hole cover or main cover is removed the connection can be broken internally before the bushing is removed.

Seal the bushing flange opening in the LV throat using a nitrile gasket (plug, bolted butterfly, or flat style) so that the tank internal components are protected, Picture 12. Once sealed, dress the LV throat flange to restore the original contour. Wire brush all edges and surfaces to be welded. Remove all debris left behind from the process and prepare the flange for welding.



Secure replacement bushing, then reattached the internal connections. Align the bushing flange and LV throat flange as flush as possible. Pay attention to the bushing axis as it must be 90o Degrees or perpendicular to the LV flange surface, in-line with adjacent LV bushings axis, and the spacing between adjacent LV Bushing axis must be equal.

This will require some skill in adjusting the final bushing position to achieve, as close as possible, a flush flange position.

Caution: Prior to welding purge the transformer gas space with nitrogen for several minutes and then maintain a continuous flow of nitrogen. Fittings on the cover or tank wall should be used with the flow entering and exiting to create a cross tank flow. A heat sink is required to complete these welds and maintain the LV Bushing integrity. The personnel that make these repairs should be certified in this welding process and demonstrate required skill by successful completion of test coupons.

Welding setup should be connected for straight polarity (electrode to the negative terminal). Test the weld setting and foot control operation on scrap material. Start arc on a carbon block held in contact with the flanged joint, wait for the arc to become steady then transfer it to the joint. Tack weld at four points approximately 90oDegrees apart around the flanged periphery, Picture 13. Verify that the alignment is as required above and that no large gaps exist between flanges (add tack points if required).

Install the heat sink over the low voltage bushing stud, Picture 14. The heat sink should be refrigerated prior to installation to insure its performance throughout the welding process and should be applied just before the final weld process is initiated.

Complete the weld around the joint in weld steps that traverse about 90° or 25% of the circumference. Weld downhill only, never uphill. Overlap each weld section by 0.25 inch. Hold the gas nozzle directly over the weld and use short arc to avoid air contamination. Taper off craters by reducing current and increasing travel speed. Always start arc away from joint. Wire brush all starts and finishes. Inspect finished welds for pinholes or other defects and repair. Remove defects with rotary file adding filler weld if necessary. Leak test using nitrogen in the tank air space at 7.0 PSIG pressure after the welds have cooled. Use a soap solution on welds to detect leaks as evidenced by bubbles. Once repairs are completed, restore fluid levels as described in section on “Insulating Fluids” using the fluid specified and indicated on the nameplate. Pressure check the entire transformer at 7.0 PSIG pressure for 4 hours to 8 hours and validate the fluid dielectric integrity as described in section on “Field testing of Secondary Network Transformers”.

Heat sinks are required in two sizes based on the LV bushing rating, the 3000 Ampere bushing has a 2.0 threaded stud and the 2000 Ampere bushing has a 1.5 threaded stud. Each rating has a different flange diameter, Pictures 15 & 16. The following pictures show the heat sinks used to create the original welds.

Contact your Prolec GE sales representative or GE account manager if a purchaser would like to discuss heat sinks or purchase them.

11. REFINISHING UNDERGROUND TRANSFORMERS IN THE FIELD

Prolec GE distribution transformers are finished with a high build, four coat epoxy-phenolic and acrylic paint system. Transformers shipped prior to 1974 were finished with a Melaprene paint system. The refinishing procedures and materials described here can be used for the repair of both old and new transformers.

Normally the original finishes will not need main tenance except when exposed to extremely corrosive conditions. Occasionally, while in storage or during installation, the paint may be damaged by sharp objects or abrasion. In such cases, it is recommended that only the damaged areas or places that show rust should be refinished. As a matter of fact, it would be quite difficult as well as unnecessary to remove the paint in undamaged areas. Refer to the preceding sections to refinish these transformers.

11.1 Damaged Paint

Repair of damaged area when Bare Metal or Primer is showing. Also, repair of significant pinholes or blisters. Grind or sand (medium grit garnet paper) the defective area to remove the damaged paint and/or debris particles. If other defects are observed such as blisters, it will be necessary to scrape or sand those areas prior to touching up the paint.

Wipe sanded area with a clean cloth & alcohol to remove loose material. Wait at least 5 minutes to allow alcohol to completely evaporate before re-painting.

If required, an extension handle on the brush or roller may be used to reach areas between radiator panels. Paint the damaged area with whichever paint is appropriate:

- Bare Metal: Zinc Rich Epoxy Primer (exposed bare metal should be painted immediately; oxidation can show up within 1 or 2 hours under humid conditions).
- Primer showing: Black Epoxy Topcoat (If Gray Epoxy Topcoat was original paint then use Gray).

Repair of cracked paint that may result from repair of a damaged area. Chip and sand out the cracked paint back to bare metal then wipe sanded area with a clean cloth & alcohol to remove loose material. Wait at least 5 minutes to allow alcohol to completely evaporate before re-painting. Paint the damaged area with Zinc Rich Epoxy Primer with brush for a small area or a roller for a large area. Allow paint to dry (see “Drying” below), then paint the damaged area with whichever paint with Black Epoxy Topcoat (If grey epoxy topcoat was original paint then use grey)

Repairing paint on network covers requires additional care to protect the hardware mounted on the cover of the unit. For HV bushings, place a plastic bushing cap over each bushing prior to sanding. Remove any cables or electronic devices that may be installed on the cover prior to sanding. Follow the repair procedures described above. The inner surfaces of panel radiators or the tank surface behind the panels will are normally not exposed to damage. If repainting is necessary, however, rust or loose paint can be removed with a sanding tool attached to a long handle.

