



Operation & Maintenance Manual

SUB-OM200

Single Phase & Three Phase Submersible Liquid Filled Transformer

KVA: Up to 2,500 KVA
Primary Voltage: Up to 34.5 GrdY/19920
BIL: Up to 150 KV



Contents

1. Safety Information:	4
2. General Information:	5
2.1 Acceptance & Inspection upon Receipt	5
2.2 Proper Handling & Unloading	5
2.2.1 Moving Transformers Shipped on Pallets	5
2.2.2 Lifting Transformers by Crane or Hoist	6
2.2.3 Skidding/Rolling Transformers	6
2.2.4 Using Jacks to Move Transformers	6
3. Storage:	6
3.1 Storage for 90 Days or Less	6
3.2 Storage for More Than 90 Days	7
4. Installation:	7
4.1 Pre-service Inspection	7
4.2 Mounting the Transformer	7
4.3 External Connection	8
4.3.1 Ground Connection	8
4.3.2 High Voltage Connection	9
4.3.3 Low Voltage Connection	9
5. Accessories:	9
5.1 Pressure Relief Valve	9
5.2 Fill Plug/Filler Valve (Fluid) with Schrader Valve (Nitrogen)	10
5.3 Drain Valve & Fluid Sampler	10
5.4 Liquid Level Gauge	11
5.5 Temperature Gauge	12
5.6 Pressure Vacuum Gauge	13
6. Switching & Protection Devices:	14
6.1 Tap Changers	14
6.2 Load Break Oil-Immersed Rotary Switches (LBOR)	15
6.2.1 Two-Position LBOR Switch	15
6.2.2 Four-Position LBOR Switch “Sectionalizing Switch”	16
6.3 Dead Front Surge Arresters	17
6.4 Fusing	18
6.4.1 Bay-O-Net Fuses	18

6.4.2	Dry-Well Canister Fuses	20
7.	Dielectric Fluid:	21
7.1	Type II Mineral Oil	21
7.2	High Fire Point Dielectric Fluid	21
8.	Factory Testing:.....	22
8.1	Routine Tests.....	22
8.1.1	Ratio	22
8.1.2	Winding Resistance	22
8.1.3	No Load & Excitation Current	22
8.1.4	Load Losses & Impedance Voltage	22
8.1.5	Dielectric Strength	23
8.2	Special/Design Tests.....	23
8.2.1	Insulation Power Factor (Tan δ).....	23
8.2.2	Insulation Resistance	23
8.2.3	Temperature Rise.....	23
8.2.4	Lightning Impulse.....	23
8.2.5	Audible Sound Level.....	24
9.	Maintenance:.....	24
9.1	Spare Parts	24
9.2	Routine Inspection	24
9.3	Dielectric Fluid Sampling.....	25

1. Safety Information:

The instructions in this manual are not intended as a substitute for proper training or adequate experience in the safe operation of the equipment described. Only competent technicians who are familiar with this equipment should install, operate, and service it. These instructions cannot cover all details or variations in the equipment, procedures, or process described, nor to provide directions for meeting every possible contingency during installation, operation, or maintenance.

The following conventions are used to indicate and classify precautions and on product safety labeling. Failure to observe precautions could result in injury to people or damage to property.

HAZARD Statement definition:



This symbol/pictorial is used to identify an **ELECTRICAL SHOCK** or **ELECTROCUTION** hazard, all installation, maintenance, or repair should be performed by trained, experienced, and qualified personnel only.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

Safety Instructions



WARNING: A potential risk exists if operating instructions are not followed which could result in severe personal injury or death, and equipment damage.



WARNING: The contents of this manual should be carefully read and understood before attempting any test, repair, installation, removal, or operation of this equipment. Severe personal injury and equipment damage can occur from the result of improper handling, maintenance, or operation of this equipment.



WARNING: Transformers should never be opened, serviced, or otherwise tampered with while they are energized, ungrounded or connected to the system. Removing or tampering with any covers, doors, bushings, or seals of an energized transformer may result in death, severe personal injury, and equipment damage.



WARNING: This equipment is not intended to protect human life. Follow all locally approved procedures and safety practices when installing or operating this equipment. Failure to comply with these warnings may result in death, severe personal injury, and equipment damage.



WARNING: This equipment requires routine inspection and maintenance. Failure to properly inspect and maintain this equipment could result in unsafe conditions in and around this unit, which could lead to death, severe personal injury, and equipment damage.

2. General Information:

2.1 Acceptance & Inspection upon Receipt

All VanTran transformers are thoroughly tested and rigorously inspected before shipment from the factory to ensure the highest quality.

Upon receipt:

1. Thoroughly check all materials against the bill of lading.
2. Locate accessory parts that may have been shipped separately.
3. Carefully check the unit and associated components for any signs of damage caused during shipment. A damaged crate or pallet can be an indication of rough handling; if this condition is found, make a close inspection of the base and radiators (if equipped) and verify no damage has occurred.
4. In the event that significant damage to the unit or any associated equipment is noticed, rejection of the shipment should be made before it is unloaded. In the event of minor damages (nicks, scratches, etc.), carefully inspect the unit and note all damage on the carriers copy of the freight receipt.

Note: VanTran ships most units FOB Point of Manufacture, and it is the customer's responsibility to file a claim against the carrier.

Note: If acceptance of the transformer is made and damage to the unit is noticed at a later time, it is extremely difficult to file a claim against the carrier.

2.2 Proper Handling & Unloading



WARNING: Heavy Equipment. Improper handling can cause severe injury, death, or damage to transformer. Before moving the transformer, read the handling instructions provided in this manual.



CAUTION: The transformer weight is shown on the transformer nameplate. Most of the weight is in the tank that holds the core and coil assembly and the insulating liquid. Do not use hoists, cranes, jacks, or forklifts with load capacity less than the transformer weight.



WARNING: Transformer accessories such as bushings, leads, arrestors, etc. should never be used as a handle to move the transformer.

