Liquid Insulated
Network Transformers
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READ THIS INSTRUCTION BOOK CAREFULLY BEFORE ATTEMPTING TO HANDLE, INSTALL, USE OR SERVICE THE TRANSFORMER. FAILURE TO FOLLOW INSTRUCTIONS COULD RESULT IN SEVERE INJURY, DEATH OR PROPERTY DAMAGE.

SAFETY NOTES FOR INSTALLATION AND OPERATION

DO NOT LIFT OR MOVE A TRANSFORMER WITHOUT ADEQUATE EQUIPMENT AND PRECAUTIONS.

TERMINALS ARE FOR ELECTRICAL LOADING ONLY, USE FLEXIBLE CONNECTORS TO AVOID MECHANICAL STRAIN.

DO NOT MAKE ANY CONNECTIONS THAT ARE NOT AUTHORIZED BY THE NAMEPLATE OR CONNECTION DIAGRAM.

DO NOT ENERGIZE TRANSFORMER WITHOUT PROPER GROUND CONNECTIONS.

DO NOT ATTEMPT TO CHANGE THE TAP SETTING WHILE THE TRANSFORMER IS ENERGIZED FROM EITHER H.V. OR L.V. SIDE.

DO NOT TAMPER WITH INTERLOCKS, ALARM AND CONTROL CIRCUIT.

IMPORTANT NOTICE: FAILURE TO OBSERVE THE REQUIREMENTS OF OSHA STANDARD 1910.269 CAN CAUSE DEATH OR SEVERE BURNS AND DISFIGUREMENT. THAT STANDARD SPECIFICALLY PROHIBITS THE WEARING OF POLYESTER, ACETATE, NYLON, OR RAYON CLOTHING BY EMPLOYEES WORKING WITH EXPOSURE TO ELECTRIC ARCS OR FLAMES.

The unit(s) covered by these instructions have been inspected and tested to meet all applicable standards of ANSI, NEMA, and IEEE, to assure you of the highest quality product.

The instructions in this manual should familiarize qualified personnel with the proper procedures to keep all new unit(s) in proper operating condition.

These instructions do not propose to cover all details or variations in equipment, or to provide for every contingency to be met in connection with installation, operation, or maintenance. Should further information be desired, or particular problems arise which are not covered, please contact ABB’s South Boston factory.
1. INTRODUCTION

These instructions apply to liquid filled network transformers manufactured by the ABB Small Power Transformer Division at South Boston, Virginia.

The equipment covered by these instructions should be operated and serviced only by competent personnel familiar with good safety practices. These instructions are written for such personnel and are not intended as a substitute for adequate training and experience in the use of this equipment.

The transformer outline drawing shows the location of nameplates and warning signs. Read and follow all warning signs and nameplates installed on the transformer.

NOTE: DO NOT REMOVE OR COVER THE WARNING SIGNS AND NAMEPLATES.

Electrical characteristics, winding connections and weights are on the nameplate. Physical details, such as weights and dimensions are shown on the transformer outline drawing. Wiring for the controls, fans and alarms circuits are shown on the wiring diagram. Repair information for all parts is not included because replacement is recommended rather than repair. If information is desired in greater detail, copies of instruction leaflets referred to, but not included with this book can be obtained by contacting the ABB Small Power Transformer Division.

2. RECEIVING

NOTE: Inspection of transformer, packages and parts is required prior to unloading from carrier, in order to establish the condition of the equipment upon delivery.

2.1 Drawing and Documents

Shipping papers, packing list, outline drawings, an instruction book and other pertinent documents furnished with the transformer must be available for use during the inspection.

2.2 External Inspection

All transformers are carefully tested at the factory and are in good condition when shipment is made. If the inspection indicates a shortage, damage or evidence of hidden damage, it must be reported to the carrier's representative and to a representative of the ABB Small Power Transformer Division before unloading the transformer. As a minimum the following inspections should be made.

<table>
<thead>
<tr>
<th>External Inspection of Transformer Tank and Fittings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is there any indication of external damage?</td>
</tr>
<tr>
<td>2. Is the paint finish damaged?</td>
</tr>
<tr>
<td>3. Are the attached fittings loose or damaged?</td>
</tr>
<tr>
<td>4. Is there evidence of fluid leakage on or around the tank coolers?</td>
</tr>
<tr>
<td>5. Are any of the bushings broken or damaged?</td>
</tr>
<tr>
<td>6. Is there any visible damage to the parts or packaging that shipped separately from the transformer?</td>
</tr>
</tbody>
</table>

2.3 Tank Pressure

The tank is pressurized before shipping. However, depending upon liquid temperature, the tank pressure may be positive or negative. In some cases, the vacuum pressure gauge may read zero, which could possibly indicate a tank leak. In such cases, perform a pressure test on the tank according to the instructions in Section 6.4.1. Report tank leaks of new transformers to the ABB Small Power Transformer Division.

2.4 Detail Parts

In making examinations of the parts crates for shipping damage, check carefully for evidence of moisture and for damage to moisture barriers or waterproof wrappings when used.

The detail parts should be stored in a clean, dry area that will minimize exposure to weather and the possibility of damage or loss.

2.5 Internal Inspections

When a new transformer is delivered, an internal inspection is normally not required. Temporary shipping braces are not used inside the transformer. No internal inspection should be performed unless authorized by ABB Small Power Division.

