# Instruction Book

TYPE SL CORE FORM SUBSTATION TRANSFORMER

CLASS OA/FA/FA, 65 DEG. RISE, 60 HERTZ

THREE PHASE, 15000/20000/25000 KVA, ~~115000 DELTA TO 1~~2470Y/7200 VOLTS

I.B. RCS2416



BONNEVILLE POWER ADMINISTRATION

CUSTOMER ORDER NO. DE-AC79-81BP23646

GENERAL ORDER NO. PO88519

SHOP ORDER NO. RCS2416

AUGUST, 1981

Westinghouse Electric Corporation

# Table of Contents

INSTRUCTION BOOK RCS2416

## DRAWINGS & INSTRUCTION PLATE

Outline - 2356D30
Instr. Plate - 245P615H01
Wiring Diagrams - 2356D31
- 2356D32
H.V. Bush. - 273C707 L.1
L.V. Bush. - D.S. 48-061-64 L.4

# Instructions for Shipment, Installation & Storage of Oil-Filled Power Transformers

## Sharon Units

**Westinghouse Electric Corporation**

**MEDIUM POWER TRANSFORMER DIVISION, SHARON, PA.**

I.L. 48-069-43D Effective February 1979 Supersedes I.L. 48-069-43C, September 1978

# TABLE OF CONTENTS



*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 Westighouse Electric Corporation representative should be contacted.*

## INTRODUCTION

A transformer is a device for transferring electric power from one system to another, usually at different voltages, by electromagnetic induction. It is designed for specific voltages and with specific power capabilities as shown on its nameplate.

This leaflet contains procedures to be followed from the time an oil-filled core-form power transformer is received until it is installed and ready for energizing. These instructions are not intended to cover all the details for all types of oil-filled power transformers, nor to provide for all contingencies which might arise. A listing of the operations required is shown, in outline form, by the Table of Contents on the preceding page.

These instructions are intended for the guidance of personnel who have been trained for or who have experience in the installation, maintenance and servicing of large high-voltage electric power equipment, including the use of good safety practices. These instructions are intended to supplement, and not to eliminate the necessity for such training.

## SHIPPING PRACTICES

**Main Transformer.** Transformers are shipped in their own tanks, filled with oil, in an upright position when shipping clearances and weights permit.

Many large core-form transformers are shipped filled with dry gas, either air or nitrogen.

Any temporary bracing which must be removed by the erectors during installation will be described on the outline drawings. All parts of such bracing are painted yellow.

**Impact Recorder.** An impact recorder is sometimes mounted with the transformer. In general, recorders will accompany all depressed car shipments. They are also used when the customer or Westinghouse wants to obtain impact data on a particular shipment.

**Divided Tanks.** It is occasionally necessary with large transformers to have a joint in the tank so that the top section may be removed for shipment. Either the regular cover or a special shipping cover is bolted on the top of the lower section of the tank for shipment. These transformers are shipped filled with dry gas.

**Detail Parts.** Fittings and bushings are shipped mounted in place when possible. Detachable cooling equipment is removed for shipment. Outline drawing notes indicate the parts that are removed for shipment. These are shipped on the same car or vehicle when possible. Separate shipment of detail parts will be made for larger transformers. Most lightning arresters are shipped direct from the arrester factory to the customer.

## PRECAUTIONS

**Safety Precautions. Normal 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 must be followed for the protection of workmen and of the transformer.**

**The transformer tank must be grounded at all times. All windings and bushings must be de-energized and grounded except when electrical tests are being made. All oil-handling equipment and vacuum pumps must also be grounded. This will reduce the possibility of static discharges, which can result in injury to personnel, or in fire or explosion.**

**Electrical tests must not be performed when vacuum is applied to the transformer, if such tests produce a potential of more than 125 volts anywhere in the transformer. Arcing may occur at quite low voltages under the pressures specified herein for vacuum operations. Such arcing could cause serious damage to the transformer.**

**Electrical equipment must be used with precautions to avoid electrical shock. The turns ratio between windings of transformers can greatly magnify the effects of improper use or malfunction of electrically powered tools or test equipment. This can be true of even direct-current devices, which can produce high-voltage pulses when voltage is applied or interrrupted at transformer terminals.**

The secondary windings of current transformers can have dangerously high voltages across them unless they are short-circuited or connected to ammeters.

The foil layers of condenser bushings, including the potential tap, may retain high-voltage charges after application of voltage to the bushing lead. Contact with ungrounded bushing leads or taps can result in electrical shock.

These are but examples of the electrical phenomena that may be encountered when working on or around power transformers, and they underscore the absolute necessity of assigning only trained persons, under the control of fully qualified supervision, to the installation, maintenance and operation of power transformers.

The tank should be filled with dry nitrogen or with oil when making any electrical tests other than the tests specified on page 7. In the event of electrical arcing during an electrical test, fire or explosion may result if the transformer is filled with air.

Before using an external supply to test the operation of motor or control equipment, make sure these are disconnected from internal potential or auxiliary power supplies, and from all transformer windings.

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 in the vicinity of the oil-handling equipment or on top of the transformer when any covers are open.

NOTE: It should be realized that the use of a fire extinguisher inside the transformer will usually severely damage or ruin the transformer insulation.

Before removing any covers or fittings from the transformer, make certain that there is zero gauge pressure in the tank and that the oil level is below that particular opening. Relieve pressure (or vacuum) slowly, using a valve above the oil level.

Never enter the transformer tank unless an analysis of the air in the tank well below any open manhole, shows at least 19.5% oxygen. If the oxygen content is below 19.5%, persons entering the tank may become drowsy, or lose consciousness, resulting in injury or death. 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.

Extreme caution must be exercised while working on top of the transformer to avoid injury from slips and falls. The top may be slippery from an oil film. The use of guard rails or ropes is recommended whenever possible.

**General Precautions.** Extreme care must be taken to protect the transformer insulation from damage and to prevent foreign materials from being introduced into the tank during inspection and assembly.

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 he has removed watches and rings.

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

Never stand directly on any electrical insulation part. This may result in injury from slipping or falling or in damage to the transformer.

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 be attached to lines made from clean cotton tape or seine cord 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 observing the precautions for opening the tank.

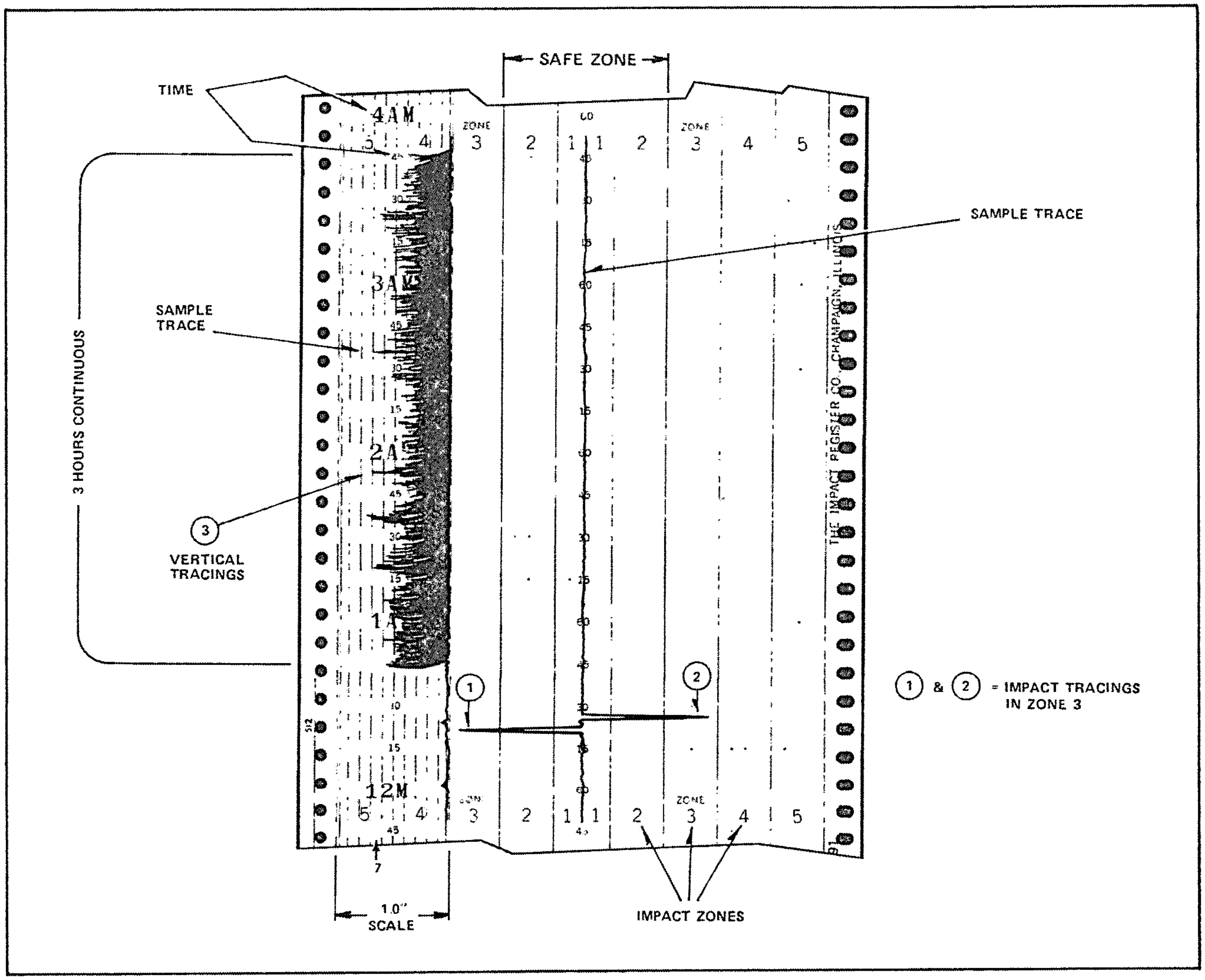



*Figure 1 Sample of Impact Recorder Tape*

Never open the transformer unless the temperature of the tank and internal parts is at least 10° C higher than the dew point of the outside air.

In the event of sudden weather changes, threatening rain or snow, provisions should be made for closing the tank quickly to protect the insulation from moisture. Do not initiate vacuum operations when it is raining, or leave the transformer unattended when vacuum operations are in progress. Loss of vacuum is indicative of a leak and vacuum operations should be interrupted if this happens.

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

When making pressure tests or applying vacuum, check the transformer instruction plate notes and equalize the pressure between the main tank and other compartments separated by terminal boards when this is required. Also, any rigid connections to the tops of bushings should be disconnected to avoid insulator breakage which might be caused by tank and cover deflection under test pressure or vacuum.

Use properly calibrated thermocouple gauges or aneroid absolute pressure gauges for measuring absolute pressure during vacuum operations.

## RECEIVING INSPECTION

**Drawings and Documents.** Shipping papers, outline and wiring drawings, instruction leaflets and other pertinent documents furnished with the transformer must be available for use during the inspection.

**Impact Recorder.** The customer will be notified when shipments are delivered with impact recorders. **The customer is required to accept full responsibility for unloading roughly handled or damaged equipment.**

**The recorder is part of the shipment. If it is missing or damaged, if the seal is broken, or if it has been disturbed in any way, a specific carrier's inspection report must be issued by the carrier to relieve the customer of responsibility for the recorder.**

Instructions for the recorder, and for special tests which may be required, are in the instruction letter enclosed in the recorder. This letter also gives instruction for returning the recorder to Sharon.

Examine the recorder in the presence of the carrier's agent. Both carrier and customer personnel should sign and date the tape end. In the presence of the carrier's agent, examine the tape.

An example of an impact recorder tape is shown in Figure 1. Notify a Westinghouse representative before unloading the unit where impacts into Zone 3 or higher are shown.

The one-inch scale on the left side of the recorder tape records ride quality information. If, for a total time of 3 hours or more, the tracing is continuous and has repeated peaks of 0.7 inches or more, contact the Westinghouse representative for discussion. Otherwise, the tracings will be analyzed in Sharon.

The tape and recorder are the property of Westinghouse Electric Corporation and must be returned. Copies of the tape will be supplied upon written request.

**External Inspection.** External inspection prior to unloading the transformer should include all of the items in the check list on page 5. Any external evidence of damage, or evidence indicating the possibility of hidden damage, must be reported to the carrier's representative with a request for a carrier inspection. The apparent damage must also be reported to a Westinghouse representative before unloading the transformer. Photographs are desirable.

A claim must be entered against the carrier in writing, with a copy of the carrier's inspection report attached. If the carrier waives his right of inspection, this waiver must be in writing from the carrier's freight claim officer.