2.2.1 Moving Transformers Shipped on Pallets

Transformers shipped on pallets may be lifted or moved by forklift trucks of proper capacity. When using a forklift, lift with the transformer tank closest to the mast of the forklift since most of the transformer weight is in the tank. Pallet mounted equipment may also be moved by crane or hoist.

2.2.2 Lifting Transformers by Crane or Hoist

Lifting lugs, welded to all transformer tanks, are designed and provided for lifting the complete unit as shipped. VanTran recommends lifting by these lugs as the primary means of movement. Care should be taken to ensure straps, chains, and cables used to lift the units are inspected prior to use. All straps, chains, cables, and lifting devices should be in good working order with sufficient capacity to perform the job intended. Straps, chains, and cables should never be looped from one lug to another to form a continuous loop around the unit or even on one side of the unit. Each chain, strap, or cable should be run only to one lifting lug at a time to prevent loss of control of the unit in the event of a failure with one of the lifting devices.

Cable pull angles should never exceed 30° from vertical or damage to the lifting lugs may occur. Spreader beams/bars should be used to hold the cables apart and as close to vertical as possible to minimize the forces on the lifting lugs and lifting devices.

2.2.3 Skidding/Rolling Transformers

VanTran transformers are designed to be rolled or skidded into place where accessibility to a crane or other overhead lifting device is limited or not available. If the unit must be rolled, ensure that the area is level, free from obstructions and debris, and is of sufficient strength and thickness to support the load. When rollers are used, use as many as necessary to distribute the weight uniformly.

2.2.4 Using Jacks to Move Transformers

Place jacks under the tank base on the open ends of the transformer tank. DO NOT place jacks under radiators, valves, cabinets, or sheet metal components. ALWAYS use at least two jacks per side and raise evenly to prevent warping of the base.

3. Storage:

3.1 Storage for 90 Days or Less

All VanTran units have been thoroughly dried at the factory and shipped with oil at the correct level. Transformers should always be stored with oil in place to prevent possible contamination and absorption of moisture.

Transformers should be stored in a dry location with no rapid or radical temperature changes. If possible, the transformer should be stored in its permanent location on the foundation which has been prepared for it. If the permanent foundation is not available, it should be stored in its correct upright position on a level foundation capable of withstanding the weight of the unit without deformation.



CAUTION: Never store a transformer solely under the jacking steps, on jacks, or on temporary blocking. Never store the transformer on rollers. Never store the transformer in or near standing water or in areas with high moisture, salt levels, or corrosive gases in the air.

3.2 Storage for More Than 90 Days

All VanTran transformers are shipped with a 2-psi dry nitrogen blanket. During long term storage, it is recommended that this nitrogen blanket be maintained by the addition of a bottle of dry nitrogen, through a regulator, to the transformer tank.

4. Installation:

4.1 Pre-service Inspection



ELECTRICAL SHOCK: Never attempt to change connections on an energized transformer. All installation, maintenance, or repair should be performed by trained, experienced, and qualified personnel only.

New transformers, or transformers which are being activated after a period of storage, should be thoroughly inspected before being connected to the power distribution system to identify damage which may have occurred during storage.

1. The transformer exterior should be inspected for nicks, dents, and scratches. Repair damage to weather-resistant finishes promptly.
2. The tank cover and manhole/hand hole cover seals and all gaskets or seals at bushings, gauges, fuses, operating devices, etc., should be inspected for evidence of insulating liquid seepage. Repair leaking or improperly tightened gaskets and seals before the transformer is placed in service.
3. The liquid level inside the tank must be checked (read directly from gauge on transformers equipped with liquid level gauge).
4. Basic electrical tests should be conducted before energizing a transformer which was stored for a period of 90 days or more. Tests include DC insulation Test and Transformer Turns Ratio (TTR). The results of these tests should be verified with the original factory test results to assure they are still within acceptable limits.



CAUTION: Check with local authorities in the intended installation area to verify compliance of any and all applicable laws.

4.2 Mounting the Transformer

The transformer must be placed on a concrete pad or steel deck of sufficient strength to support the full weight of the unit. The location must be flat and level and prepared to prevent the transformer from tilting beyond two degrees from horizontal.



WARNING: Fire Hazard. Non-level installation of transformer can result in fire and cause severe personal injury or death. Prepare transformer installation site such that transformer does not tilt more than two (2.0) degrees from horizontal while the transformer is in service at the site.

4.3 External Connection



ELECTRICAL SHOCK: Hazardous voltage can cause severe injury, death, or damage to equipment. Ground transformer following industry-accepted safe grounding practices before making other electrical connections. De-energize power distribution wires that will be connected to transformer. Verify that wires are de-energized at the transformer before connecting to transformer.



ELECTRICAL SHOCK: Live front parts such as cables, bushings and other components must be thoroughly tightened and periodically checked to prevent arcing and overheating.

Clean bushings and terminals before making Connections. Remove dirt, grease, or foreign material. Contamination can cause failure of the bushings. Cables connected to the transformer terminals are to have sufficient flex to allow normal pad movement due to ground freeze/thaw and settling. Insufficient cable flex may cause premature failure of the bushings.

4.3.1 Ground Connection

The transformer tank must be connected to a permanent, low-resistance ground. If the tank is not solidly grounded and the transformer is connected to the power distribution system, then the tank should be regarded as energized. An energized tank is extremely dangerous. Contact with an energized tank can shock, burn, or cause death.

VanTran transformers are equipped with at least two unpainted, copper-faced-steel or stainless-steel ground pads (Fig. 1A) or two ground bosses (Fig. 1B) one is located on the front of the tank, and the other is located on the back.