3. HANDLING PRIOR TO INSTALLATION

3.1 Tilting

Transformers should be handled in the normal upright position, but in no case tilted more than 15° from vertical, unless instructions have been given to the contrary. Refer to the outline for these instructions.
3.2 Lifting

Lifting hooks or eyes are provided on the transformer tank wall. Only these hooks can be used in lifting the complete transformer. Refer to the outline for the proper lifting hook locations. All four lifting hooks must be used for proper handling.

3.3 Jacking

Refer to the transformer outline drawing for jacking areas on the transformer tank. Only those areas may be used when the transformer is jacked. Note: When jacking the tank, assure that the jack does not come in contact with the panel radiators.

4. STORAGE PRIOR TO ENERGIZING

4.1 Storage of Transformer

When storing the transformer, it should be completely assembled and pressure tested in accordance with Section 6.4.1. The gas space above the liquid should be pressurized with dry nitrogen between two to three PSIG. This will aid in preventing moisture from being pulled into the tank during pressure variations caused by temperature changes. Transformers designed for indoor use must be stored indoors.

4.2 Extended Storage Guidelines

If a unit is to be stored more than 60 days before being placed into service, the guidelines listed below should be followed.

1. Store the transformer on a firm level foundation, preferably at its installation site. Perform external inspections listed in Section 2.2 and the tests and inspections listed below.

<table>
<thead>
<tr>
<th>Additional Test and Inspections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Record ambient temperature and barometric pressure for correction of test data.</td>
</tr>
<tr>
<td>2. Pressure test to insure the tank and fittings do not have leaks. After test is complete, the pressure should be reduced to two (2) PSIG.</td>
</tr>
<tr>
<td>3. Test insulating liquid for dielectric strength and moisture content.</td>
</tr>
<tr>
<td>4. Test insulation with a 1000 or 2500 volt megger.</td>
</tr>
<tr>
<td>5. Check the insulation power factor using Dobie or similar test equipment. Note: This test is not possible on a secondary with a solidly grounded neutral.</td>
</tr>
<tr>
<td>6. Test ratio in all tap positions to insure proper tap changer operation.</td>
</tr>
<tr>
<td>7. Verify liquid level by gauge reading.</td>
</tr>
</tbody>
</table>

2. The transformer should be completely assembled.

3. If the transformer has externally mounted bushings on the terminal chamber or switch, the bushings should be protected from the environment. A black polyvinyl material placed over bulk bushings and the rubber cap supplied with molded bushing wells, molded inserts and molded single piece bushings will serve as protection. All protective material should be checked during routine inspections to insure that it is not damaged or lost.

4. Parts that are shipped separate from the transformer must be stored in a clean, dry area.

The following inspection must be made while the transformer is in extended storage. Record the results for comparison with previous data to insure that there has been no deterioration in the condition of the transformer.

Quarterly Inspection*

1. Check the black polyvinyl material or rubber caps covering the bushings for damaged. Replace if damaged or lost, if necessary.

2. Record gauge readings, including the ambient temperature and barometric pressure.

   a. Take a pressure reading. Compare with previous two (2) psig reading. Variations in barometric pressure must be taken into account.

   b. If the pressure or liquid level readings indicate a possible leak in the transformer, perform a pressure test according to Section 6.4.1. Any leaks should be repaired immediately.

   c. If a leak was found, perform the following:
      - Test insulation megger test.
      - Insulation power factor.

Refer to Section 6.4.3 for acceptable results.

*Perform the first inspection one month after the transformer has been put into storage and quarterly thereafter.
Annual Inspection

1. Check the paint finish and touch up as necessary.

2. Test insulating liquid for dielectric strength and moisture content.

When the transformer is taken out of storage, the pre-energization tests and inspections identified in Section 6.4 must be performed. Review the storage records of the transformer to insure that there has been no deterioration in the condition of the transformer.

5. ACCESSORIES AND COMPONENTS

5.1 Alarm Switch Ratings

Accessories supplied are shown on the outline drawing. When accessories are equipped with alarm contacts, refer to the control wiring diagram referenced, or the outline drawing, for contact type and ratings and terminal points.

5.2 Transformer Nameplate

A nameplate is supplied on each transformer according to ANSI standard C57.12.00. The nameplate provides basic information for use of the transformer.

5.3 Current Transformers

**WARNING:** CURRENT TRANSFORMER SECONDARIES MUST BE CONNECTED TO A LOAD OR SHORT-CIRCUITED TO AVOID DAMAGING VOLTAGES AT THE TERMINALS. FAILURE TO MAKE THESE CONNECTIONS COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

Current transformers are optional accessories. When supplied, current transformers are mounted inside the transformer tank. Current transformer secondary leads are always wired to non-submersible junction box external to the tank. Refer to the wiring diagram or outline drawing. The current transformer secondary leads are always shorted and grounded to the tank when the transformer is shipped.

5.4 Liquid Level Gauge

The liquid level indicator indicates the liquid level inside the tank. When indicators are installed at the factory, the tank is filled to the level that corresponds to a liquid temperature of 25°C, which is considered the normal level. Should the tank be at some temperature other than 25°C, use Table 1 to determine the variation above or below the normal level before adjusting fluid level. The indicator is shipped mounted on the transformer tank and requires no maintenance other than the periodic inspection recommended in Section 7 of this Instruction Book.

