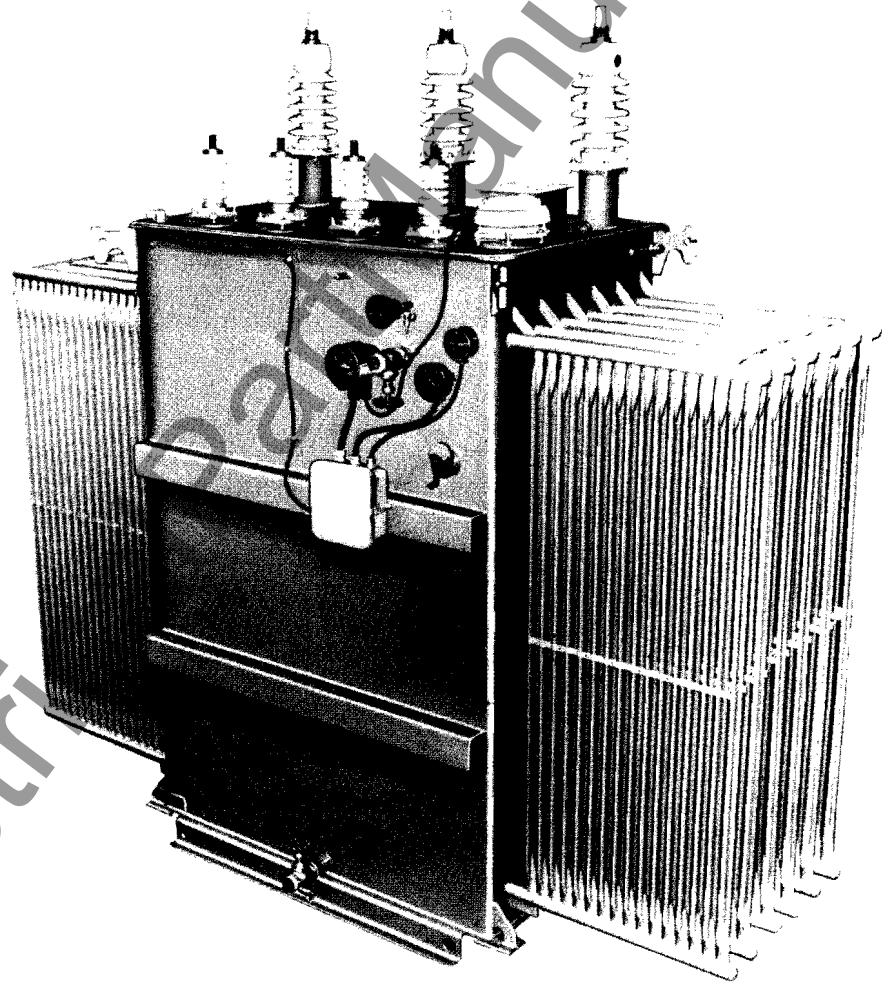


**INSTRUCTION BOOK PS-1002
FOR POWER SUBSTATION
TRANSFORMERS**



**Westinghouse Electric Corporation
Small Power Transformer Division
South Boston, Virginia 24592**

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

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1. INTRODUCTION

1.1 These instructions apply to Substation transformers manufactured by the Westinghouse Small Power Transformer Division at South Boston, Virginia.

CAUTION

Read this instruction book carefully before attempting to handle, install, use or service the transformer. Power transformers can be dangerous, and failure to follow these instructions can cause danger to life and damage to property.

1.2 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.

1.3 Read and follow all warning signs and nameplates installed on the transformer. **DO NOT REMOVE OR COVER THE WARNING SIGNS AND NAMEPLATES.** If any warning signs, labels or nameplates are missing or damaged, request replacements from your Westinghouse Sales Office.

1.4 Substation transformers are designed according to the latest revision of ANSI Standards C57.12.00 and C57.12.10 in effect at the time of design. A typical Substation transformer is shown on the cover of this Instruction Book. Electrical characteristics, winding connections and weights are on the nameplate. Refer to the outline drawing for the physical details. Fan, control and alarm wiring are on the wiring diagram called for on the outline drawing. Transformer operation is described in Sections 7.1 and 7.2 of this book.

1.5 The instructions in this book are adequate to handle, install, use or service Substation transformers manufactured by the Westinghouse Small Power Transformer Division. 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 your Westinghouse Sales Office.

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 Drawings and Documents

Shipping papers, packing lists, outline drawings, instruction leaflets 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. However, upon receipt inspect the transformer, inspect packages and parts for possible shipping damage. Also, check the bill of lading for possible shortages. If the inspection indicates a shortage, damage or evidence of hidden damage, it must be reported to the carrier's representative and to a Westinghouse representative before unloading the transformer. The external inspection should include all, but is not limited to, the items in the "CHECK LIST". When a "CHECK LIST" question is answered as shown, it should be reported as damaged.

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 6.6, Paragraph 1. Report tank leaks of new transformers to the local Westinghouse Sales Office.

2.4 Detail Parts

All detail parts should be checked against the packing list to make certain that there are no shortages. The crates and boxes should be carefully examined for evidence of damage.

In making examinations of any parts or crates for shipping damage, check carefully for evidence of moisture

CHECK LIST

<i>External Inspection of Transformer</i>	Answer Indicates Possible Damage
Blocking and Tie Chains	
1. Are all tie-down chains undamaged?	No
2. Is all blocking tight and in good condition?	No
3. Is there any evidence of load shifting in transit?	Yes
Transformer Tank and Fittings	
4. Are there indications of external damage?	Yes
5. Is the paint finish damaged?	Yes
6. Are all fittings which are shipped attached still in place and undamaged?	No
7. Is there any evidence of oil leakage? (units shipped in oil)	Yes
8. Is there either positive pressure or vacuum in the tank? (in cold weather a vacuum reading may be obtained)	No
Bushings (when shipped attached)	
9. Are any porcelains chipped or otherwise damaged?	Yes
10. Is oil level in oil-filled bushings normal?	No

and for damage to moisture barriers or waterproof wrappings when used.

The detail parts should be stored in an area that will minimize exposure to weather and the possibility of damage or loss. Refer to Section 4, "STORAGE PRIOR TO ENERGIZING".

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.

These conditions require an internal inspection:

- Transformer Tank Damage
- Broken Bushings
- Inoperative Tap Changer or Switches

Before opening the transformer, the following precautions should be taken:

a) Bleed off any internal pressure, to prevent the hand-hole cover from blowing off when the bolts are removed. Internal pressure may be relieved by use of gas sample valves; or by using a pressure relief valve when supplied. (or by SLOWLY removing the filling plug a thread at a time until the pressure starts to relieve itself.)

CAUTION

The filling plug can be blown off if the plug is removed from a pressurized transformer too quickly. Personnel could be injured by the plug. Oil or oil vapor could be expelled creating a fire hazard.

b) Ventilate the gas space with dry air to purge it of the nitrogen gas that it contains. Refer to Section 8.6.

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 OF 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.

c) 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 oil from oil-filled units for adequate inspection. If this is done, refilling of the transformer must be done as specified in Section 8.4.

The principle objective of the internal inspection is to locate any damage which might have occurred in shipment. Particular attention should be paid to leads, bolted mechanical and electrical joints, tap changers, current transformers, core and insulation structure.

If any damage is suspected, the following tests must be made:

c.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.

c.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.

c.3. 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 meggar, the resistance should exceed 100 megohms if the core is not covered with oil, or 200 megohms if the core is under oil.

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 the Westinghouse representative to whom the suspected damage was reported.

3. HANDLING

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.

CAUTION

Transformers may fall over if tilted more than 15°, or undue stress may be exerted on the bushings, causing leaks. The core and coil may be dislodged from its centering pins causing damage to the internal assembly, bushings and core and coil tie plates.

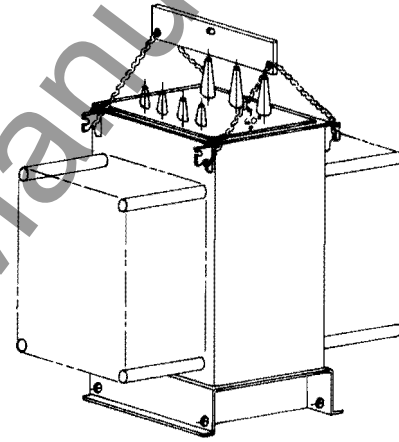
3.2 Lifting

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.

CAUTION

Lifting the transformer in places other than the tank wall lifting hooks may result in damage to the transformer causing oil leaks. It may also result in the dropping of the transformer. Use the guides for lifting contained in the table.

Chain Size (in.)	No. of Chains Req'd.	Chain Capacity (lbs.)	Chain Sling Without Spreader Bar	Capacity (lbs.)* With Spreader Bar
1/4	4	3,250	8,400	11,200
3/8	4	6,600	17,100	22,800
1/2	4	11,250	30,000	40,000
5/8	4	16,500	43,500	58,000
3/4	4	23,000	60,000	80,000
7/8	4	28,750	75,000	100,000



*Lifting capacity is the smaller of:

1. Spreader bar capacity.
 2. Chain sling capacity.
- 60° Angle is smallest angle permitted with or without spreader bar and is the angle between the chain and the cover.

3.3 Jacking

Jacking areas are provided for lifting the transformer with jacks. All such areas must be used when the transformer is to be jacked.

Check the outline drawing for any required special equipment or procedures to be used in jacking.

CAUTION

Do not jack on any area of the transformer other than the jacking areas provided for this purpose. To do otherwise may result in damage to the transformer resulting in an oil leak.

3.4 When the transformer is supplied with removable terminal chambers, these may be detached to facilitate moving the transformer.

4. STORAGE PRIOR TO ENERGIZING

4.1 Temporary Storage in Nitrogen Without Liquid

Transformers shipped in nitrogen can be stored for up to three months before filling with liquid. To assure protection of the insulation, a positive gas pressure must be continuously maintained. The best method of accomplishing this is by the temporary installation of Inertaire® equipment. The Westinghouse Electric Service Department can obtain upon request the necessary Inertaire® equipment for proper storage. The Inertaire® equipment must be installed and in operation within one week after the transformer has been delivered.

For further information on storage in nitrogen, consult the factory or obtain Instruction Leaflet 48-069-40.

4.2 Storage in Liquid

It is advisable to store the transformer completely assembled, as though it were energized, at its permanent location. In any case, the transformer should be placed on a solid, level foundation.

It is recommended that the space above the liquid be pressurized with dry air or dry nitrogen to two or three psig. This will prevent moisture from being pulled into the tank by a negative pressure. The transformer will then be ready for service at any time providing: (a) it has received the same inspection and maintenance as a transformer in service. (These inspections are listed in Section 8.1) and, (b) all checks and inspections listed under "Preparation for Energization", Section 6.6 have been made.

4.3 Separate Storage of Unmounted Accessories

Bushings which have been removed for shipment are shipped crated or boxed. Store the bushings in a clean, dry place indoors in their shipping crates. The lower end of the bushing is covered with a plastic bag to keep it clean and dry. The plastic bags on Type FS and Type OS bushings contain a bag of silica gel. If the bags are damaged, replace the bags and the silica gel before storing. Type O bushings must be stored with the top end elevated at an angle of at least 20° from the horizontal above the bottom end. A check of oil height, and of power factor and capacitance, should be made before putting an oil-filled condenser bushing into service after prolonged storage. Refer to Westinghouse Bushing Manual T.D. 33-360 for instructions on how to make these bushing tests and how to analyze the test results.

Store lightning arresters in a clean, dry place indoors in their shipping crates.

CAUTION

The line terminal assembly must not be used to lift an arrester. The lifting forces can damage the insulation and when installed may cause the arrester to fail violently and may in turn cause the transformer to fail. There will be danger to life and danger to property.

Store the detail box, containing details as shipped, indoors and in a dry place. The box contains line terminals, gaskets, internal bushing connectors, paint, gasket cement, Sudden Pressure Relay, etc., as specified on the detail packing list.

5. ACCESSORIES AND COMPONENTS

5.1 This section of the Instruction Book describes the operation and use of the transformer's accessories and components.

5.2 When accessories have control wiring or are equipped with alarm contacts, refer to the control wiring diagram referenced on the main outline drawing for contact type and terminal points.

IMPORTANT: When checking circuits through these instruments, it is necessary to follow Table I. An indicating light type device is generally recognized as best for checking circuits through instruments containing micro-switches of similar capacities.

Table 1 – Alarm Switch Ratings

Voltage	Non-Inductive Load—Amps.	Inductive Load Amps. *
125 A-C	10	10
250 A-C	5	5
125 D-C	0.5	0.05
250 D-C	0.25	0.025

*L/R equal to or less than .026.

L = Inductance in henries.

R = Resistance in ohms.