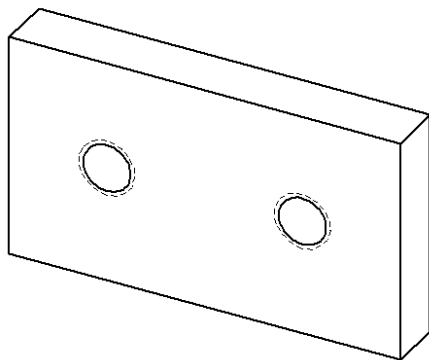


Fig. 1A

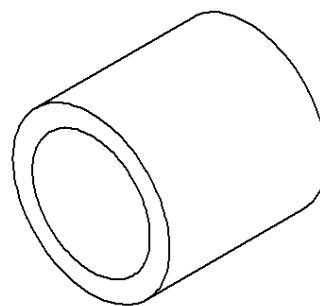


Fig. 1B

4.3.2 High Voltage Connection

Diagrams and information supplied on the nameplate must be followed for making connection.

Dead-front bushings are typically provided for high voltage connection to Submersible transformers, equipped with well and inserts or single piece bushing.

4.3.3 Low Voltage Connection

Spade terminals ranging from two holes to twenty holes are typically provided for low voltage connection to Submersible transformers.

5. Accessories:

5.1 Pressure Relief Valve

Automatic Pressure relief valve (Fig. 2) is standard on all VanTran transformers and is intended to slowly release pressure to prevent rupture of the transformer tank. These valves are factory adjusted to vent at 5 ± 2 PSI. Normal operation and atmospheric temperature fluctuations cause the oil and components in the tank to naturally expand and contract causing the gas filled head space inside the tank to fluctuate in pressure.



CAUTION: Before performing any kind of service that may include, but is not limited to, opening the tank or inspection cover, removal of fuses, removal of bushings, opening drain or fill valves, or any other similar operation, the pressure inside the tank must be safely vented manually.



CAUTION: Do not open the transformer in the presence of rain, fog, snow, or if there is condensation on the exterior components of the unit or when the outside air temperature is higher than the temperature of the unit. Even small amounts of moisture that are allowed to enter the transformer tank can decrease the dielectric strength of the insulating fluid and compromise the integrity of the unit.

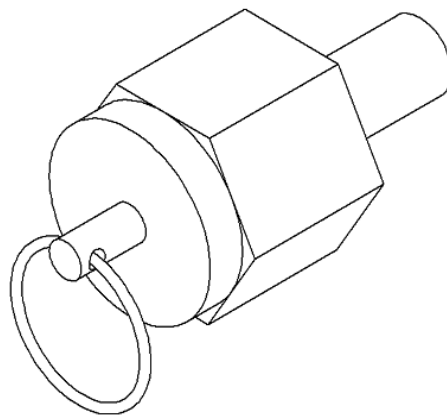


Fig.

To manually vent the tank, pull the ring supplied on the valve (Fig. 2) until all pressure or vacuum is relieved.

5.2 Fill Plug/Filler Valve (Fluid) with Schrader Valve (Nitrogen)

Fill Plug with Schrader Valve (Fig. 3A) or Filler Valve with Schrader Valve (Fig. 3B) is provided to facilitate addition of dielectric fluid and Nitrogen to the tank.

Note: The transformer departs factory with 2-3 PSI of positive nitrogen pressure (blanket) at ambient temperature above the dielectric fluid column.

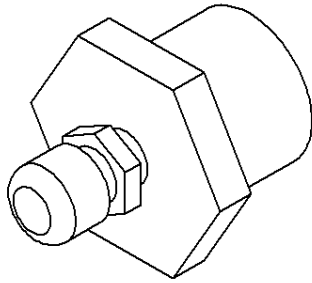


Fig. 3A

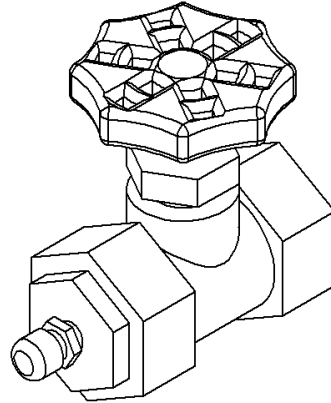


Fig. 3B

5.3 Drain Valve & Fluid Sampler

The Drain Valve and Fluid Sampler (Fig. 4) is provided to facilitate sampling of the dielectric fluid for testing and other purposes. The valve is also equipped with a plug ranging from $\frac{1}{2}$ " to 2" to provide means of draining the dielectric fluid. Three phase Submersible transformers come equipped with a drain valve and fluid sampler, while it remains optional for single phase Submersible transformers.

Sampling is usually performed on the side of the valve without the need to remove the end plug.

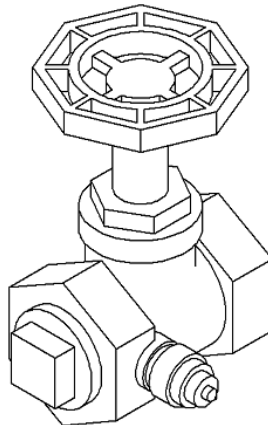


Fig.

5.4 Liquid Level Gauge

A liquid level gauge (Fig. 5) is supplied to indicate the amount of dielectric fluid in the transformer tank. The gauge consists of a float arm inside the tank magnetically coupled to the indicator needle inside the gauge. The magnetic coupling maintains a liquid tight separation between the interior oil and the outside to minimize potential leaks. Three phase Submersible transformers come equipped with a liquid level gauge, while it remains optional for single phase Submersible transformers.

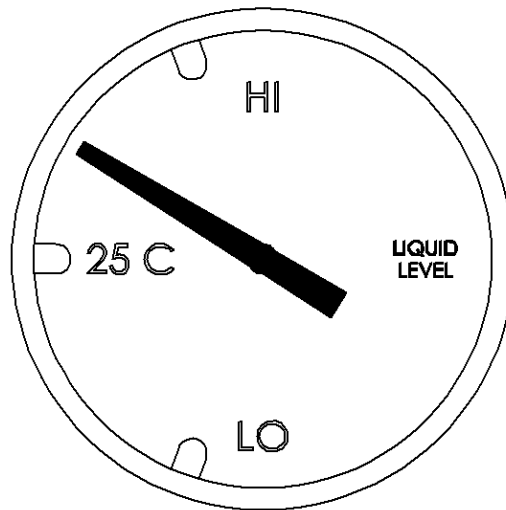


Fig.