<table>
<thead>
<tr>
<th>Average Liquid Temperature (°C)</th>
<th>Correct Level (Percent of Scale Above or Below 25 °C Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>85 (high)</td>
<td>100</td>
</tr>
<tr>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>25 (Normal)</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>-33</td>
</tr>
<tr>
<td>-5</td>
<td>-67</td>
</tr>
<tr>
<td>-20 (Low)</td>
<td>-100</td>
</tr>
</tbody>
</table>

Contact factory if liquid level gauge does not agree with Table 1.

5.5 Liquid Temperature Gauge

The temperature gauge is furnished to indicate the top liquid temperature in the tank. The temperature sensitive element is mounted in a dry, leak-proof well, permitting removal of the thermometer without lowering the liquid level. The device is furnished with a red pointer to show the highest temperature attained since last reset. To reset the maximum indicator, rotate the magnet at the center of the dial or, on some models, past the reset button. During normal operations the liquid temperature gauge should read less than the sum on the ambient temperature and the rated temperature rise. For example, 30°C ambient + 55°C rated temperature rise = 85°C top oil temperature.
5.6 Pressure-Vacuum Gauge

WARNING: WHEN THE PRESSURE-VACUUM GAUGE READS ZERO AND DOES NOT CHANGE UNDER ANY TRANSFORMER LOAD, THE TRANSFORMER SHOULD BE CHECKED FOR POSSIBLE LEAKS. A LEAK WILL ALLOW MOISTURE AND AIR TO ENTER THE TRANSFORMER, WHICH COULD DEGRADE THE INSULATION AND FLUID AND POSSIBLY CAUSE A FAILURE.

The pressure-vacuum gauge indicates the tank gas space pressure relative to atmospheric pressure. Maintenance is not required except for the periodic inspection recommended in Section 7 of this instruction book.

5.7 Pressure Relief Mechanism

WARNING: NEVER DISASSEMBLE A PRESSURE RELIEF DEVICE. DISASSEMBLY COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE FROM HAZARDOUS FLYING OBJECTS.

Some transformers are furnished with a pressure relief device others may have relief valves. The pressure relief mechanisms will vent tank gases when excessive tank pressure exists. The relief device consists of a self-resetting, spring-loaded diaphragm and a mechanical operation indicator (Semaphore). The maximum tank pressure at which the pressure relief device will remain sealed is stamped on the relief device nameplate. Should the tank pressure increase above the pressure relief device nameplate rating, the gas pressure will lift the diaphragm, vent the excess pressure, and trip the Semaphore.

Immediately after the pressure returns to normal, the diaphragm will reset and reseal the transformer. This event is not normal. If the semaphore indicator is lifted, the cause of the operation should be investigated. The mechanical operation indicator (Semaphore) must be manually reset after each operation. The pressure relief device will withstand full vacuum and need not be removed from the transformer tank during any vacuum. A hood may be bolted over the relief device.

The relief valve is a spring loaded, self-resetting valve stem fitting. As the pressure increases above the valve rating, the stem will move relieving the pressure. The relief valve can also be used to manually relieve the tank pressure.

5.8 De-energized Tapchanger

The de-energized tapchanger is provided as means to adjust the transformer voltage to closely match that of the user system voltage. It is not to be used as a means to regulate the secondary voltage. If the tap changer is used in this manner, it will result in high noise level, higher no-load losses and possible core saturation. Refer to the transformer nameplate for the tap voltages possible for the transformer.

De-energize the transformer before attempting to change tap positions. Usually, the transformer is shipped in the rated voltage position.

WARNING: DO NOT MOVE THE TAPCHANGER POSITION, UNLESS THE TRANSFORMER IS TOTALLY DE-ENERGIZED. FAILURE TO DO SO WILL RESULT IN THE FAILURE OF THE TRANSFORMER AND COULD RESULT IN SEVERE PERSONAL INJURY OR POSSIBLE DEATH.

The de-energized tapchanger is located on the tank cover under a 2-inch pipe cap. A special wrench is inserted with its flat side adjacent to the position indicator. The wrench is then turned one complete revolution for each tap position. The tapchanger must be in a tap position before the wrench can be removed from the operating mechanism. The position indicator always identifies the current tap position. Refer to Figure 1 below.

![Fig. 1 Tapchanger Operating Mechanism](image_url)
CAUTION: THE TAPCHANGER HAS STOPS AT THE MINIMUM AND MAXIMUM TAP POSITIONS AS INDICATED ON THE NAMEPLATE. DO NOT FORCE THE TAPCHANGER AT THESE POSITIONS. TO DO SO WILL DAMAGE THE TAPCHANGER AND COULD CAUSE A FAILURE.

When the tapchanger is not in use, the wrench must be removed. The 2-inch pipe cap must be in place and sealed. Apply a thread sealant, such as liquid Teflon®, to the threads of the cap coupling and securely tighten.

5.9 Bushings

5.9.1 Primary Bushings

The primary bushings bushing are normally located in the primary network switch. Information regarding these will be found in the switch section of the booklet.

5.9.2 Secondary Bushings

Shown in Figure 2 is a cut-away view of the network transformer type RFW low voltage bushing mount in the transformer throat. The type RFW is a rolled flange bushing where the copper bushing cap and flange are attached to the insulator by being rolled into grooves in the insulator over silicone rubber rings. This seal is made at the factory and cannot be repaired in the field. If the intermediate seal is defective, replacement bushings must be obtained from the factory.

