Type VRLTC™ load tap changer
Installation and maintenance guide
Recommended practices

ABB recommends careful consideration of the following factors for installation and maintenance work on load tap changers.

− ABB recommends that only service personnel with appropriate skills regarding load tap changers carry out installation, maintenance, and repairs of any sort.
− Before you start any work, make sure that the personnel doing the job have read and fully understood the installation and maintenance documents provided with the unit.
− To avoid damaging the unit, never exceed the operating limits stated in delivery documents and on rating plates.
− Do not alter or modify a unit without first consulting ABB.
− Follow local and international wiring regulations at all times.
− Use only factory authorized replacement parts and procedures.
− Approval should be given for inspections as well as for operating the load tap changer (LTC).

General cautions

− The LTC must not be included in the vapor phase drying process of the transformer.
− The transformer tank and the LTC tank must be simultaneously under vacuum when filling either tank with oil.
− Avoid ingestion of moist air into the LTC when draining oil. Let incoming air pass through a dehydrating breather with slow air flow to obtain proper dehydration in case the air is moist.
− The oil level of the transformer should always be higher than the oil level of the LTC.
− Sealing surfaces and gaskets must be clean and undamaged.

Safety notations

The following is a definition of danger, warning, caution, and notice and a description of how each will be shown.

⚠️ DANGER

A DANGER symbol indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠️ WARNING

A WARNING symbol indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠️ CAUTION

A CAUTION symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

A NOTICE addresses practices not related to personal injury.

Precautions

The following is a list of general warnings and cautions that pertain to this document:

− Before any work is carried out on the LTC, make sure that the transformer is de-energized and properly grounded.
− Before starting any work on the LTC, the mode switch of the motor drive must be set to the OFF position.
− Before starting any work inside the motor drive, the auxiliary power must be switched off. The motor drive, contacts, and heating elements may be energized from separate sources.
− The motor drive must not be installed in any explosive atmosphere. The electrical equipment creates sparks, which can cause an explosion.
− The oil in the tap changer may be hot.
− There may be a cushion of explosive gases over the oil surface. No open fire, hot surfaces, or sparks may be present when the front cover is opened.
− Small amounts of explosive gases may be exhaled by the breathing devices (dehydrating breather or one-way breather). Make sure that no open fire, hot surfaces, or sparks occur in the immediate surroundings of the breathing devices.
− Never insert the hand crank during electrical operation.
− When oil that has been used in the tap changer compartment is pumped out, conducting tubes and hoses that are grounded should be used to avoid the risk of explosion due to the gases that may be present in the LTC compartment.

Oil handling

Anyone who handles oil should consult a MSDS for the type of oil used prior to handling. Consider rags and other disposables which you use during service as hazardous waste. Avoid contact with oil as much as possible and use oil tight protective gloves when handling the oil. Should contact with oil occur follow the procedures described in the MSDS.
General information
The VRLTC load tap changer is manufactured exclusively at the ABB facility in Alamo, Tennessee. The LTC meets all of the required specifications according to IEEE C57.131-1995 and IEC 60214-1. The LTC is an on-tank, vacuum reactance load tap changer for either automatic or manual control.

Three major components make up the LTC: the tap changing components, the driving components, and the decision making/monitoring components. The tap changing components are contained in an oil-filled steel tank. The transformer's tap leads and preventive autotransformer (PA or switching reactor) leads are connected to the back of the LTC terminal board. The driving and decision-making components are contained in a separate steel air compartment mounted below the oil-filled tank with a drive shaft connecting it to the tap changer.

The drive motor is a digitally controlled servo motor which precisely responds to the commands from the digital drive. Cam switches and electromechanical relays are not used in this motor drive. The entire system is monitored and controlled by the Tap Logic Monitoring System (TLMS) mounted in the motor compartment.

The components of the tap changing circuit are:
- The preventive autotransformer - a separate device mounted inside the transformer which provides the transition impedance
- The tap changing module - consists of the tap selector and change-over selector
- The load switching module - consists of the by-pass switches and the vacuum interrupter (VI)

These components work together so that the transformer load is not interrupted at any time during a tap change operation.

Oil quality
The oil quality should meet the standards according to IEEE C57.106-2006. The oil should have an electrical withstand of at least 35 kV, measured in a 1 mm gap. The water content must be below 10 ppm.

VRLTC characteristics
The VRLTC tap changer is a 3-phase, preventive autotransformer design with vacuum interruption. It can be configured in plus/minus, coarse/fine or linear tapping arrangements. The maximum number of positions is 33 with nine (eight effective) winding sections. Table 1 contains the electrical and mechanical characteristics of the tap changer.
### Electrical characteristics

