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Small Power Transformer Division
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Instruction Book
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Liquid Insulated Primary and Secondary Unit Substation Transformers

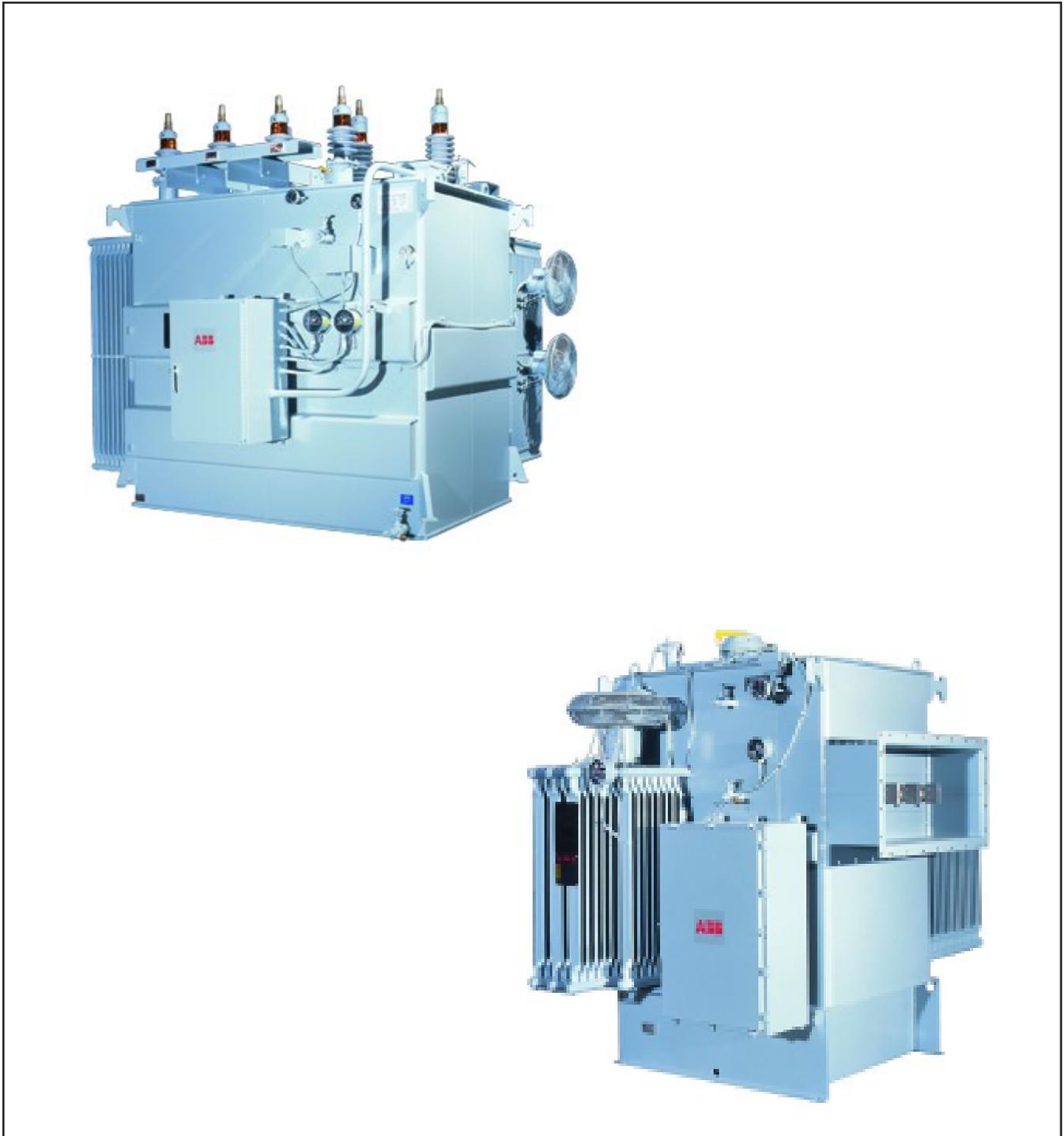




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READ THIS INSTRUCTION BOOK CAREFULLY BEFORE ATTEMPTING TO HANDLE, INSTALL, USE OR SERVICE THE TRANSFORMER. FAILURE TO FOLLOW INSTRUCTIONS COULD RESULT IN SEVERE INJURY, DEATH OR PROPERTY DAMAGE

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, nor 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 primary and secondary unit substation 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.