VanTran utilizes several different brands and models of liquid level gauges depending on the application. Transformers can be supplied with a standard gauge or more sophisticated models with either one or two SPDT (Single Pole Double Throw) alarm contacts to facilitate external monitoring.

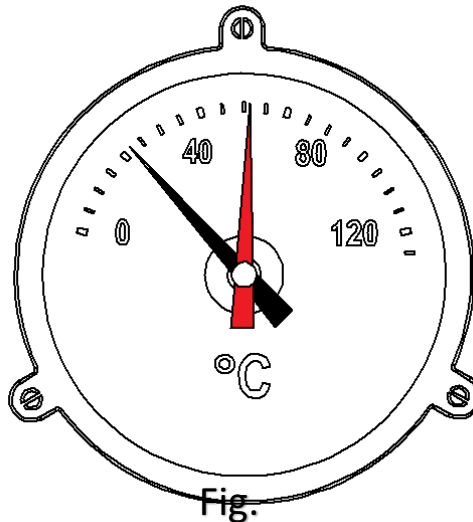
Liquid Levels may vary under normal operation according to temperature and pressure. The 25° C mark is only a reference fluid level at 25° C.

Note: For wiring and other information, please refer to the schematics included in the submittal drawings.

5.5 Temperature Gauge

The temperature gauge (Fig. 6) is supplied to indicate the dielectric fluid temperature in degrees centigrade at the top of the oil column. The gauge consists of two needles (one white and one red). The white needle is the current oil temperature of the unit, while the red needle is a resettable maximum indicator. As the temperature of the oil rises, the white needle pushes the red needle higher with it. If the temperature of the oil declines the white needle follows and goes down with temperature while the red needle remains at the highest temperature reached and acts as a recorder to indicate the highest temperature achieved by the unit. The red needle (maximum indicator) can be reset by turning the knob on the front of the gauge face.

The temperature gauge consists of a long thermocouple that extends into the tank inside a protective thermocouple well. The isolation between the thermocouple and the dielectric fluid facilitates the removal and replacement of the gauge without draining down the dielectric fluid.



The temperature gauge can be equipped with either one or two SPDT alarm contacts for remote monitoring or fan control. These alarm contacts are factory set but can be adjusted if desired.

To adjust the contacts, remove the face of the gauge. Look toward the center of the gauge for a small Allen head set screw. Loosen this set screw and manually move the contacts (red indicators toward the outer edge of the dial) to the desired temperature settings. Gently retighten the set screw and replace gauge face.

Three phase Submersible transformers come equipped with a temperature gauge, while it remains optional for single phase Submersible transformers.

Note: For wiring and other information, please refer to the schematics included in the submittal drawings.

5.6 Pressure Vacuum Gauge

The pressure vacuum gauge (Fig. 7) indicates whether the head space pressure inside the tank is positive, negative, or neutral. The pressure inside the tank will vary depending on the load of the unit, temperature of the oil and ambient temperature outside. As the oil temperature rises, the pressure inside the tank also rises. As the temperature falls, the pressure falls. It is common for a transformer to have either a positive pressure or a negative pressure.

Do not be alarmed by a consistent negative pressure (for example, if it is winter in Wisconsin, it will likely be negative for the duration of the season). However, if the gauge consistently reads zero and does not appear to be changing with environmental or load conditions, this may be an indication of a leak and may need attention. Visually inspect the unit for any signs of a leak or damaged seal.

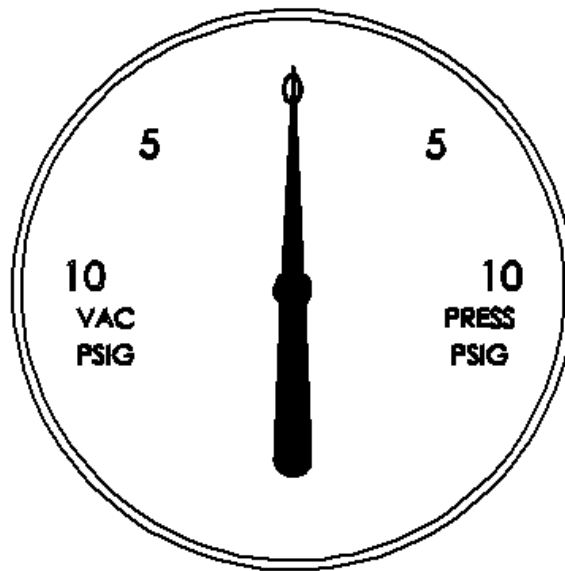


Fig.

The pressure/vacuum gauge can also be equipped with SPDT alarm contacts (by adding a separate pressure alarm switch) for remote monitoring of positive and negative pressures. When requested, the pressure/vacuum gauge can also be equipped with a bleeder or regulator; when used in conjunction with an external nitrogen supply, positive pressure can be maintained inside the tank (2.5 to 3.0 PSI) The regulator is also equipped with a fitting and valve to take gas samples.

Three phase Submersible transformers come equipped with a pressure vacuum gauge, while it remains optional for single phase Submersible transformers.

6. Switching & Protection Devices:



ELECTRICAL SHOCK: Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before operating no-load tap-changers, dual-voltage switches, or Delta-wye switches.

6.1 Tap Changers

Externally operated No-Load Tap changer (NLTC) (Fig. 8A & 8B) is provided for all transformers, unless otherwise specified, to change from one operating voltage to another. Typical taps are configured at $\pm 2 \times 2.5\%$ of rated voltage; this means that the output voltage of the transformer can be adjusted in 2.5% increments.