5.3 Transformer Nameplate

A nameplate is supplied on each transformer according to ANSI Standard C57.12.00, Section 9.4. The nameplate

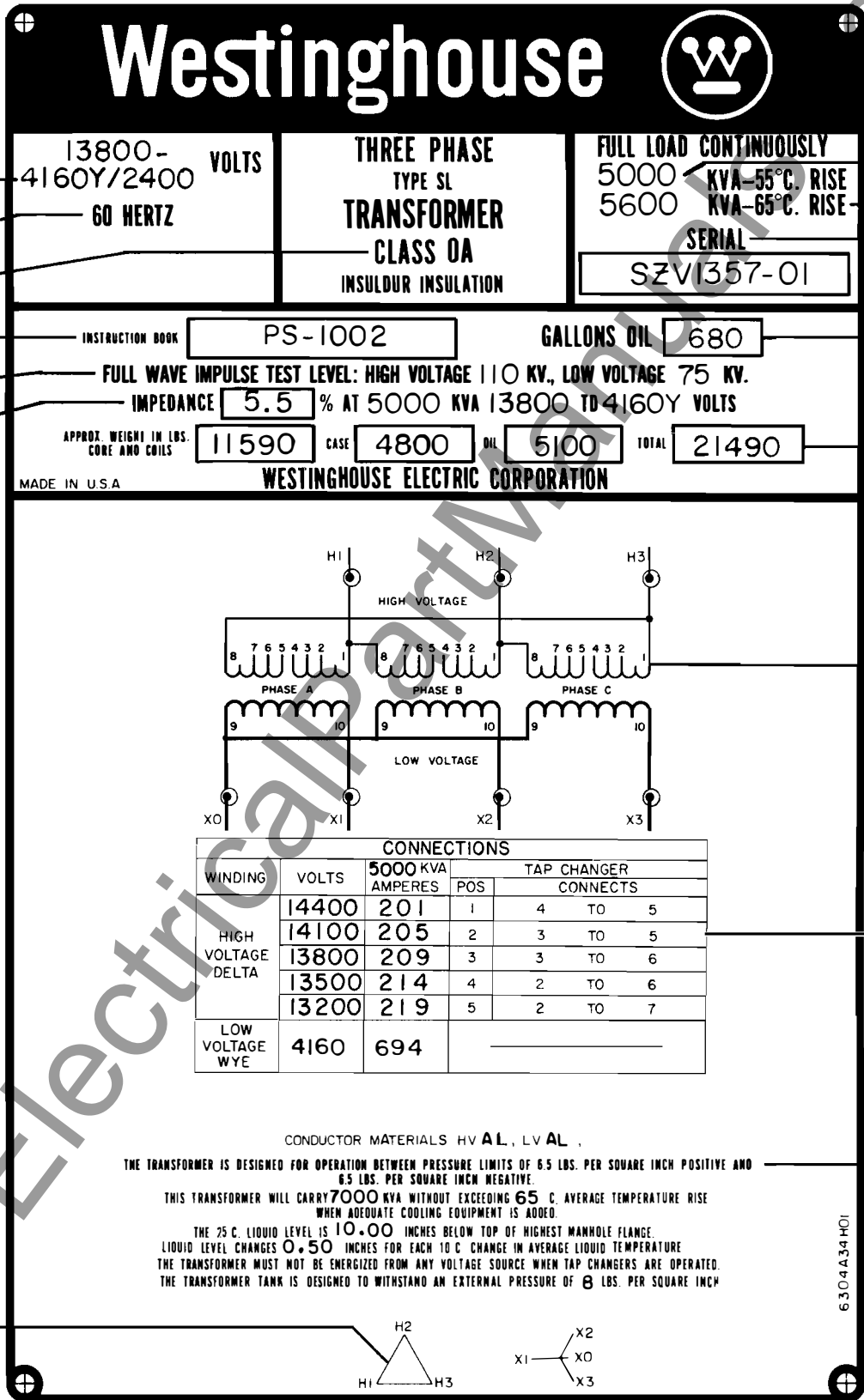


Fig. 1 Typical Nameplate

provides basic information for the correct connection and loading of the transformer. The following is a brief description of the information supplied on a typical nameplate (See Figure 1).

1. **SERIAL NUMBER:** Use this number to identify a specific transformer when communicating with Westinghouse.
2. **VOLTAGE:** The voltage shown is the rated terminal-to-terminal voltage.
3. **FREQUENCY (Hertz = cycles/second):** This is the frequency at which the transformer is designed to operate.
4. **COOLING CLASS:** This is the method of cooling used to dissipate the heat generated during operation.
5. **KVA:** This is the amount of power (or capacity) the transformer can transmit without overheating.
6. **TEMPERATURE RISE ($^{\circ}\text{C}$):** This is the average winding rise above ambient temperature.
7. **INSTRUCTION BOOK:** The instruction book that applies to the transformer.
8. **GALLONS OF FLUID AND APPROXIMATE WEIGHTS:** This information is itemized so that maximum unloading as well as total weights are known. Liquid volume of each separate compartment is specified to give the required storage capacity if the unit needs draining.
9. **IMPULSE LEVELS:** This is the full wave BIL (basic insulation level) in kilovolts of the line and neutral terminals.
10. **IMPEDANCE:** This is the percent impedance measured by test. Impedance is of particular importance when paralleling transformers. Refer to Section 7.2.6.
11. **WINDING CONNECTION DIAGRAM:** A winding connection diagram is provided to show the relative location of bushings and internal terminals.
12. **CONNECTION CHART:** This chart gives the voltage, current and connection of each tap changer position, series multiple or Delta/Wye switch position, and of internal terminal boards, when present.
13. **NOTES AND WARNINGS:** The notes below the connection chart contain important information for use in operation and maintenance. Read the notes because special features or warnings will be in the nameplate notes.

14. **PHASE RELATION:** The phase rotation and phase angle shift between the high voltage and low voltage is represented by a phasor diagram.

5.4 Liquid Level Gauge

The liquid level indicator consists of a floatarm inside the tank, an indicating pointer and a magnetic coupling between the two across a liquid-tight barrier. If the dial is damaged, the outer bezel may be replaced without disturbing the rest of the instrument without loss of liquid.

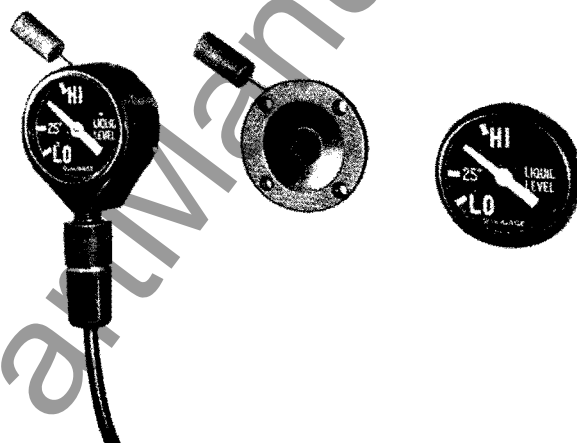


Fig. 2 Bezel with Alarm (left); Body with Float and Rod at Back (center); Bezel without Alarm Contacts

The gauge may be furnished with a Single Pole, Double Throw microswitch enclosed in the bezel to give a remote annunciation of low liquid level. Alarm switch ratings are in Table 1, page 4.

While complete instruments with or without contacts are interchangeable for a given size device, a bezel with alarm contacts should not be used on a body which was intended for use with a bezel having no alarm contacts. A larger and stronger magnet must be used in the body of an instrument when alarm contacts are in the bezel.

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 filled at some temperature other than 25°C , use Table 2 to determine the variation above or below the normal level. If these allowances are not made, excessive pressure may be built up in sealed tanks.

The indicator is usually shipped mounted on the transformer case and requires no maintenance other than the

periodic inspection required by Section 8 of this instruction book. If shipped separately or if the body is replaced, check operation of the float over its entire range to see that it is free and that the needle follows movement of the float. Coat the gasket on both sides and edges with gasket cement (53351GH). Allow to dry 15 minutes. Apply a second coat of cement, wipe off excess from the edges and put gasket in place. Mount the instrument body and tighten the bolts securely to insure against oil leaks. If alarm contacts are used, make proper connections to the control box.

Table 2 – Liquid Temperature Gauge

Average Liquid Temp. (°C)	Correct Filling 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

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 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 center of the dial. On other designs, remove the attached magnet and wipe across the face of the dial.

During normal operation the liquid temperature gauge should read less than the sum of the ambient temperature and the rated temperature rise. For example, 30°C ambient + 55°C rated temperature rise = 85°C top oil temperature.

CAUTION

Do not fill the well with solid or liquid before inserting the stem of the thermometer since this may damage the instrument without appreciably helping the transfer of heat from the oil to the sensitive element. The thermometer should not be tightened in the well any more than is necessary to place the dial in an upright position.

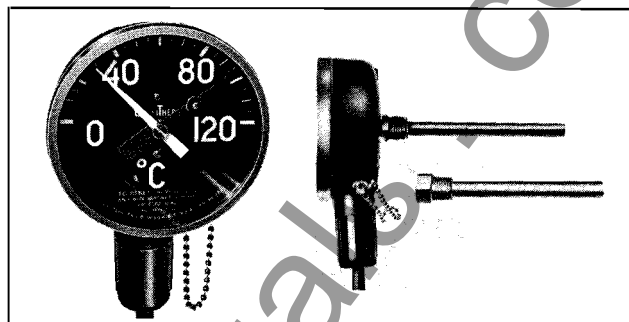


Fig. 3 Front and Side View of Indicator with Alarm Contacts

The thermometer can be furnished with a Single pole single throw contact for fan starting and a Single pole double throw contact for high temperature alarm.

The contact settings are normally 60°C with adjustments of ±10 degrees for contact number 1, and 90°C with adjustment of +10, and -25 degrees for alarm contact number 2. Alarm switch ratings are in Table 1, page 4.

The instrument is shipped fixed to the tank wall so that no installation is required. Maintenance is not required except for the periodic inspection required by Section 8 of this instruction book.

5.6 Pressure-Vacuum Gauge

The pressure-vacuum gauge indicates whether the gas space in the tank is under positive or negative pressure. The pressure will vary depending on barometric pressure and the liquid temperature, and it should normally be slightly positive. If the transformer is de-energized or operating under light load in low ambients, the pressure may go negative.

CAUTION

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, which will damage the insulation, to enter the transformer. Transformer life will be reduced if leaks are not repaired.

The gauge may be furnished with a pressure-vacuum switch with two Single pole double throw contacts for remote alarm on large positive or negative gauge pressure. Alarm switch ratings are in Table 1, page 4. The switch contacts are set to trip at 3.5 psi vacuum and 7.0 psi pressure. Ignoring an alarm may cause permanent bending or

rupture of the tank walls and cover. The design pressure on the transformer nameplate is the greatest pressure (or vacuum) that will not permanently distort the tank walls.

On oil-filled units, the pressure-vacuum gauge is furnished in combination with a pressure regulator (Sealedaire[®] valve) that will automatically bleed off gas if the pressure exceeds 6.5 psig positive or add make-up air to the tank if the pressure exceeds 6.5 psig negative. The pressure regulator is fitted with a valve and a hose fitting to take gas samples or for purging the gas space. Under normal operating conditions the Sealedaire[®] valve eliminates breathing. For further description of Sealedaire connections, send for Instruction Leaflet 48-063-2.

5.7 Pressure Relief Device

All transformers above 2500 kVA are normally furnished with a mechanical pressure relief device on the

transformer cover. The device consists of a self-resetting, spring-loaded diaphragm and a mechanical operation indicator (semaphore). Should the tank pressure increase above 10 psig, the gas pressure will lift the diaphragm and vent the excess pressure. Immediately after the pressure returns to normal, the diaphragm will reset and reseal the transformer. The mechanical operation indicator (semaphore) must be reset manually after each operation.

Replace the relief device with a blind flange before testing the transformer tank for leaks with pressure greater than 8 psi. The relief device will withstand full vacuum and need not be removed from the transformer tank during any vacuum treatment.

The relief device may be furnished with SPDT alarm contacts. The alarm device is mounted on the side of the relief device cover. Refer to Table 1, page 4, for alarm

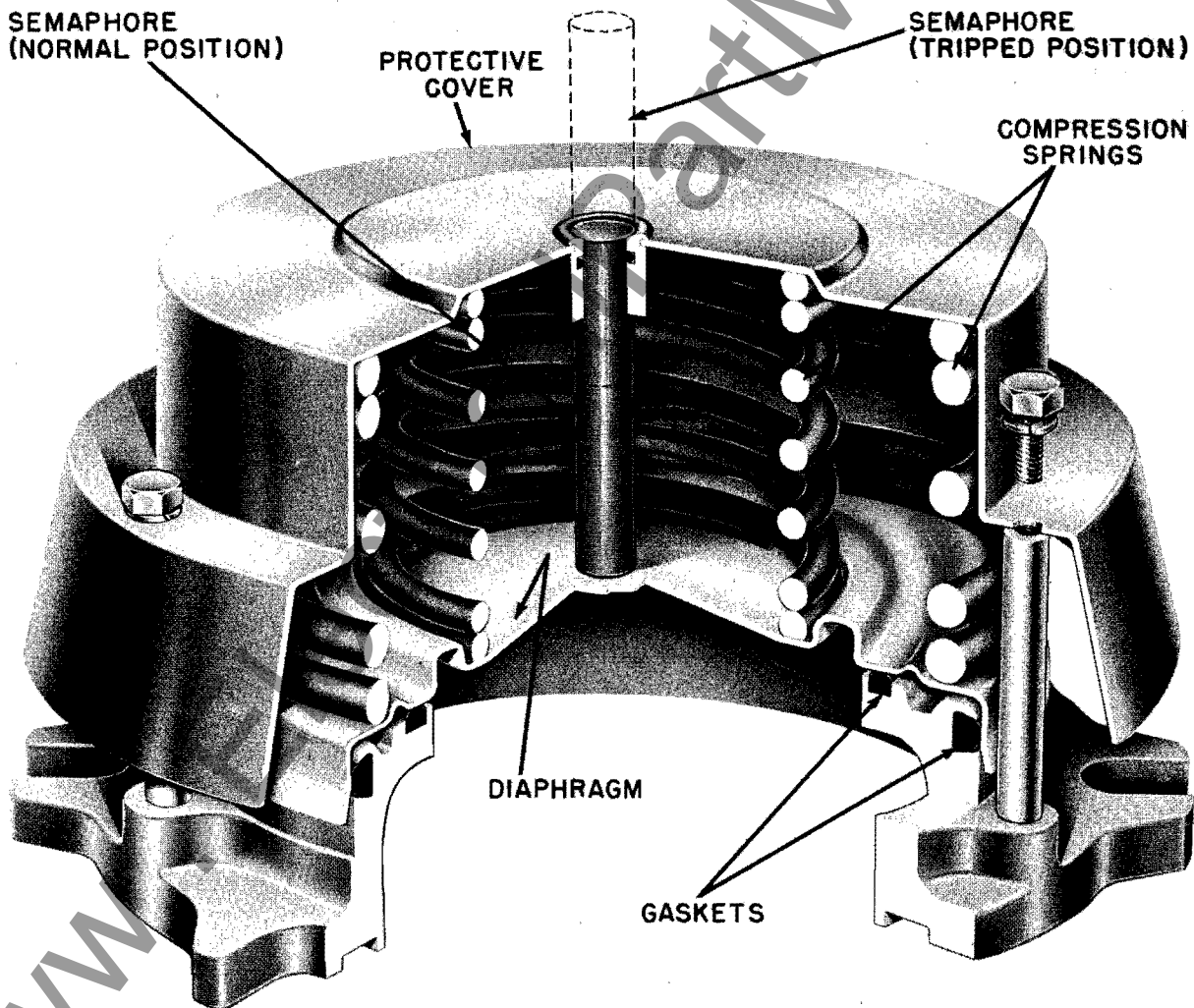


Fig. 4 Relief Device in Sealed Position

switch ratings. The alarm switch must be manually reset after each operation.