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. Control, fan and alarm wiring is 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 lists, outline drawings, this 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.

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

2.3 Tank Pressure

The tank pressure may be positive or negative when received, depending on liquid temperature. In some cases, the vacuum pressure gauge may read zero, which could indicate a tank leak. In such cases, pressure test the tank according to the instructions in Section 6.5.1. Report tank leaks of new transformers to the ABB Small Power Transformer Division.

2.4 Detail Parts

In making examinations of any parts of 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.

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 6.5.1. The gas space above the liquid should be pressurized with dry nitrogen between two to three PSIG. This will prevent moisture from being pulled into the tank by a negative pressure. 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 following guidelines should be followed.

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

Tests
<ol style="list-style-type: none"> 1. Record ambient temperature and barometric pressure for correction of test data. 2. Pressure test - to insure the tank and fittings do not have any leaks. After test is complete the pressure should be reduced to two (2) PSIG. 3. Test insulating liquid for dielectric strength and moisture content. 4. Test insulation with a 1000 or 2500 volt megger. 5. Check insulation power factor using Doble or similar test. 6. Test ratio in all tap positions to insure proper tap changer operation. 7. Verify liquid level by gauge reading. <p><i>When busings are not on tank, tests #4, #5, and #6 can be omitted.</i></p>

2. These transformers should be completely assembled, including the terminal chambers, switches and removable radiators, if any, to provide additional protection.

- If the transformer has wall-mounted bushings and the terminal chambers or switches have not been supplied, the bushings should be protected from the environment. A black polyvinyl material placed over the bushings will serve as protection. This material should be checked during routine inspections to insure that the material is not damaged.

- Cover-mounted bushings which are shipped unmounted on the transformer do not have to be installed during storage. They should be stored in a clean dry location in their original shipping cartons. Condenser bushings should be stored upright. When the transformer is ready to be put into service, the bushings should be physically inspected for damage prior to installation in the transformer.

3. A Transformer designed for indoor use must be stored indoors.
4. Parts that are shipped separate from the transformer must be stored in a clean, dry area.
5. Space heaters, when supplied in switches, terminal chambers, control cabinets, or other cases, must be connected and energized at all times.
6. For control cabinets only, if space heaters are not supplied or it is not practical to energize the heaters, silica gel packets must be placed in cabinet.

The following inspection should 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 covering the bushings to be sure it is not damaged. Replace if necessary.
2. Check the silica gel in the control cabinet and replace, if the silica gel container bag has a dark or wet appearance.
3. Record gauge readings, including the ambient temperature and barometric pressure.

Note: a. Pressure should be maintained at two (2) psig, taking into account variances in barometric pressure.
 b. If pressure or liquid level readings indicate a possible leak in the transformer, make a pressure according to the Instruction Book. Any leaks should be repaired immediately.

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

Annual Inspection

1. Check paint finish and touch up as necessary.
2. Test insulating liquid for dielectric strength and moisture content.
3. Test insulation megger test.
4. Check insulation power factor.

Omit test #3 and #4 if the bushings have not been mounted on the transformer tank.

When the transformer is taken out of storage, the pre-energization tests and inspections identified in Section 6.5 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 have control wiring or 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 Control Cabinet

WARNING: THE CONTROL CABINET CONTAINS SOME EQUIPMENT OPERATING AT HIGH VOLTAGES. ALWAYS REMOVE THE CONTROL CABINET VOLTAGE SUPPLY PRIOR TO PERFORMING WORK INSIDE THE CONTROL CABINET EQUIPMENT OR CONNECTED ACCESSORIES. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

Refer to the wiring diagram for electrical circuits inside the control cabinet. Use an indicating light type device when checking an alarm switch. Failure to do so could result in damage.