<table>
<thead>
<tr>
<th>Tap changer type</th>
<th>VRLTC 1500-200</th>
<th>VRLTC 1500-150-N</th>
<th>VRLTC 2000-150-N</th>
<th>VRLTC 2000-200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum continuous operating voltage line-to-line (IEEE/CSA)</td>
<td>38 / 35 kV</td>
<td>28 / 27.5 kV</td>
<td>28 / 27.5 kV</td>
<td>38 / 35 kV</td>
</tr>
<tr>
<td>Rated through current</td>
<td>1500 A</td>
<td>1500 A</td>
<td>2000 A</td>
<td>2000 A</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) phase-to-phase and to ground</td>
<td>200 kV</td>
<td>150 kV</td>
<td>150 kV</td>
<td>200 kV</td>
</tr>
<tr>
<td>Transformer test floor maximum impulse withstand</td>
<td>275 kV</td>
<td>200 kV</td>
<td>200 kV</td>
<td>275 kV</td>
</tr>
<tr>
<td>Power frequency withstand, phase-to-phase and to ground (rms)</td>
<td>70 kV</td>
<td>50 kV</td>
<td>50 kV</td>
<td>70 kV</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) across tap range ($V_{p}$)</td>
<td>75 kV</td>
<td>75 kV</td>
<td>75 kV</td>
<td>75 kV</td>
</tr>
<tr>
<td>Power frequency withstand across tap range ($V_{p}$) (rms)</td>
<td>34 kV</td>
<td>26 kV</td>
<td>26 kV</td>
<td>26 kV</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) tap-to-tap ($V_{t}$)</td>
<td>45 kV</td>
<td>45 kV</td>
<td>45 kV</td>
<td>45 kV</td>
</tr>
<tr>
<td>Power frequency withstand tap-to-tap ($V_{t}$) (rms)</td>
<td>15 kV</td>
<td>15 kV</td>
<td>15 kV</td>
<td>15 kV</td>
</tr>
<tr>
<td>Step voltage / tap voltage, tap to tap (rms)</td>
<td>500/1000 V</td>
<td>250/500 V</td>
<td>250/500 V</td>
<td>500/1000 V</td>
</tr>
<tr>
<td>Maximum change-over selector recovery voltage</td>
<td>20 kV</td>
<td>20 kV</td>
<td>20 kV</td>
<td>20 kV</td>
</tr>
<tr>
<td>Tank size</td>
<td>medium</td>
<td>small</td>
<td>small</td>
<td>medium</td>
</tr>
</tbody>
</table>

### Physical characteristics

<table>
<thead>
<tr>
<th></th>
<th>Small tank</th>
<th>Medium tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard number of positions</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Regulating winding sections</td>
<td>9 (8 effective)</td>
<td>9 (8 effective)</td>
</tr>
<tr>
<td>Tank</td>
<td>Withstand full vacuum (± 18 psi)</td>
<td>Withstand full vacuum (± 18 psi)</td>
</tr>
<tr>
<td>Approximate LTC tank dimensions</td>
<td>60 x 46 x 29</td>
<td>67 x 50 x 32</td>
</tr>
<tr>
<td>Total weight excluding motor drive (pounds)</td>
<td>4460</td>
<td>5350</td>
</tr>
<tr>
<td>Volume of oil (gallons)</td>
<td>270</td>
<td>350</td>
</tr>
<tr>
<td>Duration of tap change</td>
<td>Less than 2 seconds</td>
<td>Less than 2 seconds</td>
</tr>
</tbody>
</table>

1 Only rated for application at the neutral end of Wye. P must be connected to Neutral.
2 Approximate parameters — check outline drawing for exact details.
3 Less than 1 second available as a special order.

Table 1 — VRLTC characteristics

![LTC configuration diagram](image-url)  
Figure 1 — LTC configuration
Receiving and handling
Upon receipt of the VRLTC from ABB, it should be inspected for any signs of shipping damage. Open the door of the motor drive enclosure. Inspect the components in the compartment for any obvious signs of shipping damage. If any damage is suspected, file a claim with the transport company and notify ABB.

Check that the quantity delivered, the type designation and the serial numbers agree with the delivery documents. The nameplate of the tap changer and motor drive compartments will each contain a serial number (see Figure 2). Verify that both nameplates have matching serial numbers. The serial number of the tank will end with an “L” and the motor drive will end with a “M”. Contact ABB if the nameplates do not match.

Remove any drying agents before commissioning the LTC. If the packing material appears to be wet, the LTC must be dried for at least 24 hours at a maximum temperature of 158 °F (70 °C) before it is fitted to the transformer.

Storage
ABB ships the tap changer filled with helium under positive pressure. If the LTC is to be stored for a period of time and the tank was opened prior to storage, the LTC must be refilled with an inert gas. The pressure within the tap changer compartment should not exceed 4.0 psi. If you intend to store the LTC in an unheated space or outdoors, you must do the following to protect the LTC from weather:
- Fill the LTC tank with clean, dry oil and fill the gas space with an inert gas.
- If outdoors, provide weather protection for the exterior surfaces of the LTC tank and the operating mechanism. The primer paint coating is not rated for long term outdoor exposure.
- Provide heat within the motor drive compartment by providing power to the internal heaters in the compartment.

Tightening torque
The following table lists the recommended tightening torques.