Fig. 2 Cut-away view of Type “RFW” Bushing

Inert-arc welding is used to attach the bushing flange to the throat wall, as shown in Figure 3. This method of welding is ideally suited for the mounting of bushings as its high concentration of localized heating gives a quick weld while at the same time it does not cause excessive overheating to adjacent seals. More information on inert-arc welding, removal and replacement of bushing can be obtained through the ABB Small Power Transformer Division.

Fig. 3 Bushing Cross Section

6. INSTALLATION

6.1 Location and Mounting

Transformer must be placed on a foundation of sufficient strength to support the weight of the unit. The foundation must be level within one half inch per 100 inch base. If the unit is not level, the liquid may not circulate properly through the panel radiators and cause overheating that will shorten the transformer life. When a transformer is designed for operation while tilted, the degree of maximum tilt will be noted on the transformer nameplate.

6.2 Ventilation for Cooling

Natural ventilation is the basic ventilation system used for Network transformer vaults and is the most dependable. The amount of heat dissipated through the vault walls and the necessary grate openings to remove the heat loss can be calculated by various methods. However, a simplified method for an approximate determination of net grating area is generally accepted. The National Electric Code recommends three square inches of net grating opening for both the air inlet and outlet for each KVA of transformer capacity. The grating is located in the vault roof.
6.3 Opening Transformer Tank

Transformers are generally shipped sealed and need not be opened. An exception to this is when delta-wye and series-multiple connections are made using an internal terminal board. These connections are accessible through a handhole located on the cover. When entry is required read and follow the instructions given below.

Likewise, when access is required for damage inspection or other problems, the following precautions should be followed. Note: Contact the factory for assistance and directions when damage is suspected or other problems exist. Observe the safety precautions that follow.

**WARNING: RELEASE INTERNAL PRESSURE PRIOR TO REMOVING TANK ACCESSORIES WITH A PRESSURE SEAL (MANHOLES, RELIEF DEVICE, PLUGS). FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.**

Internal pressure may be relieved by use of gas sample valves; or by SLOWLY removing the filling cap a thread at a time until the pressure starts to relieve itself.

**WARNING: TO AVOID DEATH FROM SUFFOCATION NEVER ALLOW ANYONE TO ENTER THE TRANSFORMER TANK UNLESS AN ANALYSIS OF THE AIR IN THE TANK SHOWS AT LEAST 19.5% OXYGEN. THE GAS SPACE ON AN OPERATING TRANSFORMER CONSISTS OF NITROGEN GAS. WHENEVER ANYONE IS IN THE TANK, A PERSON SHOULD BE STATIONED AT THE MANHOLE OUTSIDE THE TANK TO INSURE SAFETY OF THE PERSON INSIDE.**

Safety Precautions for Opening A Tank

When it is necessary to open a transformer, the following procedure should be used. Ventilate the gas space with dry air to purge it of the nitrogen gas that it contains.

Dry air should be used to ventilate the inside of the tank when it is opened for internal fitting. When dry air is used, the following restrictions should be observed:

a. Temperature of dry air entering the transformer shall be at least as high as that of the transformer and at least 10°C higher than the dew point of the outside air.

b. Dry air shall be blown into the transformer so as to create a flow of air through the cover opening. Air hoses may be taken into the transformer if they are clean and made from an oil-proof material.

c. The dew point in the transformer should never be higher than 20°F.

d. Dry Air and Nitrogen. When nitrogen is called for, the nitrogen used should have a dew point not higher than -50°C (-58°F), and total impurities not exceeding 0.1% by volume. Nitrogen can be obtained in high-pressure steel cylinders, or in some locations in insulating low-pressure containers in liquid form. In general, liquid nitrogen that will boil in the container to yield gaseous nitrogen, will have a lower dew point than gas in high-pressure cylinders.

Dry air should also have a dew point of -50°C (-58°F) or lower. It is usually available in cylinders from the nitrogen supplier. Air drying equipment is also available which is capable of producing dry air by passing air through a desiccant bed to remove moisture.

When air or nitrogen is supplied from high-pressure cylinders the proper regulating valve must be used for introducing the gas into the transformer tank. Cylinders should not be completely emptied, but should be returned to the supplier with at least 25 psig residual pressure.

Outside air may be used for ventilating the transformer if dry air is not available. If outside air is to be used for ventilation, open the transformer only if the outside relative humidity is less than 65% and if the temperature of the transformer is at least 10°C higher than the dew point of the outside air.

The maximum total time the transformer should be open is 24 hours. If this time must be exceeded, extend the length of the vacuum prior to filling specified in Table 7 by one hour for each 4 hours that the open time exceeded 24 hours. If work is interrupted, the tank should be closed, evacuated, and refilled with dry air or nitrogen.

Do not open the transformer in an area unprotected from weather during precipitation or in an area where the air may contain dirt or other particles. Either of the above could cause a transformer failure. If the transformer is opened, the openings should be protected from the entry of foreign matter into the transformer tank at all times. It may be necessary to remove some liquid from liquid-filled units for adequate inspection.

While the transformer is open, no one should be permitted on top or inside the transformer until he has emptied all pockets, checked for loose objects elsewhere on his person, such as in pants cuffs, and has removed watches and rings.
Never stand directly on any electrical insulation. Clean drop cloths should be used under working areas in the transformer to prevent objects from dropping into the structure.

All tools must be accounted for. If possible, tools should have lines attached so that they cannot be lost.