10.2 Drying

Dry the unit thoroughly, preferably using a hose connected to a heated air source.

10.4 Priming

If repairs or refurbishments are undertaken, then these should be accomplished at the purchaser's shops facilities or by a qualified supplier of paint services in similar facilities.

The primer paint system, once mixed has a useful pot life of 16 hours and the key metric for the paint is its viscosity. Do not use the paint system after the pot life expires. Follow the paint supplier's instruction, local and federal regulations, and internal health and safety policies to properly dispose of the paint. Brushing or roller application is desired when repairing and typically results in a 5 ml coating. Do not exceed 5 ml which can be checked once the primer has dried. If 3 to 5 ml thickness is achieved, apply an addition coat and dry then remeasure the thickness. If the surface primer coat was not taken to bare metal, then check the paint thickness to verify that a minimum of primer layer is 3 mils thick and to establish a baseline measurement for future thickness measurements. The factory uses a POSITECTOR 6000 paint millage gauge. Any similar device that is in calibration and specified for use on epoxy paint can be used to measure paint millage. This coat needs at least 24 hours to air dry.

CAUTION: Do not apply paint system below 10ºC (50ºF) ambient temperature.

10.5 Finishing Coats

The finish top coat is normally a black epoxy paint applied over the zinc rich epoxy primer.

The finish top paint system, once mixed has a useful pot life of 16 hours and the key metric for the paint is its viscosity. Do not use the paint system after the pot life expires. Follow the paint supplier's instruction, local regulations, federal regulations, and internal health & safety policies to properly dispose of the paint. Brushing or roller application is desired and typically results in a 5 ml coating. Do not exceed 5mils which can be checked once the primer has dried. If 3 to 5 ml thickness is not achieved, apply an addition coat and dry then remeasure the thickness. In this case the primer thickness is the base and the gage will measure total thickness (e.g. 6.0 ml total thickness – 3.0 ml primer thickness = 3.0 ml top coat thickness).

This coat needs at least 16 hours to air dry and for refurbishing the complete tank and cover then a bake oven is recommended. It will take one week for the paint to fully harden at 25ºC (75ºF). Follow paint manufacturer's instructions for spraying and recommendations on spraying equipment, drying processes, and paint area filtration.

Caution: Do not apply paint system below 10ºC (50ºF) ambient temperature.

The refinishing process should approximate and restore transformers to their original factory condition. Paint products referred to herein and paint manufacturer's contact info can be obtained from your by contacting your Prolec GE sales representative or GE account manager.

12. REMOVING AND REWELDING LIQUID FILLED NETWORK COVERS

12.1 Removing the Cover

Carefully follow these instructions when removing and rewilding covers. These instructions are proven to produce a strong sound joint. Technicians making these modifications need to certified as welders per the American Welding Society (AWS) standard processes that apply to the gouging and welding on the transformer.

Welded covers can be removed by either chipping, grinding, oxygen gouging, or arc air gouging. Arc-air gouging is the fastest and is recommended for material 0.125 thick or larger. Network covers are 0.50 inch thickness steel.

CAUTION:

- Adequate precautions must be taken for the fire hazard which exists with oxyacetylene, grinding, air-arc gouging, and welding operations. All gouging is recommended to occur in a booth designed and ventilated for this purpose. Comply with all local, state, and federal standards & regulations.
- The liquid filled transformer must be prepared for gouging. A continuous supply of dry nitrogen is required in the gas space during the entire process and adequate time must be allow ahead of gouging to ensure that the gases are purged. Dry nitrogen should enter and exit from opposite ends or corners of the cover, then a gas blanket is in place under the entire cover.
- SafeNET covers, transport can cause some insulating fluid is frequently between tank wall and cover, need a small hole in opposing cover corners at bottom of weld adjacent tank flange to drain trapped fluid.

Grinding, which is preferred for thinner material, may be done using an edge-cutting disk but will take a long time.

12.2 Gouging: Arc-Air or Oxygen method

Before gouging of welds on a liquid filled transformer, purge thoroughly the air space inside the tank with dry nitrogen gas. Maintain a small flow of gas during the entire gouging operation.

The equipment required for arc air welding includes a 300 ampere (minimum) variable voltage (conventional) arc welding supply, and a 90 PSIG high capacity supply of compressed air. A special electrode holder combines a jet of air with a copper coated electrode, 0.25inch diameter, to melt and blow away the fillet weld metal. A recommended equipment supply would be AIR TORCH, their Model 6-062. Reverse polarity (electrode positive) is used at approximately 300 amperes.