<table>
<thead>
<tr>
<th>Size</th>
<th>Torque N-m (lbf-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>10 (7.5)</td>
</tr>
<tr>
<td>M8</td>
<td>24.5 (18)</td>
</tr>
<tr>
<td>M10</td>
<td>49 (36)</td>
</tr>
<tr>
<td>M12</td>
<td>84 (62)</td>
</tr>
</tbody>
</table>

Table 2 — Recommended tightening torques

![Nameplate locations on motor drive and LTC](image-url)
Attaching the VRLTC to the transformer

Welding
Verify that the LTC opening in the transformer tank is compliant with the specifications on the outline drawings furnished with the LTC. Weld the LTC compartment to the transformer main tank. This weld must be oil tight, pressure and vacuum resistant.

⚠️ CAUTION

Welding adjacent to the epoxy terminal board may distort its mounting surface and cause damage to the terminal board or its oil seal.

The transformer tank wall must be braced to withstand a 15 psi pressure test. A 0.25" oil-tight weld is required around the outside perimeter of the LTC mounting flange. Welding on the transformer side of the LTC is not required.

Bolting
A one piece cork neoprene gasket is provided to seal against the transformer tank. Gaskets should not be cemented at temperatures below 32 °F (0 °C). The required amount of cement (ABB 1 3401-608) is 1.0 lb. When you install the LTC, the gasket should be cemented as described below:

- Ensure that the surfaces in contact with the gaskets are clean and free from grease and oil.
- After cleaning the contact surfaces, attach the gaskets to the transformer tank flange with ABB cement 1 3401-608, by brushing cement on both the gasket and the flange.
- Allow the cement to dry for a minimum of 10 minutes and a maximum of 30 minutes.
- Keep the gaskets in the correct position by using clamping blocks for a minimum of 3 hours.
- Set the LTC in its place on the transformer and tighten the bolts to approximately 65 lb-ft (90 N-m) torque.
- Tighten the dome nuts with 31 lb-ft (42 N-m) before oil filling.

⚠️ NOTICE

When a gasket is subjected to the force from the flange bolts it will change its shape and settle. This reduces the forces on the bolts, making them loose. The settling effect will increase at higher temperatures. For this reason, retightening is required. Retighten one day after assembly and again after the transformer has been in service for two weeks to let the gaskets settle at service temperature.

Mounting the motor drive compartment

ABB ships the LTC and motor drive in the service position with a locking plate secured to the LTC mounting flange and a locking pin located in the motor drive (see figure 3). The service position is determined by the connection configuration of the tap changer. Plus / minus and course / fine configurations are shipped on the neutral position and the linear configuration is shipped on position 17. The locking mechanism should not be removed until the motor drive compartment is ready to be installed onto the LTC. Before installing the motor drive enclosure, check the position indicator to confirm that the motor drive is in the service position according to the nameplate. Open the motor drive and verify that the locking pin is in place.

⚠️ WARNING

Do not energize the transformer before the LTC compartment is filled with oil. Do not fill the compartment with oil until the motor drive is correctly assembled to the oil-filled compartment.

Direct mount

- Ensure the motor drive is locked in the service position (figure 3)
- Remove the locking plate secured to the LTC drive flange by removing the six bolts. Be careful not to rotate the LTC coupling pin. Please note the orientation of the LTC coupling pin.
- On the motor drive enclosure, remove the packing tape covering the hole and verify the o-ring is installed in the mounting groove (figure 4).
- Apply a thin layer of grease (GULF-718EP synthetic grease, Mobil grease 28 or SHELL Aero Shell Grease 22) to the o-ring, drive shaft upper slot, and the motor drive coupling pin. (see figures 4 and 7)
- Attach the mounting brackets to the motor drive enclosure as shown and hand tighten the four horizontal bolts.

Figure 3 — Motor drive secured in service position by locking pin
CAUTION

Do not attempt to install the drive shaft assembly before lifting the motor drive into place. Doing so could result in damage to the LTC or motor drive.

- Lift the motor drive enclosure up to the LTC compartment being sure to keep the LTC drive flange and motor drive mounting boss aligned.
- Attach the motor drive to the LTC by installing the hardware as indicated (figures 5 and 6).
- Tighten the vertical bolts in a crisscross pattern to the proper torque (table 2)
- Using a crisscross pattern tighten the horizontal bolts to the proper torque (table 2)
- Open the motor drive door and the swing panel.
- Ensure that the swing panel is aligned with the alignment pin (figure 15) by opening and closing the swing panel and motor drive door while verifying minimum interference. If the alignment pin is not aligning with the swing panel or the motor drive door will not properly latch, loosen the bolts in the mounting brackets adjusting the orientation of the motor drive enclosure. Be sure to re-tighten the bolts to the proper torque once the motor drive has been squared.

- From within the motor drive enclosure, insert the drive shaft and raise it through the motor drive mounting boss with the upper slot aligned so that it will engage the LTC coupling pin (the orientation of which was noted earlier). Be careful not to rotate the LTC coupling pin and input shaft while installing the drive shaft.
- Install the coupling halves securing the drive shaft to the motor drive coupling pin with the screws. Be sure the screws are properly tightened (table 2)
- Remove the locking pin from the motor drive
- Make all the electrical connections to the motor drive according to the wiring diagram supplied with the tap changer (please see the Connect the motor drive to the LTC section).