**Special Instructions When Shipment is F.O.B. Destination.** In event of shipping loss or damage:

(1) Notification must be given to the Westinghouse location from which the shipment originated within 72 hours of delivery;

(2) Written notations of apparent loss and damage must be made on the carrier's delivery receipt;

(3) Concealed damage must be immediately reported to the delivering carrier with a request for an inspection.

**Gas Pressure and Condition.** The gas pressure in transformers which are shipped in gas should be measured as soon as possible after arrival, and after the temperature has been reasonably constant for several hours. Measurement should be made using a low-pressure compound gauge, attached to an opening that is above the level of any oil that may be in the transformer. The transformer will have been pressurized at the factory to about 3 psi gauge pressure at about 25° C. In the absence of any leaks, the pressure may fluctuate with the temperature in either direction from this value. If a pressure reading of some value, either positive or negative (vacuum) is obtained, with the temperature stable, the tank is probably free of leaks. If the gas in the tank is at

## CHECK LIST

### External Inspection of Transformer on Car

**Blocking and Tie Rods**

1. Are all tie rods undamaged and nuts tight?
2. Is all blocking tight and in good condition?
3. Is there any evidence of load shifting in transit?

**Impact Recorder (when used)**

4. Does the recorder tape indicate any Zone 3 or higher impacts?

**Transformer Tank and Fittings**

5. Are there indications of external damage?
6. Is the paint finish damaged?
7. Are all fittings which were shipped attached still in place and undamaged?
8. Is there any evidence of oil leakage? (units shipped in oil)
9. Is there either positive pressure or vacuum in the tank? (in cold weather a vacuum reading may be obtained)

**Bushings (when shipped attached)**

10. Are any porcelains chipped or otherwise damaged?
11. Is oil level in Type "O" bushings normal?

atmospheric pressure, there may be a leak in the tank; add dry gas immediately to about 3 psi gauge pressure and check for leaks.

If the shipping gas is nitrogen, check the gas in the tank for oxygen content using an Orsat apparatus or a Fyrite Oxygen Indicator (Westinghouse S#888A049H01).

**Insulation Dryness.** Drying operations in the factory reduce the moisture content of the paper insulation to a very low level. This dry condition must be maintained. If there is reason to question the dryness, the amount of moisture can be estimated by a dew point measurement for units shipped in dry gas, or by measurement of insulation resistance or of insulation power factor for units shipped in oil.

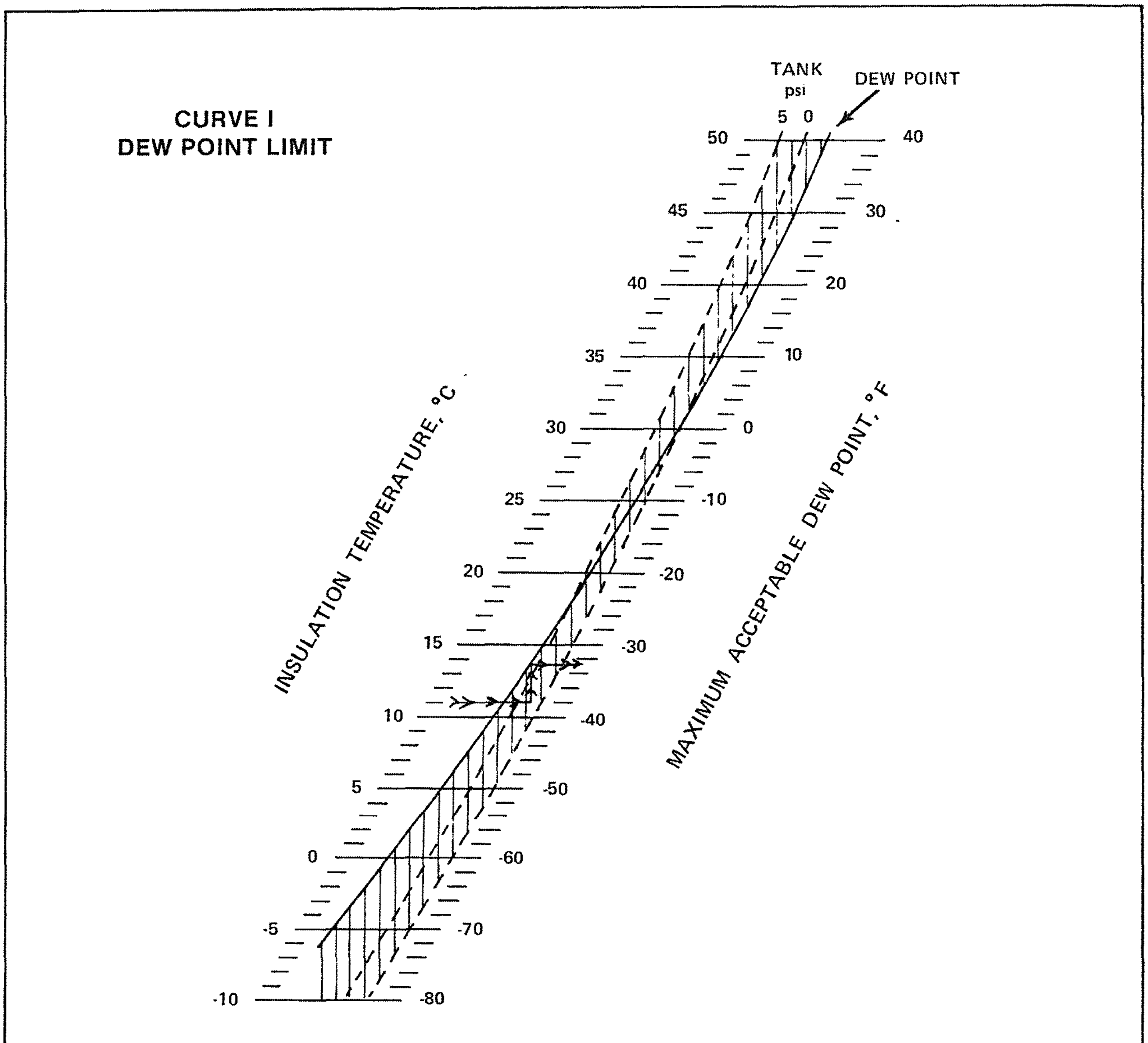
The dew point can be measured using an apparatus such as an Alnor Dewpointer or a Panametrics Aluminum Oxide Hygrometer. In making dew point measurements, at least 24 hours should elapse after the transformer has been sealed and filled with dry gas following vacuum or draining of oil, so that the gas can come to equilibrium with the surfaces of the insulation. Measurements of dew point made at intervals several hours apart may be helpful in determining when equilibrium is reached. An estimate must be made of the average temperature of the transformer insulation. This will require some judgment, depending upon the weather conditions and exposure of the transformer to wind and direct sun. The gas in the transformer should be at a slight positive gauge pressure, preferably not higher than 2 psi, when the dew point is measured. To determine if dryness is acceptable refer to **CURVE 1.**

If the transformer is oil filled, insulation resistance and power factor measurements should be made and compared with measurements made at the factory. Factory measurements are shown on the certified test sheets.

Factory measurements of insulation resistance and power factor are obtained with the unit oil filled. Therefore, direct comparison of these quantities when measured with gas instead of oil in the unit is not possible.

Indications that the transformer is dry include:

1. Positive gas pressure in the tank.
2. Low (2% or less) oxygen content of gas for units shipped in nitrogen.
3. Satisfactory dewpoint as given in Curve I.




(1) Enter Curve from left at insulation temperature, °C.
(2) At tank pressure (broken line) move vertically to dew point (solid line).
(3) On right scale, read maximum acceptable dew point, °F.

Example: Insulation temperature = 11°C.
Transformer tank pressure = 2 psi.
By Curve I, dew point must be -33°F or lower.

Note: In (2) use tank psi minus meter psi if dew point meter being used does not give dew point at atmospheric pressure.

4. Power factor and insulation resistance readings close to factory values for oil-filled units.

Excessive moisture should be suspected if:

1. Any of the applicable indicators above deviate from the described condition.
2. Externally visible damage has occurred to the transformer tank during transit.

If there are suspicions that the transformer may not be dry, the factory should be contacted immediately for confirmation of the analysis of the available data, and for recommendations as to what action should be taken. In most cases it will be necessary to dry out the transformer before it can be placed in service.

**Internal Inspection.** Before opening the transformer tank for internal inspection, be certain to be prepared to follow all applicable safety precautions and general precautions as given, beginning on page 1. Do not open the transformer until pressure has been brought to atmospheric pressure. The oil level must be below that of the cover that will be removed.

If the transformer is opened for internal inspection before the insulation is covered with oil, the time the transformer is open for inspection should not exceed 2 hours. (This 2 hours is not counted as open time when determining final vacuum.) After this, the transformer should be sealed and evacuated to an absolute pressure of 5 torr or less for at least 2 hours. Admit dry gas to the tank to break vacuum until the pressure reaches 3 psi gauge. If a Sudden Pressure Relay is mounted on the transformer do not allow pressure in the tank to change more rapidly that 1/4 psi/second.

If it is anticipated that the transformer will be stored for more than three months before filling with oil, the vacuum applied after inspection should be broken using nitrogen.

It may be necessary to remove some oil from oil-filled units for adequate inspection. This normally will not require exposing the core and coil assembly, and the transformer can be refilled as specified in **FINAL OIL FILLING.** If for any reason it is necessary to lower oil so that the core and coil assembly is exposed, all oil must be drained, then both preliminary and final oil-filling instructions, or optional final oil-filling instructions, must be followed.

The 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, cores and insulation structure. Temporary shipping braces are painted yellow and should be removed after the transformer is placed on its foundation.

**CAUTION: Never enter the transformer tank unless an analysis of the air in the tank well below any open manhole shows at least 19.5% oxygen. Do not assume that units shipped in dry air will meet this requirement. If the oxygen content is less than 19.5%, persons entering the tank may become drowsy or lose consciousness, resulting in injury or death.**

**Electrical Tests.** The following tests must be made as part of the internal inspection.

a. A ratio test on all windings and tap positions.

b. Resistance and temperature measurements. Compare with the factory test values.

c. If the transformer is filled with oil, make a test of insulation resistance of each winding to all other windings and ground and from all windings to ground. Record the temperature of the oil. These readings should be comparable with the measurements made at the factory.

d. Disconnect the core ground connection and measure the resistance from the core to the tank or end frames at 1000 volts. The resistance, corrected to 20°C, should be at least 200 megohms for oil-filled units or at least 100 megohms for gas-filled units.

e. If any measurements in (a) through (d) are not as expected, contact the Westinghouse Industry Services Division for instructions.

**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. If there is evidence of damage, file claim with carrier. If there is shortage, report this at once to Westinghouse Engineering Service.

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

Radiators, coolers, and pumps will have all openings closed with blind flanges, plugs, or other closures. These should be examined for signs of damage.

The lower ends of Type FS and Type OS condenser bushings will be protected with plastic bags. These should be examined for signs of damage and moisture entrance.

Accessories and detail parts must be placed in locations which will minimize exposure to weather and the possibility of damage or loss. If the transformer is not to be installed immediately, the parts must be stored in accordance with the following information.

**Separate Storage of Unmounted Accessories.** When accessories are not mounted immediately after the transformer is received they must be given care to protect them from damage or loss during storage. The following general instructions and the more detailed instructions given in instruction leaflets for the accessories must be followed. In the event of conflict between this leaflet and the instruction leaflet for the individual accessory, the latter shall take precedence.

Indoor storage is required for all items marked FRAGILE and for porcelain stored more than one month.

**Radiators and Coolers.** The radiators are shipped with the top and bottom openings sealed airtight and watertight. Store radiators indoors or in a weather-proof shed in such a manner that water cannot stand around the sealed openings. If they are to be stored more than 3 months, they should be on blocks to keep them off the floor.

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, recemented and retightened before storage. Teflon sealing tape may be used for sealing plug threads.

**Bushings.** Bushings are shipped crated or boxed. The lower ends of the bushings are covered with plastic bags to keep them clean and dry. If the bags are damaged, replace them.

Store condenser bushings in a clean, dry place indoors in their shipping crates. 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. They may be stored in the shipping box.

**Load Tap Changers.** The load tap changer will generally be shipped attached to the transformer. If the tap changer is shipped detached from the main transformer, it must be stored in a clean, dry place. In either case, all oil compartments of the load tap changer must be filled with oil, to positive pressure during storage. The electrical space heaters in the control compartments are to be connected to a power circuit and energized to keep the control equipment dry.

Air filled spaces, such as cam switch compartments of some load tap changers, which normally receive heat from adjacent compartments are not equipped with heaters. If storage will be longer than one month from date of shipment, install a temporary heater (a 40 watt light bulb, for example) and operate it continuously to prevent condensation.