Necessary maintenance is the resetting of the semaphore and alarm switch (if supplied) after each operation. If the gasket between the transformer boss and the relief device must be replaced, follow the instructions in Section 8.7.

CAUTION

Never enter a vault or any other confined area in which a transformer relief device has been known to operate or in which a transformer has failed, until the area has been thoroughly ventilated. Gases released may be toxic and could cause danger to life. Then enter cautiously, with another person in attendance.

When requested a vent hood is supplied bolted over the pressure relief device. The purpose of the vent hood is to allow the toxic and/or combustible gas released by relief device operation to be vented outside a vault or building. It is the owner's responsibility to properly connect the vent hood.

CAUTION

Should disassembly of the relief device be necessary, caution must be exercised when removing the protective cover because the springs are under compression. The relief device cover could blow off and injure personnel.

5.8 Winding Temperature Gauge

This device, also known as a Hot Spot Thermometer, simulates the hottest spot temperature of the transformer windings.

A temperature sensitive bimetal stem is mounted in a leak-proof well, permitting removal of the instrument and heating element without lowering the liquid level. The stem is heated by both the surrounding liquid and a heater element which is fed from a current source that is proportional to load current, in order to simulate the hot spot winding temperature gradient above top liquid. The combination of the two temperatures is indicated on the gauge. A red pointer is furnished to show the highest temperature attained since last reset and is resettable by means of a push button projecting through the bottom of the dial bezel.

The gauge has four single-pole, normally open contacts with normal settings of 70, 75, 112 and 117°C.

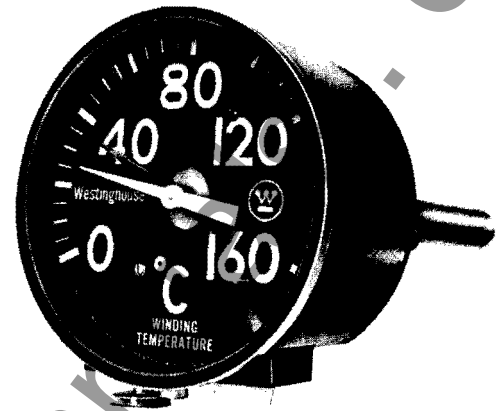


Fig. 5 Front View of Winding Temperature Gauge

Should it become necessary to adjust any of these contacts from the above factory settings, a ± 17.5 degree adjustment is possible by turning the calibration screws located on rear of case. The calibration screws are arranged in counter-clockwise order (facing the rear of the case) by ascending temperature with the 70 degree contact in the 5 o'clock position. Clockwise rotation of the screw increases the temperature at which the given switch will close. Should a check on accuracy and calibration be indicated send for Instruction Leaflet 48-062-10.

5.9 TRO-2 Thermal Overload Relay

Transformers may be furnished with a Thermal Overload Relay (type TRO-2) as an optional item for the Hot Spot Thermometer when registration is required in terms of Percent Thermal Load rather than winding hot spot temperature.

The TRO-2 relay provides no continuous indication of simulated winding hot spot temperatures but a related reading in terms of "Percent Thermal Load." It uses 3 single-pole, normally open contacts, the first of which is for actuation of fans when supplied.

The TRO-2 relay dial has two colored zones. Operation in the yellow zone will cause moderate loss of transformer life. Excessive loss of transformer life is caused by operation in the red zone. Passage into the yellow zone is accompanied by the closing of an alarm contact, while a tripout contact closes if the loading continues into the red zone above 110% thermal load. For long and satisfactory transformer life, it is recommended that the transformer be operated at all times below 100% thermal load, with whatever margin experience shows to be advisable for an-

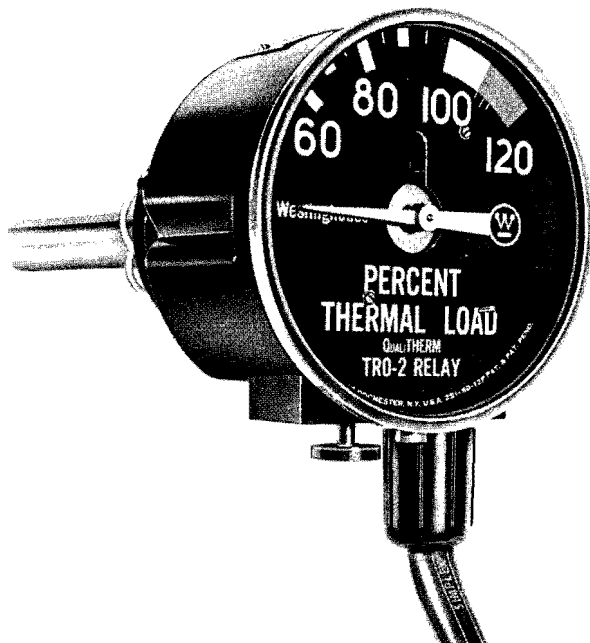


Fig. 6 Front View of TRO-2 Relay

anticipated rises in ambient. In that region of the dial above 80%, a change of 1°C in ambient temperature is virtually equivalent to a 1% change in thermal load.

Should a check on accuracy and calibration be indicated, consult with the factory or obtain Instruction Leaflet 48-062-17.

5.10 Sudden Pressure Relay

Transformers may be furnished with a sudden pressure relay as an optional item. The sudden pressure relay is mounted on the case cover with its main pressure sensing element 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 itself.

CAUTION

The sudden pressure relay must be correctly installed on its mounting boss. The bellows and equalizer holes must be above the opening in the boss. If the relay is installed 180° from the correct position, the relay may fail when vacuum is pulled on the transformer.

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. The Voltrap must be disconnected if trip circuit voltage is higher than 270 volts.

If field tests are required to check out the relay, consult the factory or obtain Instruction Leaflet 48-065-1.

After a Sudden Pressure Relay has tripped the primary circuit breaker and disconnected the transformer, it becomes necessary to decide whether to reclose the breaker and put the transformer back in service. If the transformer is severely damaged, it would probably trip again immediately but not before suffering additional damage. If the transformer is not badly damaged, it might carry load for some time. The transformer might not even be damaged at all. The decision must be made by the user, but the following steps are suggested to help determine the extent of damage:

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.

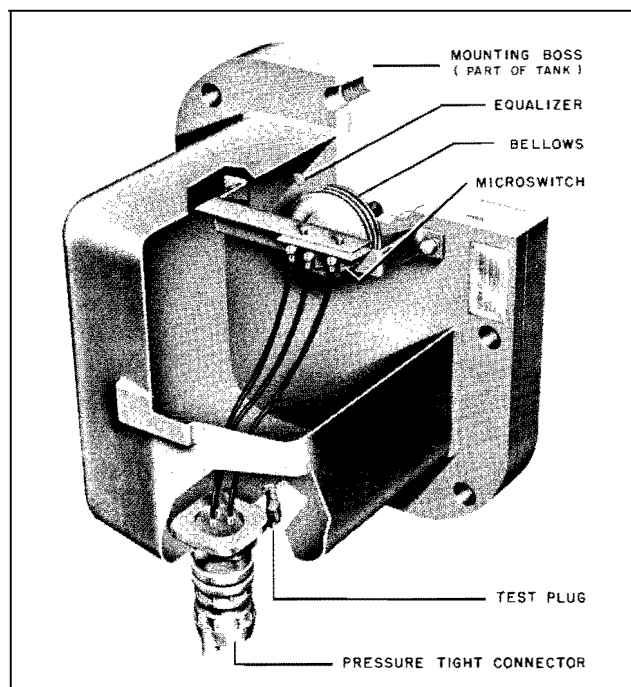


Fig. 7 Sudden Pressure Relay

2. Make the Field Tests of the Sudden Pressure Relay and its Panel to determine whether the Relay is in proper operating condition. Refer to Instruction Leaflet 48-065-1.
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 reclosed 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.

5.11 Transformer Cooling Fans

In order to provide for greater transformer loads without overheating the windings, a set of fans will be clamped to the top or to the sides of the transformer cooler assembly.

Fan control will be automatic from either the liquid temperature gauge, the winding temperature gauge, or a thermal relay (when furnished), in parallel with a "MANUAL-AUTO" control switch in the control cabinet. A starter contactor is used when fan capacity exceeds the alarm switch duty rating. When a starter contactor is required, a forced air control panel is supplied. The forced air control panel is located in a weatherproof cabinet normally attached to the tank wall. Automatic control consists of a De-ion[®] type AB line breaker, a contactor, a "manual-auto" switch and additional terminals for alarm or lamp indication. For manual control only the AB breaker is supplied.

The thermal trip AB breaker provides short circuit protection and a means of de-energizing the panel for inspection and for maintenance.

A thermally-actuated switch included in the liquid temperature gauge or the winding temperature gauge controls the solenoid of a magnetic contactor which in turn starts and stops the fan motors in response to a change in liquid or winding temperature.

The circuit is energized from the load side of the panel power circuit. The "manual-auto" switch provides a

means of starting the fans independently of the position of the thermal switch. With the thermal switch in the closed position, the fans may be stopped by opening the AB breaker. An "Auto-Off-Manual" switch is supplied instead of the "Manual-Auto" switch when requested by the customer.

Fan motors come equipped with drain plugs on the housing to prevent collection of condensate inside the motor. **WHEN INSTALLING THE FANS IN THE FIELD, IT IS IMPORTANT TO PERMANENTLY REMOVE THE BOTTOM DRAIN PLUG.**

Fan motors are single-phase, 50-60 Hertz, 1/6 hp, capacitor start and capacitor run. Rotation of the fan blade is counter-clockwise when looking at the motor from the lead end. The motors will operate between 208 and 240 v.a.c. The fan motors have permanently sealed ball bearings that require no maintenance. When replacing motors it is recommended that the capacitor also be replaced. A bad capacitor will cause the motor to draw excessive current and fail due to overheating.

WARNING

FAN BLADES ARE SHARP AND CAN CAUSE PERSONAL INJURY. ALWAYS DE-ENERGIZE THE TRANSFORMER AND THE FAN CIRCUIT WHEN DOING MAINTENANCE ON OR INSTALLING COOLING FANS. NEVER REACH INSIDE THE FAN GUARD OR FAN CAGE.

5.12 Tap Changer

The tap changer provides a means of changing the voltage ratio of a de-energized transformer without breaking the transformer seal. It is operated by means of a rotatable handle located on the side wall or cover of transformer. This handle is attached to the tap changer by means of a shaft which extends through the liquid and gas tight packing gland in the tank. The tap changer is normally provided with five positions, as indicated on the tap changer dial plate and transformer instruction nameplate.

One tap position change requires one complete revolution of the external operating handle. The transformer must not be energized unless the tap changer is locked in an operating position.

A locking pin holds the tap changer handle in any of the tap positions. By pulling this pin outward, the handle is allowed to move freely to the position desired. The locking pin can only be reset in the indexed boss. This as-

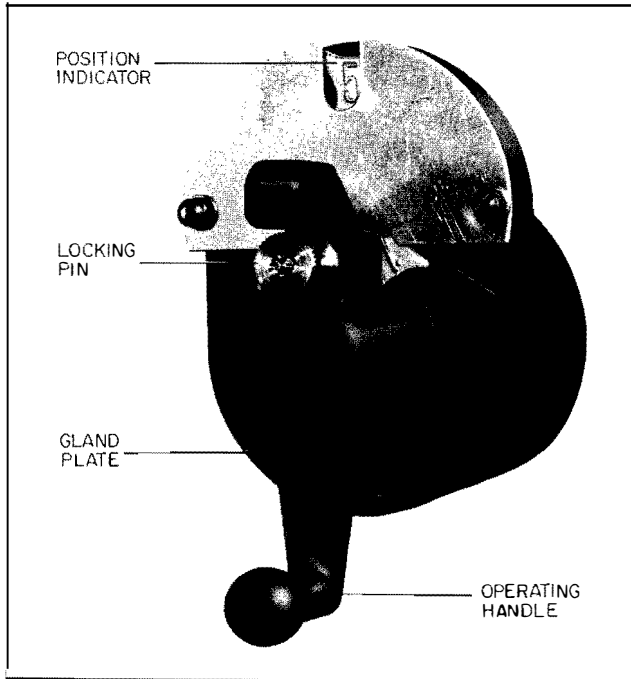


Fig. 8 Operating Mechanism and Position Indicator

ensures the proper positioning. Once the tap changer locking pin is in position, the tap changer handle cannot be moved. For added safety, the handle may be secured in position with a padlock. Kirk Key Interlock System is optional.