One person should be responsible for policing the people and materials into and out of the tank and for making certain that nothing is left in the tank accidentally. This person should also be responsible for limiting the length of time the tank is left open to 24 hours.

After the tank has been opened the following tests should be made.

1. A ratio test should be made on all windings and tap positions. If any measurement is off ratio by more than 0.5%, resistance and temperature measurements should be made of the windings in question and compared with factory test values.

2. Insulation resistance of each winding to all other windings and ground and from all windings to ground should be made with the windings under liquid. Record the temperature of the liquid. These readings should be comparable with measurements made at the factory.

3. When accessible, disconnect the core ground connection on core form transformers and measure the resistance from the core to the tank or end frames, using a 1000-volt megger. The resistance should exceed 100 megohms, if the core is not covered with liquid, or 200 megohms, if the core is under liquid. When the internal inspection is complete, resal the tank and refill the gas space with dry air or dry nitrogen.

6.4 Preparation for Energization

The following are instructions that must be followed when preparing the transformer for energization. These instructions provide minimum requirements to determine the transformer's readiness for service. Check off each section as it is completed.

6.4.1 ( ) Pressure Test

Prior to energization, check the integrity of the transformer tank by introducing dry air or dry nitrogen through the pressure test fitting (this may be identified as the air test valve or gas sampling valve on the transformer out-line) until a positive internal pressure of 3 to 4 psig is established. Allow the tank to stand for one to two hours, then examine the tank and fittings for leaks.

A leak above the liquid level can be located by applying a soap solution to all joints, pipe fittings and cable connections. When the pressure test is complete, reduce the internal pressure to 1 or 2 psig.

6.4.2 ( ) Insulating Liquid Test

Before energizing the transformer, the liquid must be tested in accordance with Section 8. The dielectric strength of new liquid must be 26 KV or higher.

6.4.3 ( ) Insulation Megger Test

To insure that no grounding of the windings exists, a 1000-volt megger test and a power factor test should be made. Refer to Table 2 and 3 for allowed values of insulation resistance.

<table>
<thead>
<tr>
<th>Table 2 - Minimum Insulation Resistance in Oil at 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-L Voltage</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>1.2</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>8.66</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>34.5</td>
</tr>
</tbody>
</table>

| Table 3 - Insulation Resistance Transformer Correction |
|-----------------|-----------------|-----------------|-----------------|
| Transformer Temperature °C | Correction Factor | Transformer Temperature °C | Correction Factor |
| 95               | 89.0            | 35              | 2.5             |
| 90               | 66.0            | 30              | 1.8             |
| 85               | 49.0            | 25              | 1.3             |
| 80               | 36.2            | 20              | 1.0             |
| 75               | 26.8            | 15              | 0.73            |
| 70               | 20.0            | 10              | 0.54            |
| 65               | 14.8            | 5               | 0.40            |
| 60               | 11.0            | 0               | 0.30            |
| 55               | 8.1             | -5              | 0.22            |
| 50               | 6.0             | -10             | 0.16            |
| 45               | 4.5             | -15             | 0.12            |
6.4.4 ( ) Ratio Test

A ratio test should be made at all tap positions to insure proper transformer ratios and tapchanger connection.

6.4.5 ( ) Continuity, Resistance Test

There should be a continuity check of all windings. If possible, measure the winding resistance and compare to the factory test values. An increase of more than 10% could indicate loose internal connections.

WARNING: DO NOT CHANGE CONNECTIONS ON A TRANSFORMER THAT IS ENERGIZED NOR MAKE ANY CONNECTIONS EXCEPT AS AUTHORIZED BY THE NAMEPLATE OR CONNECTION DIAGRAM. TO DO SO WILL RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

6.4.6 ( ) Connections

When electrical connections are made:

( ) a. All mating joints must be clean. All electrical connections must be to the correct terminal and be mechanically secure.

( ) b. Check that the tap changer operating mechanism is in the proper position for the required voltage.

( ) c. If the transformer is equipped with an internal terminal board, read Section 6.3 for instructions and warnings prior to opening tank.

Delta-wye and series-multiple connections are made using an internal terminal board or a de-energized switch. Make the connection according to the chart on the transformer nameplate. Terminal board connections must be mechanically tight to prevent overheating of the joint.

( ) d. The transformer tank must be grounded permanently by connecting a ground cable per the National Electric Code to a ground pad located at the bottom of the tank.

6.4.7 ( ) Liquid Level

Liquid level should be at the correct level according to Table 1.

WARNING: THE TRANSFORMER MUST HAVE THE CORRECT LIQUID LEVEL BEFORE ENERGIZING THE UNIT (REFER TO TABLE 1). FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.

6.4.8 ( ) Tank Finish

All damaged paint surfaces should be cleaned, primed, and repainted.

6.4.9 ( ) Bolt Check

Tighten all external bolts.

6.4.10 ( ) Tools

All tools or other objects used in installation are accounted for and have been removed from the transformer.

6.4.11 ( ) Liquid Temperature

The liquid temperature must be no lower than -20°C when the unit is energized. The liquid temperature gauge can be used for this determination.

When inspections and tests in Sections 6.4.1 through 6.4.12 are completed and any required repairs have been made, the transformer may be energized.