Tap-changers will have a hot stick operable handle.

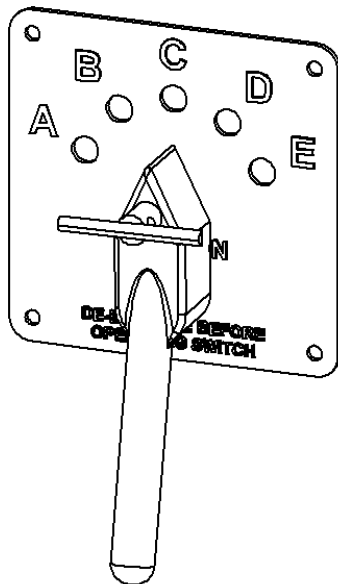


Fig. 8A

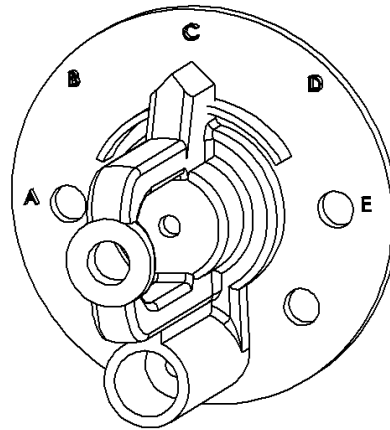


Fig. 8B

Note: Please refer to Name Plate and other supplied information for more details.

6.2 Load Break Oil-Immersed Rotary Switches (LBOR)



WARNING: Do not operate load break equipment if a fault condition is suspected. Doing so can cause an explosion or fire.



WARNING: Use a hotstick to operate transformer load break equipment.



WARNING: After operating transformer load break equipment, check that voltages at transformer terminals are the expected values. Checking voltages verifies that load break equipment operated properly and that electrical circuit conditions are as expected.



WARNING: Before servicing transformer secondary connected equipment, verify that all transformer secondary terminals have zero voltage and ground the transformer secondary terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.

6.2.1 Two-Position LBOR Switch

The Two-Position LBOR Switches (Fig. 9A) are provided optionally in Submersible transformers to achieve load breaking or making and loop feed switching. LBOR's will have a hotstick operable handle.

Multiple Two-Position LBOR Switches may be utilized to achieve loop-feed switching. (Fig. 9B)

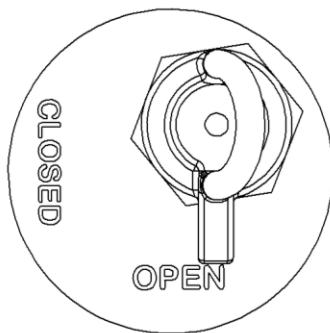
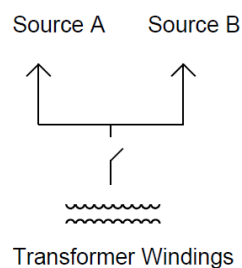
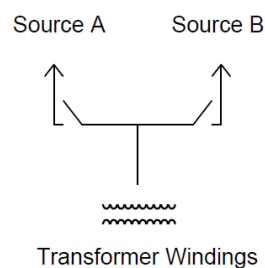


Fig. 9A

1 On/Off Switch



2 On/Off Switches



3 On/Off Switches

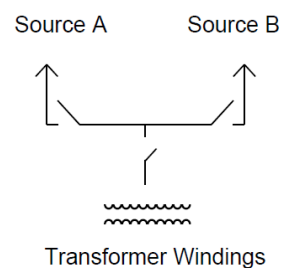


Fig. 9B

The spring-loaded activating mechanism of the switch ensures quick load break or load make operations in less than one cycle and should be performed with a hotstick.

Note: Please refer to Name Plate and other supplied information for more details.

6.2.2 Four-Position LBOR Switch “Sectionalizing Switch”

The Four-Position LBOR Sectionalizing Switch (Fig. 10A & 10B) is provided optionally in loop-feed Submersible transformers to select the feed source, open/close the feed-through loop, and open/close the transformer.

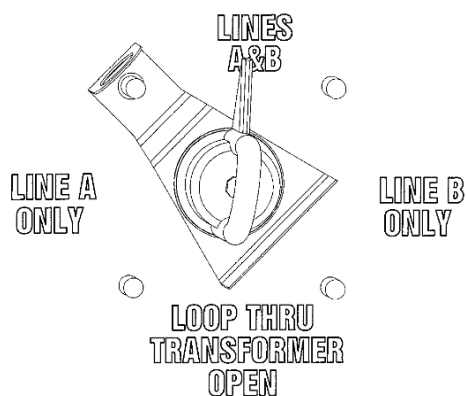


Fig. 10A

T-Blade 4-Position LBOR Switch

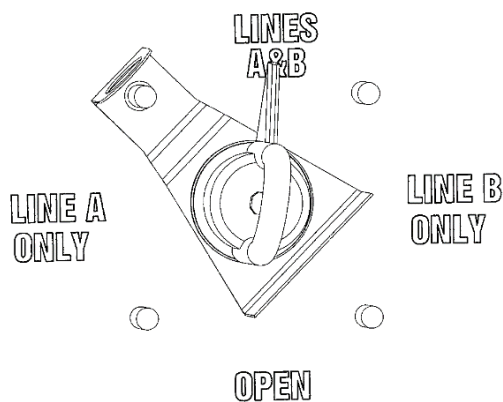


Fig. 10B

V-Blade 4-Position LBOR Switch

The spring-loaded activating mechanism ensures quick load break action and positive contact engagement through all positions. Switching can be accomplished in less than one cycle and should be performed with a hotstick.

Note: For switch ratings and additional switch configurations refer to submittal drawings provided with the transformer.

6.3 Dead Front Surge Arresters



ELECTRIC SHOCK: Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before servicing or operating surge arresters or disconnect switches. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.