For oxygen gouging, cutting torch equipment, is necessary with gouging tips like AIR REDUCTION Style No. 183. One recommendation for best performance of the gouging operation is a cutting torch like AIRCO Series 3000 having a gradual control of the high-pressure oxygen flow. Tip sizes and gas pressures recommended for various fillet weld sizes are shown in the table below.

Table 3. Oxygen Gouging Tips Sizes and Gas Pressures

Fillet Weld Size (in)	Tip Size	Oxygen Pressure PSIG	Acetylene Pressure PSIG
Up to 0.312 (5⁄16)	8	60	8
0.375 (3⁄8) to 0.4375 (5⁄16)	10	70	9
0.5 and up	12	75	9

CAUTION: Clamp the cover during cutting operation to prevent its raising and admitting sparks and metal/slag particles into tank interior. Protect all openings against entrance of foreign material.

The entire weld may be removed in one pass, with care to avoid deep gouging of the tank cover edges and the tank cover flange. Slag and metal adhering to the cover, tank wall, and tank flange after gouging can be removed by a light chipping operation. Grind the edges of the cut smooth with a disk grinder in preparation for rewilding.

CAUTION: Keep the cover tightly clamped and continue the flow of dry nitrogen until all cleaning operations are completed. Clean all surfaces of foreign material prior to proceeding to remove the cover.

12.3 Gouging: Chipping Method

Where it is desired to remove welds by chipping, this can be accomplished with a diamond-point chisels and a pneumatic hammer. Flat Covers, clamp the to the flange to prevent raising as the weld is chipped away. Use "C" clamps and bring the cover down tight on the gasket. If the cover is SAFENET style with no gasket, then bring cover tight down on the tank flange. Protect all openings in the cover against chips entering the transformer.

CAUTION: Keep the cover tightly clamped and continue the flow of dry nitrogen until all cleaning operations are completed. Clean all surfaces of foreign material prior to proceeding to remove the cover.

Remove the cover at the end of the process, then shut off the dry nitrogen flow. Let transformer stand for 4 hours before working on the transformer.

12.4 Rewelding the Transformer Cover

Before re-welding the cover to the transformer tank thoroughly clean the cover edges and the tank flange to remove all foreign material. Take extra care to remove all traces of transformer fluids on or adjacent to the welding surfaces.

Welded flat covers have a strip of weld gasket around the cover perimeter to protect the transformer. A new dry gasket is required to re-weld the transformer cover. Locate the outer gasket edge approximately 0.5 inch from outer edge of the cover,

Welded SafeNET covers are designed to be without a gasket. The tank wall extends pass the flange. The tank wall locates the transformer cover, see Figure19.

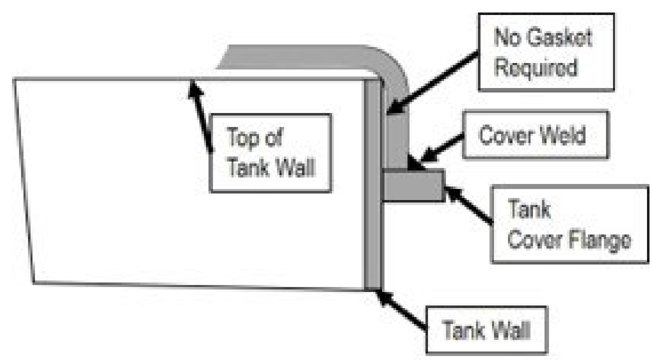


Figure 19. Transformer Tank

CAUTION: Adequate precautions must be taken for the fire hazard which exists with oxyacetylene, grinding, air-arc gouging, and welding operations. Comply with all local, state, and federal standards & regulations. The liquid filled transformer must be and prepared for welding and the cover clamped tight to the tank flange. A continuous supply of dry nitrogen is required in the gas space during the entire process and adequate time must be allow ahead of welding to ensure that the gases are purged. Dry nitrogen should enter and exit from opposite ends or corners of the cover to create nitrogen gas blanket under the entire cover.

The nitrogen prevents any possible accumulation of explosive welding gases above the liquid in the tank. Weld the cover to the flange using the metal arc process with 0.188 (3/16) inch diameter electrodes of AWS Class E-6013 or E-7014. On the 0.5 inch covers is best made with a 0.375 (3/8) inch radius fillet weld which is best made with multiple weld passes (2 or more) with thorough removal of slag and splatter between passes. After welding the cover and allowing the cover weld too cool, stop the flow of dry nitrogen. Let the transformer stand with gas space vents(all) open for at least 4 hours.

12.5 Testing the Weld

After the welding is completed, remove all weld scale and pressure test the weld at 5.0 PSIG using dry compressed nitrogen gas applied through the filling hole in the cover. Follow pressure test instructions found in “Installation” section.

After a satisfactory pressure test, clean the weld and adjacent surfaces impacted by the process used that need to be painted. Paint these surfaces using the techniques and process described in the section on “Refinishing Underground Transformers ”.

CAUTION: The transformer must be electrically tested to be sure that all activities described in this section or other actions have resulted in a robust transformer, see section on “Field testing of Secondary Network Transformers”.