7. MAINTENANCE

WARNING: ALWAYS DE-ENERGIZE THE TRANSFORMER WHEN WORKING ON THE TRANSFORMER. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

7.1 It is the responsibility of the owner to inspect, maintain, and keep the transformer in good repair.

7.2 Report all failures during the warranty period to the ABB Small Power Transformer Division. All warranty repairs must be made or approved by the ABB Small Power Transformer Division.

7.3 The core and coil assembly can be repaired or replaced by authorized ABB personnel. Contact the ABB Small Power Transformer Division.
7.4 Tank leaks must be repaired immediately to prevent serious damage to the transformer and danger to life. Request Instruction Leaflet 48-069-20 for detailed instructions on tank repair.

7.5 The periodic test and inspections listed in Table 4 are recommended as routine maintenance.

<table>
<thead>
<tr>
<th>Check Period</th>
<th>One Month After Initial Energizing</th>
<th>Once A Year After Energizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5.1 Gauge Readings</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7.5.2 Tank Leaks</td>
<td></td>
<td>X</td>
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<tr>
<td>7.5.3 Paint Finish</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>7.5.4 Liquid Dielectric Test</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

7.5.1 The gauge readings should be recorded as well as the ambient temperature and the KVA load. Any abnormal reading is justification to make other diagnostic test or inspections immediately. Section 5 may be of assistance in determining abnormal readings.

7.5.2 If the pressure or liquid level readings give cause to suspect a leak, make a pressure test in accordance with the instructions and warnings of Sections 6.4.1

7.5.3 Inspect the paint finish for scratches or wear that expose the prime coat or the tank steel itself. Any paint damage must be repaired to prevent base metal corrosion or further deterioration of the paint surface. Contact the factory for repair instructions, if needed.

7.5.4 Liquid Dielectric Test. It is recommended that a liquid sample be taken periodically and tested. The dielectric strength of the liquid should not drop below 26 KV.

7.5.5 If additional instructions are needed, contact the factory.

8. SAMPLING OF INSULATION LIQUID

Care should be taken to procure a sample that fairly represents the liquid in the tank. A quart of liquid should therefore be drawn off before the sample is taken to insure that the sample will not be that which is stored in the sampling pipe. If the sample taken contains free water, it is not suitable for dielectric tests and the sample should be discarded. A second sample should then be taken after at least two quarts of liquid have been withdrawn. If free water still exists, the liquid should be run through a blotter filter press and re-tested for dielectric strength.

The sample of the liquid should be taken when the unit is warmer than the surroundings to avoid condensation and should also be taken only on clear days. When sampling oil from the transformer, the sample must come from the bottom of the tank.

When sampling SILICONE FLUID from the transformer, the sample may come from either the top liquid level or the bottom of the tank.

It is recommended that a 16-ounce amber glass container be used as a sampling receptacle so that any water present may readily be seen. Do not use rubber gaskets or stoppers on SILICONE FLUID sample bottles.

Additional information concerning handling, sampling, filtering, testing and reconditioning can be obtained by ordering Instruction Book 45-063-100 for OIL, and Instruction Book 45-063-102 for SILICONE FLUID through the ABB Small Power Transformer Division.

9. GASKETS

Before replacing a gasket, carefully and thoroughly clean the steel surfaces between which the gaskets are compressed to remove rust, oil grease, paint, and other foreign material. Scraping or wire-brushing the surface with de-natured alcohol is a satisfactory method of cleaning. When applying gaskets, suitable gasket cement must be used. Put the gasket in place and bolt the two surfaces together under uniform pressure. After the unit has been in service for a period of six months, retighten all the bolts.

10. RENEWAL PARTS

Order renewal parts from the ABB Small Power Transformer Division, giving description of parts wanted, as well as the serial number on the transformer nameplate. A renewal parts list can be obtained in the same manner. In order to expedite maintenance, the user should stock the parts listed on the Recommended Parts List.
11. INTRODUCTION

The Network disconnect and grounding switch, see Figure 4, is normally welded to one end of the transformer tank. The switch is divided into two parts, a switch chamber and a terminal chamber. In the ground position, the switch will withstand a short circuit current of 15,000 amperes for five seconds without any appreciable movement of the contacts.

11.1 Description

The three-position switch is designed to have the following sequence: "open", "transformer", "ground", while the two-position sequence is "open" and "transformer." The operating mechanism compels a pause in the "transformer" position to allow the electrical interlock to "pick up" or lock the switch in the "transformer" position in case the feeder is energized.

The operating mechanism on both two and three position switches includes a latching device which holds the switch in any normal operating position unless released by the operator and also provides a means by which the customer may padlock the handle.

The Network switches can be designed to interrupt the transformer exciting current (known as a Mag-Break switch) or designed for de-energized operation (known as a Deadbreak switch). The following interlock schematics show the types of operation. Figure 5 shows the operation of the three-position Mag-Break switch.

The three-position, Mag-Break switch has two interlocks. Interlock "A" prevents movement from "closed" to "ground" position while the transformer is energized; Interlock "B" prevents movement from "closed" to "open" position while the LV breaker or network protector is closed.

Interlock "A" is connected directly to the transformer low voltage so that the interlock is engaged whenever the transformer is energized. Its associated cam is slotted so that the interlock does not interfere with movement from "closed" to "open" position but prevents movement from "closed" to "ground" position if the interlock is energized.

Interlock "B" is connected through an auxiliary switch on the Network Protector to the low voltage grid or separates power supply. When the protector is closed, this auxiliary switch is open and interlock coil de-energized. This interlock is arranged to lock when de-energized. Therefore, as long as the protector is closed the switch cannot be operated.