CAUTION: Excessive test voltage can damage surge arresters. Disconnect surge arresters before running impulse or applied potential tests on the transformer.

Surge Arresters (Fig. 11) are provided optionally in Submersible transformers to protect equipment and cables from overvoltage surges.

During steady state conditions, line-to-ground voltage is applied continuously across the arrester terminals. When surges occur, the arrester immediately limits the overvoltage to the required protective level by conducting the surge current to ground. Upon passage of the surge, the arrester returns to its initial state, conducting minimal leakage current.

A dead front surge arrester (Fig. 11), also called an elbow arrester, is a pre-molded rubber elbow that houses zinc oxide Varistor technology to provide over-voltage system protection to dead front Submersible transformers.

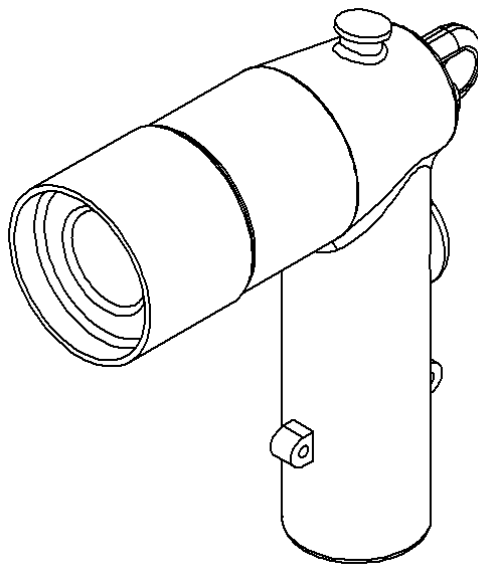


Fig. 11

6.4 Fusing



ELECTRIC SHOCK: Can cause severe injury, death, or damage to equipment. Use a hotstick to service a Bay-O-Net fuse. Do not install a fuse to complete an electrical circuit if a fault condition is suspected. Do not re-energize suspected failed equipment. After installing fuses, energize transformer from a remote upstream source.



WARNING: Never attempt to remove fuses with pressure on the tank. Severe burns and personal injury may result from hot dielectric fluid.

6.4.1 Bay-O-Net Fuses

The Bay-O-Net fuse (Fig. 12A) is used in series with an isolation link, or current-limiting fuse “ELSP Back-up Fuse”, to achieve over-current protection and high current interrupting current rating. The Bay-O-Net fuses are field replaceable and do not require opening the transformer tank.

Bay-O-Net fuses are only available for single phase Submersible transformers.

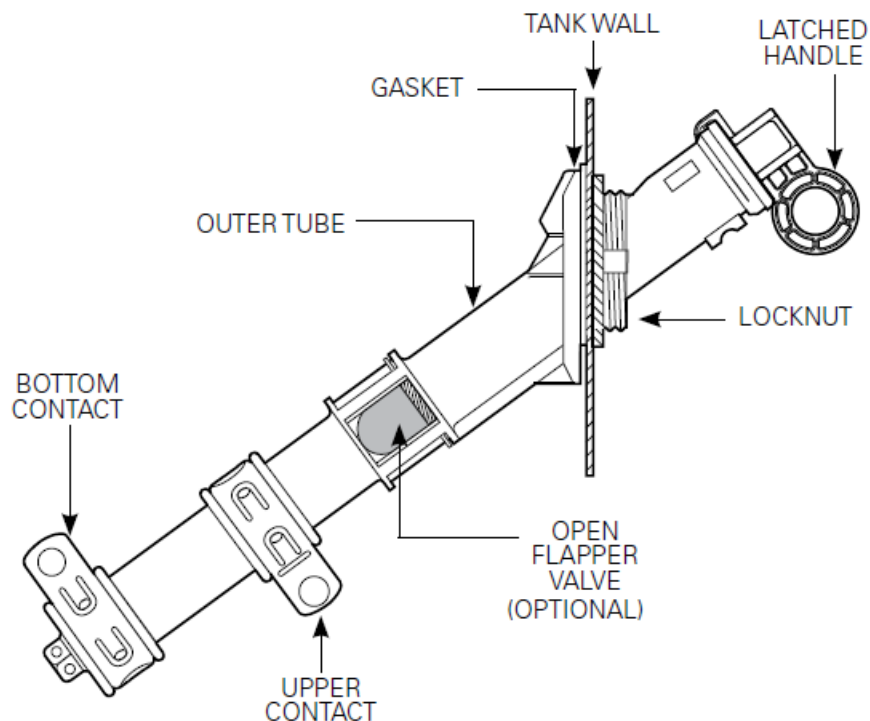


Fig. 12A

Bay-O-Net Fuse Replacement Instructions (Fig. 12B)

1. Relieve pressure in the transformer tank by pulling out the pressure relief valve for 30 seconds, or until the hissing sound of the valve stops.
2. Repeat step #1 to ensure any residual pressure is released.
3. Attach a hotstick to the fuse holder eye and twist to unlock.
4. Turn fuse holder 90° to break seal gasket and Bay-O-Net housing.
5. Quickly draw fuse holder out 8-10 inches to interrupt load.
6. Wait several seconds for fluid to drain from the fuse holder and remove from housing.
7. Remove fuse cartridge from fuse cartridge holder using a $\frac{3}{4}$ inch wrench.
8. Remove end plug using a $\frac{3}{4}$ inch and a $\frac{1}{2}$ inch wrench.
9. Replace the fuse.