13. FIELD TESTING OF SECONDARY NETWORK TRANSFORMERS

13.1 AC Tests

These instructions cover the field testing of Secondary Network Transformers, which at the factory are given low frequency dielectric tests in accordance with voltages established by American Standards Association (ASA), Publication for distribution, Power and Regulating Transformers C-57.12 - Section 12 - 02 - 110.

When testing network transformers in the field, ASA recommended test values should be applied. These values are less than the factory test values and are given in Table 1. These recommendations relate to dielectric tests applied between windings and ground, and for induced voltage tests. These are taken from ASA Publication C-57.12, Section 12 - 92.042.

Table 4. Factory Testing

Field Test Classification	Percent of AC Factory Test (1 Minute)
Acceptance Test (New or Rebuilt Apparatus)	75
Periodic Service Test	65

For convenience, factory test voltage values and the corresponding recommended field tests values are tabulated in Table 5. The table gives values for 60 cycles, 1 minute hught potential test for winding-voltage classes 1.2 through 34.5 kilovolt.

Table 5. 60 Cycle, 1 Minute High Potential Tests from each Windings and Ground

Winding Voltage Class	Factory Test Voltage	Recommended Voltage for Field Test	
		Field Acceptance (75% of Factory Test)	Periodic Field Test (65% of Factory Test)
1200	10000	7500	6500
5000	19000	14250	12350
8660	26000	19500	16900
15000	34000	25500	22100
25000	50000	37500	32500
34500	70000	52500	45500

Table 6 gives the original factory test voltage values and the recommmended field test valuesfor induced voltage tests. Induced voltage tests should be made with at least doule rated frequency. Duration of tests should not exceed 7200 cycles. If this test produces a voltage between the terminals of any winding in excess of values given for field tests in Table 5, the induced voltage should be limited to the specidied high potential test voltage for that winding.

Table 6. Induced Voltage Test

Original Factory Test	Field Test	
	Field Acceptance Test	Periodic Field Test
Twice Rated Voltage	1.5 Times Rated Voltage	1.3 Times Rated Voltage

13.2 DC Tests

Under some conditions it may be necessary or desirable to subject the transformer to periodic insulation tests using direct voltage from kenotron sets. In such cases, the direct voltage should not exceed the factory test RMS alternating voltage; For example, if the factory test on the transformer was amde at 34 kV RMS, direct voltage should not exceed 34 kV. Periodic kenotron tests should not be made on transformers rated above 34.5 kV.

13.3 Test Duration

Referring to NEMA "Standards for Transformers" TRI-1954, Section TRI-2.064 the duration of the foregoing transformer insulation tests should not exceed the factory a-c test duration. If an alternating or direct voltage test is applied to the transformer for 5 minutes, its value should not be more than 90% of the 1 minute test voltage value.

13.4 DC Primary Cable Testing

Prolec GE Network Transformers are usually equipped with 3-pole, 3-position disconnecting and grounding or 2-position disconnecting switches. The dielectric strength of these liquid-filled switches in the open position is such as to permit DC, 5 minute cable tests with kenotron sets in the field as is indicated in Table 4 for the common switch voltage classes. When using the voltage values from Table 7 for primary cable tests, the switch must be in the open position and the terminal chamber filled with oil or cable compound.

Table 7. Permissible 5-Minute DC Dielectric Test Voltage

Switch Voltage Class	DC Cable Test Voltage
15000 and Below	45000
25000	65000
34500	80000
(Liquid-Filled Switch in Open Position)	

14. INSULATING FLUIDS

CAUTION: GE type II Insulating OIL, High Fire Point CARGILL FR3™ Insulating fluid, and SILICONE Insulating fluid are highly regulated products. Federal, State, and local regulations apply to receiving, storage, disposal, use of these insulting fluids. The purchaser is responsible for compliance with appropriate technical regulations and standards. The standards control the labeling of all containers used to deliver, store, or dispose of these insulation fluids. Properly label all containers and keep each fluid type in separate containers. Do not mix these fluids. Only use the fluid specified and labeled on the transformer nameplate for the transformer. If the wrong fluid is used in any amount or If you have questions, contact your Prolec GE sales representative or GE account manager.

14.1 GE Type II Inhibited Insulating Oil

Prolec GE approved insulating oil is used to transfer heat and provide the major part of the insulation for the transformer. The properties of the oil contribute to long life and low maintenance requirements. The materials in the transformer are compatible with the oil.

CAUTION: Only GE approved oil should be used in General Electric transformers. The use of other than General Electric Company approved oil voids standard warranties apart from obvious structural or mechanical defects that in no way can be related to the oil.

Deterioration of oil, which takes place principally through oxidation is a complicated process due to the many hydrocarbon compounds involved. Oxidation produces sludge which causes a blanketing effect on cooling surfaces, thereby increasing internal temperatures and reducing the life of the equipment. GE Type II inhibited oil is more resistant to oxidation than Type I oil, and under certain conditions favoring oxidation shows increased life. A sealed oil-preservation system, such as the Prolec GE Network Distribution Transformer, reduces greatly the opportunity for oil to oxidize. All approved insulating oil is refined to meet the Prolec GE standards and is conditioned for many years of service. General Electric Type II inhibited oil is Type I oil with an inhibitor added to extend the oxidation life.