The interlock system requires a source of power independent of the associated transformer and at auxiliary contact on the protector. The schematic diagram shows one lead grounded and the other connected to the low voltage source for each interlock. In some cases both leads from each interlock are carried through and connected to the source.

The two-position Mag-Break switch schematic shown in Figure 6 uses only one interlock.

The interlock prevents movement from "closed" to "open" position while the LV breaker or Network Protector is closed.

This interlock system requires a source of power independent of the associated transformer and an auxiliary contract on the Network Protector.

The interlock is connected through the auxiliary switch on the protector to the low voltage grid or separate power supply. When the protector is closed, this auxiliary switch is open and interlock coil de-energized. This interlock is arranged to lock when de-energized. Therefore, as long as the protector is closed the switch cannot be operated.

The Deadbreak switch interlock schematic is shown in Figure 7.

This interlock system uses one electrical interlock. The interlock prevents movement of the switch from "closed" to "open" and from "closed" to "ground", unless the transformer is de-energized. One side of the interlock is connected to the secondary side of the transformer and the other to ground. The interlock is engaged when the transformer is energized.

Voltage required for the interlock coils will be found on the instruction nameplate furnished with the transformer.
Fig. 4 Network High Voltage Disconnect and Grounding Switch
12. INSTALLATION

Before the transformer is installed, carefully examine the switch chamber for leaks. All switch chambers are tested at the factory. It is advisable to make a test at installation to make sure that no joints have opened during shipment. See “Pressure Test” in Part I, Section 6.4.1.

Operate the switch a few times to make sure that all parts move freely. The switch chamber is shipped filled with liquid unless otherwise requested and the cover is sealed in place. It is not necessary to open the switch chamber since all cables are terminated in the terminal chamber.

12.1 Terminal Chamber

The terminal chamber cover gasket is cemented to the chamber side only. Cement is not used on the other side of this gasket to facilitate removal of the cover.

The terminal chamber is usually shipped dry and must be filled with the proper insulating oil or compound (refer to nameplate) after making cable connections and replacing cover.

12.2 Cable Connections

Cable connections are made in the terminal chamber. The cable entrance to the terminal chamber is normally through either:

1) Wiping sleeves
2) Packing glands (stuffing boxes)
3) Potheads or terminators

The type cable used is the key to the kind of connection required. The cable dictates the stress cone used, entrance required and the type compound needed to fill the terminal chamber.

Caution: Refer to the cable manufacturer for stress relief cone requirements. Improper stress cone installation can cause cable failure.

12.3 Insulating Compound or Oil

When specified on the purchase orders, either compounds or oil can be supplied, otherwise the procurement is the user’s responsibility. When compound is used, the selection of the proper compound for a particular installation depends on:

1) Cable type and kind of insulation
2) Operating temperatures and voltages
3) Cable system elevation differential (PILC cables only)

**Caution:** Check specifications on cable to make sure the compound to be used is compatible. Incorrect compound may cause cable failure.

The following instructions apply to preparation and pouring of compounds.

1) Consult compound characteristics for pouring temperature. The compound type or manufacturer's style number is also shown on transformer nameplate, if compound is supplied with transformer.

2) Always use a thermometer to assure proper pouring temperature. Voids may be formed if compound is not heated sufficiently. Compound that is heated too much may damage the insulation on the cable.

**Caution:** Voids contain trapped air that can lead to partial discharge problems and possible cable failure.

3) Warm the metal parts to at least 70°F (22°C) of the terminal chamber to drive off all moisture and wipe the bushings dry before replacing cover.

4) A filling plug is provided on top of the terminal chamber and a vent plug is located on the cover plate. Remove the filling plug and install a standpipe in its place. Remove the air vent plug.

5) Pour compound through the standpipe into the terminal chamber until it comes out the air vent hole.

6) Disconnect the standpipe and replace the filling and vent plugs.

**12.4 Cable Insulation Test**

The cable insulation can periodically be tested when connected to the switch bushing. Place the switch in the "open" position and test as follows:

<table>
<thead>
<tr>
<th>Table 5 - Cable Test Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch Rating</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>15KV</td>
</tr>
<tr>
<td>25KV</td>
</tr>
<tr>
<td>35KV</td>
</tr>
</tbody>
</table>

**13. Switch Accessories**

Switches, when specified, may be equipped with auxiliary devices that aid in the installation of the transformer and/or provides additional safety.

**13.1 Tap Changer Mechanical Key Interlock**

This manually operated interlock is designed to prevent operation of the tap changer unless the switch is in "open" or "ground" position.

**13.2 Sequential Grounding Provisions**

On the three-position disconnect and grounding switch, phasing out contacts may be provided, if specified on the order, so that one phase of the cable can be grounded at a time. Buttons are provided on the operating handle for this operation. Sequence of grounding may be either left to right or right to left.

Move the switch handle from "transformer" toward "ground" with the latch pins on the switch control set for phasing out cable.

**Caution:** High voltage cable must be de-energized. To ground an energized cable will cause catastrophic failure of the switch that may cause injury or death to those in the immediate area of the switch.

1. When pin marked A on the handle (See Figure 8) stops the movement, the contacts are engaged for phase A. Phases B and C are open-circuited. Check for circuit through phase A with test voltage, then tag.