WARNING

DO NOT OPERATE THE TAP CHANGER WHILE THE TRANSFORMER IS ENERGIZED FROM ANY SOURCE. THE TAP CHANGER WILL FLASHOVER AND CAUSE TRANSFORMER FAILURE. THE TANK MAY RUPTURE AND CAUSE PERSONAL INJURY.

Details of the internal tapchanger mechanism can be obtained through your local Westinghouse Sales Office.

Tap changers are designed to operate without maintenance; however, the moving and/or stationary contacts may be removed for replacement in the case of minor damage. Unit replacement is recommended in case of breakdown.

5.13 Bushings

5.13.1 Cover-Mounted 25 KV Class and Below

Bulk-type bushings are used for voltage classes of 25 KV and below. For currents up to 600 amperes, Westinghouse Draw Lead, Type "RJ" bushings are used (See Fig. 9).

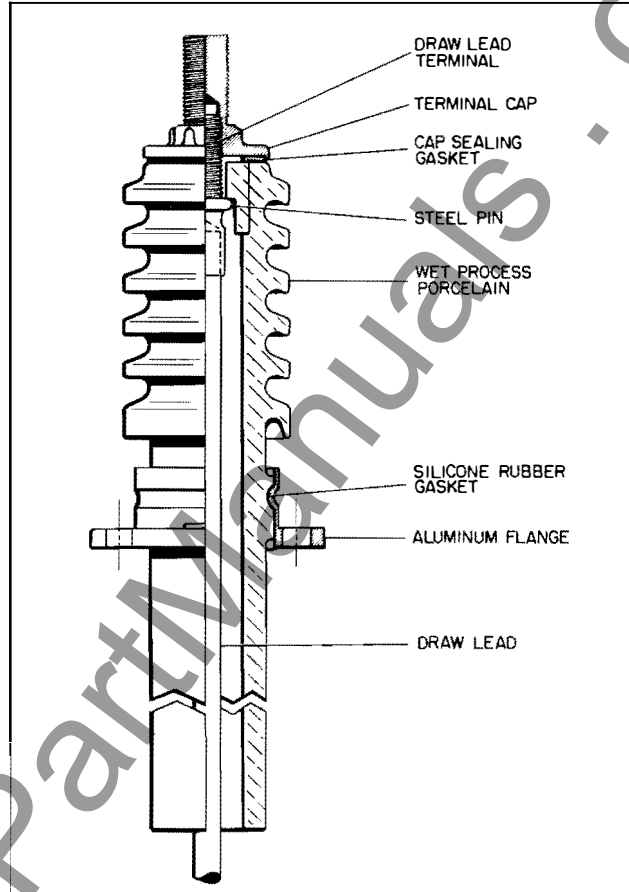


Fig. 9 Typical Cross-Section of "RJ" Draw Lead Bushing

Installation of "RJ" Draw Lead Connection

The terminal which is crimped to the draw lead has a steel pin pressed through a hole in the terminal diameter below the threads. About 1/4 inch of pin extends on both sides of the terminal to engage a slot inside the porcelain top end. A hole at the top of the draw lead terminal facilitates holding the lead while sliding the bushing over it into position. When the draw lead terminal is properly engaged in the slot about 1/2 inch of thread protrudes above the porcelain top. 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.

A thin coating of petrolatum is applied to the top surface of the cap sealing gasket. The coated side of the gasket is then pressed against the terminal cap gasket seat and held in place. The terminal cap has a tapped hole in the bottom and is screwed onto the draw lead terminal until hand tight. The gasket should be properly seated and the

terminal cap centered on the porcelain. To obtain proper compression of the gasket the terminal cap is turned 1/2 turn with a wrench after tightening as much as possible by hand.

For further details obtain Instruction Leaflet 48-061-63.

For current ratings above 600 amperes, stud-type bottom-connected, Type "RJ" bushings are used. (See Fig. 10).

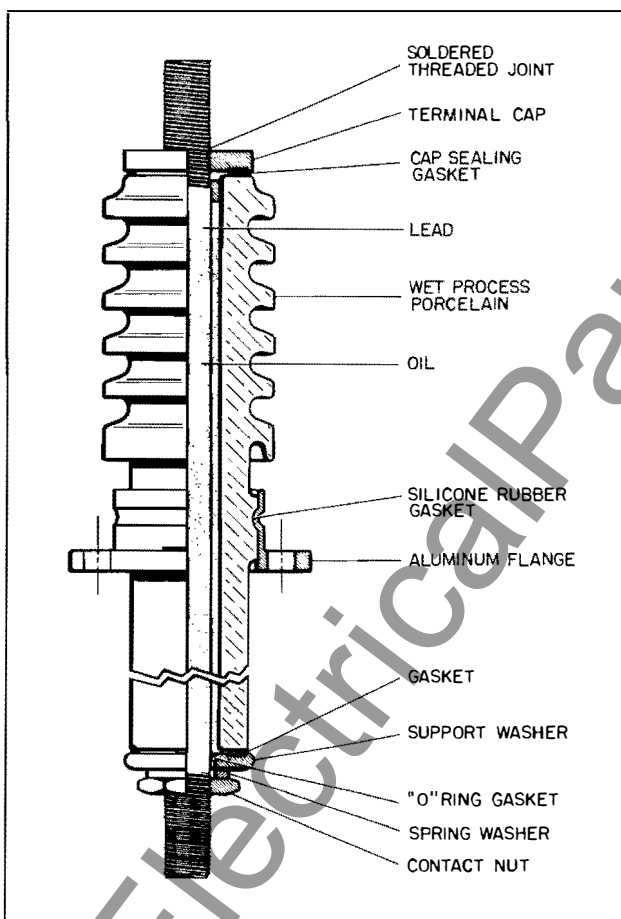


Fig. 10 Type RJ Bottom-Connected Bushing

The conductor through the center of the bushing has threaded ends defined in the NEMA Standards. A metal cap nut soldered to the conductor, and a retained nitrile gasket between the cap nut and porcelain provide the seal at the top end. The space between the porcelain and conductor is filled with oil, except for a sufficient gas space to provide for oil expansion. This oil is retained by gasket seals at the porcelain support at the lower end.

For further details obtain Instruction Leaflet 48-061-64.

Type "RJ" bushings are usually shipped mounted in place on the transformer. The bushing is mounted on a boss which is welded to the transformer tank cover. A recessed groove in the boss contains a gasket to seal between the bushing flange and the boss.

Care must be taken in handling the bushing to avoid cracking the porcelain or damaging its surface.

5.13.2 Cover-Mounted Above 25 KV Class

Outdoor Condenser Bushings are used for voltage classes of 34.5 KV and above. Westinghouse bushing Types "RCP", "OS", and "●" are normally supplied. Each bushing consists principally of a cylindrical condenser assembly, protected on its outer end with a porcelain weather casing made by the wet process. The space between the condenser and the weather casing is filled with a high dielectric strength compound or "WEMCO C" transformer oil depending on the bushing type. Each bushing is equipped with a power factor test terminal which permits making power factor tests of the bushing while it is installed by the "Ungrounded Specimen Method" without disconnecting the bushing from the transformer winding. Refer to Westinghouse Bushing Manual, T.D. 33-360, for instructions on how to make bushing test and how to analyze the test results. During normal operation the power factor test terminal must be grounded.

WARNING

THE POWER FACTOR TEST TERMINAL MUST BE GROUNDED DURING NORMAL OPERATION. IF THE POWER FACTOR TERMINAL IS LEFT UNGROUNDED DURING NORMAL OPERATION, A HAZARDOUS VOLTAGE WILL BE IMPRESSED ON THE POWER FACTOR TEST TERMINAL. FAILURE TO GROUND THE POWER FACTOR TERMINAL COULD CAUSE DANGER TO LIFE.

Figures 11 and 12 show the relative location of the power factor terminal (or voltage tap receptacle) on the Type RCP and Type ● bushings.

Figure 13 is a detail drawing of the power factor test terminal of the Type RCP bushing. Note that flange installation bolts may be installed with the bolt head up or in the down position *except* for the bolt in the bushing ground washer position. This bolt is a standard flange bolt that has been provided with a 1/4-20 threaded hole