**Fan Motors.** Fan motors on coolers are wrapped in waterproof paper when shipped. They can be stored in this wrapping, on blocks to keep them off the ground. Fan motors mounted on radiators and not mounted on the transformer must also be covered with waterproof material and blocked off the ground. Store indoors, if possible.

**Pump Motors and Pumps.** Openings are sealed by blind flanges. Check to make certain the power plug is handtight. Indoor storage is recommended. If this is not possible, then the pump motors must be blocked off the ground and protected from the weather.

**Detail Box.** Store the box, containing details as shipped, indoors and in a dry place. The box contains items such as Inertaire connections, gaskets, internal bushing connectors, tape, paint, gasket cement, Sudden Pressure Relay, etc., as specified on the detail packing list.

**Inertaire.** The Inertaire equipment is shipped on the transformer when shipping clearances permit. The pressure gauge and reducing valves (one assembly), three-way valve, sump and plastic hoses are assembled and in the cabinet. Flexible tubing for connecting the nitrogen tank to the cabinet is shipped in the detail box. The nitrogen tank must be assembled on the transformer before the transformer is stored or any work is started.

**Paint Finish.** Inspect the paint finish on the main transformer tank and on all painted detail parts for damaged areas, and apply touch-up paint to these areas.

## HANDLING

Core-form power transformers must be handled in the normal upright position unless instructions have been received to the contrary. Lifting hooks or eyes are provided for crane lifting. When the transformer is lifted, all hooks or eyes must be used. Similarly, jacking pads are provided for lifting the transformer with jacks. All such pads must be used when the transformer is to be jacked. Never attempt to lift the transformer by using cranes or jacks or any part of the transformer other than the fittings provided for this purpose.

When the transformer has a removable top section or a bolted main cover, the top section or cover must be welded or bolted in place when lifting. Check the outline drawing for special equipment or procedures to be used in lifting.

## STORAGE PRIOR TO ENERGIZING

**General Requirements.** The transformer must be placed on a solid level foundation in the storage area. If the transformer does not have a structural steel base, it should be blocked to allow ventilation under the bottom of the transformer. However, if it is stored in its permanent location, it may be set in place. The Inertaire equipment must be installed within one week after the transformer has been delivered. Ground the tank and any bushings that are mounted. See page 8 for **Separate Storage of Unmounted Accessories.**

Air-filled compartments such as tapchanger control cabinets may be equipped with space heaters to prevent condensation. All such heaters should be energized during storage. Any other compartments in which there are components which might be damaged by condensation should be fitted with temporary space heaters, which should be energized during the entire storage period.

**Storage in Oil.** With proper preparation and maintenance transformers may be stored indefinitely if they are filled with oil.

As soon as possible after receiving the transformer, locate it on its permanent foundation, or on a solid temporary foundation, and perform all tests and checks outlined under **RECEIVING INSPECTION.** Install the Inertaire equipment, if supplied, immediately. Report any shipping damage and/or shortage before storage.

As many of the accessories as possible should be installed and all others stored as recommended under **Separate Storage of Unmounted Accessories.**

Transformers with sectionalized tanks must have the permanent cover installed.

Perform both preliminary and final oil-filling operations before storage. Test oil from bottom sampling valve for dielectric strength, power factor, and moisture content, before storage, as detailed in **ENERGIZING THE TRANSFORMER.**

Positive nitrogen pressure must be maintained during the storage period. Keep a log of gas pressure readings made during the storage period. Record the pressure daily for two weeks, then weekly for another month, followed by monthly readings. Nitrogen consumption by the Inertaire equipment should also be recorded.

After six months, if the storage period lasts that long, and at least once a year thereafter, withdraw oil samples from the transformer tank and all other separate oil compartments for determination of dielectric strength, power factor and water content.

At the end of the storage period, the records of pressure readings should be reviewed to make certain that positive nitrogen pressure was present at all times. Samples of oil should be drawn from the bottom of the transformer and from the tap changer compartments and tested for dielectric strength, power factor, and water content. Make insulation resistance and power factor tests on each winding to other windings and to ground, and from all windings to ground, and compare with factory test values.

If all tests are satisfactory, the transformer should be placed on its permanent foundation and assembly and installation completed. If installation was completed before storage, the transformer can now be energized.

**Storage in Gas.** If a transformer is to be stored for more than a few weeks prior to installation it is preferred that it be filled with oil prior to the storage period. When this is not practical, storage in dry gas is acceptable, with suitable precautions.

In all cases where gas storage is performed it is necessary that positive gas pressure be maintained in the transformer tank at all times. If the unit is equipped for Inertaire, this can be used for maintaining pressure. If the unit does not have Inertaire a temporary installation of Inertaire apparatus can be made, using the upper filter press valve or other connection into the tank.

If storage for more than three months is anticipated, the transformer should be filled with nitrogen. This can most easily be accomplished by filling with nitrogen following the vacuum operation after **Internal Inspection** (Page 7).

Check the transformer for gas leaks prior to any storage period. This may be done by a simple pressure test at 6 psi gauge pressure, using a Freon leak detector or a soap solution to locate leaks. Reduce the gas pressure to 3 psi following the leak test.

A log of gas pressure in the unit must be maintained to make certain that no leakage of air from the outside occurs. Daily measurements should be taken for two weeks, then weekly for another month, followed by monthly readings. Nitrogen consumption by the Inertaire equipment should also be recorded.

The dewpoint of the gas in the transformer must be measured at the beginning of the storage period, after three months and six months and at six-month intervals thereafter, and at the end of the storage period. In the event of loss of gas pressure, the dewpoint must also be measured after restoration of pressure.

If positive gas pressure is maintained during the entire storage period and if no deterioration of the dewpoint of the gas has occurred, the transformer may be oil filled at the end of the storage period, using procedures as described below. If the pressure and dewpoint readings do not clearly show that proper conditions have been maintained during the entire period, then Westinghouse Industry Services Division should be asked to make recommendations for preparing the unit for service.

**After Storage in Gas for Three Months or Less.** If the dewpoint and pressure readings show the transformer to be dry, proceed to prepare the unit for service in the same manner as would be followed if it had just been received.

**After Storage in Nitrogen for Three to Twenty-four Months.** It will be necessary for the insulation to be reimpregnated with oil after these longer storage periods. If the gas pressure and dewpoint records show the transformer to still be dry, then apply vacuum to the tank, holding an absolute pressure of no more than 2 torr for at least 24 hours. During this operation the temperature of the insulation should be 20°C or higher. This should be accomplished in cold weather by use of a temporary heated enclosure around the transformer, or by preliminary heating with hot oil, using the procedure on Page 13.

After the 24 hour vacuum period, fill with oil heated to 50-75°C. Spray the oil into the top of the

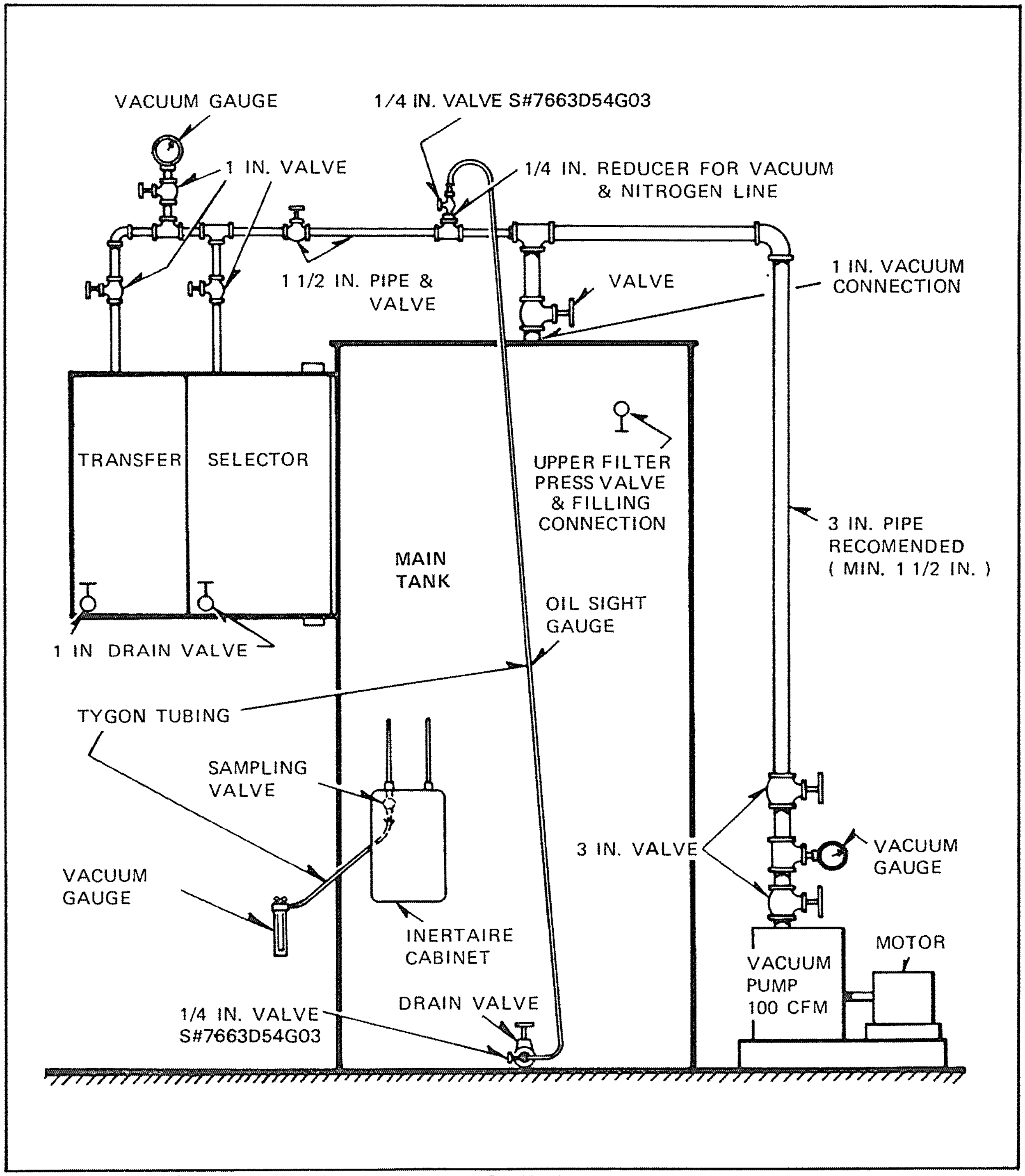



*Figure 2 Typical Piping Arrangement for Vacuum or Dry Gas Hookup*

transformer, maintaining an absolute pressure of 5 torr or less during the filling operation. After the filling is complete, and vacuum broken, no insulation should be exposed by lowering of the oil level for at least 96 hours. Do not energize the transformer until this 96 hour soaking period is ended.

Proceed with preparation of the transformer for service in the same manner as if it had just been received.

**After Storage in Nitrogen for More than Twenty Four Months.** Storage beyond 24 months without oil filling is not approved. In the event that a transformer has been stored without oil filling for more than 24 months, all available data must be reviewed by Westinghouse Industry Services Division and by the factory for determination of procedures to be followed before putting the transformer into service.

## ASSEMBLY OF PERMANENT COVER AND PRELIMINARY OIL FILLING

**General.** All power transformers must be vacuum treated and filled with oil under vacuum. This filling is normally done in two steps, preliminary oil filling as soon as possible after the transformer is received and final oil filling when installation is complete. When transformers are shipped in oil, the preliminary oil filling has been done at the factory. When transformers are shipped in dry gas, the preliminary oil filling may be omitted provided the optional final filling process is used.

The tank should not be opened prior to oil filling except (1) for inspection under the conditions specified in **Internal Inspection,** (2) for replacement of a temporary cover or top tank section as specified below in **Sectionalized Tanks,** or (3) if the **Optional Procedure for Installing Transformers without Preliminary Oil Filling** is followed.

**Drawings and Other Documents.** The outline drawing, the instruction plate, and the wiring diagrams for the specific transformer must be observed carefully in the planning and performance of all work. Instruction leaflets for accessory equipment are more detailed, and take precedence over this leaflet if conflicting directions are given.

**Sectionalized Tanks.** The permanent cover of sectionalized tanks must be assembled before oil filling. During the operation of changing the covers, dry air should be blown in at an opening near the bottom of the transformer, in order to reduce exposure of the insulation to moist outside air. While the cover is off, place a clean plastic or canvas sheet over the top of the unit to reduce loss of dry air. The time required for installing the permanent cover is not counted as open time, page 15, but special allowance is made in Table I.