Extended Mount

The motor drive can be mounted between 12 and 60 inches below the bottom of the oil filled tank. The external drive shafts consist of a square tube surrounded by a cylindrical, protective tube. The square tube fits over the coupling pins on the LTC input shaft and motor drive enclosure. Couplers secure the shaft in place. The square shafts and protective tubes must be cut before mounting. The inclination of the shaft (the square tube) must not be more than 4 degrees (=2.75 inches for every 40 inches shaft length).

CAUTION

Before mounting shafts and couplings, everything must be cleaned and greased for correct function and to avoid corrosion. Apply a thin layer of grease, GULF-718EP synthetic grease or Mobil grease 28 or SHELL Aero Shell Grease 22 to all coupling pins.
Perform the following steps to install the motor drive with an extended mount.

− Determine the distance, “D”, between the connecting pins (figure 8) located at the bottom of the LTC tank and the top of the motor drive enclosure.

− Cut the vertical square shaft to the length D - 0.25 inches. Remove the burrs.

− Cut the protective tubes (items 2 and 3 in figure 9) to the length specified below.

Outer protective tube \( d_{outer} = (0.75)D \)

Inner protective tube \( d_{inner} = (0.75)D - 0.75" \)

− Attach the tube mounting flange to the bottom of the LTC tank.

− Fit the two protective tubes over the shaft with the outer tube on top. Fit two coupling halves on the upper end of the square shaft with four screws and washers. Begin by tightening the bottom two screws to clamp the shaft.

− Connect the square shaft with the mounted coupling halves to the shaft of the bevel gear exiting the LTC.

− Slide the outer protective tube over the surface of the tube mounting flange and tighten the hose clamp.

− Align the bottom end of the square shaft with the pin from the motor drive and mount the two remaining coupling halves.

− Mount the lower protective tube to the mounting flange on top the motor drive and tighten the hose clamp.

NOTICE

Leave a 0.125” gap between the bottom of the inner tube and the mounting flange for water draining.
WARNING

Important safety features of the VRLTC are disabled in the no-load mode which could result in an electrical failure causing serious damage to equipment, personal injury, or death.

When in the no-load mode, a message will appear on the TLMS screen and an amber LED will appear on the “TLMS” keypad indicating limited protection. This “TLMS” LED will change to red if the no-load mode time-out alarm activates.

Connect transformer leads to LTC terminals
The rear terminals of the LTC are connected to the transformer. Connect the transformer’s regulating leads to the proper LTC terminals on the epoxy terminal board. Verify that the terminals have through holes for 1/2 inch bolts. Refer to the LTC outline drawing provided for the proper terminal connections.

Connect the motor drive to the LTC
ABB ships the motor drive and LTC with all internal connections already wired (see wiring diagram provided with the LTC). Connect the cable exiting the motor drive enclosure to the connector located on the side of the LTC tank (figure 14). This connection allows the vacuum interrupter (VI) monitoring system to feed information to the TLMS. In order to complete the wiring of the LTC to the transformer controls system, make the connections from the controls wiring to the appropriate terminal blocks in the motor drive compartment.

TLMS no-load mode
The TLMS module (see TLMS manual 1ZUA5492-515) is a critical component and is vital to the safe operation of the VRLTC tap changer. The TLMS module monitors the operation of the LTC and controls the progress of tap changes to minimize risks created due to malfunctions such as the loss of vacuum in an interrupter. As a part of this protection, the TLMS module monitors the current in the vacuum interrupter before it opens, after it opens and after it recloses. In this way, the system ensures that the monitoring circuit can detect current, that current is interrupted and that the current returns once the interrupter is closed. If abnormalities are detected during this process, the LTC aborts the tap change, returns to position and locks out in an alarm condition.

There are times when the tap changer will have to be operated when no current is present. In these cases, the TLMS module must know that a lack of current is allowed so that it can allow normal operations. ABB has provided for this by way of a no-load mode. A contact, provided by the user and connected to terminal block pins X1:17 and X1:18 (see table 3), must be closed to enable the no-load mode. In this mode, the TLMS module will not verify the presence of current before and after a VI open-close sequence. However, the TLMS module will continue to verify that current flow does not exist when the VI is open. If the TLMS module detects current flow when the VI is open, it will abort the operation. While this protection is critical, it is not considered satisfactory for normal service. Therefore, the TLMS module will alarm and lockout if the contact is left closed and the no-load mode condition remains for 8 hours. If this time-out occurs, it will be necessary to reset the alarm (see TLMS manual 1ZUA5492-515) before any operations can be performed.
At a minimum, ABB recommends that the contact supplied by the user be a contact indicating that the load side of the transformer is not connected to the load circuits. This can be satisfied by a contact which is closed when the load side breakers are open. For maximum safety, ABB recommends both source and load side circuit contacts be incorporated.

To activate the no-load mode when the transformer is not installed, a jumper can be installed to replace the contact. ABB supplies this jumper on new VRLTC tap changers for use at the transformer factory. It is critical to remove the jumper before the transformer is energized because important safety features of the TLMS module are disabled with this jumper installed. It is marked with a label that indicates it must be removed before placing the transformer in service.

It should also be noted that the TLMS maintenance modes are not accessible unless the aforementioned contact is closed.