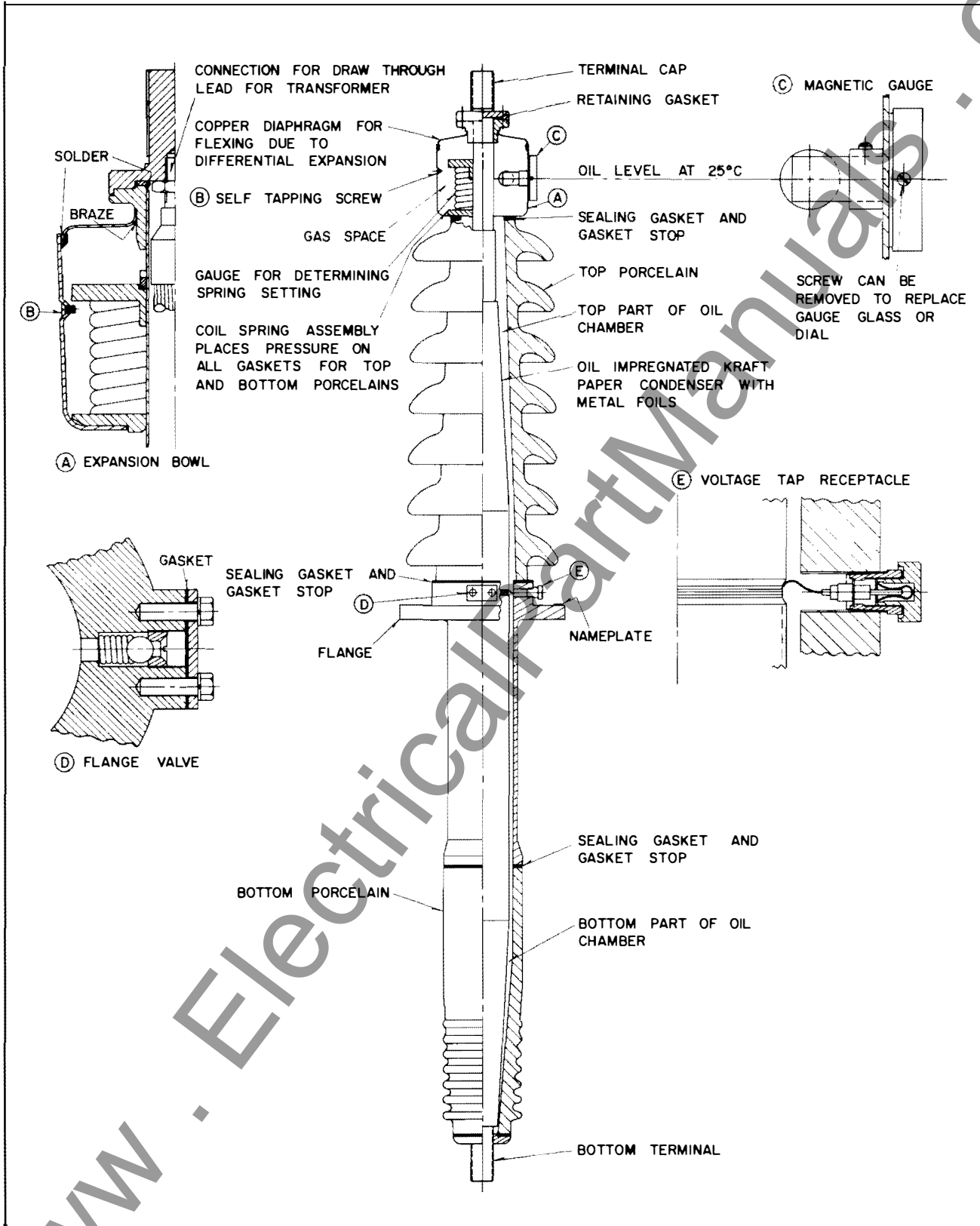


Fig. 11 Sectional View – Condenser Bushing, Type "O", 69KV

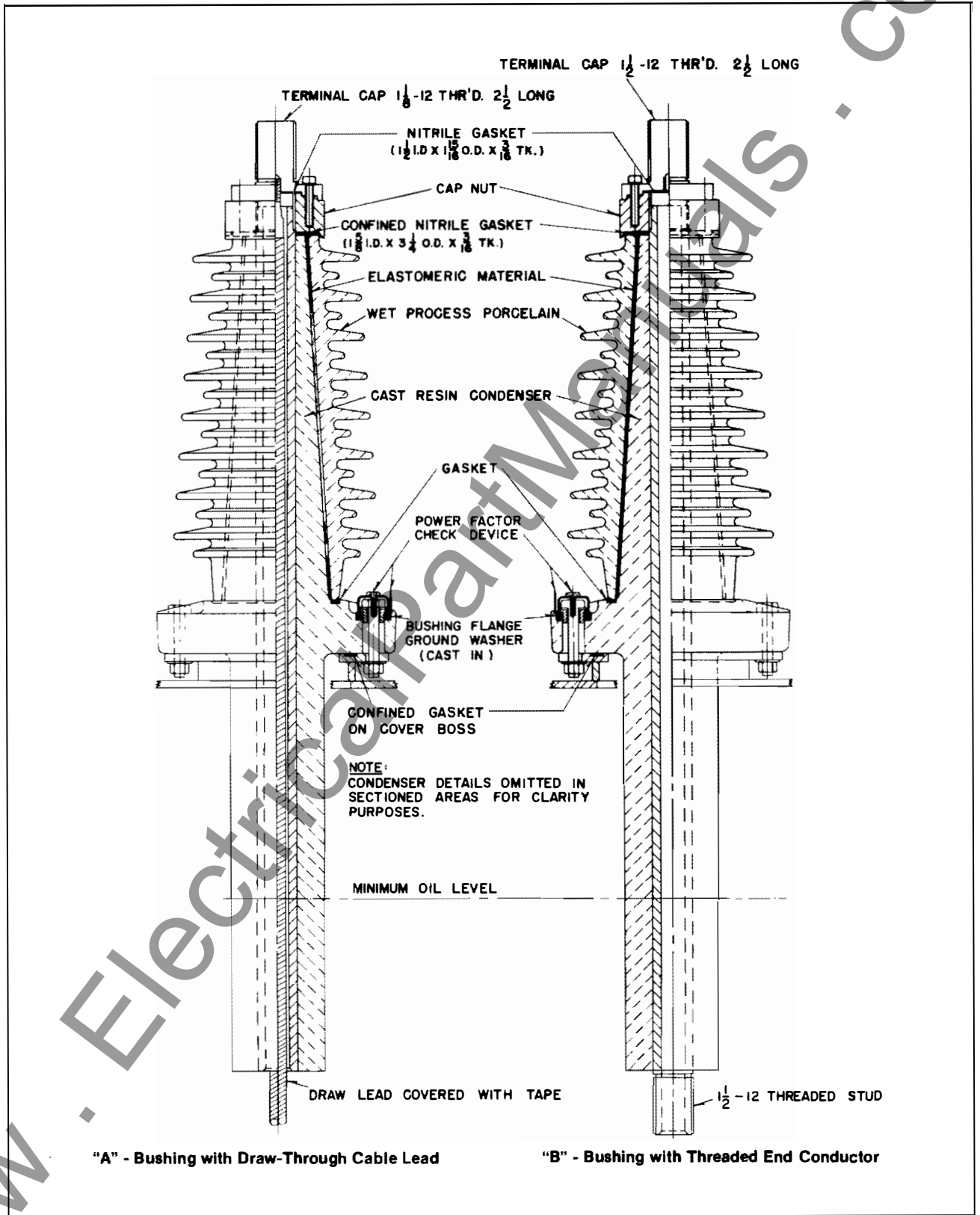


Fig. 12 Outdoor Condenser Bushings, Type RCP

in the bolt head. *This bolt must be installed with the bolt head up so as to accept the power factor check device cap.* All bushing flange installation bolts are to be tightened to a maximum torque of 250 inch-pounds. Greater torque may damage the bushing flange. Bolts should be tightened in an alternating diagonal pattern to properly seat the gasket. For normal operation, the power factor check device cap is to be tightened down so that it seats on the bushing flange ground washer.

Note: Before installing the flange bolt in the ground washer position, clean the ground washer surface if necessary to assure good contact.)

Specific condenser bushing construction is described in the following Instruction Leaflets:

Outdoor Condenser Bushing, Type RCP-IL-48-061-69

“ASA” Condenser Bushing, Type S & OS-IL-48-061-4

Outdoor Condenser, Type 0, 69 KV-IL-48-061-32

Condenser Bushing Installation

Before installing in the apparatus, wipe the bushing clean of all dust, grease or particles of packing material using cloths wrung out of transformer oil, and finish with a dry cloth.

On Type “OS” bushings, remove the wrapping from the lower end of the condenser. Do not use knives, scrapers or other sharp objects that could damage the condenser. When cleaning the condenser, use a clean cloth saturated with transformer oil.

It is recommended that condenser bushings which have been removed for shipment have the power factor and capacitance measured before they are installed in the transformer to find if internal shipping damage has occurred. This may avoid expensive disassembly from the transformer, and later questions of bushing quality when power factor tests are made on the transformer.

Important: It should be noted that the normal inherent power factor of these bushings is so low that the correct values of the bushing power factor may be greatly distorted if either of the porcelain surfaces are dirty or wet, if tests were made with the bushing near wet or grounded surfaces, or if external parts are connected to the bushings.

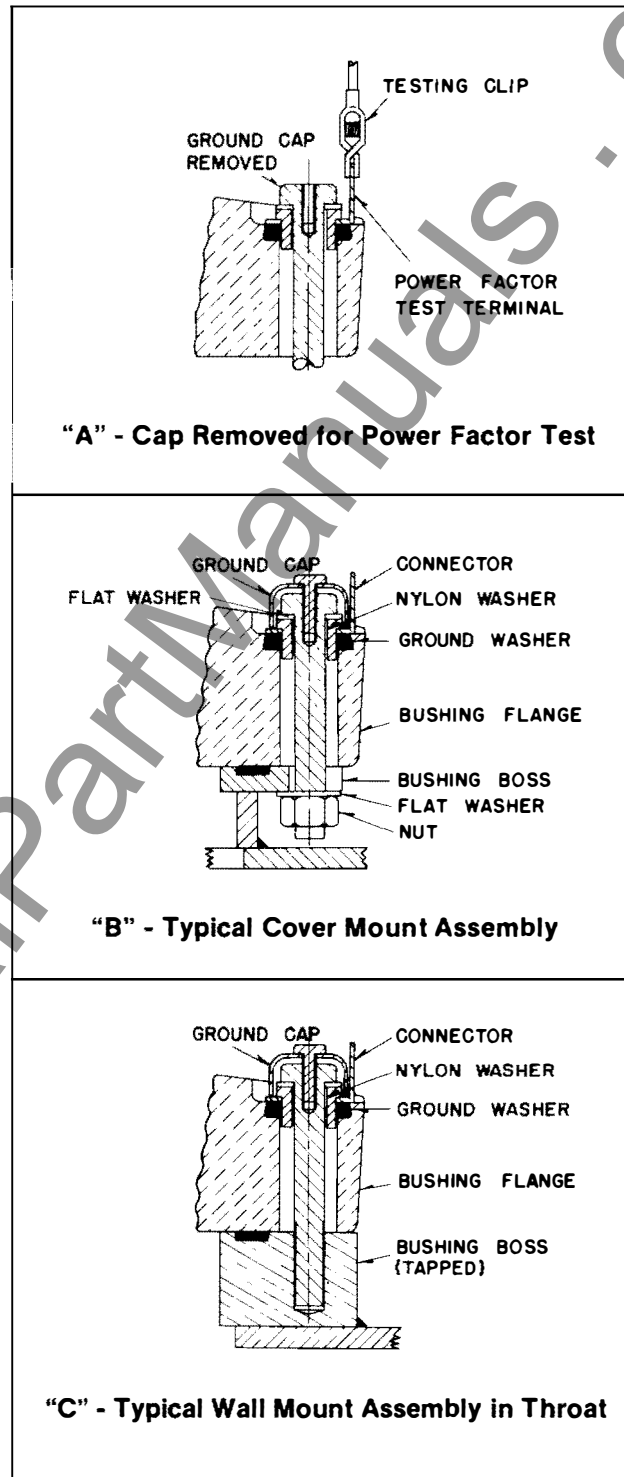


Fig. 13 Power Factor Test Device of Type RCP Bushings

Transformer bushing bosses are flat with a recess to retain the gasket and limit its compression. The side of the gasket in the recess should be covered with gasket cement

(53351GH) before it is installed. The bushing should be correctly rotated and carefully centered as it is lowered against the boss so that clearances from internal parts of the transformer are adequate.

Bushings removed for shipment are normally supplied with draw-through leads unless the current exceeds the amp rating of the largest available draw lead cable in which case the transformer leads are connected to the lower end of the bushing and the current is carried in the central tube. When bushings are removed for shipment on transformers 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 conveniently located near the bushing hole so that the bushing may be installed without lowering the oil level in the transformer.

A stout cord or wire should be fished through the bushing tube and attached to the top threaded hole in the terminal on the end of the draw-through lead. The lead should be drawn taut so that it is free of twists and kinks and the bushing is then slipped over it. If a lead appears to be too short, it indicates that something prevents its free passage through the tube and the condition should be cleared.

After the bushing is bolted down, place a drift pin or screwdriver through the lower hole in the lead terminal to hold it while the draw cord is removed. Turn the locking nut and the terminal cap (with gasket cemented in place) on the lead terminal and lock the two together. Remove the drift pin and bolt the terminal cap to the cap nut on the bushing.

It is recommended that the gas space be purged and pressurized with two to three psig of dry nitrogen after installation of bushings and checked for tank gas space leaks.

CAUTION

External connectors must not impose strains on the bushing in excess of those specified by Table 8 ANSI Standard C76.2 - 1977. Limit the cantilever load to 100 pounds on type RCP, type RJ (15 KV and below), and all cast resin and cast resin welded bushings. Greater force may cause bushing damage that can result in violent transformer failure.

5.13.3 Wall Mounted Bushings 2.5 KV - 25 KV Class

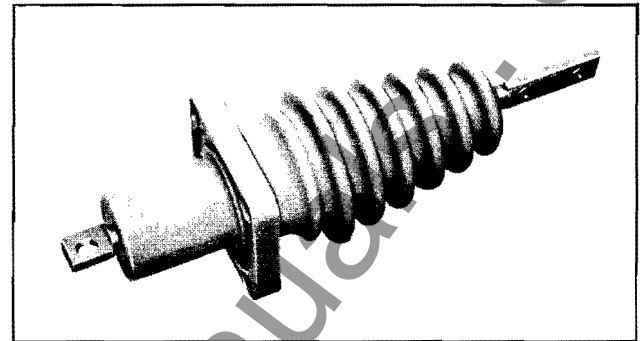


Fig. 14 Cast Resin Bushing

Cast Resin Bushings (Type CR)

Winding leads for voltage ratings of 2.5 KV through 25 KV, when brought through the case wall, use a Cast Resin Bushing. To prevent excessive mechanical loading of the bushing, only flexible connections should be made to the bushing conductor. The exposed insulating surface should be cleaned periodically to prevent accumulation of contaminating dust, dirt or chemical residue.

Care must be taken in handling the bushing to avoid cracking the resin or damaging its surface.

Should it become necessary to replace a wall bushing or its gasket, proceed as follows: Vent the tank to the atmosphere through the air test valve, until pressure is zero. Lower the liquid level to a point below the bushing level. Remove the four nuts and washers used to clamp the flange of the bushing. Disconnect the cable connection on the inner end and remove the bushing.

CAUTION

Take care to not damage the insulation on the cable connected to the inner end of the bushing. Insulation becomes brittle with age. Excessive pulling or twisting of the cable may damage the insulation. The transformer may fail violently when energized causing danger to life and damage to property.

When reinstalling the bushing, cement a new gasket in the gasket recess on the underside of the flange to insure that the gasket is properly seated in the groove. A 1-inch outside diameter metal washer and lock washer should be placed between the mounting nut and the flange. After the nuts are finger-tight, each one should be tightened until the flange is 0.10 ± 0.01 inch from the surface. After

completion, pressure test the transformer as described in Section 2.3 of this booklet.

Cast Resin Welded Bushings (Type CRW) (See Fig. 15)

Type CRW bushings can be used for wall mounted 1.2 kv class applications for use indoors or within an enclosure. This is a cast resin, hermetically-sealed bushing with a metal flange for welding to a non-magnetic steel plate on the transformer tank. Both the conductor and flange are permanently attached and sealed to the cast epoxy body.

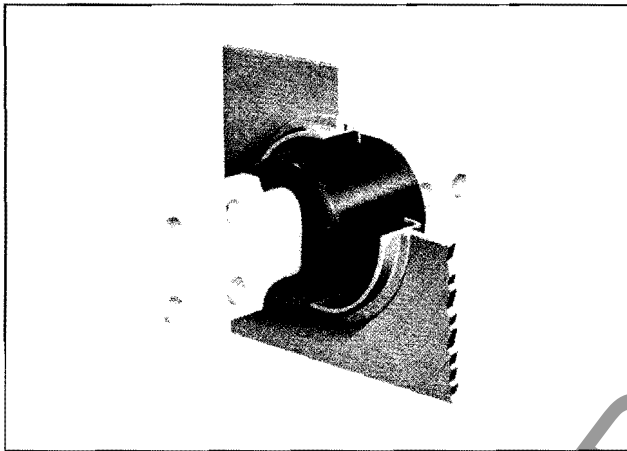


Fig. 15 *Type CRW Bushing*

Only flexible connections should be made to the air or liquid ends of the bushing conductor in order not to apply thermal expansion forces to the bushing. As a general rule, a maximum cantilever load of 100 pounds acting at the end of the bushing conductor should not be exceeded.

For axial loads applied to the bushing connector, a maximum loading of 100 pounds is permissible. Should maintenance be required due to damage, refer to Instruction Leaflet 47-061-8, "Instruction for Weld-On, Cast Resin Bushing, Type CRW".

Cast Rolled Flange Bushing (Type CRFW) (See Fig. 16)

Type CRFW bushings can be used for wall mounted 1.2 kv class applications for use indoors or within an enclosure. An insulating epoxy resin is cast around a solid copper or aluminum conductor to provide an oil tight seal. A stainless steel flange is swaged over silicone rubber o-rings, forming a sealed, weldable assembly. The bushing can be welded to the bushing plate by TIG welding techniques without heat sinks. In the bolted version the stainless steel flange incorporates a gasket retaining groove.

The assembly can then be bolted to the transformer with an aluminum clamping plate, using either a cork-Buna "N" or nitrile ring gasket to seal the bushing to the wall.

Make only flexible connections to the air or liquid ends of the bushing conductor in order to limit the thermal expansion forces on the bushing. As a general rule, a maximum cantilever or axial load of 100 pounds acting at the end of the bushing conductor should not be exceeded.

For detailed instructions on application, installation, or replacement, request Instruction Leaflet 47-051-1 for the weld-on version, or 47-051-2 for the bolted version.

5.14 Lightning Arresters

Transformers may be furnished with Type IVL Intermediate Class or Type CPL Station Class Lightning 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 porcelains. Check the parts with the packing list. Each arrester pole should include: one or more arrester units which add up to the pole voltage rating; one ground terminal bracket; one line terminal; and hardware to connect units together. In order to prevent arrester damage that can result in violent arrester failure take the following precautions.