**NOTE: Oil filling procedures in this leaflet are for transformers of 230KV or less. If any winding is rated above 230KV, contact Westinghouse Industry Services Division for instructions.**

**Preliminary Oil Filling.** The vacuum and oil equipment must conform to the requirements given in **VACUUM EQUIPMENT AND PROCEDURES**, page 20 and **OIL**, page 22. The core and coils of the transformer must be covered with oil prior to opening the tank for internal fittings.

Temporary pipe connections are necessary for connecting the vacuum pump to the filling connection on the cover. A sight gauge is needed to monitor the oil level. A suggested arrangement, which leaves the filter and drain valves available for connecting oil handling equipment, is shown in Figure 2.

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.

If Inertaire equipment has been installed, close the shut-off valve.

When vacuum filling a transformer having a load tap changer mounted on it, observe the vacuum-filling instructions on the transformer instruction plate. Make temporary pipe connections between the transformer tank and the load tap changer compartments if necessary. See Figure 2.

In any case do not operate the load tap changer during the oil filling process.

Apply the vacuum level prior to oil filling for the number of hours prior to preliminary filling as specified in Table I, column 1 or 8 for full vacuum or partial vacuum tank, respectively. Then admit oil into the tank while holding the vacuum level during oil filling as specified in Table I until the core and coil assembly is completely covered.

**CAUTION: Transformer oil is a flammable liquid. Under some conditions, closed compartments may contain mixtures of air and vapors which are flammable or explosive. Oil pumping or filtering operations can generate electrostatic charges which upon discharge, can ignite a fire or explosion or cause injury to personnel. All equipment used for oil treatment or handling, the transformer tank, and all bushings should be electrically grounded to prevent accumulation of such charges. No smoking or other sources of sparks or flames should be permitted in the vicinity of oil handling operations.**

In cold weather, the core and coil temperature must be raised above 0°C prior to the vacuum cycle in the preliminary oil-filling operation. The following procedure can be used to elevate the temperature of the core and coils.

1. Pull the vacuum specified in Table I for one-half of the hours specified.

2. Following this, spray hot oil in through the upper filter press valve of the transformer. The oil should be sprayed so the stream is broken up into droplets for more efficient heating of the core and coils. Maintain a vacuum of 10 torr or better on the transformer during the oil spraying operation in order to prevent oxidation of the oil and to aid in the removal of gas from the insulation.

It will probably be necessary to maintain some oil in the bottom of the unit to feed the output pump. Usually 12 to 24 inches of oil in the bottom will be sufficient. Do not allow the oil level in the bottom to exceed 36 inches. A clear plastic hose can be used as an oil-level indicator. See Figure 2.

Pump the oil from the bottom of the transformer through filters, through the heat exchanger, and back to the cover of the transformer. The temperature of the oil entering the top of the transformer whould be as high as possible, but it should not exceed 75°C. Continue spraying the hot oil under vacuum until the temperature of the core and coils is well above 0°C. The temperature of the core and coils will be at equilibrium conditions when the output oil temperature becomes constant and will be near the temperature of the output oil.

3. After the temperature of the core and coils has been elevated above 0°C, drain all oil from the main tank and coolers or radiators. It will be necessary to break the vacuum in order to drain the oil. The vacuum must be broken with dry gas to prevent condensation in the tank.

4. As soon as the oil is drained from the tank, immediately pull the vacuum specified in Table I and hold for the time period specified. Then fill with oil to a level above the core and coil assembly.

Following the preliminary oil filling, break the vacuum with dry gas. Do not use atmospheric air, as this may cause condensation of moisture in the transformer.

**Optional Procedure for Installing Transformer without Preliminary Oil Filling.** The oil filling may be delayed until after all other installation operations are complete. If this option is selected, the following procedure must be followed.

a. After installing the permanent cover, evacuate the tank to the vacuum prior to filling specified in Table I, column 3 or 10, then break vacuum with dry gas and raise the pressure to 2 or 3 psi gauge.

b. In order to maintain the dry gas atmosphere in the tank as long as possible complete the external assembly before performing the internal assembly operations.

c. Finally, fill with oil, using the procedure for **Final Oil Filling of Units not Previously Oil Filled,** page 17.

## INSTALLATION

**Location.** In determining the location of a transformer, give careful consideration to accessibility, ventilation and ease of inspection. Make sure the foundation for mounting the transformer is entirely adequate.

For transformers not having a structural steel base, either the foundation should provide a minimum of 1/2 inch ventilation under the bottom of the transformer, or the foundation should be sealed with an appropriate material and caulking used around the bottom of the transformer to prevent water from entering.

If the transformer is installed near fire walls or soundproofing walls, prior consideration should have been given to providing adequate air circulation for cooling the transformer. Typical minimum clearances vary from 2 feet to 10 feet, depending upon type and arrangement of coolers and nature of air flow obstructions. Report all air obstructions less than 8 feet from cooling equipment.

Water-cooled transformers depend entirely upon the flow of water through the cooling coils for carrying away heat. Air circulation is of minor importance, and these transformers may be located in any convenient place without regard to ventilation, except where there are heavy copper busses on furnace transformers which do require ventilation to carry heat away from the busses. Thermometers and water inlet and outlet of cooling coils should be located so that the attendant can conveniently observe any abnormality in the transformer temperature or water supply flow.

## ASSEMBLY

Assembly operations are divided into two categories. External assembly consists of mounting and connecting all accessories (coolers, for example) which can be installed without opening the transformer tank. Internal assembly consists of mounting and connecting all accessories (bushings, for example) requiring that the tank seal be broken. A few accessories (expansion tanks, for example) are involved in both external and internal assembly.

Instructions for mounting accessories are given in the Instruction Leaflets for the respective equipments.

The sequence of internal and external assembly operations depends upon the circumstances of the particular installation. The general considerations are:

For units shipped in oil

> If shipped with normal oil level, either internal or external assembly may be first.
>
> If shipped with oil overfilled, external assembly must be first so that oil can be admitted to coolers to bring oil level to normal or below for internal assembly.

For units shipped in dry gas

> If preliminary oil fill is used, either internal or external assembly may be first after the preliminary fill.
>
> If preliminary oil fill is omitted, external assembly should be first to preserve the tank seal as long as possible.

## INTERNAL ASSEMBLY

**Transformer Temperature.** Never open the transformer unless the temperature of the tank and of internal parts is at least 10°C higher than the dew point of the outside air.

**Insulating Fasteners.** Nonmetallic bolts, nuts, and studs are sometimes used on insulation structures. Nuts of this type should be tightened to a snug fit only since breakage or thread stripping may occur. Bolts and studs installed at the factory will either have the nut cemented or use a second nut as a jam nut. Re-tightening should not be necessary.

**CAUTION: Never enter the transformer tank unless an analysis of the air in the tank well below any open manhole shows at least 19.5% oxygen. Do not assume that units shipped in dry air will meet this requirement. If the oxygen content is less than 19.5%, persons entering the tank may become drowsy or lose consciousness, resulting in injury or death.**

**Ventilation of Tank.** Dry air must 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 oilproof material. In the case of preliminary oil filling having been omitted, blow 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 (-7° C).

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.

**Assembly.** Complete the assembly of all items, such as bushings, which require working inside the transformer tank or through an open manhole as rapidly as careful workmanship will permit. When work is complete, all openings should be sealed. For gasketing instructions, see I.L. 48-069-1.

On units shipped in oil it may be necessary to remove some oil for adequate access for good workmanship. The oil should not be lowered below the top of the core and coil assembly. Refilling, after assembly is complete, must be according to the instructions in **Final Oil Filling.**

During assembly and installation, the time that any tank opening is unsealed is considered open time from the time the seal is broken until it is resealed and the tank evacuated.

When work is interrupted, close the tank, evacuate it to the pressure specified in Table 1, column 2 or 9, and break vacuum with dry air to a positive pressure to 2 to 3 psi gauge. Time after evacuation is started until tank is reopened is not considered open time.

Keep a log of all open time. The separate open times are totaled for determining vacuum hold time before final oil filling as follows:

For normal processing, from preliminary fill to final fill.

For optional processing, from shipment to final fill.

For refill after lowering oil, from lowering to refill.

If the total for the process being used exceeds 16 hours, contact Westinghouse Industry Services Division for special instructions.

**CAUTION: Vacuum operations must be conducted in such a manner that no water can enter the transformer through leaks in the tank or piping. Never conduct vacuum operations while it is raining. Never leave the transformer unattended during vacuum operations. Vacuum should be applied to the transformer only as specified for moisture removal or oil filling operations. At other times, except when the transformer must be open, it is recommended that a slight positive gauge pressure of dry gas be applied, particularly during rain. If moisture, especially liquid water, is permitted to enter the transformer, serious damage to the insulation and possible failure of the transformer can result.**

## EXTERNAL ASSEMBLY

Radiators or any of the various types of coolers and the associated oil pumps and piping shipped as detail items with transformers to be assembled at the final location must be thoroughly inspected prior to assembly to be certain that no water or foreign material is in the oil space. To prevent condensation, avoid opening the equipment when it is at a lower temperature than the ambient air.

If there is any evidence of moisture, the equipment must be thoroughly dried either by blowing hot air through it or by flushing with hot oil. In any case it is desirable to flush out the cooling equipment thoroughly with hot oil. The radiators or coolers 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 and pump valves should be closed during installation of cooling equipment, and opened immediately prior to final vacuum treatment and oil filling.

Radiator mounted fan motors must have the temporary seal removed from the breathing plugs on the lower side of the motors before putting in service.

All other external parts removed for shipment, including expansion tank or COPS tank should be mounted. All such items are shown on the outline drawing.

Connections from bushings to lightning arresters and lines must have sufficient flexibility that bushing insulators are not mechanically stressed as the tank cover (wall, if wall bushings) deflects due to internal pressure changes within the limits set by Inertaire or Sealedaire equipment. Note that the vacuum during oil filling is much greater than during normal operation, therefore bushing connections should not be made until oil filling procedures have been completed.

## FINAL OIL FILLING

**Preparation for Filling.** Before the final oil filling, the transformer must be completely assembled, including all pumps and coolers. In addition to this, where tank braces are used as auxiliary gas space, drain residual oil or moisture from the braces by removing pipe plugs located at the bottom of the braces. Replace pipe plugs after draining.

Temporary piping for vacuum, oil, and sight gauge is required, as described under **Preliminary Oil Filling.**

Select the procedure which is appropriate for the specific installation:

**Final Oil Filling of Units Shipped with Oil or Units Given Preliminary Oil Fill.**

**Final Oil Filling of Units Not Previously Oil Filled.**

The following instructions apply to both procedures. Specific instructions start on page 17.

All oil, oil-conditioning and vacuum equipment, and piping used in Final Oil Filling must meet all conditions described and specified on pages 20 and 22.

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.

When vacuum filling a transformer having a load tap changer mounted on it, observe the vacuum-filling instructions on the transformer instruction plate. Make temporary pipe connections between the transformer tank and the load tap changer compartments if necessary. See Figure 2, page 11. In any case do not operate the load tap changer during the oil-filling process.

The evacuation and oil-filling operations specified in the following are intended to be accomplished as continuous uninterrupted processes; however, if a partial loss of vacuum occurs, due to power failure for example, proceed as follows:

a. If the pressure in the transformer does not go above 50 torr, stop the timing of the process when the pressure reaches the upper limit specified in Table I. Discontinue the oil flow at the same time, if oil is being added. When the pressure is again brought down to the specified level, start the process again at the point at which it was interrupted.

b. If the pressure exceeds 50 torr in the transformer tank it is not necessary to drain out any oil, but the process should be started over again beginning with the vacuum treatment prior to filling.

**CAUTION: Transformer oil is a flammable liquid. Under some conditions, closed compartments may contain mixtures of air and vapors which are flammable or explosive. Oil pumping or filtering operations can generate electrostatic charges which upon discharge, can ignite a fire or explosion or cause injury to personnel. All equipment used for oil treatment or handling, the transformer tank, and all bushings should be electrically grounded to prevent accumulation of such charges. No smoking or other sources of sparks or flames should be permitted in the vicinity of oil handling operations.**

**Final Oil Filling of Units Shipped With Oil or Units Given Preliminary Oil Fill.** Open all valves to all radiators, pumps, coolers, or other cooling equipment. Make vacuum connections to load tap changer compartments if required by the tap changer instruction leaflet. Close the shut-off valve to Inertaire equipment. Set valves to expansion tanks or COPS tanks according to the instruction leaflet for that equipment.

Request special filling instructions from Westinghouse Industry Services Division if open time exceeds 16 hours.

Apply the required vacuum level prior to oil filling, as specified in Table I, column 2 or 9. If additional oil is required to bring the oil level up to normal as shown by the liquid level gauge, hold the vacuum level during oil filling as specified in Table I while the oil is being added. Break vacuum with dry nitrogen to a positive pressure of 2 to 3 psi gauge, operate pumps, and let the unit stand as specified in Table I.