It should be noted that in maintenance modes, such as “Bypass” or “Jog”, no monitoring functions are active and tap changes should never be performed while the transformer is energized.

**WARNING**

All safety features of the TLMS are disabled in the maintenance modes. Operation of the LTC in these modes could result in an electrical failure causing serious damage to equipment, personal injury, or death.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1:1</td>
<td>Protective Earth</td>
<td>PE</td>
</tr>
<tr>
<td>X1:2</td>
<td>Controls Power Supply</td>
<td>L1</td>
</tr>
<tr>
<td>X1:3</td>
<td>Motor Mains Supply</td>
<td>L1</td>
</tr>
<tr>
<td>X1:4</td>
<td>Motor Mains Supply</td>
<td>L2</td>
</tr>
<tr>
<td>X1:6</td>
<td>Heater and Outlet</td>
<td>L1</td>
</tr>
<tr>
<td>X1:7</td>
<td>Transformer No-Load</td>
<td>XFMR A</td>
</tr>
<tr>
<td>X1:8</td>
<td>Transformer No-Load</td>
<td>XFMR B</td>
</tr>
<tr>
<td>X1:9</td>
<td>Remote Raise / Lower Switch</td>
<td>Raise</td>
</tr>
<tr>
<td>X1:10</td>
<td>Remote Raise / Lower Switch</td>
<td>Lower</td>
</tr>
<tr>
<td>X1:11</td>
<td>Remote Raise / Lower Switch</td>
<td>Common</td>
</tr>
<tr>
<td>X1:12</td>
<td>Remote Raise / Lower Switch</td>
<td>Alarm A</td>
</tr>
<tr>
<td>X1:13</td>
<td>Remote Raise / Lower Switch</td>
<td>Alarm B</td>
</tr>
<tr>
<td>X1:14</td>
<td>Remote Raise / Lower Switch</td>
<td>Alarm C</td>
</tr>
<tr>
<td>X1:15</td>
<td>Remote Raise / Lower Switch</td>
<td>Alert A</td>
</tr>
<tr>
<td>X1:16</td>
<td>Remote Raise / Lower Switch</td>
<td>Alert B</td>
</tr>
<tr>
<td>X1:17</td>
<td>Tap pos 4 — 20 mA</td>
<td>Current Loop A+</td>
</tr>
<tr>
<td>X1:18</td>
<td>Tap pos 4 — 20 mA</td>
<td>Current Loop A−</td>
</tr>
</tbody>
</table>

Table 3 — Standard terminal connections inside motor drive enclosure
Electrical connection and testing
Before the transformer is energized, perform tests to make sure that all mechanical and electrical connections are correct and to check for proper functioning of the motor-drive mechanism and the LTC. When testing the transformer, the LTC can be operated either electrically or by the hand crank.

Make all connections to the motor drive according to the wiring diagram supplied with the LTC.

Manual testing
Ensure that the transformer has been de-energized. Then, put the motor drive mode switch into hand-crank mode. With the LTC compartment open and the motor drive outer door open, insert the hand-crank into its socket and engage the motor drive. Check the LTC operation in the lower direction by rotating the hand crank 10 revolutions counterclockwise which moves the selector switch from its service position. While hand cranking you will first observe the P2 by-pass contact open. The VI will then open followed by the tap selector breaking contact with its stationary contact. The change-over selector (for plus/minus or course/fine tap arrangements) then moves from position B to position A. This action only takes place when going from the service position to the first position in the lower direction and vice versa. The selector switch makes contact on the next stationary contact and the VI closes. When the P2 by-pass contact closes, the tap change is complete. Verify that the selector switch and reversing switch moving contacts operate smoothly without binding. Hand crank in the raise direction (clockwise) back to the service position. The same sequence of events will occur in the reverse order.

Check the LTC operation in the raise direction by hand cranking in the clockwise direction from the service position to the first raise position. While hand cranking in the raise direction (clockwise) observe that the by-pass switch P3 opens, then the VI opens, followed by the tap selector moving to the next position. Continue hand cranking and the vacuum interrupter will re-close, then the by-pass switch P3 will reclose, positioning the LTC on the first raise position. Observe the engagement of the tap selector moving contacts for smooth, nonbinding operation.

Hand crank in the lower direction (counterclockwise) back to the service position. The same events should take place in reverse order. Withdraw the hand crank and return it to its holder. Put the motor drive mode switch into the off position.

Motorized test procedures
Power down the compartment and then open the motor drive swing panel (figure 15). Make sure the jumper between the transformer no-load relay terminals is properly attached according to the wiring diagram supplied with the LTC. Close the swing panel and lock it in place. Supply a voltage source to the motor drive according to the wiring diagram. Turn the motor drive mode switch to the local position. Acknowledge the TLMS is in no-load monitoring mode (see TLMS user guide 1ZUA5492-515 for more information).

Place the TLMS system into by-pass mode by completing the following commands:

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**NOTICE**

Some VRLTC tap changers will have resistors installed across the A1 and A2 contacts of both the raise and lower relays. These resistors are required for compatibility with certain types of automatic voltage regulators and controls. If installed, the resistors should not be removed or modified in any way.