2. Release pin A on the handle and move the switch handle until pin marked AB stops movement. The contacts are then engaged for phases A and B. Phase C is open-circuited. Check for circuit through phase B with test voltage, then tag.

3. With the switch in "ground" position, all three contacts are fully engaged.

![Network Switch Operating Handle](image)
13.3 Phasing Out Tubes

When specified on the order, phasing out tubes will be supplied to provide a means for phasing out the incoming feeder. The tubes are located on the switch cover and are angled such that when phasing probes are inserted through the tubes, the probes will come in contact with the live portion of the switch bushing. The phasing out tubes are sealed with either pipe plugs or pipe caps.

13.4 Primary Bushing

The location of the primary bushings can be seen in Figure 4. There are usually six stud type bushings provided with each network transformer. All six bushings are located in the switch chamber. Three of the bushings terminate in terminal chamber for the cable connections. The other three terminate in the transformer tank opening for the coil connections. These bushings have been carefully aligned at the factory with the switch mechanism to insure proper line connections and grounding of the incoming feeder lines. Generally, additional alignment adjustment of the bushings or contacts is not required. However, alignment inspections are recommended as part of the maintenance schedule. Refer to the maintenance schedule for inspection frequency.

When replacing the bushings is required, it will be necessary to remove the switch contacts located at the end of the bushing stud as well as the cable connected to it. Note the contact location as they are removed.

Remove the nuts from the mounting studs or remove mounting bolts and pull bushing directly down to break the gasket seal. Carefully remove any gasket material remaining on mounting surface.

Important: Replace bushing gasket before installing new bushing. Be sure to use a lock washer and cup washer on each bolt head or nut to insure locking.

When installing the new bushing, tighten all four nuts until the bottom of the flange is 0.13 inches from the mounting surface. Then tighten one nut 1/2 turn. The opposite nut 1/2 turn and the remaining two nuts 1/2 turn. Repeat this procedure until bushing flange on all sides is .10 ± .01 from the mounting surface.

Caution: Failure to follow the above procedure may result in a broken flange on the cast epoxy resin bushing.

After the bushings are replaced, re-install the switch contacts as previously noted. Carefully aligning the contacts with the switch mechanism before tightening.

13.4.1 Special High Voltage Bushings

Occasionally, instead of the standard HV entrance, separable insulated connectors (Universal Bushing Wells) are mounted on the terminal compartment. In these cases the terminal chamber is filled with insulating liquid at the factory and need not be opened in the field. In making cable connections to these bushings, follow bushing manufacturer's recommendations for installation.

13.5 Quick-Break Mechanism

The quick-break mechanism furnished on Mag-Break switches normally will not require maintenance. The mechanism uses an auxiliary contact arm that maintains the circuit as the switch is moved from "transformer" toward the "open" position. When sufficient clearance between main blade and its contact has been obtained, the auxiliary contact arm opens the circuit by quick-break action regardless of the speed at which the operating handle is moved.

If a bushing of the quick-break arm is replaced, it should be adjusted so that all arms break or snap at the same time. This may be done by filing the end of the arm as necessary.

13.6 Electrical Interlock

The electrical interlock is of the spring-loaded type. The moving latch is equipped with an adjustable tension spring to adjust the pick-up and drop-out voltages of the interlock. This assembly is adjusted at the factory according to the following table:

<table>
<thead>
<tr>
<th>Table 6 — Interlock Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil Rating</td>
</tr>
<tr>
<td>125V-60 Hertz</td>
</tr>
<tr>
<td>277V-60 Hertz</td>
</tr>
<tr>
<td>460V-60 Hertz</td>
</tr>
<tr>
<td>125V-DC</td>
</tr>
<tr>
<td>250V-DC</td>
</tr>
</tbody>
</table>

Do not disturb this adjustment unless the interlock is dismantled. The interlock is located in the main switch chamber, to the rear and below the rotary bushing, see Figure 4. The tension spring adjustment can be varied using the screw attached to the spring and locked with two brass nuts.
14. MAINTENANCE

14.1 Maintenance Schedule

Make a periodic examination to keep the switch in good condition and to insure trouble-free operation. Listed below is a recommended maintenance schedule for the Network switch.

<table>
<thead>
<tr>
<th>Table 7 — Recommended Maintenance Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Main Contacts and Alignment</td>
</tr>
<tr>
<td>Auxiliary Contacts Alignment</td>
</tr>
<tr>
<td>Shaft Packing Gland</td>
</tr>
<tr>
<td>Interlock Pickup Voltages and Operation</td>
</tr>
<tr>
<td>External Mechanical Interlocks</td>
</tr>
<tr>
<td>Switch Operation</td>
</tr>
<tr>
<td>Quick-Break Latching Mechanical</td>
</tr>
<tr>
<td>Case Liquid Leaks</td>
</tr>
<tr>
<td>Internal Liquid Leaks</td>
</tr>
<tr>
<td>Condition of Liquid (Color and Dielectric)</td>
</tr>
</tbody>
</table>

(1) Two 1-year intervals followed by 3-year periods.
(2) Or check after every 200 operations.
(3) Operate switch at least once a year.

In addition to the above, all cover bolts should be tightened and the pushbuttons on the operating mechanism should be oiled with a fine grade light machine oil.

15. GASKETS

Refer to PART I Section 9.

16. LIQUID DIELECTRIC TESTS

The dielectric strength of the switch liquid should be checked on a regular basis same as the transformer. See the transformer section of this book for further instructions.