5.4 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. They are mounted inside the transformer tank around the transformer line leads. When the bushing is on the cover, the current transformer is mounted to the bottom of the cover around the bushing. When the bushing is on the tank wall, the current transformer may be mounted on top of the core and coil assembly. Current transformer secondary leads are always wired to a junction box. Refer to the transformer wiring diagram to identify the wire codes. The current transformer secondary leads are always shorted and grounded to the tank when the transformer is shipped.

5.5 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 which 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 7.5 of this Instruction Book.

Table 1 – Liquid Level Gauge	
Average Liquid Temp. (°C)	Correct Level (Percent of Scale Above or Below 25°C Level)
85 (High)	100
70	75
55	50
40	25
25 (Normal)	0
10	-33
-5	-67
-20 (Low)	-100

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

5.6 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, leakproof 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.

5.7 Pressure-Vacuum Gauge

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

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 7.5 of this instruction book.

5.8 Pressure Relief Device

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 on the transformer cover. The pressure relief device will vent tank gases when excessive tank pressure exists. The 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 reset manually 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. When supplied, the hood must be vented to the outdoors.

5.9 Winding Temperature Gauge

This device is also known as a Dial Hot Spot Thermometer. It simulates the hottest spot temperature of the transformer windings by sensing both the surrounding liquid temperature and a current source that is proportional to the load current.

The sensing stem is mounted in a dry well, permitting its removal without lowering the fluid level. A red pointer is furnished to show the highest temperature attained since last reset. Rotating the magnet that is located on the dial face can reset this pointer.

Should a check on accuracy and calibration be desired, obtain additional information from ABB Small Power Transformer Division.

Maintenance is not required except for the periodic inspection recommended in Section 7.5 of this instruction book.

5.10 TRO-2 Thermal Overload Relay

The Thermo Overload Relay (TRO-2) operates similar to the Winding Temperature Gauge described in section 5.8. The TRO-2 relay provides a simulated winding hot spot temperature in terms of "Percent Thermal Load." The TRO-2 is wall mounted in a well which permits removal of the instrument without lowering the liquid level. The dial face of the TRO-2 device has two colored zones, red and yellow. The yellow zone indicates a thermal load that exceeds 100%. When the indicator hand reaches this area, an alarm contact is actuated. The red zone indicates thermal loads that have reached the 110% region. In this zone, a tripout contact closes. In regions above 80%, a change in the ambient of 1°C is approximately equivalent to a 1% change in the thermal load. Maintenance is not required except for the periodic inspection recommended in Section 7.5 of this Instruction Book.

5.11 Sudden Pressure Relay and Rapid Pressure Rise Relay

The Sudden Pressure Relay (SPR) or a Rapid Pressure Rise Relay (RPRR) are optional items. Each relay's main pressure sensing element is in direct contact with the gas cushion of liquid-filled transformers. Positive operation of the bellows-actuated micro-switch occurs only in the event of an abnormal rate of rise of internal pressure and energizes a multi-contact seal-in relay fed from a separate voltage source. The relay's sensitivity is essentially unaffected by the existing static pressure in the gas space, making it sensitive to the high rates of rise that are associated with arc-producing faults in the transformer winding.

A seal-in relay reset switch, and the associated circuitry are mounted in a separate control cabinet. The seal-in relay is energized when the sudden pressure micro-switch operates and remains so until manually reset with the reset switch. Seal-in relay loads should be limited to the values given in the table listing given on the wiring diagram.

If field tests are required to check out the sudden pressure relay, consult the factory. If field tests are required to check out the rapid pressure rise relay, consult the factory.

If the SPR or the RPRR device has tripped the primary circuit breaker and disconnected the transformer, the following steps are suggested to assess the extent of damage to the transformer, if any.

1. Use a portable combustible gas detector to check for combustible gas products of decomposition in the gas space. Refer to the operating instructions for the Gas Detector.
2. Make the Field Tests of the Pressure Relay and its Panels to determine whether the Relay is in proper operating condition. Refer to instructions furnished with device or contact the factory.
3. Make insulation power factor and insulation resistance tests and check the transformer Turns Ratio.
4. Remove the manhole cover for observation. Sometimes the odor of burning is obvious.
5. Make any other tests which may be suggested by the results of the above checks.