**Final Oil Filling of Units Not Previously Oil Filled.** During the vacuum and oil filling operations the temperature of the core and coils must be above 0° C. The procedure given on page 13 can be used to increase the temperature of the core and coils.

Open all valves to all radiators, pumps, coolers, or other cooling equipment. Make vacuum connections to load tap changer compartments if required by the tap changer instruction leaflet. Close the shutoff valve to Inertaire equipment. Set valves to expansion tanks or COPS tanks according to the instruction leaflet for the equipment.

Request special filling instructions from Westinghouse Industry Services Division if open time exceeds 16 hours.

Apply the vacuum level prior to oil filling for the number of hours prior to filling as specified in Table I, column 4 or 11. Then admit oil into the top of the tank, while holding the vacuum level during oil filling as specified in Table I, until oil reaches the normal level as shown by the liquid-level gauge.

Break vacuum with dry nitrogen to a positive pressure of 2 to 3 psi gauge, run the oil pumps and let the unit stand before energizing as specified in Table I.

**Final Oil Filling Units with COPS Oil Preservation System.** All of the requirements in this leaflet apply to units with the COPS Oil Preservation System as well as units with Inertaire oil preservation. The same procedures are used until the COPS tank is to be oil filled. See I.L. 48-063-35 for details on units with the COPS system.

## FILLING OR ADDING OIL IN THE FIELD

**NOTE: All transformers are processed and filled at the factory with oil that meets the federal Polychlorinated Biphenyls (PCB) regulations in effect at that time. The purchaser should take the necessary precautions so that PCB contamination is not introduced during field oil filling or maintenance of the transformer.**

## ENERGIZING THE TRANSFORMER

After oil filling is complete, the pumps have been operated, and the transformer has set idle for the specified time, a final check of the complete installation should be made before energizing the transformer.

If at this time there are signs of oil leaks at any pump or cooler valve stem, the packing gland should be tightened as follows:

(a) Loosen set screw and remove valve handle.

(b) Tighten packing gland nut.

(c) Temporarily replace handle and operate valve 8 or 10 times.

(d) Remove handle and again check tightness of packing gland nut.

(e) Replace handle and tighten set screw.

The final check should include tests as follows:

When the voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. If this is not possible, then back feed without load. It is recommended, especially if the excitation is through cables or fuses, that the output voltages be measured to be sure all three phases are energized.

After full voltage has been applied, the transformer should remain energized at full voltage for a few hours without a load. It should be kept under observation during this time and also during the first few hours that it delivers load. After four or five days service it is advisable to test the oil again for moisture, and the gas for oxygen content.

| REQUIRED TESTS (except • = recommended test) | ACCEPTABLE VALUES | |
|---|---|---|
| | Full Vacuum Tanks | Partial Vacuum Tanks |
| *Dielectric Breakdown of Oil-Miminum by ASTM D877 by ASTM D1816 | 30 KV<br>28 KV | 30 KV<br>28 KV |
| *Moisture Content of Oil-Maximum by ASTM D1533 | 20 ppm | 25 ppm |
| Core Ground Resistance by 1000 volt megger | 200 megohms, minimum | |
| Voltage Ratio | Agreement with nameplate | |
| Insulation Resistance<br>Insulation Power Factor<br>• Winding Resistance | Comparable to factory tests reported on Certified Test Report. | |

*Do not attempt to take oil samples when there is a vacuum in the gas space.

## LOWERING OIL AFTER UNIT IS FILLED

It may be necessary to lower the oil level after filling is completed to repair auxiliary apparatus.

**CAUTION: 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.**

**Lowering Oil Such That Coils, Insulation, and Lead Insulation Remain Covered.** If the oil covers the lead insulation, it is not necessary to pull vacuum above the oil before refilling. The transformer can be refilled according to Table I, column 7 or 14, by lowering the hose from the filter press below the oils surface and directing the flow horizontally above the core and coil assembly. If the upper filter valve is below the oil surface, the oil may be pumped in through this valve. Note that it is desirable that the normal gas pressure be maintained while the oil level is below normal to prevent atmospheric air from contacting the oil. After filling, run oil pumps at least 2 hours and let the unit stand idle for at least 8 hours prior to energizing.

The tests to be made before energizing depend upon the nature of the repairs which were made. In any case, oil dielectric breakdown and moisture content should be checked.

**Lowering Oil Below Lead Insulation.** If the oil must be lowered so that insulation is exposed, the oil level should be kept as high as possible while the work is being performed in order to prevent moisture re-entrance. Use dry air to ventilate the space above the oil level, and maintain 2 to 3 psi positive gas pressure whenever work is interrupted.

When repairs have been completed the oil level should be restored to normal as soon as possible.

Rigid external bushing or arrester connections should be removed during vacuum filling operations.

Open all valves to all radiators, pumps, coolers, or other cooling equipment. Make vacuum connections to load tap changer compartments if required by the tap changer instruction leaflet. Close the shut-off valve to Inertaire equipment. Set valves to expansion tanks or COPS tanks according to the instruction leaflet for that equipment.

Apply the required vacuum level prior to oil filling, as specified in Table I, column 6 or 13. Hold the vacuum level during oil filling as specified in Table I while the oil is being added. Break vacuum with dry nitrogen to a positive pressure of 2 to 3 psi gauge, operate pumps, and let the unit stand as specified in Table I.

The tests to be made before energizing depend upon the nature of the repairs which were made. In any case, oil dielectric breakdown and moisture content should be checked.

**Lowering Oil Below Top of Core and Coils.** If the oil must be lowered so that any part of the core and coils is exposed, use dry air to ventilate the space above the remaining oil and maintain 2 to 3 psi positive gas pressure whenever work is interrupted.

When the core and coil assembly is out of oil, 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 filling.

When repairs are complete, remove any rigid external bushing or arrester leads prior to vacuum treatment. Open all valves to all radiators, pumps, coolers, or other cooling equipment. Make vacuum connections to load tap changer compartments if required by the tap changer instruction leaflet. Close the shut-off valve to Inertaire equipment. Set valves to expansion tanks or COPS tanks according to the instruction leaflet for that equipment.

Drain any oil 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 column 5 or 12 or Table I. If the time the core and coil assembly is out of oil before evacuation for refilling is started does not exceed 16 hours oil flow into the tank may start soon as the required vacuum is obtained.

Then admit oil into the top of tank through the upper filter press valve while holding the vacuum level during oil filling as specified in Table I, until oil reaches the normal level as shown by the liquid-level gauge.

Break vacuum with dry nitrogen to a positive pressure of 2 to 3 psi gauge, run the oil pumps and let the unit stand before energizing as specified in Table I.

The tests to be made before energizing depend upon the nature of the repairs which were made. In any case, oil dielectric breakdown and moisture content should be checked.

## TESTS

A number of tests are available which can be used to determine the condition of the transformer. Some of these test are listed elsewhere in this leaflet as being required, while others may be used only under special circumstances.

The most frequently used tests are:

1. Insulation Resistance
   a. Each winding to ground and to other windings, at 1000 to 2500 volts.
   b. Core to ground at 1000 volts.
2. Insulation Power Factor
   a. Each winding to ground and to other windings.
   b. Bushings (when equipped with a test connection).
3. Winding Ratio (Note: LTC transformers may require extra test source capacity because of preventive auto exciting current on odd numbered positions).
4. Winding Resistance
5. Dielectric Strength, Power Factor, Water Content, Interfacial Tension, Gas Content and Neutralization Number of Insulating Oil.
6. Oxygen Content, Dew Point and Combustible Gas Content of Gas in the Transformer.

A permanent record should be made of all test results to serve as a basis for comparison with future maintenance tests.

## VACUUM EQUIPMENT AND PROCEDURES

In order to attain the vacuum levels specified and to maintain these levels during oil 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 blankoff 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 2 inches in diameter, preferably larger, particularly on larger transformers. There should be no low spots in the vacuum line in which oil can collect.

The pressure in the tank during vacuum operations should be measured through a connection to the upper part of the tank, above the oil 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.

A suggested piping arrangement is shown in Figure 2 for an Inertaire transformer. For Sealedaire transformers, since Sealedaire has no sampling valve, it is necessary to disconnect the Sealedaire pipe at the tank wall and connect the vacuum gauge to the tank at that point.

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 oil-filled compartments should be open during vacuum, if necessary, to limit differential pressures to values specified on the transformer instruction plate.

For smaller core-form transformers, the nameplate may specify something less than full vacuum as a safe limit. These units are almost always shipped filled with oil. For final filling of these units in the field, apply the partial vacuum which is permitted by the nameplate for the length of time specified in Table I.

The vacuum piping should be so related to the oil piping that oil will not splash or spray into the vacuum line. It is advisable to provide an oil trap in

# TABLE I

## VACUUM TREATMENT AND OIL FILLING
### of Westinghouse Transformers rated 230KV or below built at Sharon plant

| | TANK CONSTRUCTION (See Nameplate) | FULL VACUUM | | | | | | | PARTIAL VACUUM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TREATMENT | INITIAL FILL | | | | REFILL AFTER REPAIR | | | INITIAL FILL | | | | REFILL AFTER REPAIR | | |
| | | NORMAL PROCEDURE | | OPTIONAL PROCEDURE | | | | | NORMAL PROCEDURE | | OPTIONAL PROCEDURE | | | | |
| | PROCEDURE | Prelim Oil Fill | Final Oil Fill | Prelim Air Fill | Final Oil Fill | Any Part of C&C Out of Oil | Cables or Insulation Out of Oil | No Insulation Out of Oil | Prelim Oil Fill | Final Oil Fill | Prelim Air Fill | Final Oil Fill | Any Part pf C&C Out of Oil | CABLES Insulation Out of Oil | No Insulation Out of Oil |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| PREPARATION | INSTALL COVER (If sectional tank) | X | | X | | | | | X | | X | | | | |
| PREPARATION | REMOVE EXTERNAL BUSHING CONNECTIONS | | | | | X | X | | | | | | X | X | |
| PREPARATION | MAKE SET-UP FOR VACUUM IN LTC | X | X | X | X | X | X | | X | X | X | X | X | X | |
| PREPARATION | COMPLETE ALL ASSEMBLY | | X | | X | | | | | X | | X | | | |
| PREPARATION | COMPLETE REPAIRS | | | | | X | X | X | | | | | X | X | X |
| PREPARATION | RAISE C&C TEMP. ABOVE 0°C. | X | | | X | | | | X | | | X | | | |
| PREPARATION | DRAIN ALL OIL | X | | | X | X | | | X | | | X | X | | |
| PREPARATION | CLOSE INERTAIRE SHUT-OFF VALVE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| PREPARATION | OPEN ALL COOLER VALVES | | X | | X | X | X | X | | X | | X | X | X | X |
| PREPARATION | OPEN ALL PUMP VALVES | | X | | X | X | X | X | | X | | X | X | X | X |
| VACUUM | VACUUM, ABS. PRESS. TORR (mmHg) MAX | 5 | 5 | 5 | 5 | 5 | 5 | NO VAC | TANK LIMIT | TANK LIMIT | TANK LIMIT | TANK LIMIT | TANK LIMIT | TANK LIMIT | NO VAC |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | UP TO 1 MONTH AFTER SHIPMENT | | | | | | | | | | | | | | |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | NORMAL TANK, HOURS, MIN. | 6 | 0 | | 8+T/8 | | | | 12 | 0 | | 16+T/4 | | | |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | SECTIONAL TANK, HOURS, MIN. | 12 | 0 | 0 | 14+T/8 | | | | 24 | 0 | 0 | 28+T/4 | | | |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | 1 to 3 MONTHS AFTER SHIPMENT | | | | | | | | | | | | | | |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | NORMAL TANK, HOURS, MIN. | 10 | 0 | | 12+T/8 | | | | 20 | 0 | | 24+T/4 | | | |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | SECTIONAL TANK, HOURS, MIN. | 16 | 0 | 0 | 18+T/8 | | | | 32 | 0 | 0 | 36+T/4 | | | |
| VACUUM — HRS. VAC. HOLD BEFORE FILLING | REFILL AFTER REPAIR, HOURS, MIN | | | | | Note A | 0 | | | | | | Note A | 0 | |
| FILLING | OIL TEMPERATURE | | | | | | | | | | | | | | |
| FILLING | MINIMUM, °C (Note C) | Note B | 10 | | 10 | 10 | 10 | 10 | Note B | 10 | | 10 | 10 | 10 | 10 |
| FILLING | MAXIMUM, °C | 75 | 75 | | 75 | 75 | 75 | 75 | 75 | 75 | | 75 | 75 | 75 | 75 |
| FILLING | PUMP OIL THRU FILTERING EQUIP | X | X | | X | X | X | X | X | X | | X | X | X | X |
| FILLING | PUMP OIL THRU DEGASSING EQUIP | R | R | | R | R | R | R | R | R | | R | R | R | R |
| FILLING | OIL DIELECTRIC BREAKDOWN, KV MIN | 30 | 30 | | 30 | 30 | 30 | 30 | 30 | 30 | | 30 | 30 | 30 | 30 |
| FILLING | WATER CONTENT OF OIL, ppm, MAX. | 20 | 20 | | 20 | 20 | 20 | 20 | 20 | 20 | | 20 | 20 | 20 | 20 |
| FILLING | ADMIT OIL THRU UPPER FILTER PRESS VALVE | X | X | | X | X | X | | X | X | | X | X | X | |
| FILLING | ADMIT OIL HORIZONTALLY BELOW OIL | | | | | | | X | | | | | | | X |
| FILLING | VACUUM DURING FILLING, TORR, MAX. | 6 | 6 | | 6 | 6 | 6 | NO VAC | TANK LIMIT | TANK LIMIT | | TANK LIMIT | TANK LIMIT | TANK LIMIT | NO VAC |
| FILLING | RATE OF FILLING | | | | | | | | | | | | | | |
| FILLING | OIL FLOW gpm, MAX | 40 | 40 | | 40 | 40 | 40 | 40 | 40 | 40 | | 40 | 40 | 40 | 40 |
| FILLING | HOUR TO FILL, MIN | 4 | Note D | | 4 | 4 | Note D | Note D | 4 | Note D | | 4 | 4 | Note D | Note D |
| FILLING | OIL HEIGHT AFTER FILLING | | | | | | | | | | | | | | |
| FILLING | OVER CORE AND COILS | X | | | | | | | X | | | | | | |
| FILLING | NORMAL PER GAUGE | | X | | X | X | X | X | | X | | X | X | X | X |
| FILLING | RAISE PRESSURE IN TANK TO 2 to 3 psi | | | | | | | | | | | | | | |
| FILLING | WITH DRY AIR | X | | X | | | | | X | | X | | | | |
| FILLING | WITH DRY NITROGEN | | X | | X | X | X | X | | X | | X | X | X | X |
| Absorption | UNITS WITH PUMPS | | | | | | | | | | | | | | |
| Absorption | RUN PUMPS, HOURS | | 2 | | 2 | 2 | 2 | 2 | | 2 | | 2 | 2 | 2 | 2 |
| Absorption | STAND IDLE, HOURS, MIN. | | 8 | | 16 | 16 | 8 | 8 | | 8 | | 16 | 16 | 8 | 8 |
| Absorption | UNITS WITHOUT PUMPS | | | | | | | | | | | | | | |
| Absorption | STAND IDLE, HOURS, MIN | | 10 | | 20 | 20 | 10 | 10 | | 10 | | 20 | 20 | 10 | 10 |