CAUTION

1. When installing the arrester, all mounting feet must be flush before tightening bolts. Shim if necessary.
2. The arrester should not be climbed for any reason.
3. The line terminal must not be used to lift the arrester.
4. Arrester exhaust port should be directed away from protected equipment and other arrester poles.
5. Poles must be made of the serial numbered units identified on the master nameplate (the master nameplate is located on the bottom arrester unit).

Arrester mounting brackets are supplied welded or bolted to the transformer tank. Each arrester pole should be connected to the same ground as the transformer. Line connections should be made in such a way that no excessive mechanical strain is placed on the arrester. The cantilever strength of the Type IVL Arrester is 5000 foot pounds and of the Type CPL Arrester 5800 foot pounds.

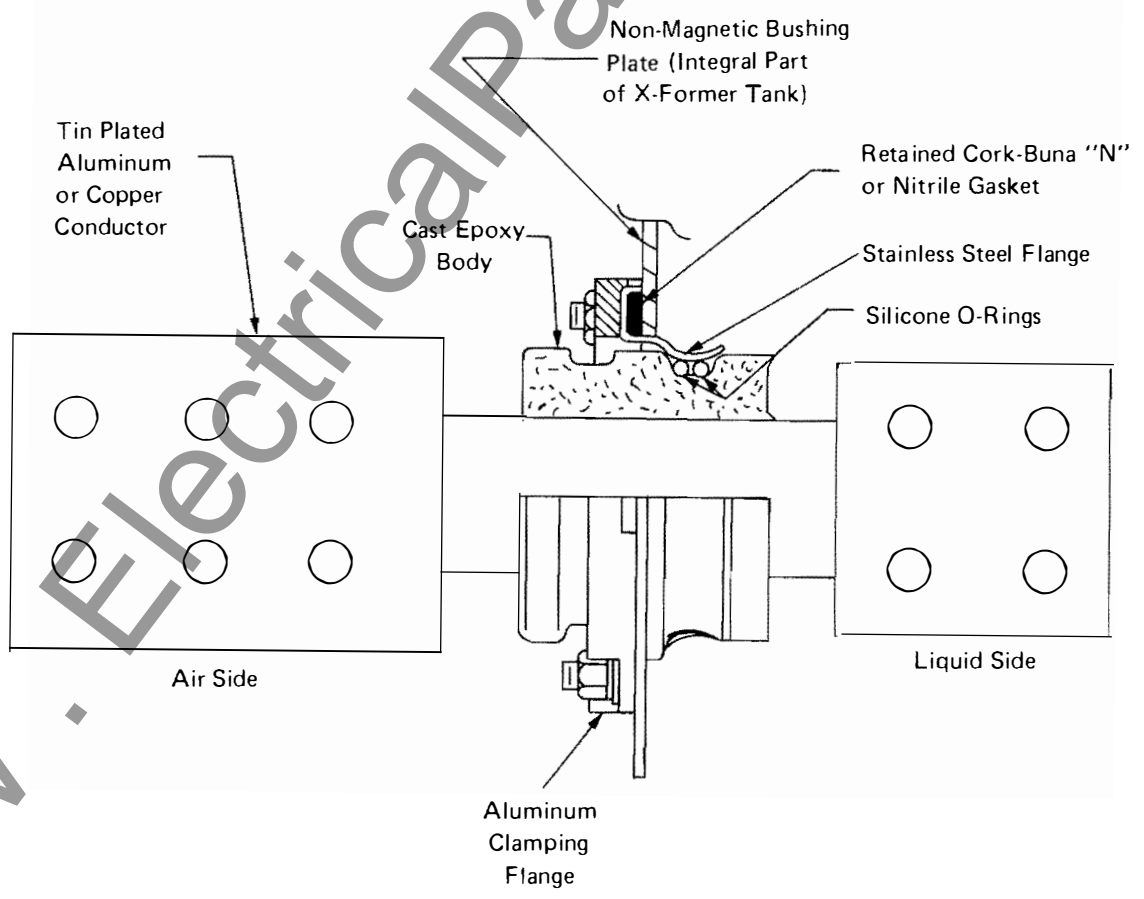
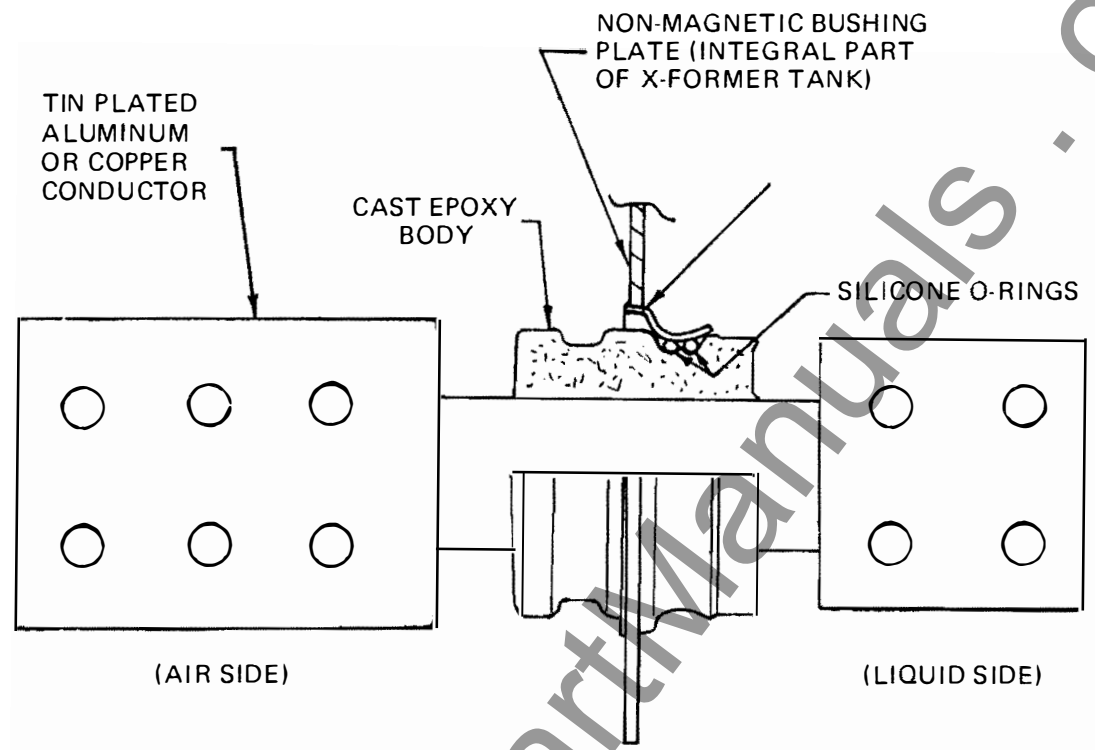


Fig. 16

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The cantilever strength should not be exceeded under any combination of forces.

Lightning Arrester Installation Procedure

1. If an insulating base is used, bolt it to the mounting bracket. If the insulating base is installed, but not used for recording or measuring equipment, ground bottom unit above insulating base.
2. The bottom arrester unit (see master nameplate) is bolted to the insulating base, or the foundation if no base is used. Include the ground terminal assembly under one of the mounting bolts—above the mounting foot.
3. After the bottom unit and associated parts are firmly anchored, install remaining units as indicated on the master nameplate.
4. Terminals

Terminal connectors, suitable for use with copper or aluminum, are supplied with each pole. Bolt to the ground terminal bracket, and to the line terminal of metal top arresters to form the line terminal assembly. These terminals accept cable .250 to .750 inch diameter. Line terminals on porcelain top units accept .255 to .681 inch diameter cable.

5. For metal top arresters, bolt the line terminal assembly to the top unit.

The IVL or CPL arrester requires no regular maintenance other than occasional inspection. In locations where the porcelain becomes contaminated by dirt, soot, salt, etc., it is recommended that the arresters be cleaned periodically.

5.15 Current Transformers

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 on the tank cover. 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.

WARNING

CURRENT TRANSFORMER SECONDARY LEADS MUST BE CONNECTED TO A LOAD OR SHORT CIRCUITED WHEN THE TRANSFORMER IS ENERGIZED. IF THE SECONDARY LEADS ARE OPEN, EXTREMELY HIGH PEAKS OR PULSES OF VOLTAGE ARE PRESENT AT THE SECONDARY TERMINALS. THESE HIGH PEAKS OF VOLTAGE MAY NOT REGISTER ON CONVENTIONAL VOLTMETERS, BUT THEY CAN BREAK DOWN INSULATION AND ARE DANGEROUS TO PERSONNEL.

5.16 Inertiaire®

Inertiaire® is the system for maintaining a cushion of inert dry gas above the liquid of transformers. When Inertiaire® is supplied, obtain Instruction Leaflet 48-063-36. A copy of that Instruction Leaflet is usually shipped inside the Inertiaire® control cabinet.

5.17 Radiators

When radiators are shipped detached, all openings will be closed with blind flanges and plugs. These 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 tight. 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 oil space. Avoid opening the radiator when it is at a lower temperature than 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 oil. In any case, it is desirable to flush out the cooling equipment thoroughly with hot oil 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 oil filling. Radiator valves should be closed until immediately prior to final vacuum oil-filling. Lock open *all* radiator valves before final vacuum oil filling.

6. INSTALLATION

6.1 Precautions

SAFETY

GOOD SAFETY PRACTICES MUST BE FOLLOWED DURING THE INSPECTION AND INSTALLATION OF TRANSFORMERS. IN ADDITION, THERE ARE PROCEDURES THAT ARE MORE OR LESS PECULIAR TO TRANSFORMERS WHICH SHOULD BE FOLLOWED FOR THE PROTECTION OF WORKMEN AND OF THE TRANSFORMER.

THE TRANSFORMER TANK MUST BE GROUNDED AT ALL TIMES. WINDINGS AND BUSHINGS MUST BE GROUNDED EXCEPT WHEN ELECTRICAL TESTS ARE BEING MADE. ALL FLUID HANDLING EQUIPMENT AND VACUUM PUMPS MUST ALSO BE GROUNDED. THIS WILL REDUCE THE POSSIBILITY OF STATIC DISCHARGES.

ELECTRICAL TESTS MUST NOT BE PERFORMED WHEN VACUUM IS APPLIED TO THE TRANSFORMER IF SUCH TEST PRODUCES A POTENTIAL OF MORE THAN 125 VOLTS ANYWHERE IN THE TRANSFORMER.

FIRE EXTINGUISHERS SHOULD BE PROVIDED FOR EMERGENCY USE. ONE SHOULD BE AVAILABLE ON TOP OF THE TRANSFORMER WHEN WORK IS BEING DONE INSIDE THE TANK. NO SMOKING SHOULD BE PERMITTED ON TOP OF THE TRANSFORMER WHEN ANY COVERS ARE OPENED OR IN THE VICINITY OF THE OIL HANDLING EQUIPMENT.

NOTE: IT SHOULD BE REALIZED THAT THE USE OF A FIRE EXTINGUISHER INSIDE THE TRANSFORMER WILL USUALLY SEVERELY DAMAGE OR RUIN THE TRANSFORMER INSULATION. CO₂ EXTINGUISHERS CAUSE THE LEAST DAMAGE.

BEFORE REMOVING ANY COVERS OR FITTINGS FROM THE TRANSFORMER, MAKE CERTAIN THAT THERE IS ZERO GAUGE PRESSURE IN THE TANK, AND THE FLUID LEVEL IS NOT ABOVE THAT PARTICULAR OPENING.

NEVER ALLOW ANYONE TO ENTER THE TRANSFORMER TANK UNLESS AN ANALYSIS OF THE AIR IN THE TANK SHOWS AT LEAST 19.5% OXYGEN. WHENEVER ANYONE IS IN THE TANK, A MAN

SHOULD BE STATIONED AT THE MANHOLE OUTSIDE THE TANK.

LIGHTS MUST BE EXPLOSION PROOF AND HAVE OIL RESISTANT CORDS.

Avoiding Transformer Damage

Transformers are generally shipped sealed and ready for energizing without opening the tank. In cases where it is necessary to open the tank for changing terminal board connections or installing high voltage bushings, extreme care is required to protect the insulation from damage. Internal parts are located to provide the necessary electrical clearances and must not be bent or moved out of position. All contaminating materials must be kept out of the tank.

While the transformer is open no one should be permitted on top of 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.

Persons entering the transformer must not have loose dirt particles on their clothing. Clean cloth shoe covers or nitrile rubber overshoes must be worn by anyone entering the tank.

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 as specified in Sections 8.4 and 8.6 of this book.

In the event of sudden weather changes, threatening rain or snow, provisions should be made for closing the tank quickly to protect the insulation.

If any object is dropped into the transformer and cannot be retrieved, a Westinghouse representative must be notified immediately.

Do not conduct vacuum operations when it is raining or while the transformer is unattended.

The use of pressure gauges containing mercury should be avoided unless an effective trap is placed between the gauge and the transformer because of the possibility of an accident resulting in mercury getting into the transformer. For measuring vacuum, properly calibrated thermocouple gauges or aneroid absolute pressure gauges are preferred.

In most cases, it is not necessary nor desirable to open the transformer tank. There are no internal braces to be removed.

The voltages of the high voltage circuit and the low voltage circuit must match the transformer voltages as shown on the nameplate. The tap changers must be set on the correct positions. The transformers must also be phased out correctly before closing the circuits. Energizing the transformer at the wrong voltage or out of phase may result in damage requiring complete rebuilding of the internal parts.