After the condition of the transformer and Relay have been checked, and if no damage has been found, it is necessary to decide whether the breaker should be re-closed to put the transformer back into service. The risk of possible further internal damage must be balanced against the possibility that there is no serious internal damage.

5.12 Transformer Cooling Fan Motors

WARNING: ALWAYS DE-ENERGIZE THE FAN CIRCUIT WHEN INSTALLING FANS. IN ADDITION, DE-ENERGIZE THE TRANSFORMER WHEN IT IS POSSIBLE TO COME CLOSE TO LIVE PARTS. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY OR DEATH.

The cooling fan motor electrical data can be found on the motor nameplate or the wiring diagram. The controls for the motor are contained in the control cabinet mounted on the transformer. The "Manual-Auto" switch determines the mode of operation for the fan motors. When the switch is in the "Manual" position, the fans will operate continuously. When the switch is in the "Auto" position, the fans will be automatically controlled from a thermal device mounted on the transformer.

The fan motors are provided with thermal overload protection. Usually, the overload protection is contained within the motor. However, if the motors are located in a hazardous location, the overload protection device may be located in the control box. Refer to the wiring diagram for specifics.

The fan motors have permanently sealed ball bearings and require no additional maintenance, other than that recommended in Section 7.5.

When fan packages are installed by the user, IT IS IMPORTANT TO PERMANENTLY REMOVE THE LOWER DRAIN PLUG FROM THE MOTOR HOUSING. This will prevent the build up of condensation inside of the motor housing. The motors will be shipped with the plugs installed.

5.13 De-energized Tap Changer

WARNING: DO NOT MOVE THE TAP CHANGER 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 tap changer 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 and higher no-load losses and possible core saturation. Refer to the transformer nameplate for the tap voltages possible for the transformer.

The de-energized tap changer is provided with an operating handle, tap voltage position indicator and a position locking mechanism. Some de-energized tap changers may have provisions for a pad locking or a Kirk Key Interlock System.

Usually, the transformer is shipped in the rated voltage position. To change the tap voltage position, follow these steps:

- 1) DE-ENERGIZE THE TRANSFORMER
- 2) Disengage the position lock. This is done one of three ways, depending upon the tap changer used:
 - A. When a locking pin is provided, pull pin out and turn the operating handle;
 - B. When the locking provisions are in the operating handle, pull the handle straight out beyond the indicator plate, then turn the handle; or
 - C. When the model is locked in place by a small bolt, back the bolt out until it is passed the indicator plate, turn the handle to the new position.
- 3) Move the operating handle to the desired tap position. The tap voltage indicator plate identifies the tap position. On some models, the operating handle must be rotated 360° to engage the next position. Other models require only short movement to the next position indicator.

- 4) Re-engage the position lock. Only when the tap changer is in the correct position, can the position lock be engaged. DO NOT ENERGIZE THE TRANSFORMER UNLESS THE POSITION LOCK IS FIRMLY IN PLACE.

5.14 Bushings

WARNING: EXTERNAL CONNECTIONS MUST NOT EXCEED A CANTILEVER LOAD OF 100 POUNDS. GREATER LOADS MAY CAUSE BUSHING DAMAGE THAT COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

5.14.1 Bulk Type Draw Lead Bushings

Bulk type draw lead bushings require no maintenance except as described in section 7.5 of this Instruction book. If Bulk-type draw lead bushings were removed for shipment, install them as follows:

1. Remove the blind flanges covering the bushing holes.
2. Locate and untie the draw lead and pull the free end out of the bushing hole. **NOTE:** When bushings are removed for shipment, the draw-through leads are coiled up and tied to the underside of the blind flange on the bushing boss, or to a loop on the underside of the transformer cover near the bushing hole.
3. Install the gasket supplied with the bushings to the bushing boss:

Cork-neoprene gaskets:

Apply a uniform coating of gasket cement part # 53351GH to the gasket area of the mounting boss, and to the bottom of the gasket. Allow cement to become tacky, then position gasket on boss. Apply a thin coating of petrolatum to the top surface of the gasket.

CAUTION: When applying gasket cement, keep all sparks and flames away from work area. Avoid breathing large quantities of vapor and avoid continuous or excessive contact with skin.