Oil is normally shipped in the transformer tank(s) with which it is used unless otherwise specified by the transformer purchaser. This method of shipment prevents entrance of moisture and air into the windings during transit, and usually eliminates the necessity of drying the transformer apparatus upon arrival. When shipped separately, the oil is shipped in properly marked and sealed totes

In order obtain the best service from GE approved Type II oil, the care and maintenance described in this instruction should be followed.

14.1.1 Inhibited Oil, GE Type I Inhibited Insulating Oil

Inhibited oil is GE Type I oil with 0.15 percent by weight of inhibitor 2, 6 di-tertiary butyl para creosol added, which extends oxidation life of Type I oil. When the inhibitor is exhausted then the Type II reverts to Type I oil characteristics. Type II is extremely soluble in Type I oil. The inhibitor does not:

- Discolor the oil.
- Alter the initial chemical characteristics.
- Alter the initial physical characteristics.
- Deteriorated by free water.
- Easily be removed from oil by fuller's earth.
- Form pseudo sludge by itself.

When Type II oil becomes exhausted by normal oxidation, the reaction product remains soluble and innocuous.

14.1.2 Deposits, GE Type II Inhibited Insulating Oil

If a sample of oil reveals oil that is badly discolored or contains sediment. Inspect the inside of the tank or compartment for sludge deposits. Sludge causes a blanketing effect on the cooling surfaces; reducing transformer life due to over-heating. Deposits from an event are likely to obtain carbon and affect dielectric clearance. Dissolve gas analysis can be very helpful in determining why the sludge or deposits occurred in the sample. Using a Dissolved Gas kit and following the instructions take a sealed sample of the oil. Instruction are provided with the lab kits as are the shipping boxes to facilitate sending to the issue laboratory. Should there be any deposits above the base of the transformer or floor of a compartment take necessary steps to prepare and then un-tank the transformer.

Reviewing the data from the laboratory and physical inspections will likely point to the sequence of events and dictate the actions required to remedy the sludge or deposit build-up.

CAUTION: It is recommended that this contaminated insulation is disposed of as required local, state, and federal regulations.

14.1.3 Testing Services, GE Type II Inhibited Insulating Oil

Each region of country(USA) has independent oil testing services that are known certified laboratory businesses, a division or service of a laboratory equipment supplier, or a service offered by some Utility Company laboratories. Each can provide their own procedures and sampling containers.

Tests are categorized as Routine or Comprehensive.

Routine Tests	Comprehensive Tests
Dielectric Strength	Power Factor at 25ºC
Color	Pour Point
Acidity	Interfacial tension
Visual Condition	Corrosive Sulfur
Viscosity	All Routine tests
Specific Gravity	
Water Content	

Important data to share with the independent service:

- State what tests are desired.
- Give the serial number and rating of the transformer
- State whether samples are from original oil or when oil or newer.
- State temperature and weather when samples were taken.
- Any data that may clarify this transformer's condition or events that lead to sampling.
- State who will receive the report and how to contact that individual.

14.2 Cargill Insulating FR3™ Liquid High Fire Point Fluid for Interior Vaults Above & Below Ground

FR3™ is chosen to achieve an optimum balance of heat transfer and fire resistant properties. Materials that are compatible with FR3™ insulation fluid have been chosen and no substitutes should be made without the approval of Prolec GE.

CAUTION:

- *As a class, new FR3™ liquids are non-toxic. FR3™ fluid in contact with the eyes may cause local irritation but this irritation is only temporary. If desired eyes may be irrigated with water and if irritation persists, consult a physician.*
- *Only Prolec GE approved FR3™ insulating fluid should be used in Prolec GE transformers. The use of other than Prolec GE approved FR3™ insulating fluid voids standard warranties apart from obvious structural/mechanical defects, that in no way can be related to the FR3™ Fluid.*

FR3™ insulating fluid is a higher viscosity fluid and typically requires separate equipment to handle and condition per the instructions that follow. Viscosity impacts pumping, piping, filtering, and draining procedures. FR3™ will impact cooling slightly increasing fluid volumes and cooling surfaces. Lastly all operating equipment especially switch handles and tap changer will require a small addition force during movement.

CAUTION: FR3™ insulating fluid can absorb moisture much faster that other insulating fluids and can hold moisture and gas in suspension for 24 to 48 hours after the fluid has been agitated or moisture has entered the fluid. Conveying or transporting the transformer can cause this to occur even over short distances or at relatively slow speeds. FR3™ is quick to release trapped gas but does have a much higher moisture limited for normal operation and below that limit the moisture will remain suspended in the fluid and not released.

All approved FR3™ insulating fluid is required to meet the Prolec GE standards and is conditioned for many years of service.

FR3™ insulating fluid is normally shipped in the transformer tank(s) with which it is used unless otherwise specified by the transformer purchaser. This method of shipment prevents entrance of moisture and air into the windings during transit, and usually eliminates the necessity of drying the transformer apparatus upon arrival. When shipped separately, the fluid is shipped in properly marked and sealed in totes.

In order obtain the best service from Prolec GE approved FR3™ Insulating Fluid, the care and maintenance described in this instruction or available from the manufacturer should be followed.