CODES
- X or VALUE = REQUIRED PROCEDURE
- R = RECOMMENDED PROCEDURE
- T = OPEN TIME – SEE PAGE 15

CAUTION
IF CORE AND COILS ARE EXPOSED TO MOISTURE AT ANY TIME, SEE INSTRUCTION LEAFLET IL 48-620-1

NOTES
A. IF OUT OF OIL FOR 16 HOURS OR LESS, REQUIRED HOLD TIME IS ZERO. FOR LONGER OUT OF OIL TIME CONSIDER DATE OF LOWERING OIL AS SHIPPING DATE AND SELECT HOLD TIME FROM COLUMN 4 OR 11 AS APPLICABLE
B. 10°C. IF TANK WILL BE OPENED SOON AFTER OIL FILL OIL TEMPERATURE SHOULD BE AT LEAST 10°C ABOVE DEW POINT OF AMBIENT AIR
C. USE HEAT EXCHANGER IN OIL LINE BETWEEN FILTER AND TRANSFORMER, IF NECESSARY, TO HOLD MINIMUM OIL TEMP
D. MINIMUM HOURS TO FILL = 4x $\frac{\text{HEIGHT FROM OIL SURFACE TO ℄ OIL GAUGE}}{\text{HEIGHT FROM TANK BOTTOM TO ℄ OIL GAUGE}}$

the vacuum line to protect the pump from the insulating oil. The efficiency of most vacuum pumps is dependent upon the condition of the pump oil. If the pump oil becomes cloudy from the moisture or thins out because of insulating oil contamination it should be changed.

## OIL

The transformer oil must meet the requirements of Westinghouse Purchasing Department Specification 55822AG. Transformer oil is very sensitive to contamination, so tanks, pumps, pipes and hoses in which the oil is shipped or handled must be clean and free from moisture and other contaminants. I.B. 45-063-100 contains instructions which must be followed in sampling, testing and handling the oil.

Samples of oil should be drawn from the lowest point of each container in which oil is received. These samples must be tested and inspected. Do not use oil from any container unless the sample meets all of the following requirements:

**Visually Detectable Water — None**
**Dielectric Strength — 30 KV Minimum**
**Power Factor — .05% Maximum**
**Water Content — 35 ppm Maximum**

The temperature of the oil when it is added to the transformer during vacuum filling must be 10° C or higher. If the transformer is to be opened after adding oil, the oil temperature must be at least 10° C higher than the dew point of the outside air.

Oil should be pumped through the upper filter press valve into the top of the transformer through oil conditioning equipment. Filtering equipment to deliver clean oil with a maximum water content of 20 ppm is a necessity. Heaters to raise the oil temperature as high as possible, but not exceeding 75° C, help assure dryness of the filled transformer; they are a necessity if oil temperature is below the limits given above. Degassing equipment, while not a necessity for transformers with a maximum rated voltage of 230KV or less, is recommended in all cases to reduce the gas content of the oil to 1% or less and to further reduce moisture content below the 20 ppm maximum allowable, for increased assurance that the filled transformer will be dry and free of bubbles. The pumps, valves and piping should be arranged so that the oil is at a slight positive gauge pressure until it reaches a throttling valve and all connections between it and the transformer should be checked carefully for leaks, in order to prevent air and moisture from being drawn into the oil as it enters the transformer.

There are two standard methods of measuring the dielectric breakdown voltage of transformer oil. Method ASTM D877 has been in widespread use for many years and is the basis for the 30KV value shown above and in the section **Energizing the Transformer.** The newer method, ASTM D1816, is recommended for the final check, using the 28KV limits, as applicable, shown in the section **Energizing the Transformer.** For the range of transformers covered by this instruction leaflet, either method is acceptable.

## DRY GAS

When nitrogen is required, it must have a dew point not higher than -50° C (-58° F), and total impurities not exceeding 0.1% by volume. Nitrogen can be obtained in high pressure steel cylinders or in some locations in insulated low pressure containers in liquid form. In general, liquid nitrogen, which will boil in the container to yield gaseous nitrogen, will have a lower dew point than gas in high pressure cylinders.

Dry air must also have a dew point of -50° C (58° F) or lower. It is usually available in cylinders from the same sources 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.

## MISCELLANEOUS EQUIPMENT

The following list of acceptable auxiliary equipment for installing transformers is furnished for reference. It is not intended to be a complete listing of approved materials, devices, or suppliers.

**Oil Hose**

B. F. Goodrich Co. Type 82A
Boston Jaguar Transformer Oil-Handling Hose
U.S. Rubber PS120 Hose

**Device for Measuring Moisture Content of Oil**

Karl-Fischer Titrator
Photovolt Aquatest 700

**Device for Measuring Dew Point**

Alnor Dewpointer, Type 7300
Panametrics Hygrometer

**Vacuum Gauges**

Hastings Vacuum Gauges
Wallace and Tiernan Vacuum Gauges

## REFERENCES

I.B. 45-063-100—Instructions for WEMCO C and WEMCO C1 Insulating Oils

I.L. 48-063-35—Instructions for Oil Preservation System (COPS)

I.L. 48-063-36—Instructions for Inertaire Equipment, Types RN and RNE

I.L. 48-069-1—Gaskets

I.L. 48-069-15—Instructions for Standard Outside Finish, Oil Insulated Transformer Tanks

I.L. 48-069-20—Instructions for Repairing Tank Leaks

Westinghouse P.D.S. 55822AG—Mineral Insulating Oil

# Memorandum

# Memorandum

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Westinghouse · Medium Power Transformer Division · Sharon, Pa.

Printed in U.S.A.
(H.)

# INSTRUCTIONS

## DETERMINATION OF DRYNESS and METHODS OF DRYING OUT

All transformers are dry when they leave the factory, but since they may absorb more or less moisture during shipment and storage, they should not be put into service until it has been determined that the oil and insulation are dry enough for safe operation. The higher the voltage, the more chances there are of trouble from moisture, and the greatest care should be exercised to make sure that the moisture is practically eliminated.

### DRYNESS OF OIL AND WINDINGS

When a transformer has been shipped assembled in its case with the oil, four or five samples of oil should be drawn from the bottom of the case and tested. If the average of these tests shows a breakdown value of not less than 22,000 volts on a standard 1/10″ gap test-cup, the insulation and oil are in a satisfactory condition for service. If the average breakdown value is less than 22,000 volts, the oil must be dried. Whether the windings must also be dried should be determined as described under "Insulation Resistance". If the insulation resistance is of the proper value, drying of the windings is unnecessary and the transformer may be put into service.

When a transformer is shipped without either oil or dry nitrogen gas, drying out will be necessary, except in the cases of transformers 500 kva, and under, and of less than 7500 volts. These latter transformers should be tested for dryness before being put into service.

There is no absolute method of determining when the insulation of a transformer is dry, but proper measurements of insulation resistance will serve as an approximate indication of its condition.

**Insulation Resistance.** Insulation resistance measured with the transformer cold is greater than when measured with it hot and is also greater out of oil than when immersed in oil. Therefore, in order to determine the condition of the insulation all of the measured values must be reduced to a fixed set of conditions. The reference conditions are a temperature of 20°C and with the transformer filled with dry transformer oil in good condition. For these conditions the minimum satisfactory insulation resistance corresponding to each nominal line to line voltage class is given. Corrected measured values lower than those tabulated indicate that the transformer should be dried before energizing (See Figure 1).

**Minimum Insulation Resistance in Oil at 20°C**

| L-L VOLTAGE CLASS KV | MEGOHMS | L-L VOLTAGE CLASS KV | MEGOHMS |
|---|---|---|---|
| 1.2 | 32 | 92 | 2480 |
| 2.5 | 68 | 115 | 3100 |
| 5 | 135 | 138 | 3720 |
| 8.66 | 230 | 161 | 4350 |
| 15 | 410 | 196 | 5300 |
| 25 | 670 | 230 | 6200 |
| 34.5 | 930 | 287 | 7750 |
| 46 | 1240 | 345 | 9300 |
| 69 | 1860 | | |

FIG. 1

**Insulation Resistance Temperature Correction**

| TRANSFORMER TEMPERATURE °C | CORRECTION FACTOR | TRANSFORMER TEMPERATURE °C | CORRECTION FACTOR |
|---|---|---|---|
| 95 | 89.0 | 35 | 2.5 |
| 90 | 66.0 | 30 | 1.8 |
| 85 | 49.0 | 25 | 1.3 |
| 80 | 36.2 | 20 | 1.0 |
| 75 | 26.8 | 15 | 0.73 |
| 70 | 20.0 | 10 | 0.54 |
| 65 | 14.8 | 5 | 0.40 |
| 60 | 11.0 | 0 | 0.30 |
| 55 | 8.1 | − 5 | 0.22 |
| 50 | 6.0 | − 10 | 0.16 |
| 45 | 4.5 | − 15 | 0.12 |
| 40 | 3.3 | | |

FIG. 2

The measured insulation resistance at the transformer temperature is corrected to 20°C by multiplying the measured value by the correction factor corresponding to the transformer temperature. If the insulation resistance is measured with the transformer out of oil the measured values should first be divided by 20 and then corrected for temperature. It is desirable to have the temperature of the transformer between +40°C and 0°C to keep from making large corrections.

## METHOD OF MEASUREMENT

**Megger.** The most satisfactory method of measuring the insulation resistance is by a megger. This instrument is very convenient to use and indicates the megohm resistance directly. In order to secure uniform results, measurements of insulation resistance with the megger type of instrument should follow a regular procedure.

The recommended practice in measuring insulation resistance is to always ground the tank and the core iron or be sure they are grounded. Short-circuit each winding of the transformer at the bushing terminals. Resistance measurements are then made between each winding and all other windings grounded. Windings are never left floating for insulation resistance measurements. Solidly grounded windings must have the ground removed in order to measure the insulation resistance of the winding to other windings grounded. If the ground cannot be removed as in the case of some windings with solidly grounded neutrals, the insulation resistance of the winding cannot be measured. It is then treated as part of the grounded section of the circuit.