Nitrile or Viton gaskets:

Apply a thin coating of petrolatum to the bottom surface of the gasket and place the gasket in the center of the gasket area on the boss.

4. Fish a stout cord or wire through the bushing porcelain and attach the bottom end of it to the hole at the top of the terminal on the end of the lead.

5. Draw the lead taut so that it is straight and free of twists and kinks.

6. Slip the bushing down over the draw lead while holding lead by the cord or wire. Take care not to damage the insulation on the lead while doing this.

7. Install the bushing mounting hardware (use a flatwasher and lockwasher on the nut side, and a flatwasher on the bolt side if a bolt is used) and tighten it by alternately tightening opposite corners until the flange is properly tightened:

Bushings with porcelain flange and clamping flange: Torque hardware to 8 foot pounds.

Bushings with metal flanges: Tighten until the bushing flange has contacted the bushing boss and lock washers are flattened.

8. Rotate the terminal slightly until the steel pin pressed in the draw lead seats in the slot inside the porcelain top end. With the pin seated in the groove and the draw lead pulled up, approximately ½ inch of thread should protrude above the porcelain top.

9. If the lead appears to be too short it indicates a problem which should be investigated and corrected before proceeding.

10. Apply a thin coating of petrolatum to the top surface of the cap sealing gasket and press the coated surface into the gasket recess in the terminal cap.

11. Remove the cord or wire previously attached to the draw lead. A stiff draw lead will remain in position. However it may be necessary to hold some leads by pressing between threads of the terminal with a screwdriver until the terminal cap is partially threaded onto the draw lead terminal.

12. Install the terminal cap onto the draw lead terminal and hand tighten, being careful to keep the steel pin seated in the slot inside the porcelain top.

13. Verify that the gasket is properly seated and the terminal cap centered on the porcelain.

14. To obtain proper gasket compression, torque the terminal cap to 35 ft-lbs.

15. Apply 2-3 psi of dry air or nitrogen to the transformer and check the bushing mounting and the terminal cap gasket for leaks using soap bubble solution.

5.14.2 Condenser Bushings

Instruction literature for the condenser bushings will be shipped with the transformer. These instructions will cover installation of the bushings, maintenance, and use of the power factor test terminal.

5.14.3 Other Bushings

Unless specific bushing instruction literature is delivered with the transformer, other bushing types will be factory installed and require no maintenance except as described in section 8.1 of this instruction book. Contact the factory if additional information is required.

5.15 Surge Arresters

WARNING: TO PREVENT SURGE ARRESTER DAMAGE, FOLLOW THESE INSTRUCTIONS. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

A) When installing the arrester, all mounting feet must be flush before tightening bolts. Shim if necessary.

B) The arrester must not be climbed or stood on.

C) Use only the lifting devices provided on the arrester for lifting.

D) Arrester port exhaust, if supplied, must be directed away from protected equipment and other arrester poles.

E) Poles must be made of the serial numbered units identified on the master nameplate (located on the bottom of the arrester unit).

F) Maximum cantilever force is 100 pounds for intermediate and SMX Station Surge arresters. Distribution type arresters are not to be mounted in a cantilever mode.

Transformers may be furnished with Intermediate Class, Station Class, or distribution type surge arresters as optional items. These arresters are shipped separately in a protective carton or crate. On receipt, unpack the units and examine for breakage or other damage, especially to the porcelain. Check the parts with the packing list.

5.16 Radiators

When radiators are shipped detached, all openings will be closed with blind flanges and plugs. The Radiator opening Flanges and Plugs should be examined for signs of damage.

Store radiators in such a manner that water cannot stand around the sealed openings.

Make a visual inspection of vent and drain plugs to see if the plugs are right. If they have been loosened, plugs must be removed, re-cemented and re-tightened (Teflon sealing tape may be used for sealing the threads). Store indoors or in a weatherproof shed. Radiators should be blocked off the floor if stored three months or more.

Lift individual radiators only by the lifting eye on the top end.

Radiators must be thoroughly inspected prior to assembly to be certain that no water or foreign material is in the liquid space. Avoid opening the ambient in order to prevent condensation.