14.2.1 Deposits, FR3™

If a sample of fluid reveals a cloudiness, discoloration, or contains sediment. Inspect the inside of the tank or compartment for sludge deposits or significant oxidation. Sludge and oxidation causes a blanketing effect on the cooling surfaces; reducing transformer life due to over-heating.

Deposits from an event are likely to obtain carbon and affect dielectric clearance. Dissolve gas analysis can be very helpful in determining why the sludge or deposits occurred in the sample. Using a Dissolved Gas kit and following the instructions take a sealed sample of the fluid. Instructions are provided with the lab kit and shipping box to facilitate sending sample to the issuing laboratory. Should there be any deposits above the base of the transformer or floor of a compartment take necessary steps to prepare and then un-tank the transformer. Reviewing the data from the laboratory and physical inspections will likely point to the sequence of events and dictate the actions required to remedy the sludge or deposit build-up.

CAUTION:

- *It is recommended that this contaminated insulation is disposed of as required local, state, and federal regulations.*
- *FR3™ will oxidize when exposed to the atmosphere for over 8 hours. Heating the fluid and filtering is required to remove the oxidation.*

14.2.2 Testing Services, FR3™

Each region of country(USA) has independent fluid testing services that are known certified laboratory businesses, a division or service of a laboratory equipment supplier, or a service offered by some Utility company laboratories. Each can provide their own procedures and sampling containers. Tests are categorized as Routine or Comprehensive.

Routine Tests, ASTM	Comprehensive Tests
Dielectric Strength, D877 or D1816	Power Factor at 25ºC
Color, D2129	Pour Point
Acidity, D974	Interfacial tension
Visual Condition, D1702	Corrosive Sulfur
Fire Point, D 92	All Routine tests
Viscosity, D445	
Specific Gravity	
Water Content, D1533B	

Important data to share with the independent service:

- State what tests are desired.
- Give the serial number and rating of the transformer
- State whether samples are from original oil or when oil or newer.
- State temperature and weather when samples were taken.
- Any data that may clarify a transformer's condition or events that lead to sampling.
- State who will receive the report and how to contact that individual.

CAUTION: A transformer impacted by moisture ingress will likely have moisture in the fluid and in the paper insulation on the cabling or in the coils. A transformer with excess moisture or suspended moisture must be dried using a portable vacuum-filter-heater-dryer and will require multiple attempts to remove the moisture. It is likely that the fluid will require disposal before and after this process until the moisture levels and the dielectric levels return to specified ranges. The transformer coils may be permanently damaged and required a replacement.

FR3™ is a moisture tolerant fluid compared to GE Type II Oil and Silicone, higher H2O ppm levels in suspension are expected in the routing fluid testing.

14.3 Silicone Insulating Liquid
High Fire Point Fluid for Interior Vaults Above & Below Ground

Silicone Liquid is chosen to achieve an optimum balance of heat transfer and fire resistant properties. Materials that are compatible with silicone insulation fluid have been chosen and no substitutes should be made with the approval of Prolec GE.

CAUTION:

- *As a class, new silicone liquids are non-toxic. Silicone fluid in contact with the eyes may cause local irritation but this irritation is only temporary. If desired eyes may be irrigated with water and if irritation persists, consult a physician.*
- *Only Prolec GE approved silicone insulating fluid should be used in Prolec GE transformers. The use of other than Prolec GE approved silicone insulating fluid voids standard warranties with the exceptions for obvious structural/ mechanical defects, that in no way can be related to the silicone fluid.*

Silicone insulating fluid is a high viscosity fluid and typically requires separate equipment to handle and condition per the instructions that follow. Viscosity impacts pumping, piping, filtering, and draining procedures. Silicone will impact cooling significantly increasing fluid volumes and cooling surfaces. Lastly all operating equipment especially switch handles and tap changer will require addition force during movement. Additional wear should be expected on any surface where moving components contact stationary components.

CAUTION:

- *Silicone Insulating Fluid can absorb moisture much faster that other insulating fluids and can hold moisture or gas in suspension for 24 to 48 hours after the fluid has been agitated or moisture has entered the fluid. Moisture will be released to adjacent insulating materials, prevent or minimize moisture exposure (normal atmosphere).*
- *Conveying or transporting the transformer can cause this to occur even over short distances or at relatively slow speeds. The dielectric strength of the fluid is temporarily compromised and any flat surfaces may trap moisture or gas until the fluid rests.*

All approved Silicone insulating fluid is required to meet Prolec GE standards and is conditioned for many years of service.

Silicone insulating fluid is normally shipped in the transformer tank(s) with which it is used unless otherwise specified by the transformer purchaser. This method of shipment prevents entrance of moisture and air into the windings during transit, and usually eliminates the necessity of drying the transformer apparatus upon arrival. When shipped separately, the fluid is shipped in properly marked and sealed in totes

In order obtain the best service from Prolec GE approved Silicone Insulating Fluid, the care and maintenance described in this instruction or available from the manufacturer should be followed.