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**WARNING**

Failure to ensure that equipment is de-energized before manual operation or service could result in death or serious injury.

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**CAUTION**

ABB does not recommend extended operation of the LTC without oil in the LTC compartment. However, the LTC may be run once to both limits and back to service position for test purposes.
Operate the LTC via the RAISE / LOWER switch located on the swing panel. Move the tap changer from the service position in the lower direction. Check the movement of the position indicator to confirm that the motor is connected properly. Operate the LTC one step at a time from the service position to the lowest tap position. Verify that the LTC will not operate past the lowest position.

Turn the motor drive mode switch to the hand crank position and insert the hand crank. Use the hand crank to verify that the mechanical end-stop actuates by turning counterclockwise from the 16L position or clockwise from the 16R position. The mechanical end-stop should operate in approximately 1.5 hand-crank revolutions past the final tap position. The hand crank will come to an abrupt stop. Do not force the hand-crank. Remove the hand crank and turn the motor drive mode switch to Local.

Operate the tap changer in the raise direction, one step at a time, until the highest tap position is reached. Repeat the same checks that were performed in the lower direction. After turning the mode switch back to the local setting, press the Return to service position button on the swing panel. This will return you to the service position.

Use the jog mode feature to perform a visual check of all tap change events. Place the TLMS into the Jog mode by using the following commands:

1. Press the Test Mode button
2. Scroll to jog mode
3. Press the Enter button

Observe the action of the LTC components for any abnormalities by cycling from the service position to the first lower position. Jog from the first lower position to the first raise position. Upon completion of the checks return the tap changer to the service position and exit jog mode by executing the following commands:

1. Press the System Information or System Status button
2. Press the Down Arrow button to accept

Turn the mode switch to the Off position and disconnect the motor drive power source.

Open the swing panel and disconnect the No-Load jumper according to the wiring diagram supplied with the LTC. Perform a visual check to make sure no tools or debris are present in the motor drive. Close the swing panel and secure the latches. Perform a raise or lower operation. The TLMS should stop the tap change operation and display “CT-X No Signal”. Turn the motor drive mode switch to the Remote position. Close the enclosure door and secure the latches of the motor drive enclosure.

**WARNING**

Failure to remove the No-Load jumper will defeat important safety features of the TLMS.
NOTICE

If the LTC is oil filled under atmospheric pressure, a waiting period of three hours is needed before energizing. To save out of service time of the transformer, carry out all work on the LTC and do the oil filling before the maintenance of the motor-drive mechanism is started.

WARNING

Dielectric fluids can produce a significant high voltage static charge during pumping operations. It is recommended that all equipment, winding leads, containers and piping be grounded during pumping.

Oil filling

Before oil filling, retighten the front cover mounting bolts. The required tightening torque is 31 lb-ft (42 N-m). Do not overtighten the nuts.

ABB requires that first time oil filling take place under vacuum. At any time after the initial filling that the LTC must be drained, refilling may take place under vacuum or atmospheric pressure.

The molded epoxy backboard is designed to withstand ±18 psi. This accounts for vacuum on one side of the terminal board and oil head pressure on the other.

Correct oil level

At 68 °F (20 °C), fill the LTC with oil until the pointer of the oil level indicator points half-way between MIN and MAX. For temperatures other than 68 °F (20 °C) proceed as follows:
- For every 55 °F (13 °C) increase of temperature, adjust the oil level upwards a tenth of a scale range of the oil level indicator.
- For every 55 °F (13 °C) decrease of temperature, adjust the oil level downwards a tenth of a scale range of the oil level indicator.

Once the oil level has been properly adjusted and the unit is in service, the oil level should be periodically checked.

Filling under vacuum

1. Open the conservator valve, if any.
2. Dismantle the pipe to the breather. Removing the air relief valve or the dehydrating breather is also an option.
3. Apply vacuum.
4. Connect the oil filling equipment to the oil valve on the LTC tank. Open the valve and let oil into the tank until the correct level is shown on the oil level indicator (see section on oil filling).
5. Close the oil valve and disconnect the filling equipment.
6. Reassemble the pipe to the breather. Use O-rings in the flanges and sealing tape on the threads so that all connections are air tight.

Electrical tests on transformer

Acceptance tests on the transformer or commissioning can now be performed.

Putting into operation

Put the LOCAL/REMOTE switch to REMOTE. Reset the drag hands. Make sure that no tools or foreign objects are left in the motor drive cabinet. Close the door.

Inspection and maintenance schedule

ABB recommends a brief inspection of the tap changer on a yearly basis. The only time the transformer is required to be taken out of service on behalf of the VRLTC tap changer is for the 500,000 operations inspection and the 1,000,000 operations overhaul. At 500,000 operations, the oil of the tank should be drained so that internal components can be inspected. Once the LTC reaches 1,000,000 operations the VI must be replaced.