If there is any evidence of moisture, the radiator must be thoroughly dried either by blowing hot air through or by flushing with hot liquid. In any case, it is desirable to flush out the cooling equipment thoroughly with hot liquid if at all possible. The radiators should be installed on the transformer the same day they are opened and not permitted to stand exposed after opening for inspection or flushing. All cooling equipment must be installed prior to final liquid filling. Radiator valves should be closed until immediately prior to final vacuum liquid filling. Lock open all radiator valves before final vacuum liquid filling.

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 through all the cooling tubes and cause overheating that will shorten transformer life. When a transformer is designed to be energized while tilted, the degree of maximum tilt will be noted on the transformer nameplate. The location of the transformer should provide for adequate accessibility, ventilation and ease of inspection for the unit. To assure proper air circulation for cooling, the transformer coolers should be at least 24 inches from any obstruction. Location in areas of corrosive chemicals should be avoided.

6.2 Opening Transformer Tank

Transformers are generally shipped sealed and need not be opened. When transformers are shipped without bushings or internal field connections are required or core ground tests are required which require internal access the following precautions should be followed.

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° 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 which 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 same source which supply nitrogen. 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 psi 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 at all times be protected against entry of foreign matter into the transformer tank. It may be necessary to remove some liquid from liquid-filled units for adequate inspection. If this is done, refilling of the transformer must be done as specified in Section 6.3.1.

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, reseal the tank and refill the gas space with dry air or dry nitrogen. Subsequent steps will be given by ABB Small Power Transformer Division to whom the suspected damage was reported.

6.3 Filling in the Field (when required)

When transformers are to be filled or topped off in the field, they must be filled under vacuum according to specific instructions. Contact the factory for these specific instructions.

CAUTION: TRANSFORMER OIL SHOULD ALWAYS BE HANDLED AS A FLAMMABLE LIQUID. IT SHOULD ALSO BE REMEMBERED THAT CLOSED TRANSFORMER TANKS MAY UNDER SOME CONDITIONS ACCUMULATE EXPLOSIVE GASES, AND THAT HANDLING PROCEDURES MAY GENERATE STATIC ELECTRICITY. SAFETY PRECAUTIONS SHOULD INCLUDE PURGING ALL GAS SPACES WITH NITROGEN BEFORE OIL-FILLING OR FILTERING AND GROUNDING THE TRANSFORMER, ITS BUSHINGS, AND ALL OIL-HANDLING EQUIPMENT. OTHERWISE, STATIC ELECTRICITY COULD IGNITE THE OIL.

CAUTION: TRANSFORMERS SHOULD NOT BE LEFT UNDER VACUUM EXCEPT DURING THE VACUUM FILLING OPERATION. LEAKS IN THE TEMPORARY PIPING AND CONNECTIONS LEAD TO DANGER OF DRAWING MOISTURE INTO THE TANK IF IT IS UNDER VACUUM DURING PERIODS OF HIGH HUMIDITY OR DURING A RAIN. IT IS RECOMMENDED THAT THE TANK BE UNDER POSITIVE PRESSURE DURING RAIN TO PREVENT DRAWING MOISTURE INTO THE TANK.

6.4 Air Terminal Chamber and 15 KV and 5 KV Switchgear Adapter Installation

WARNING: POOR INSTALLATION OF CONNECTING CHAMBERS AND ADAPTERS MAY ALLOW WATER AND OTHER CONTAMINANTS TO CONTACT LIVE PARTS. FAILURE TO PROPERLY INSTALL CONNECTING EQUIPMENT COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

Air terminal chambers are designed to provide adequate electrical insulation by maintaining a clean, dry environment around connections and to protect personnel from high voltages. Installed chamber must be installed as per instructions on drawing. Refer to the transformer outline, details and station plan drawings.

Bolt the flexible connectors to the switchgear bus bars. The number of flexible connectors supplied are determined by the transformer current and not by the current ratings of the bus bar. Check the length of flexible connectors. There should be approximately 0.375 inch (10 mm) slack to permit some movement of the bus bars to expansion and contraction and possible settling of the transformer. Next, make the ground bus connection between the transformer and switchgear. Before reinstalling the adapter housing, check electrical clearances as indicated on the outline drawing and the tightness of connections and supports. Complete the installation by assembling the housing. Install the adjustable plate so that the switchgear throat is sealed by the gasket.