14.3.1 Deposits, Silicone Fluid

If a sample of fluid reveals a cloudiness, discoloration, or contains sediment. Inspect the inside of the tank or compartment for sludge deposits. Sludge causes a blanketing effect on the cooling surfaces; reducing transformer life due to over-heating. Deposits from an event are likely to obtain carbon and affect dielectric clearance. Dissolved gas analysis can be very helpful in determining why the sludge or deposits occurred in the sample. Using a Dissolved Gas kit and following the instructions, take a sealed sample of the oil. Instruction are provided with the lab kits as are the shipping boxes to facilitate sending to the issue laboratory. Should there be any deposits above the base of the transformer or floor of a compartment take necessary steps to prepare and then un-tank the transformer.

Reviewing the data from the laboratory and physical inspections will likely point to the sequence of events and dictate the actions required to remedy the sludge or deposit build-up.

CAUTION: It is recommended that this contaminated insulation fluid is disposed of as required local, state, and federal regulations.

14.3.2 Testing Services, Silicone Fluid

Each region of country(USA) has independent fluid testing services that are known certified laboratory businesses, a division or service of a laboratory equipment supplier, or a service offered by some Utility company laboratories. Each can provide their own procedures and sampling containers. Tests are categorized as Routine or Comprehensive.

Routine Tests, ASTM	Comprehensive Tests
Dielectric Strength, D877 (modified)	Power Factor at 25ºC
Color, D2129	Pour Point
Acidity, D974	Interfacial tension
Visual Condition, D1702	Corrosive Sulfur
Viscosity, D445	All Routine tests
Specific Gravity	
Water Content, D1533 (modified)	

Important information to share with the independent service:

- State what tests are desired.
- Give the serial number and rating of the transformer
- State whether samples are from original oil or when oil or newer.
- State temperature and weather when samples were taken.
- Any data that may clarify a transformer's condition or events that lead to sampling.
- State who will receive the report and how to contact that individual.

CAUTION: A transformer impacted by moisture ingress will likely have moisture in the fluid and in the paper insulation on the cabling or in the coils. A transformer with excess moisture or suspended moisture must be dried using a portable vacuum-filter-heater-dryer and will require multiple attempts to remove the moisture. It is likely that the fluid will require disposal before and after this process until the moisture levels and the dielectric levels return to specified ranges. The transformer coils may be permanently damaged and require replacement.

14.4 Dielectric Strength – New Fluid, All Insulating Fluids

The use of a fluid as an insulating material requires that it have high dielectric strength. The presence of impurities in the fluid, particularly moisture, may lower the dielectric strength to such a value as to make the fluid unsafe to use. GE insulating fluid is tested by the supplier using a Prolec GE approved process, during the factory processes at filling/storage/conditioning locations, and confirmed that it meets requirements of the latest IEEE C57.12.40 standards and Prolec GE specifications for received and new unit fluid shipped.

CAUTION:

- *Whenever new fluid is used, sample then dielectric test the fluid before placing into equipment. It is emphasized that additional processing (degasification, dehydration, and filtration) is normally required for the fluid to be used in certain high-voltage apparatus such as a Network transformer. When fluid is from multiple containers sample and test each container.*
- *If the fluid meets or exceed the required minimum dielectric strength for received and new fluid, then it is suitable for use. If the fluid breakdown voltage is below the minimum requirement, then the dielectric strength must be restored to the specified minimums by additional processing (degasification, dehydration, and filtration).*

After obtaining the required minimum dielectric strength, pump the fluid into the transformer following the instructions furnished. A filter press, deaerator, and a properly sized micron cartridge for the fluid (ex: 1 or 2 microns for Type II oil) are recommended for transferring the fluid to the transformer tank(s).

A best practice is to check the fluid dielectric by taking a sample during the first week, again after 6 months, and then at the end of the first year of operation. This can be used to baseline the transformer and to establish the condition in relation to the other units operating within the Network.

CAUTION: A transformer whose data not consistent with expected operating conditions should be monitored at more frequent intervals or the transformer then removed from service to investigate the cause.

After the first year, the purchaser should consider the time between inspections and test that considers the impact of local climate conditions, the loading in various LV networks, and the importance of coordinating service interruptions in each network. Record keeping is a critical in preventing issues and for determining conditions that can increase service intervals.

14.4.1 Periodic Inspection, All Insulating Fluids

Since the insulating fluid in the apparatus is a major part of the insulation, it is important that a regular system of inspection or monitoring and testing be followed.

Periodic checking of the fluid level, the dielectric strength, the possible formation of deposits will help prevent major faults from developing in the equipment.

Maintain the fluid at the proper level, adding fluid when necessary. The 25ºC (fluid temperature) level is indicated on a magnetic liquid level gage. Check the fluid level during filling, upon receipt, prior to release into service, and during any regular inspection of the equipment. The liquid level indicator should closely match the level represented by the fluid temperature read on the transformer temperature gauge.

14.4.2 Handling and Storage, All Insulating Fluids

When insulating fluid is received in separate containers, the apparatus in which it is to be used and the equipment used in transferring it must be clean and only for use with that GE insulating fluid. Before opening fluid containers, allow them to stand 8 to 48 hours until the fluid reaches the temperature of the surrounding air and gas held in solution during transportation agitation can be released from the liquid into the container gas space.