500,000 operations inspection

The first time the transformer is taken out of service for inspection and maintenance occurs at the 500,000 operation milestone. To perform this inspection, you must drain the oil from the tap changer compartment and inspect the internal components. Use table 4 to estimate when this milestone will occur based on the average number of daily operations. The following should be completed while performing this inspection along with all inspection points involved in the annual inspection:
- Drain oil from LTC tank
- Flush tank with new oil to cleanse the internal surfaces
- Operate the tap changer in Jog Mode to perform visual check
- Evaluate the remaining contact life of the VI
- Replace the door gasket of the tank door. The tank door gasket should be replaced every time the door is opened.
- Refill the LTC with new oil according to the section on oil filling.

Checking of the dehydrating breather

Generally, if the VRLTC tap changer is equipped with a regenerating breather, like the SDB series of breathers, no inspection is required. For all other types of breathers or to confirm whether an inspection is required for a regenerating breather, please consult the breather manufacturer.
Checking of the pressure relay
ABB recommends inspection per the relay manufacturer’s instructions.

Checking of the motor drive mechanism
When checking the motor drive during an inspection, use the following procedure.
1. Turn the motor drive mode switch to the OFF position.
2. Download the TLMS event data log via the USB port located on the swing panel of the motor drive (see TLMS manual 1ZUA5492-515).
3. Open the cabinet door and turn the switch to the LOCAL position. Then turn the control switch to the RAISE / LOWER position.
4. Check that the motor works properly, the position indicator increases one step, and the counter advances one step for each operation.
5. Turn the control switch to the LOWER / RAISE position. Check that the motor also works properly in that direction, the position indicator decreases one step and the counter advances one step more. Reset the drag hands. Record the total operations of the counter.
6. Check the motor-drive for any undue wear, confirming that grease is present on the open gearing, and re-lubricate if necessary.
7. Check the ground fault interrupter by pressing the test button on the outlet. After testing press the reset button.
8. Disconnect the incoming auxiliary power.
9. Check that all cable connections within reach are secure.
10. Use the TLMS to force the heater to power on. Verify that heat is being generated by the heater.
11. Reconnect the incoming auxiliary power.
12. Complete the inspection by turning the switch to the REMOTE position and closing the cabinet door.

WARNING
Before any work is carried out on the LTC make sure that the transformer is disconnected and grounding is properly carried out. Make sure the motor drive mode switch is in the OFF position.

Oil testing and draining
The tank of the LTC is equipped with an oil valve located on the side wall. For connection dimensions see the outline drawing of the LTC.

Take an oil-sample from the oil valve and carry out the dielectric strength test according to ASTM 1816 (IEC 60156). The dielectric strength of the oil should not be less than 120 kV/cm (30 kV measured in a gap according to IEC 60156) for an LTC in service. The dielectric strength for new oil must be at least 160 kV/cm, which corresponds to 40 kV measured in a gap according to IEC 60156.

Use filtering equipment or the pump to drain oil from the LTC into a clean oil drum. Connect the pump to the oil valve and drain the oil from the LTC tank. Flush the tank with new oil.

Vacuum interrupter evaluation
Inspect the VI every time the LTC is drained and opened. Each inspection should include a visual inspection and Dissolved Gas Analysis (DGA). The rating of the vacuum interrupter is one million operations at full load. Two laser scribed lines (figure 16) on the actuating shaft indicate the expected wear at 500,000 and 1,000,000 operations. If the lower line is visible during the 500,000 operation inspection then the wear on the VI contacts is normal. If it is not visible, then the VI may need to be checked and replaced before reaching 1,000,000 operations.

Table 4 — Estimation of first overhaul and bottle replacement based on operations per day.

<table>
<thead>
<tr>
<th>Operations per day</th>
<th>Operations per year</th>
<th>15 years</th>
<th>20 years</th>
<th>30 years</th>
<th>40 years</th>
<th>50 years</th>
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<tbody>
<tr>
<td>20</td>
<td>7,300</td>
<td>109,500</td>
<td>146,000</td>
<td>219,000</td>
<td>292,000</td>
<td>365,000</td>
</tr>
<tr>
<td>30</td>
<td>10,950</td>
<td>164,250</td>
<td>219,000</td>
<td>328,500</td>
<td>438,000</td>
<td>547,500</td>
</tr>
<tr>
<td>40</td>
<td>14,600</td>
<td>219,000</td>
<td>292,000</td>
<td>438,000</td>
<td>584,000</td>
<td>730,000</td>
</tr>
<tr>
<td>60</td>
<td>21,900</td>
<td>328,500</td>
<td>438,000</td>
<td>657,000</td>
<td>876,000</td>
<td>1,095,000</td>
</tr>
<tr>
<td>80</td>
<td>29,200</td>
<td>438,000</td>
<td>584,000</td>
<td>876,000</td>
<td>1,168,000</td>
<td>1,460,000</td>
</tr>
<tr>
<td>100</td>
<td>36,500</td>
<td>547,500</td>
<td>730,000</td>
<td>1,095,000</td>
<td>1,460,000</td>
<td>1,825,000</td>
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<td>1,533,000</td>
<td>2,044,000</td>
<td>2,555,000</td>
</tr>
</tbody>
</table>

Figure 16 — Laser scribed lines indicate wear of the VI
**Hipot test**

Hipot testing is not required on VRLTC VI bottles. However, in order to perform a Hipot test on the vacuum interrupter, the vacuum interrupter must be isolated from the LTC circuit. This is accomplished by opening the lower by-pass switch at the P3 bus contact. Follow the instructions below to complete a Hipot test.