For example, in the case of a three-winding transformer, the high-voltage, tertiary-voltage, and low-voltage windings are each short-circuited by connecting their terminals together. The high-voltage winding insulation resistance is measured by connecting the high-voltage terminals to the line or resistance terminal of the megger. The low-voltage and tertiary-voltage windings are connected together and to ground and to the ground terminal of the megger. The guard terminal of the megger, if the instrument has a guard terminal, is not used but left floating. The resistance measured is commonly designated the H-LTG resistance. Likewise, the other windings are measured and the measurements called T-HLG and L-HTG resistances. Two-winding transformers would have only two resistances, H-LG and L-HG.

The instrument used to measure the resistance should have a voltage output of at least 500 volts. The maximum insulation resistance to be measured must be less than the megohm rating of the instrument. Resistance readings at the extreme upper end of the instrument scale are not reliable. Where this condition exists an instrument capable of measuring a higher resistance should be used. The measuring lead should be air insulated from all other leads and from ground and grounded objects in order to prevent misleading results due to measuring conductor insulation resistance instead of the transformer insulation resistance.

The megger type of instrument may be motor driven, hand cranked or supplied by a rectifier built in the instrument. If a motor driven or a rectifier instrument is used the insulation resistance indicated by the instrument should be recorded approximately one minute after the voltage from the instrument is applied to the transformer. In other words, the voltage from the instrument should be applied for one minute before recording the resistance value. In the case of the hand cranked instrument the time interval after starting to crank the instrument until recording the resistance value indicated should not be less than 30 seconds and preferably should be approximately one minute. This reduction in time is permissible due to the difficulty of cranking a megger continuously for one minute. In any case the time interval during which the voltage is applied should be consistent throughout the tests and should be recorded with the insulation resistance values. All measurements should be made with the same procedure to avoid errors and to obtain comparative results.

**Insulation Power Factor.** Insulation power factor tests either by special bridge circuits or by the voltampere-watt method may be used for determining the moisture condition of insulation. These tests are described in AIEE Standard Number 505. Single values of insulation power factor may not be significant, however, reference values on transformers as shipped from the factory can be obtained through the nearest Westinghouse office if the serial number of the transformer is known. The measured power factors may then be compared. A large increase in power factor (50% or more) should be considered as an indication of moisture in the insulation.

## METHODS OF DRYING OUT

The primary objective of any method of drying out is to remove the moisture from the insulation of the transformer. The exact procedural instructions for achieving this objective cannot be given in general instructions since conditions at the particular location of the transformer dictate the detailed plan to be followed. Drying out a large power transformer is a major operation involving equipment worth a considerable amount of money and requiring careful supervision to prevent damage to the equipment. The engineer in charge of the operation should be sure the workmen understand the procedure to be followed. In some cases continuous direct supervision may be necessary.

Three methods are presented to illustrate and provide information that may be useful in setting up the exact operational procedures.

1. By internal heat.
2. By external heat.
3. By heating and applying vacuum.

The order in which the use of the above methods is recommended, if there is any choice of the methods that can be used, is 3, 2, 1.

Method 3 is the one recommended by Westinghouse and should be used whenever possible. The other methods are much slower and less positive in the drying. In using any of the methods the drying cannot be accomplished in less than 72 hours of drying time. Some cases may require as much as four or five weeks depending on the amount of moisture to be removed, the method of drying used and the size and voltage of the transformer.

Method 1 is suitable for use only on medium and small power transformers 69 kv and below, 3000 kva three phase or 1000 kva single phase and lower. Adequate drying of large or high-voltage power transformers cannot be accomplished using this method.

Method 2 requires longer time than method 3, but properly used gives satisfactory drying where a vacuum pump is not readily available.

**1. Drying Out by Internal Heat.** Alternating current is required for this method. The transformer should be placed in its case with oil and with the manhole cover removed to allow free circulation of air in the gas space. The low-voltage 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 ½ percent to 1½ 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 end terminals of the full winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat or a regulator in series with the high-voltage winding.

This method of drying out is slow and is most effective with small transformers and then only when local conditions prohibit the use of one of the other methods.

Another method of heating may be used on large transformers when they are filled with oil. An electric heater may be constructed using standard oil-immersion heating elements. This is an oil-tight sheet metal box with an oil inlet near the bottom and an oil outlet in the top near the opposite side from the inlet. The immersion heaters are inserted in the top of the box. Oil is pumped out of the bottom of the transformer through the heater and back into the top of the transformer. It is usually necessary to have a screen in the oil intake line to the pump to prevent any possibility of jamming. This is particularly true using positive displacement pumps. The pump capacity should be sufficient to provide a complete change of oil in the transformer approximately once an hour.

The immersion heating capacity necessary is about 1¼ times the estimated tank radiation plus convection heat dissipation based on a tank wall temperature of 85°C. The tank heat dissipation may be considered as ¾ watt per square inch of tank surface area effective as cooling surface. This is the total area of the tank walls plus the area of the top. The electrical load may be estimated at 1 watt per square inch. This allows for some heat loss in the piping and heater. The heating capacity can be reduced by blanketing the cooling surfaces to reduce their effectiveness.

The oil temperature in the heater must not exceed 90°C. A thermometer well and thermometer or thermocouple are necessary in the top oil near the outlet of the heating chamber. Heating elements can be cut out of the heating circuit to control the temperature of the oil leaving the heater.

The pump power supply and the heating circuit must be interlocked so that if the power supply to the pump fails, the heater will automatically be shut off. This is necessary to prevent severe overheating of the oil in the heater in case the pump stops.

The drying can be accelerated by either continuously filtering the oil or by applying a high vacuum (28 inches of mercury or higher) to the gas space of the transformer. In case the vacuum is used, all the piping and fixtures in the oil circuit must be designed to withstand a full vacuum. If a filter press is used, the filter press oil circuit should, preferably, be separated from the heating oil circuit. The capacity of the filter press is ordinarily limited to 10 GPM or less. This would not be sufficient oil circulation for heating purposes under ordinary circumstances.

Automatic control of the oil heaters based on the 90°C oil temperature is easy to install. Automatic control of the temperature is well worth the extra expense involved in the additional safety of operation provided by preventing excessive oil temperatures.

**2. Drying Out by External Heat.** The transformer may be placed in its own tank without oil and externally heated air blown into the tank at the bottom. A blower or fan should be used to get proper circulation of the air through the transformer. It is essential to force as much heated air as possible up through the ducts in the coil and insulation assembly. Baffles may be necessary between the core and coils and the tank wall to close off as much air leakage space as possible to force the air up through the ducts.

It is essential, with this method of drying, to have sufficient blower capacity. The blower rating required may be estimated on the basis of one cubic foot of free air per minute for each ten kva of transformer rating.

The air inlet opening or openings should have a cross-sectional area of at least 20 square inches for each 1000 cfm of air supplied. The manhole is generally used for the air exit, thus the air exit cross-sectional area is easy to obtain. In any case, the exit section area should not be less than the total inlet area.

The heat input to the heater may be estimated as 2.44 BTU per minute for each cubic foot per minute of air flow. The power input to the heaters may be estimated as 43 watts for each cubic foot per minute of air flow. The advantage of using a steam to air heat exchanger where steam is available is obvious.

It is desirable to have several inlet openings in order to insure good air distribution. The total cross-section aera of drain, radiator or other openings at the bottom of large power transformers generally will not provide sufficient area for using this method of drying.

Example: 30000 kva transformer.

The minimum blower capacity required is 3000 cubic feet per minute free air. A larger blower could be used, but one of lower capacity should not be used. The minimum total cross-section area of the air inlet openings should be at least 60 square inches. If openings of this area are available this method could be used. Using a 16-inch diameter manhole for the exit, the area is 201 square inches and is satisfactory.

The method of heating the air must be selected in view of local conditions where the drying is performed. In some cases electric heaters may be used, in others steam to air heat exchangers may be used. In some cases heating indirectly by fuel combustion may be the only method available. This might be by gas or fuel oil. The hot products of combustion are circulated through a heat exchanger to exclude the products of combustion from the air being heated. Any method using fuel combustion for heat generation must completely exclude and seal the products of combustion from the air being circulated through the transformer.

The air heating surface of either the electric heaters or the indirect combustion heat exchangers must be large enough to keep the surface temperature below the metal scaling point. Particles of hot scale blown into the insulation could result in serious trouble. It is necessary to be extremely careful in both of these methods of heating to be sure that no sparks or incandescent particles can be blown into the transformer. This is particularly true with electric heaters where poor electrical contacts must be guarded against.

Close continuous control of the temperature of the hot air entering the transformer is necessary. The air temperature should not exceed a maximum of 90°C. Air temperature in excess of this may cause spontaneous combustion in the oil treated insulation.

If for any reason it is not expedient to place the transformer in its own tank, it may be placed in a wooden box with air inlets at the bottom and air vents near the top. The same precautions as given for drying in its own tank should be taken to see that the air is forced to circulate through the oil ducts in the insulation.

It is essential that every precaution be taken to prevent fire when drying out by this method. The set-up must be watched very carefully during the entire drying period. If the blower should stop, the heater must be shut off at once to prevent severe overheating. Do not try to accelerate the heating by circulating current in the transformer windings. The transformers are designed to be cooled by a liquid. The heat generated in the windings by circulating current with the assembly in air may allow extreme temperatures to develop and damage the windings and insulation. Automatic temperature control and complete interlocking of blower and heater controls are desirable. The interlocking should be such that failure of control voltages, failure of blower power or failure of the heat source will completely shut down the process. A failure resulting in shutdown should require manual restarting of the equipment. The advantage of automatic control in obtaining satisfactory drying using this method cannot be overemphasized.

**3. Drying Out by Heating and Applying Vacuum.** This is a combination of heating and vacuum drying that will give rapid, thorough drying. The transformer in its own tank is heated by Method 1 or 2, until the winding temperature measured by resistance is 80°C to 90°C. The sources of heat are then regulated to maintain this temperature for at least 24 hours in order to have the transformer uniformly and thoroughly heated. The sources of heat are then shut off. If Method 1 is used, remove the oil. The transformer tank is sealed. A vacuum is applied to the transformer tank through the upper filter press or other connection in the top of the tank. The vacuum should reduce the pressure to as low a value as possible. The highest vacuum permitted by the tank design is stated on the instruction plate. The pressure should not be reduced below that allowed by the instruction plate statement. If the instruction plate does not give this information, the Westinghouse Electric Corporation, Sharon, Pennsylvania, should be consulted before applying any vacuum to the tank. In the case of full-vacuum tanks the evacuating equipment should be capable of producing a continuous vacuum of at least 28 inches of mercury in the transformer tank. The rate of removal of moisture is increased by the use of a high vacuum with the corresponding depression of the boiling point of water.

The vacuum is maintained by continuous pumping until the temperature of the windings drops about 40°C measured by resistance. At this point the pumping is discontinued, the vacuum is released and the heating resumed to bring the windings again up to 80° to 90°C. The insulation resistance is then measured to check the progress of the drying. The process described above is then repeated until the insulation-resistance-versus-drying time curve indicates that the windings and insulation are dry.

The number of heating and vacuum drying cycles necessary will depend upon the amount of insulation to be dried and on its moisture content. The minimum number of drying cycles will be at least three, the maximum may be as many as seven or more complete cycles in extreme cases. Drying time will require from one to two or more weeks depending on the number of drying cycles necessary.

Drying may be accelerated in Method 1 by obtaining more uniform heat distribution in the insulation where facilities are available for readily transferring and storing the oil in the transformer.

The procedure is as follows: The transformer, in its own tank and filled to the normal oil level, is heated by circulating full load or 1¼ times full load current through the full windings as described in Method 1. Self-cooled units with radiators may be heated by closing the radiator valves on all except 2 or 3 radiators. These valves are left open to allow oil circulation through the transformer thereby obtaining more uniform heating of the insulation by the hot oil. Forced-oil-cooled units should have at least one oil pump running.

The temperature of the windings should not be allowed to exceed 80° to 90°C as measured by winding resistance. If check measurements during the heating period indicate that this temperature range will be overshot, the current should be reduced.

Top oil temperature serves as a good indication of the heating of the internal parts of a transformer. A constant value of top oil temperature indicates that the heating for a constant input has reached an equilibrium condition. Thus, after the top oil temperature has been constant for four hours and the winding temperature constant in the range of 80° to 90°C, the heating may be assumed to have reached an equilibrium condition. The current is then shut off and the oil transferred from the transformer to the storage tank as rapidly as possible. The insulation resistance is measured and the tank sealed. Vacuum is then applied as previously described.