6.2 Location and Mounting

Transformers must be placed on a foundation of sufficient strength to support the weight of the unit. The foundation must be level. If the unit is not level, oil may not circulate through all the cooling tubes. The overheating that can result will shorten transformer life. When a transformer is designed to allow operation at a tilt, the degree of tilt will be noted on the transformer nameplate. The location of the transformer, whether indoor or outdoor, 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 (610 mm) from any obstruction. Location in areas of corrosive chemicals should be avoided.

6.3 Assembly

Whenever possible, transformers are shipped completely assembled, liquid filled, with all accessories installed. If it should be necessary to open the tank to install bushings or accessories, follow the precautions in Sections 2.5 and 6.1 of this book.

CAUTION

The transformer may contain positive internal pressure. Release pressure before removing manhole bolts. Internal pressure can blow the manhole cover off injuring personnel.

If possible, fill transformers shipped in dry gas with fluid before opening the tank. When the transformer can-

not be filled with fluid before the tank is opened, limit the total open time to 24 hours. Refer to Sections 8.4 through 8.6 for instructions on liquid filling and ventilation of transformer tanks.

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 OF 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.

Instructions for the installation of bushings are given in Sections 5.13.1 through 5.13.3 of this book. Complete the assembly of all items, such as bushings, which require work inside the transformer tank or through an open manhole as rapidly as careful workmanship will permit. When work is complete, all openings must be sealed. For gasketing instructions, see Section 8.7.

6.4 Filling in the Field

When transformers are shipped filled only with dry gas, they must be filled under vacuum according to the instructions in Section 8.4, "Vacuum Filling of Transformers". Do not exceed the maximum pressure (positive or negative) that the transformer tank is designed to withstand as shown on the nameplate. To do so may cause the tank to collapse.

6.5 Air Terminal Chamber and Switchgear Adapter Installation

Air terminal chambers are designed to provide adequate electrical insulation by maintaining a clean dry environment around connections and to protect personnel from dangerous high voltage. Installed chambers must be sealed tight to assure safe operation.

CAUTION

Poor installation may allow water and other contamination to enter the chamber which can cause exposed terminals to flashover, cause transformer failure, and put personnel in danger.

The unit substation-switchgear adapter is designed to permit greater flexibility in transformer design while allowing the designer of metal clad switchgear to use stand-

ardized units. To install the switchgear adapter, first remove the adapter housing if it is shipped installed on the transformer and then align the transformer with the switchgear. When aligned, there should be 17 inches between the face of the transformer throat and the face of the switchgear throat, and the centerline of the switchgear throat should coincide with the centerline of the H2 or X2 bushing in the transformer throat. Refer to the transformer outline, outline details and station plan drawings.

Next, 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 rating 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.

6.6 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.

1. () Pressure Test

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. The transformer must be de-energized when checked by this method.

When the pressure test is complete, reduce the internal pressure.

2. () Insulating Liquid Test

Before energizing the transformer, the liquid must be tested in accordance with Section 8.1. The dielectric strength of new liquid must be 26 KV or higher.

3. () Insulation Meggar Test

To insure that no grounding of the windings exists, a 1000 volt meggar test and a power factor test should be made. Refer to Section 8.3 for allowed values of insulation resistance. Compare measured insulation power factor to the values measured at the factory.

4. () Ratio Test

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

5. () Continuity 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. Use a wheatstone or Kelvin Bridge — not an ohmmeter to measure resistance.

6. () Connections

Proper connections must be made *before* the transformer is energized. Check all electrical connections to be sure they are made to the correct terminal and are mechanically secure. Check the following items:

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 CAUSE DANGER TO LIFE AND DAMAGE TO PROPERTY.

() a) Line connections must be made without placing more than 100 pounds cantilever force on Type RCP, Type RJ (15 KV and below) and all cast resin and cast resin welded bushings. Above 15 KV, external connections must not impose strains on the bushing in excess of those specified by Table 8, ANSI STANDARD C76.2-1977. Bushings should be checked for cleanliness at time connections are made and cleaned if necessary.

CAUTION

A loose connection will result in a hot joint causing damage to the adapter and could cause transformer failure.

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

WARNING

DO NOT OPERATE THE TAP CHANGER WHILE THE TRANSFORMER IS ENERGIZED FROM ANY SOURCE. THE TAP CHANGER WILL FLASHOVER AND CAUSE TRANSFORMER FAILURE. THE TANK MAY RUPTURE AND CAUSE PERSONAL INJURY.

() c) 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. Transformers are shipped connected in the higher voltage connection unless requested otherwise by the Purchaser.

WARNING

DO NOT OPERATE THE DELTA-WYE AND/OR SERIES MULTIPLE SWITCH WHILE THE TRANSFORMER IS ENERGIZED. TO DO SO WILL CAUSE DANGER TO LIFE AND DAMAGE TO PROPERTY.

() d) A secure, effective low resistance ground is essential for protection. 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.

WARNING

A POOR GROUND CONNECTION MAY RESULT IN DANGER TO LIFE OR DAMAGE TO PROPERTY.

() e) Check all condenser bushings to be sure the power factor test terminal is grounded before the transformer is energized.

WARNING

THE POWER FACTOR TEST TERMINAL MUST BE GROUNDED DURING NORMAL OPERATION. IF THE POWER FACTOR TERMINAL IS LEFT UNGROUNDED, A HAZARDOUS VOLTAGE WILL BE IMPRESSED ON THE POWER FACTOR TEST TERMINAL. THE TERMINAL MAY FLASHOVER. LIFE COULD BE IN DANGER.

7. ()

Make a physical examination of control circuit wiring and alarm devices. Look for cut or broken insulation, and open connections.

8. ()

Liquid level should be at the correct level according to Section 5.4, Table 2.

9. ()

Refinish all paint scratches. See Section 8.8

10. ()

Tighten all external bolts and hardware. Check handholes, mechanical relief devices, etc.

11. ()

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

When the inspections and tests in paragraphs 6.6.1 through 6.6.11 are complete and any required repairs have been made, the transformer may be energized.

7. OPERATION

7.1 Basic Transformer Theory

The electrical power transformer is an energy conversion device. It is used to convert electric energy from the high voltage levels used to transmit power to the low voltage levels where the energy is consumed.

A simple transformer consists of an iron core with two separate windings that are wound around the core. Refer to Figure 17. When voltage is connected to the turns of the primary winding, voltage is induced in the secondary winding by electromagnetic induction. **VOLTAGE WILL BE ON THE SECONDARY TERMINALS X1 AND X2 ANYTIME VOLTAGE IS CONNECTED TO THE PRIMARY WINDING TERMINALS H1 AND H2.** When an electrical load is connected to the secondary, current will flow in the secondary winding. The magnetic flux in the core and the current flowing in the windings generate heat, which is an indication that some of the energy is consumed in the voltage conversion. Typically, the energy lost as heat is less than 1% of the total transformed.

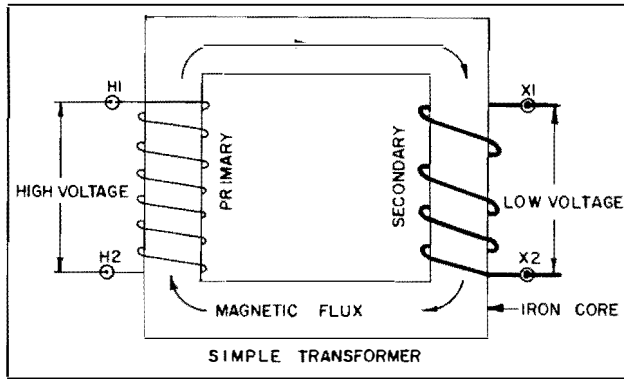


Fig. 17

7.2 Operation Instructions

This power transformer was built in accordance with the American National Standards Institute (ANSI) C.57.12, series of standards. It will perform as designed if it is operated in accordance with the applicable standards, which include:

General requirements for distribution, power and regulating transformers - A.N.S.I. C.57.12.00.

Requirements for transformers 138000 volts and below 501 through 10000/13333/16667 Kva, single phase 501 through 30000/40000/50000 Kva, three phase A.N.S.I. C.57.12.10.

Test code for distribution, power and regulating transformers - A.N.S.I. C.57.12.90.

Guide for loading oil immersed distribution and power transformers - A.N.S.I. Appendix C.57.12.92. (or NEMA TR 98)

Follow these guidelines to prevent damage to the transformer and to reduce hazard to personnel.

1. If the applied voltage is 105% of the rated voltage (for example, 15120 volts when the tap changer is on the 14400 volt position), then the load amperage must be reduced by 5%. The maximum allowed overvoltage when the transformer is connected to a load is 5% above rated. CONNECTION TO A VOLTAGE OTHER THAN THE RATED TERMINAL-TO-TERMINAL VOLTAGE MAY DAMAGE THE TRANSFORMER AND CAN CAUSE INJURY TO PERSONNEL.

2. If the transformer is energized but the secondary is not connected to a load, the applied voltage should not

exceed 110% of the rated voltage. (For example, 15840 volts when the tap changer is in the 14400 volt position).

3. Transformers depend entirely on the surrounding air to dissipate heat from the transformer losses. The ambient should not exceed 40°C (104°F) and the average temperature of the air for any 24 hour period should not exceed 30°C (86°F). The dial thermometer should read less than the sum of the maximum ambient temperature and the rated temperature rise during normal operation. That is, the maximum top liquid temperature for a 55°C rise transformer is 95°C, and 105°C for a 65°C rise transformer. The transformer's useful life will be shortened if the transformer is operated with a greater liquid temperature.

4. The kva capacity of a transformer may be increased by adding fans to force air over the cooling tubes. The amount of allowed kva increase is on the transformer nameplate. It is very important that all fans and fan controls be in operating condition and receive the maintenance required by Section 8.1. If the fans fail to operate, the transformer's useful life will be reduced and it may fail from overheating.

5. Mount the transformer on a level base so that the insulating fluid will circulate through all coolers. If the transformer has been designed to allow operation at a tilt, the nameplate will state the maximum tilt in degrees. If the maximum design tilt is exceeded, the transformer may fail immediately because energized parts are no longer under liquid. The transformer may fail from overheating if the transformer is mounted at a tilt such that some coolers are ineffective.

6. Transformer may be connected in parallel if these conditions are met.

a) Polarity, additive or subtractive must be the same (single phase transformers).

b) Phase angle shift must be the same (three-phase transformers). Phase angle shift is shown on the nameplate by the phasor diagram. Refer to Section 5.3.

c) Phase rotation must be the same. (Three-phase transformers). The phase rotation is shown on the nameplate by the phasor diagram. Refer to Section 5.3.

d) Transformer turns ratios and voltage ratings must be the same within 0.5%.

e) Percent impedance on the same kVA base must be the same within 7.5% for two winding transformers. For multiwinding and auto transformers the limit is 10%.

Refer to Instruction Leaflet 48-067-1 for further instructions.

7. Transformers are normally designed for operation at altitudes below 1000 meters (3300 ft.). To operate a transformer above 1000 meters, it is necessary to reduce the electrical load and to increase the electrical insulation clearances between energized terminals. Refer to ANSI C57.12.00 and C57.12.92 for detailed guidelines.

If the transformer has been designed to allow operation at altitudes above 1000 meters, the nameplate will state the maximum design altitude.

8. *Do not connect a load* to a transformer whose temperature is -20°C (-4°F) or less. When the temperature is less than or equal to -20°C , the liquid level gauge will indicate "LO" liquid or less. The transformer should be energized and allowed to warm up (above -20°C) before connecting electrical load. To do otherwise may result in electrical failure or overheating the transformer. Electrical failure can result if energized internal parts are above liquid. The core and coils can overheat if solidified liquid blocks the cooling tubes.

9. Some transformers have internal terminal boards or switches to select either of two voltages on a winding or either delta or wye connections on a winding. The transformer must always be de-energized to change these connections. Depressurize the tank before opening a handhole to gain access to an internal terminal board.

7.3 Inherent Hazards

Transformers by the nature of their construction and use can be dangerous.

1. The voltage present in energized transformers is a danger to the life of anyone coming in contact with it.
2. Internal pressure may become excessive causing mechanical pressure relief device operation. Anyone near the transformer may be sprayed with hot flammable insulating liquid. Anyone attempting to remove a bolted handhole runs the risk of being hit by the cover if the internal pressure is not vented first.

3. Oil filled transformers present a fire hazard to the installation area. All liquid leaks must be repaired immediately because transformer liquid is very flammable.

4. Should an internal arc occur in the unit, the internal pressure will increase and may increase so rapidly that the tank may rupture, even though the mechanical pressure relief device has operated.

WARNING

IN THE EVENT OF TRANSFORMER FAILURE, CONTINUED CONDUCTION OF FAULT CURRENT MAY RESULT IN THE VIOLENT RUPTURE OF THE TRANSFORMER TANK, CAUSING A HAZARD TO LIFE AND PROPERTY.

8. MAINTENANCE

8.1 After the transformer has been properly installed and is in operation under the conditions for which it was designed, it must receive periodic tests and inspections.

The following periodic test and inspections are recommended so that the owner can detect the adverse affects of unusual operation conditions or verify that the transformer's operation is normal. Refer to Table 3 for frequency of inspections.

1. The gauge readings should be recorded as well as the ambient temperature and the Kva load at that time. Any abnormal reading as explained in the accessory description section of this book is justification to make other diagnostic tests or inspections immediately. Readings should be made on a schedule that is rigidly adhered to.
2. Whenever the transformer is de-energized, inspect bolted electrical connections to the transformer. A loose bolted connection is a high resistance connection that will generate enough heat during operation to melt the electrical conductors causing at the very least an interruption in service and worse a transformer failure.
3. The transformer should be inspected for leaks at weld joints and gasket surfaces. If there is reason to suspect a gas or liquid leak, make a pressure test according to the instructions in Section 6.6.1.
4. Check the cooling fans by setting the control switch to the "manual" or "on" position. The fans should rotate at full speed within 5 seconds. The fans should rotate with very little vibration. The bearings of fan motor are

sealed at the factory and need no lubrication for the life of the motor.