Place the LTC in Jog mode and operate the LTC until the lower bypass switch and vacuum interrupter are fully open. Ensure that the impact mass is resting on the lower surface of the pawl.

Loosen and remove the fasteners that secure the round copper P3 bus bar to the end of the rectangular P3 bus bar affixed to the diverter board. Insert a 0.50" thick solid insulation wedge (material such as G-10 can be used) between the loose round P3 bus bar. The P3 bus bar will be grounded via the grounded transformer windings.

---

**NOTICE**

The material used to isolate the P3 bus bar must be able to withstand a dielectric puncture stress of 1 kV/mm.
Attach the grounding lead to the bar between the P2-P3 by-pass contacts. Attach the test lead to be energized to the lower support holding the vacuum interrupter. It is important that the test leads are not reversed.

---

**CAUTION**

Wipe down the external surfaces of the vacuum interrupter to remove any contaminants that could result in a flashover from one end of the interrupter to the other end of the interrupter.

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Perform the Hipot test with a 12 kV, 60 hertz voltage applied for 1 minute. Note that the vacuum interrupter will emit low-energy X-rays when the 12 kV voltage is applied across the open contacts. Stand back away from the vacuum interrupter, several feet if possible, to limit possible exposure to X-ray activity. Placing the metal door between yourself and the interrupter will provide more than adequate shielding against any X-ray activity. If the bottle fails the Hipot test then the bottle must be replaced. Move to the section titled *Removing the old vacuum interrupter*.

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After the Hipot test is complete, remove the 1/2 inch thick insulation, attach the P3 bus bar, and jog the tap changer back to its original tap position.

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**Gasket installation**

Clean the metal surface before applying the new gasket. Remove all moisture, oil, or grease by wiping with a clean, dry cloth. The section of the gasket that has been spliced together should be oriented to fit below the lower door studs. This is the only way to install the gasket due to the stainless steel guide pins.
Removing the old bottle

Remove the shield, braided cable and the four shoulder bolts that secure the VI to the diverter assembly.

Remove the shoulder bolt from the actuating shaft and lower the VI assembly.

1,000,000 operations overhaul

The second time the transformer is taken out of service for tap changer inspection and maintenance occurs at the 1,000,000 operations milestone. The overhaul is very similar to the 500,000 operations inspection except the VI must be replaced after it has seen 1,000,000 operations. At this time, the oil of the VRLTC will be drained so the internal components of the tank can be inspected. Use Table 4 to estimate when this milestone will occur based on the average number of daily operations. The TLMS internal counter must be reset. Complete the following while performing this inspection along with all inspection points involved in the annual inspection:

- Perform all steps in the procedure used for the annual inspection.
- Drain oil from LTC tank
- Flush tank with new oil to cleanse the internal surfaces
- Operate the tap changer in Jog Mode to perform visual check
- Replace the VI with new interrupter
- Replace the door gasket of the tank door. The tank door gasket should be replaced every time the door is opened after oil draining.
- Refill the LTC with new oil according to the section oil filling.
VI replacement

Remove the three shoulder bolts and their wedge-lock washers from the lower VI support.

Remove the shoulder bolt that secures the collar to the VI.
With the new bottle, lower VI support, and appropriate hardware, begin assembly of the VI mechanism by placing the collar on the lower VI support and inserting the three shoulder bolts and three wedge-lock washers.

Insert the bottle and allow it to sit flush on the collar. Tighten the shoulder bolt of the collar to secure the bottle to the collar (see table 2 for proper torque).
Insert the shoulder bolt and wedge-lock washer and tighten to secure the bottle in place.

Place the corona ring around the exposed thread of the should bolt and tighten the nut to complete the assembly of the VI mechanism.
Installing the new vacuum interrupter

From the service position, Jog the LTC in the RAISE direction so that the lower, P3 by-pass opens and continue until the impact mass sits flush on the lower pawl. Use a depth gauge and zero the distance between the surface of the piston and the face of the unidirectional cylinder.

Fit the VI assembly onto the actuation shaft until the slot in the coupling aligns with the cross-hole of the actuation shaft. Insert the shoulder bolt through the slot and cross-hole. Secure the shoulder bolt by using a distorted thread lock-nut on the opposite side. Remove the shoulder bolt from the cross-hole if you used it to rotate the shaft.
Insert and finger tighten the four shoulder bolts and washers that attach the VI mechanism assembly to the P3 bus bar.

Insert a screw into the threaded hole found on the bottom side of the lower VI support. Next, insert a block to bridge the gap between the head of the screw and the G-10 insulation board. Use the depth gauge to measure the gap between the top of the cylinder and face of the piston. Use the screw on the bottom of the lower VI support to jack up the VI mechanism until the reading on the depth gauge reads 3.5 mm ± 0.25 mm.
Tighten the four shoulder bolts that were inserted during step 4 (see table 2 for proper torque).

Apply Loctite 272 in the threaded holes of the mounting bus for the braided cable. Attach the braided cable and its shield.
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