Use clean metal hose, metal piping, or nitrile rubber hose for fluid lines. This piping and equipment should be dedicated to GE insulating fluid type being transported to eliminate any contamination.

> *CAUTION: Static charges can be developed when transformer insulating fluid flow in pipes, hoses, and tanks. Fluid leaving the processing equipment may be charged over fifty thousand volts. To accelerate dissipation of the charge in the fluid, ground the processing equipment, the piping, the tank, and all bushings or windings during fluid flow into the tank. Conduction through the fluid is slow, therefore it is desirable to maintain these grounding connections for at least 1 hour after the fluid flow has been stopped.*

It is recommended that the fluid be pumped through a filtering system. Refer to the section on filtering and degassing.
Unused fluid in a partial container should be resealed and stored in a protected area with containment features per local, state, and federal regulations.

Follow all regulations and standards that pertain to insulating fluid storage. Seal individual containers per the manufacturer's instructions. Store, label, and contain as is required based on the fluid quantity stored and the container sizes. The preferred locations for fluid storage are a temperature controlled space designed to house insulating fluid. Extra care should be taken to ensure the fluid in the containers does not get exposed until needed for filling operations to minimize exposure to moisture and air.

14.4.3 Sampling of Transformers, All Insulating Fluids

> *CAUTION: The accuracy of the test results and the repeatability of sampling process may be seriously affected if the fluid samples are not obtained and handled correctly before testing. All equipment should be for use testing only the GE insulation fluid type being sampled.*

Use glass receptacles so that if any free water is present it can be observed. Chemically cleaned, one quart, amber glass, screw cap sample bottles are recommended.

Thoroughly rinse the sample containers that have been used previously with Stoddard solvent, "trichloro-trifluoroethane", or other cleaning agent that completely dissolves the liquid residue, until the containers are entirely clean. Invert and drain the containers, and then wash with a detergent or strong soap solution. Rinse thoroughly with clean water, then rinse with distilled water and dry in an oven at 105ºC to 110ºC for at least 1 hour. After drying store the containers uncapped in a dry, dust free cabinet or compartment at a temperature of not less than 38ºC(100ºF). If not stored in a hot cabinet, cap the containers immediately after drying.

Take a sample when the fluid and sample containers are at ambient room temperature. Insulating fluid is not hydroscopic but cold fluid may condense enough moisture from a humid atmosphere to adversely affect the insulating properties.

CAUTION: Take samples from outdoor apparatus on clear dry day only and guard against contamination by wind-blown dust or other vault debris.

Before sampling from the transformer carefully clean the valve and allow enough fluid to drain that any contamination in the valve will be removed. After purging, rinse the container with some fluid from the valve and discard the residue. Take the sample from the valve. Seal the container with the screw cap to prevent leakage of fluid or exposure to the atmosphere. Good record keeping is essential. Mark the container with a unique number then record the number, the unit sampled, the date and time, the ambient conditions, and which chamber (main tank, switch chamber, terminal chamber, etc.) was sampled.

Recommended insulating fluid testing limits for fluids used in Prolec GE Liquid Filled Network Transformers. The values below meet or exceed supplier and ANSI standard guidelines.

Table 8. Insulating Fluid Testing Limits

	Location	Dielectric Strength Min (kV)	ASTM	Power Factor Max %	ASTM	Water Content H_20 Max (ppm)	ASTM
GE Type II Oil	Bulk	20	D1816, 0.04 Gap	0.3	D924@100C	25	D1553
	Line	28	D1816, 0.04 Gap	0.3	D924@100C	20	D1553
	Finished	28	D1816, 0.04 Gap	0.4	D924@100C	20	D1553
FR3™	Bulk	20	D1816, 0.04 Gap	0.2	D924@25C	200	D1553B
	Line	35	D1816, 0.04 Gap	0.5	D924@25C	300	D1553B
	Finished	35[3]	D1816, 0.04 Gap	0.5	D924@25C	300	D1553B
	Finished**	35[1]	D1816, 0.04 Gap	0.5	D924@25C	100[2]	D1553B
Silicone	Bulk	35	D877	0.1	D924@25C	50	D1553B Modified
	Line	30	D877	0.1	D924@25C	50	D1553B Modified
	Finished	30	D877	0.1	D924@25C	25	D1553B Modified

14.4.4 Insulating Compounds

Various cable product companies offer a variety of dielectric compounds that can be poured at elevated temperatures into junction boxes and high voltage terminal chambers. Prolec GE supports the insulating fluids approved and described in this section. Compounds are purchased by the Network transformer purchaser for their specified needs and are controlled by their procedures. All materials in the liquid filled Network transformer are rated for 140ºC insulating fluid continuous temperatures. This is consistent with the Prolec GE approved insulating fluid maximum operating temperatures.

Caution: Follow instructions, safety practices, and installation procedure recommendations of the compound manufacturer. Material compatibility and environmental disposal are the responsibility of the transformer purchaser and his compound supplier. Inappropriate compounds will violate the transformer warranty, create adverse impacts on materials, and potentially damage terminal chamber or junction box integrity. When compounds are specified the transformer terminal chamber or junction box will be shipped dry to the purchaser.