6.5 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.

6.5.1 () 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 outline) 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.

6.5.2 () Insulating Liquid Test

Before energizing the transformer, the liquid must be tested in accordance with Section 7.6. The dielectric strength of new liquid must be 26 KV or higher.

6.5.3 () 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 2 – Minimum Insulation Resistance in Oil at 20°C	
L-L Voltage Class KV	Megohms
1.2	32
2.5	68
5	135
8.66	230
15	410
25	670
34.5	930
46	1240
69	1860

Table 3 – Insulation Resistance Temperature Correction			
Transformer Temperature °C	Correc-tion-Factor	Transformer Temperature °C	Correc-tion 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

6.5.4 () Ratio Test

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

6.5.5 () 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.

DANGER: 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.

6.5.6 () Connections

When electrical connections are made, all mating joints must be clean and connections must be tight. All electrical connections must be to the correct terminal and be mechanically secure. Check the following items:

() a) Line connections must be made without placing undue stress on the bushings per Section 5.14.

() 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 6.2 for instructions and warnings prior to opening tank.

Delta-wye and Series X 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.

6.5.7 () Wiring

Make a physical examination of control circuit wiring and alarm devices, if provided. Look for damaged insulation, and loose connections.

6.5.8 () Liquid Level

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

Liquid Level Gauge

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

6.5.9 () Tank Finish

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

6.5.10 () Bolt Check

Tighten all external bolts.

6.5.11 () Tools

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

6.5.12 () Liquid Temperature

The liquid temperature must be no colder than -20°C when the unit is energized. For more information, refer to Section 7, paragraph F and Table 3.

When inspections and tests in Sections 6.5.1 through 6.5.12 are completed and any required repairs have been made, the transformer may be energized.

7. REPAIR MAINTENANCE

WARNING: ALWAYS DE-ENERGIZE THE TRANSFORMER WHEN WORKING ON 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 following periodic test and inspections are recommended as routine maintenance.

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

7.5.2 If pressure or liquid level readings give cause to suspect a leak make a pressure test in accordance with the instructions and warnings of Sections 6.5.1

7.5.3 Check the cooling fans, if supplied, by setting the control switch to the “MANUAL” position. The fans should rotate at full speed within 5 seconds. The fans should rotate with very little vibration.

Check Period	One Month After Initial Energizing	Once A Year After Energization
7.5.1. Gauge Readings	x	x
7.5.2. Tank Leaks		x
7.5.3. Fan Operation		x
7.5.4. Control Wiring and Circuits		x
7.5.5. Paint Finish		x
7.5.6. Liquid Dielectric Test		x
7.5.7. Temperature Scan Bushing Terminal and Surface	x	x
7.5.8. Insulator Cleanliness Inspection		x

7.5.4 The control wiring should be checked for integrity of insulation: The conduit and control cabinet should be inspected to assure that weather resistant seals are intact. Control power supply voltage should be checked with respect to the wiring diagram.

7.5.5 Inspect the paint finish for scratches or wear that expose the prime coat or the tank steel itself. Repair paint in accordance with the instructions and warnings of Section 8.8.

7.5.6 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.

7.5.7 Using an infrared scanner, check the bushings terminal temperatures. A loose or dirty connection would be indicated by an excessive bushing terminal temperature. (NOTE: Bushing temperature will be approximately 10°C hotter than liquid temperature when transformer is at rated kVA). If the transformer is not energized, the bushing terminal connections should be checked to ensure that they are tight. Loose connections will cause excessive conductor temperatures.

7.5.8 Bushing and surge arrester insulators (porcelain, epoxy) should be clean. If the surfaces are excessively dirty, they should be cleaned while the transformer is not energized.

7.6 Sampling of Insulation Liquid

Care should be taken to procure a sample which 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.

7.7 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. The cleaning may be done by scraping or wire-brushing the surface with de-natured alcohol. Use a recommended gasket cement when applying gaskets. 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.

7.8 Additional Maintenance Instructions

If additional instructions are needed contact the factory.

7.9 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 parts listed on the Recommended Parts List should be stocked by the user.