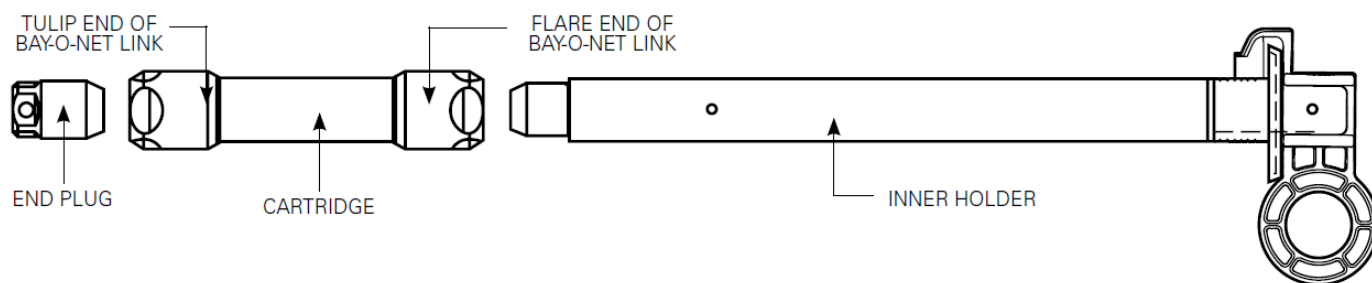


Fig. 12B

6.4.2 Dry-Well Canister Fuses

The dry-well housing (Fig. 13A & 13B) consists of filament-wound glass tubing with a resin-rich outer surface. This outer surface serves as the barrier against oil permeation through the tubing wall. The current limiting fuse that these fuse-holders are designed to accept will not function properly if exposed to transformer oil, which is why the interior of the fuse holder must remain oil tight.

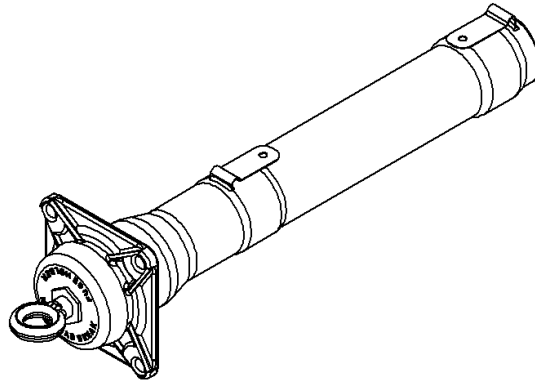


Fig. 13A

Non-Loadbreak Dry-Well Canister Fuse Replacement Instructions (Fig. 13B)

1. De-energize transformer from a remote upstream source.
2. Disassemble by loosening the four sets of screws.
3. Attach a hotstick to the fuse holder eye and pull out.
4. Draw fuse holder out.
5. Replace the fuse and reinsert the new fuse in the fuse holder.
6. Assemble by tightening the four sets of screws.

Loadbreak Dry-Well Canister Fuse Replacement Instructions (Fig. 13B)

1. Disassemble by loosening the four sets of screws.
2. Attach a hotstick to the fuse holder eye.
3. Quickly draw fuse holder out to interrupt load “Load Break”.
4. Replace the fuse and quickly reinsert the new fuse in the fuse holder “Load Make”.
5. Assemble by tightening the four sets of screws.

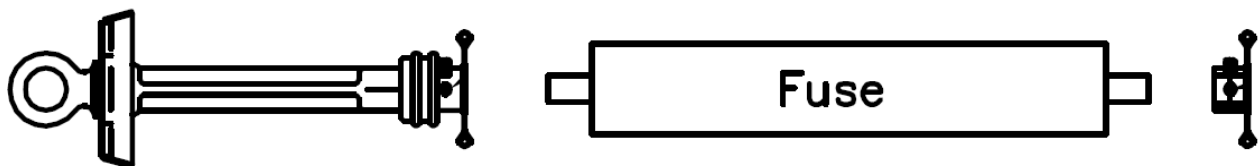


Fig. 13B

7. Dielectric Fluid:

7.1 Type II Mineral Oil

Submersible transformers filled with mineral oil that complies with ASTM D-3487, TYPE II.

Typical Physical and Chemical Properties

pH: N/A	Closed cup flash point: >145°C
Auto ignition temperature: > 315°C	Boiling point: >238°C
Relative density (H ₂ O = 1): 0.89	Vapor pressure (mm Hg): < 0.01 @ 20°C
Pour point: -54°C	Vapor density (air = 1): N/A
Evaporation rate (butyl acetate = 1): N/A	Solubility in water: negligible; < 0.1%
Volatile organic compounds: < 0.001 g/L	Viscosity: 9.3 TO 9.5 CsT at 40°C
Miscibility: mixes with other dielectric fluids except silicone	
Appearance and odor: Clear bright liquid with Mineral odor	

7.2 High Fire Point Dielectric Fluid

Submersible transformers filled with High Fire Point Dielectric fluid typically use Envirotemp FR3 fluid which complies with ASTM D-6871.

FR-3 is a natural ester derived from renewable vegetable oils – providing improved fire safety and environmental benefits that are superior to mineral oil.

Typical Physical and Chemical Properties

pH: neutral	Closed cup flash point: 320 – 330°C
Auto ignition temperature: 401 – 404°C	Boiling point: >360°C
Relative density (H ₂ O = 1): 0.92	Vapor pressure (mm Hg): < 0.01 @ 20°C
Pour point: -18 to -24°C	Vapor density (air = 1): N/A
Evaporation rate (butyl acetate = 1): nil	Solubility in water: negligible; < 0.1%
Volatile organic compounds: < 0.001 g/L	Viscosity: 32 – 34 CsT at 40°C
Miscibility: mixes with other dielectric fluids except silicone	
Appearance and odor: clear light-green liquid with slight vegetable oil odor	

8. Factory Testing:



CAUTION: The information below is not intended to be as a guideline for testing transformers. Please refer to IEE/ANSI C57.12.90-2006 and ANSI/NETA ATS-2009 for more details.

8.1 Routine Tests

8.1.1 Ratio

The turn ratio of a transformer is the ratio of the number of turns in the high voltage winding to that in the low voltage winding. When the transformer has taps, the turn ratio shall be determined for all taps and for the full winding.

Note: The ratio test can also be used to test polarity, phase relation, and phase sequence.