5. The control wiring should be checked for integrity of insulation. The conduit and control cabinet should be checked to assure that they are weatherproof. Control power supply voltage should be checked with respect to the wiring diagram.

6. Inspect the paint finish for scratches or wear that expose the prime coat or the tank steel itself. Repair paint flaws as soon as practical. Local climates vary too widely to give definite recommendations as to frequency of re-painting.

7. Using an infrared scanner, inspect the operating transformer's surface temperature. Be sure to check bushing terminals and cooling fins. At 50% or less of rated load, uneven heat distribution on cooling fins is common. Any unusually hot or cold surface should be investigated.

Table 3. Recommended Maintenance Schedule

Check Period	Just Prior To Energizing	One Month After Energizing	Once a Year
1. Gauge Readings	X	X	X
2. Bolted Connections	X		
3. Tank Leaks	X		X
4. Fan Operation	X		X
5. Control Wiring & Circuits	X		X
6. Paint Finish	X		X
7. Surface Temperature with Infrared Scanner		X	X
8. Liquid Dielectric Test	X		X

8. 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.

If the dielectric strength drops below 22 Kv, the liquid should be filtered. Sampling and testing procedures can be found in Instruction Book 45-063-100 for OIL, I.B. 45-063-102 for SILICONE FLUID, and I.B. 47-053-1 for WEMCO "FR" insulating oil.

8.2 Sampling of Insulating Liquid

Care should be taken to procure a sample which fairly represents the liquid in the tank. A sufficient amount 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, Instruction Book 45-063-102 for SILICONE FLUID and Instruction Book 47-053-1 for WEMCO "FR" through the nearest Westinghouse Sales Office.

8.3 Drying of Transformer

Occasionally, moisture will be absorbed in the windings and insulation which a liquid filtering process will not remove. Whether the windings must also be dried after the liquid filtering process is determined by an insulation resistance test. The measured insulation resistance should be compared to factory test values. If that data is not available, use the values in Figures 18 and 19 as a guide.

CAUTION

It is hazardous to attempt drying out a transformer unless constant attention is given the job. An unattended transformer could be destroyed if the coils are allowed to overheat.

A recommended method of drying the windings and insulation is by circulating current through the windings. The LV winding should be short-circuited and sufficient voltage impressed across the high voltage winding to circulate enough current through the coils to maintain the coil temperature at 80°C to 90°C as measured by winding resistance. About one-fifth of normal full-rated current is generally sufficient to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers. This voltage will generally be approximately 1/2 percent to 1-1/2 percent of the normal voltage of the winding at normal frequency. The cooling tubes or radiators should be blanketed to prevent air circulation and thus heat loss. Otherwise, the power requirements will be excessive.

The transformer should be placed in its case with the liquid and with the handhole cover removed to allow free circulation of the air in the gas space.

For complete information on determination of dryness and additional methods of drying out, order Instruction Leaflet 48-620-1.

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

Fig. 18

8.4 Vacuum Filling of Transformer

The evacuation and liquid-filling operations specified in the following are intended to be accomplished as continuous uninterrupted processes.

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
40	3.3		

Fig. 19

During the vacuum and liquid-filling operations, the temperature of the core and coils must be above 0°C (32°F). The temperature of the liquid when it is added to the transformer during vacuum-filling, must be 10°C (50°F) or higher.

When vacuum filling a transformer on which a Sudden Pressure Relay is mounted, care must be taken that the Relay is not filled with oil. Also pull vacuum and break vacuum at 1/4 psi/second maximum to avoid any possibility of straining the bellows. The Sudden Pressure Relay must be correctly installed according to the instructions in Section 5.10 to prevent failure during vacuum treatment. If the transformer is shipped with a dummy plate mounted in place of the Sudden Pressure Relay, the transformer should be filled with liquid before the Relay is mounted.

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 oil-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.

Table 4 – Vacuum Treatment and Liquid Filling

15 PSI or Full Vacuum Tanks		
Condition	Absolute Pressure in Tank Torr	Vacuum Holding Time Hours
Before Filling	5 Maximum	4
During Filling	6 Maximum	—
After Filling	5 Maximum	2
8 PSI Tanks		
Before Filling	347 Minimum	4
During Filling	347 Minimum	—
After Filling	347 Minimum	2

Note: 1 Torr = 1 mm Hg = .0193 PSI

Caution: Where “MINIMUM” is specified lower pressures may result in tank damage or permanent deformation with serious damage to internal parts.

a. Final Filling of Transformers Shipped in Liquid

Apply the required vacuum level prior to liquid-filling, as specified in Table 4. If additional liquid is required to bring the liquid level up to normal as shown by the liquid level gauge, hold the vacuum level during liquid-filling as specified in Table 4 while the liquid is being added. Break vacuum with dry gas to a positive pressure of 2 to 3 psi gauge.

b. Final Filling of Transformers Shipped in Dry Gas

Apply the vacuum level prior to liquid-filling for the number of hours prior to filling as specified in Table 4. Then admit liquid into the top of the tank, while holding the vacuum level during liquid-filling as specified in Table 4, until liquid reaches the normal level as specified in Table 2, page 7.

Break vacuum with dry air or dry nitrogen to a positive pressure of 2 to 3 psi gauge.

c. Lowering Liquid Below Top of Core and Coils

If the liquid must be lowered so that any part of the core and coils is exposed, use dry air to ventilate the space above the remaining liquid and maintain 2 to 3 psi positive gas pressure whenever work is interrupted.

When the core and coil assembly is out of liquid, the conditions are similar to those during shipment in dry gas. It is, therefore, important to make repairs quickly and get the core and coils submerged, in order to avoid the long vacuum hold times required for initial fillings.

Drain any liquid which was not drained before repairs were made. Apply the required vacuum level prior to filling and hold it for the specified time according to Table 4. If the time the core and coil assembly is out of liquid, before evacuation for refilling is started, does not exceed 16 hours, liquid flow into the tank may start as soon as the required vacuum is obtained. Then admit liquid into the top of the tank, while holding the vacuum level during liquid-filling as specified in Table 4 until liquid reaches the normal level as specified in Table 2, page 7.

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 a rain to prevent drawing moisture into the tank.

8.5 Vacuum Equipment and Procedures

In order to attain the vacuum levels specified and to maintain these levels during liquid-filling, a good vacuum pump of adequate capacity is required. For smaller transformers, a 100 cfm pump will be adequate, but for larger units, a pump of 140 cfm capacity or greater is desirable. The pumps should be capable of attaining a blank-off pressure of .02 Torr or less.

Connections from the pump to the transformer tank should be as short and as large in diameter as possible. The line should be at least 1 inch in diameter, preferably larger, particularly on larger transformers. There should be no low spots in the vacuum line in which liquid can collect.

The pressure in the tank during vacuum operations should be measured through a connection of the upper part of the tank, above the liquid level. Do not use pressure measurements at locations other than the tank itself. For measuring the pressure in the tank, a properly calibrated aneroid gauge or thermocouple gauge is recommended. Use mercury gauges only if a trap is provided which will prevent mercury from entering the transformer.

It is important that the entire system be free from leaks, otherwise it may be difficult or impossible to attain the specified vacuum levels. Any leaks will permit moist air or water to be drawn into the transformer. If a high capacity pump is used, it is especially important to eliminate leaks so that moisture drawn into the system is minimized.

Openings for relief devices and other accessories must be sealed in accordance with instructions furnished for the particular accessory in order to prevent air from entering the transformer during vacuum operations. Valves in pipe connections between the main tank and liquid-filled compartments should be open during vacuum, if necessary, to limit differential pressures to values specified on the transformer instruction plate.

If it is necessary to fill units in the field, apply the vacuum which is permitted by the nameplate for the length of time specified in Table 4.

The vacuum piping should be so related to the liquid piping that liquid will not splash or spray into the vacuum line. It is advisable to provide a liquid trap in the vacuum line to protect the pump from the insulating liquid. The efficiency of most vacuum pumps is dependent upon the condition of the pump liquid. If the pump liquid becomes cloudy from the moisture or thins out because of insulating oil contamination, it should be changed.

8.6 Ventilation of Tank

When it is necessary to open a transformer, the following procedure should be used.

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 out through the cover opening. Air hoses may be taken into the transformer if they are clean and made from an oil-proof material. In the case of a transformer shipped without insulating fluid, blow dry air into the tank through an opening near the bottom of the main tank.
- c. The dew point in the transformer should never be higher than 20°F.

- d. In order to conserve dry air, place a light cover of plywood, hardboard, or plastic over the manhole opening. The work should be performed in a sequence such that when accessories such as bushings are being installed, only one opening other than the manhole will be open at any time.

Dry Air and Nitrogen. When nitrogen is called for the nitrogen used should have a dewpoint 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 dewpoint than gas in high pressure cylinders.

Dry air should also have a dewpoint 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 are 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 4 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.

8.7 Gaskets

All gaskets used on Substation Transformers are normally made of a gasket material consisting of cork and synthetic rubber; and for satisfactory results replacement gaskets should be of the same material. 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 and then wiping the gasket surface with de-natured alcohol. Use gasket cement

53351GH 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.

8.8 Finish

Instructions for refinishing transformer are as follows:

1. If the paint on the unit is generally firm and sound, it is not advisable to strip the entire surface.
2. All rusted areas should be thoroughly wire-brushed, sanded, etc., to remove all rust, loose paint, etc.

CAUTION

Eye protection should be worn to prevent injury from flying paint and rust chips.

3. Thoroughly wipe down with solvent-soaked rags to remove all dirt, oil, abrading dust, etc. Sometimes it is advisable to give the unit a light blasting using sand, ground corn cob or ground walnut shell to roughen up the surface.
4. Apply by brush method a coat of fast-dry primer 32230DU to all areas abraded to base metal; then follow with a complete spray coat of the fast-dry primer. The method of paint applying (spray or brush) is not critical.
5. Allow to air dry overnight or apply moderate heat of 65°C to 75°C for several hours.
6. After the primer coat is thoroughly dried, apply a heavy, uniform spray coat of air dry enamel in the desired finish color.
7. Allow to air dry for at least 24 hours before placing the transformer back in service. Moderate heat of 65°C to 75°C for several hours is preferable if available.
8. Should extra protection be desired, then a second coat of the finish enamel can be applied.

8.9 Additional Maintenance Instructions

The following are additional instructions that may be useful in maintaining the Substation Transformer. These

leaflets may be obtained through the nearest Westinghouse Sales Office.

Removing and Replacing Welded-On

- | | |
|---|----------------|
| Covers | I.L. 47-600-21 |
| Instructions for Repairing Tank Leaks . . . | I.L. 48-069-20 |
| Cleaning Transformer Insulation | I.L. 48-069-13 |

9. REPAIR

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

9.2 Report all failures during the warrantee period to your Westinghouse Sales Office. All warrantee repairs must be made or approved by Westinghouse.

9.3 To assure proper operation, use only Westinghouse approved replacement parts. Transformers used in explosive atmosphere environments (Class 1, Division II, Group D) must have sealed alarm switches. If replacement is necessary, identical devices must be used to maintain safe operation.

9.4 It is recommended the owner limit repairs to replacing broken parts unless the owner has a well trained repair shop. Because many parts and accessories are peculiar to transformers, it is usually less expensive to replace broken parts than repair them.

9.5 ALWAYS DE-ENERGIZE THE TRANSFORMER WHEN ANY REPAIRS ARE MADE.

9.6 The operation and construction of accessories is in Section 5 of this book.

9.7 A damaged oil thermometer or liquid level gauge bezel can be replaced without breaking the transformer's pressure seal. See paragraphs 5.4 and 5.5. Fans can be replaced if both the transformer and the fan power supply are first de-energized.

9.8 Some devices can be replaced only after the transformer has been de-energized and then de-pressurized. These devices are the mechanical pressure relief device, sudden pressure relay, vacuum pressure gauge, sealedaire device, current transformer junction block and cover mounted bushings. Before de-pressurizing or ventilating the transformer, refer to "Ventilation of Tank" Section 8.6 of this instruction book.

To depressurize the transformer, slowly open the air test valve until the vacuum-pressure gauge reads zero psi. If the transformer does not have these items SLOWLY loosen the filling connection until pressure is equalized.

9.9 Some internal accessories such as current transformers, bushings, or fuses that are under the insulating fluid can be replaced without completely draining the tank. In such cases, only that fluid necessary to expose the accessory should be drained. There may also be occasions when complete draining of the transformer tank may be necessary. Before partially or completely draining fluid from the transformer tank, refer to "Maintenance" Section 8.4 and Part I "Receiving, Storing and Handling" of I.B. 45-063-100 Instructions of Wemco C and Wemco CI Insulating Oils, or Instructions for Handling Silicone Insulating Fluid I.B. 45-063-102, or Instructions for Handling WEMCO "FR" Insulating Oil I.B. 47-053-1.

CAUTION

When working inside a transformer tank, extreme care must be exercised to avoid dropping tools or other objects into the core and coils or into the tank. Objects dropped on the coils or left in the tank can cause a failure to the transformer.

9.10 The core and coil assembly can be repaired or replaced by Westinghouse personnel at either the factory or at a Westinghouse Repair Plant. Contact the nearest Westinghouse Sales Office for more details.

9.11 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.

9.12 Paint repair procedure is in Section 8.8.

9.13 If there are questions concerning repair procedures that are not explained to your satisfaction, contact your Westinghouse Sales Office and you will receive an answer.

A Renewal Parts List listing authorized replacement parts is available through the nearest Westinghouse Sales Office.

www . ElectricalPartManuals . com