8.1.2 Winding Resistance

Resistance measurements are of fundamental importance for the calculation of the I^2R component of conductor losses and calculation of winding temperatures at the end of a temperature rise test.

8.1.3 No Load & Excitation Current

No-load (Excitation) losses are losses that are incident to the excitation of the transformer. No-load losses include core loss, dielectric loss, conductor loss in the winding due to excitation current, and conductor loss due to circulating current in parallel windings. These losses change with the excitation voltage.

Excitation current (no-load current) is the current that flows in any winding used to excite the transformer when all other windings are open-circuited. It is generally expressed in percent of the rated current of the winding in which it is measured. The no-load losses consist primarily of the core loss in the transformer core, which is a function of the magnitude, frequency, and waveform of the impressed voltage. No-load losses also vary with temperature and are particularly sensitive to differences in waveform; therefore, no-load loss measurements will vary markedly with the waveform of the test voltage.

8.1.4 Load Losses & Impedance Voltage

The load losses of a transformer are losses incident to a specified load carried by the transformer. Load losses include I^2R loss in the windings due to load current and stray losses due to eddy currents induced by leakage flux in the windings, core clamps, magnetic shields, tank walls, and other conducting parts.

The impedance voltage of a transformer is the voltage required to circulate rated current through one of two specified windings when the other winding is short-circuited, with the windings connected as for rated voltage operation. Impedance voltage is usually expressed in per unit or in percent of the rated voltage of the winding across which the voltage is applied and measured.

8.1.5 Dielectric Strength

The dielectric test of the transformer is intended to check the ability of main insulation to earth, inter turn and line end insulation to earth. It is generally performed in two different steps, likewise, separate applied voltage withstands test (Hi-Pot) and induced voltage withstand test.

8.2 Special/Design Tests

8.2.1 Insulation Power Factor (Tan δ)

The insulation power factor is the ratio of the power dissipated in the insulation in watts to the product of The effective voltage and current in volt-amperes when tested under a sinusoidal voltage and prescribed conditions.

8.2.2 Insulation Resistance

Insulation resistance tests are made to determine the insulation resistance from individual windings to ground or between individual windings. Insulation resistance tests are commonly measured in mega ohms or may be calculated from measurements of applied voltage and leakage current.

8.2.3 Temperature Rise

A temperature-rise test is defined as a test to determine the temperature rise above ambient of one or more of the transformer's windings, as measured at the terminals. The result for a given terminal pair or winding is the average value of the temperature of the entire circuit; it is not the temperature at any given point in a specific winding.

The term average temperature rise refers to the value determined by measurements on a given terminal pair of the winding. It does not refer to the arithmetic average of results determined from different terminal pairs of the transformer.

8.2.4 Lightning Impulse

Lightning impulse tests shall consist of and be applied in the following order: one reduced full wave, two chopped waves, and one full wave. The time interval between applications of the last chopped wave and the final full wave should be minimized without intentional delays, to avoid recovery of dielectric strength if a failure were to occur prior to the final full wave.

Impulse tests shall be made without excitation.

Note: Please refer to IEEE Standard C57.98-2011.

8.2.5 Audible Sound Level

Audible sound from transformers originates principally in the transformer core and transmits through the dielectric fluid and/or structural supports, to the outer shell and/or other solid surface, where it radiates as airborne sound.

In some situations, the windings may be a noise source under rated load conditions, but this noise is not included in this standard. The frequency spectra of the audible sound consist primarily of the even harmonics of the power frequency; thus, for a 60 Hz power system, the audible sound spectra consist of tones at 120 Hz, 240 Hz, 360 Hz, 480 Hz, etc.

The audible sound also contains the noise emitted by any dielectric fluid mechanical cooling system. Mechanical cooler sound consists of broadband fan noise, plus discrete tones at the fan blade passage frequency and its harmonics.

9. Maintenance:

9.1 Spare Parts

VanTran specializes in manufacturing custom transformers and makes only limited quantities of any one design. Replacement parts are best handled on a case-by-case basis. Should additional or replacement parts be necessary for any VanTran transformer, please contact the factory and provide all available nameplate data.

9.2 Routine Inspection

Routine inspection of the exterior of the unit should be performed periodically. The inspection interval should take the environmental conditions of the site into consideration. Salty, damp, or otherwise corrosive environments will require shorter inspection intervals than dry/mild conditions.

Periodically check between the radiators (if equipped) for debris and obstructions. Ensure that the unit is getting adequate airflow and that brush, overgrowth, or surrounding equipment is not impeding proper airflow. If the unit is equipped with forced air cooling, manually cycle the fans using the switch in the control panel to ensure proper operation.

Clean any dirt or buildup away from the base and cabinet areas to prevent premature rust and deterioration.

During an external inspection, check the paint for signs of deterioration, including cracked/chipping paint and rust. If paint damage or deterioration has occurred, touch-up or repaint the exterior of the unit as soon as possible to prevent further degradation. VanTran uses several different painting processes depending on the application. An inquiry to the factory, with the serial number of the unit, will determine the type and compatibility of the touch-up paint required.

Gauges should be checked regularly for proper operation. The temperature gauge should fluctuate with load conditions and ambient temperature. However, the gauge should never read over the design value on the nameplate plus the average daily ambient temperature. For example, if it is a 25°C day and it has a 65°C rating on the nameplate it should not read over 90°C on the gauge.

The liquid level gauge will also fluctuate slightly with temperature and loading but a steady drop may indicate a leak and should be addressed. The pressure/vacuum gauge will vary with temperature as well but should never register zero for prolonged periods of time (another indication of a leak).

9.3 Dielectric Fluid Sampling

Dielectric fluid samples should be taken at least on an annual basis and analyzed by DGA (Dissolved Gas Analysis). Routine DGA testing is one of the best methods of determining the “Health” of a transformer. Although the ultimate failure of a transformer may be impossible to predict, routine oil testing can often indicate a detrimental internal condition before it destroys the unit.