When the temperature of the windings as measured by resistance drops to about 40°C the oil is allowed to flow back into the transformer without releasing the vacuum. The vacuum increases the rate of oil transfer but considerable care is necessary to prevent oil from being drawn over into the vacuum line. Extreme care should be used in this regard if a reciprocating type of vacuum pump is being used as they have very small clearance compared to air compressors. A slight amount of oil in the cylinder may result in a blown gasket, fractured or blown cylinder head.

The vacuum is released after the transformer is filled to the normal oil level and the heating cycle started. If facilities are available for maintaining an oil temperature of about 90°C during the storage period the heating cycle of the transformer will be shortened.

## DRYING OUT PROCEDURE

**Time Required.** There is no definite length of time required for drying out a transformer. One to four weeks or more will generally be required for Methods 1 and 2, depending upon the condition of the transformer, the size, the voltage and method of drying used. Method 3 will generally be more rapid than Method 1 or 2. In general, any power transformer will require at least one week of drying time regardless of the method used.

**Details To Be Regarded.** The insulation resistance measured at a constant temperature will generally have a gradually increasing trend as the drying proceeds. Towards the end of the drying period the increase will become more rapid. Sometimes the resistance will rise and fall a short range one or more times before reaching a steady high point. This is caused by moisture working its way out from the interior of the insulation through the outer portions of the insulation which were dried first. Large changes in the measured insulation resistance may be caused by temperature variations. Insulation resistance measurements should be made at the same temperature insofar as it is possible to do so. Measurements should be taken at about four-hour intervals when drying by Method 1 or 2 and at the end of each heating cycle but before applying vacuum when using Method 3.

**Resistance Curve.** A curve of the insulation resistance measurements should be plotted with time as abscissa and resistance as ordinates. The resistance points plotted should be the measured resistance corrected to a temperature of 20°C. The drying curve will generally show wide variations in the resistance values during the first part of the drying period. The variation of plotted resistance values from the mean curve becomes less as the moisture works out of the insulation. The drying should be continued until consistently high values of resistance are obtained for at least four consecutive measurements covering a period of at least 16 hours of the drying period. (See Figure 2.)

**Precautions To Be Observed in Drying Out.** As the drying temperature approaches the point where organic fibrous materials deteriorate, great care must be taken to keep the winding temperature as measured by winding resistance below 90°C. It is considered good practice to try to keep from exceeding 80°C. This allows a 10°C margin for errors in measurement and for the difficulty of controlling temperature.

**Caution:** When the transformer is received from the factory it is soaked with oil and in an inflammable condition. It may be ignited very easily by an arc, spark or flame of any kind. Smoking near a transformer during the process of drying out should not be permitted. It is essential that adequate fire fighting equipment be at hand during the drying process. It is recommended that only an inert gas be used for extinguishing a fire if one should occur. Carbon tetrachloride, soda-acid, foamite or water type fire extinguishers should not be used as they cause considerable additional damage. The extinguishing equipment may be in the form of several large fire extinguishers or cylinders of inert gas; such as, carbon dioxide or nitrogen. The gas may be piped direct to the transformer tank in order to flood the tank rapidly with gas if a fire starts. All personnel concerned with the work of drying should be fully informed as to the procedure to be followed if a fire occurs. Each person should know exactly what to do if a fire starts. Alertness in extinguishing a fire may mean the difference between a total loss and only minor damage and will greatly reduce the expense and time required to repair a transformer.

It is not safe to attempt the drying out of transformers without constant attention by competent personnel.

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
Printed in U.S.A.

# Instructions For Preparing Transformers for Operation with Nitrogen Gas

I.L. 48-063-9

GAS-PROTECTED TRANSFORMERS may be installed with air in the gas space when simplicity of installation is of prime importance. In time, depending upon the oil temperature, the oxygen content is depleted by oxidizing oil leaving a blanket of inert gas above the oil. The amount of oxidation caused by this oxygen is so small that it is not harmful to the oil. During the early part of this period, when the oxygen content is greater then 7 percent, the transformer is not completely protected against the possibility of secondary explosion or fire in event of an internal fault. Therefore, if the customer wishes to obtain initial increased protection to the transformer, he can do so by purging the oxygen from the transformer with nitrogen.

## METHODS OF PURGING OXYGEN FROM THE TRANSFORMER

Vacuum Filling. If the instruction plate specifies that the transformer tank will withstand full vacuum and a vacuum pump is available, the procedure outlined below can be followed for complete removal of oxygen from the gas space and oil:

### Inertaire.

1. Assemble the transformer complete for operation (with the oil at the proper level); replace the operating nitrogen cylinder with a "purging" nitrogen cylinder (Westinghouse Nitrogen P.D.S. 5622) if transformer oil exceeds 7500 gallons, otherwise use operating nitrogen cylinder. (Westinghouse Nitrogen P.D.S. 6306). Close shut-off valve (clockwise to limit); attach a vacuum line to gas sampling valve in the Inertaire cabinet, and pump the gas from the space over the oil.

2. After obtaining the maximum vacuum which the pump will produce, hold for one hour, open test valve and cylinder valve, and then open the shut-off valve slowly 1-1/2 turns to mid-position. (Do not exceed the vacuum limits of the transformer pressure indicator.) Allow nitrogen gas to flow into the gas space. Do not exceed the maximum pressure of the pressure limiting device.

3. Replace the purging cylinder with the operating cylinder if nitrogen P.D.S. 5622 was used for purging.

### Sealedaire.

1. Assemble the transformer complete for operation (with the oil at the proper level); remove the pipe plug from the vent hole in the cover and attach a vacuum line. Seal the open end of the pressure-vacuum bleeder with rubber stopper or plug. Pump the gas from the space over the oil.

2. After obtaining the maximum vacuum which the pump will produce, hold for one hour and then attach a nitrogen cylinder, with pressure reducing unit, to the top filter press connection and allow low pressure nitrogen to flow into the gas space. At atmospheric pressure, remove vacuum line and replace pipe plug in the vent hole. Additional nitrogen may be fed into the transformer tank, but do not exceed the maximum pressure of the bleeder valve. Close the top filter press valve and remove nitrogen equipment. Remove rubber stopper from bleeder valve.

### Gas-oil Seal.

1. Assemble the transformer complete for operation (with the oil at the proper level); seal off the gas-oil seal compartment with the back-seating angle valve; attach a vacuum line to the gas sampling valve on the transformer; and pump the gas from the space over the oil.

2. After obtaining the maximum vacuum which the pump will produce, hold for

Effective October, 1962
Supersedes I.L. 46-710-9C, November, 1956

one hour and then attach a nitrogen cylinder, with pressure-reducing unit, to the gas sampling valve in place of the vacuum line. Open gas sampling valve on the transformer and allow low pressure nitrogen to flow into the gas space. Do not exceed 5 PSI.

3. With low but positive pressure in the transformer gas space, open the sampling valve on the expansion tank and reopen the back seating angle valve and allow dry nitrogen to flow through transformer gas space into the expansion tank until the gas from the expansion tank valve is comparatively free of oxygen. Close the sampling valve on the expansion tank and allow pressure to increase to force all the oil from the lower compartment of the expansion tank into the upper compartment (indicated by gas bubbling from lower to upper compartment). Close transformer sampling valve and remove nitrogen cylinder.

Transferring Oil from One Unit to Another. Where two units are being installed, they may be piped together through their drain valves or lower filter press connections. Nitrogen pressure can then be used to force oil from the first unit into the second until the oil flows from the gas sampling valve (which must be left open before starting). This will leave less than one inch of gas space above the oil in the Sealedaire transformer. The oil can be forced back into the first unit with nitrogen pressure as mentioned above. Nitrogen pressure can then be added to the first unit with the connection between the tanks open until the oil in the two tanks is at the same level. The entire process is repeated after several hours.

When more than two units are being installed, they may be connected in series with the last unit connected to the first unit. Oil is forced from the first unit to the second unit, then to the third unit, etc. The procedure is the same as described in the previous paragraph and must also be repeated after several hours.

This method is applicable for Inertaire, Sealedaire and Gas-Oil Sealed units.

BLOWING OUT WITH NITROGEN

Inertaire.

1. Assemble the transformer complete for operation (with the oil at the proper level); replace the operating nitrogen cylinder with a purging nitrogen cylinder; open the test valve on the pressure reducing unit; turn the shut-off valve to the mid-position (see Instruction Leaflet "Inertaire Equipment"); open the sampling valve and open the nitrogen cylinder valve. This permits the nitrogen to flow into the gas space, forcing the air out of the sampling valve. The nitrogen should be allowed to flow until the oxygen in the escaping gas is reduced to 3 percent.

2. Continue tests specified in Instruction Leaflet "Inertaire Equipment".

Sealedaire.

1. Assemble the transformer complete for operation (with oil at proper level); remove pipe plug from vent hole on cover and attach nitrogen cylinder, with a pressure-reducing unit, to top filter press connection. Do not use sampling valve on pressure-vacuum bleeder to introduce gas into the transformer.

2. Allow nitrogen to flow into transformer and out the vent in cover. The nitrogen should flow until the oxygen in the escaping gas is 5% or less.

3. Close vent in cover and let pressure in tank increase to about 6 PSI and then close valve and remove nitrogen cylinder.

4. Allow the unit to stand for a day and then discharge the pressure, and again build up to the maximum. After another day repeat this procedure and leave the unit with this pressure.

Gas-oil Sealed.

1. Assemble the transformer complete for operation (with the oil at the proper

level); attach a nitrogen cylinder with a pressure reducing unit, to the gas sampling valve on the transformer; open the gas sampling valve in the lower gas space of the gas-oil seal compartment; and open the back-seating angle valve in the line between the transformer and compartment.

2. Allow the nitrogen to flow into the transformer gas space, to the lower gas space of the gas-oil seal compartment, and out through the sampling valve. The nitrogen should flow until the oxygen in the escaping gas is reduced to 3 percent.

3. Return valves to normal conditions, and remove nitrogen cylinder.

NOTE: For initial deoxygenation, or where the transformer oil has been open to the atmosphere for more than 48 hours, it is a waste of nitrogen to try to reduce oxygen content to less than 3 percent. This waste is due to: (1) sufficient oxygen is in the oil to require subsequent purging; (2) about four times as much nitrogen is required to purge oxygen down from 3 to 1 percent as from 20 to 3 percent.

During shipment the oil may absorb oxygen which will be replaced slowly by the nitrogen. Thus the oxygen content of the gas space may actually increase after installation requiring additional purging.

CAUTION: If a manhole cover or handhole cover of an Inertaire, Sealedaire, or Gas-Oil Sealed unit is removed, do not enter the transformer until the gas space has been opened to the atmosphere for several minutes, as the gas will not contain sufficient oxygen to sustain life.

PRESSURE REDUCING UNITS

The standard pressure reducing unit used on Inertaire equipment is the preferred device for delivering low pressure gas in the deoxygenation work. However, if it is not available a special fitting should be used to reduce the cylinder pressure to a few pounds-per-square-inch which is required for purging a gas space. This fitting, style number 1165 915, should be ordered from the Sharon Plant when required (see Fig. 1).

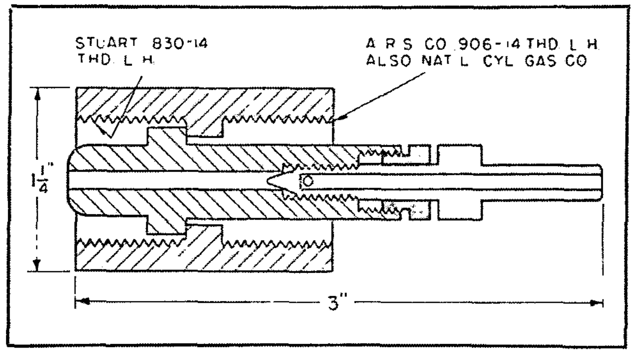



Fig. 1 *Standard Pressure Reducing Unit*

NITROGEN

The nitrogen used for purging oxygen from transformers must be dry. Commercial nitrogen is not always free from moisture; therefore, only oil-pumped nitrogen or nitrogen supplied under a guarantee that the moisture content is less than 0.03 percent by weight and impurity content less than 0.30 percent by volume should be used.

If the customer has chosen to purge the transformer he may order nitrogen from the supplier as Westinghouse nitrogen, P.D.S. 5622. Do not use any other grade of nitrogen or any other gas. Purging cylinders are the property of the nitrogen supplier and should be promptly returned since demurrage will be charged after 30 days.

Operating cylinders which are furnished with Inertaire equipment are the property of the customer. Nitrogen for these cylinders is covered by Westinghouse nitrogen P.D.S. 6306. Proper ordering information is contained in the Instruction Leaflet "Inertaire Equipment".

The following is a list of recommended nitrogen suppliers. Send orders and cylinders to the addresses given, unless otherwise specified.

# LIST OF RECOMMENDED NITROGEN SUPPLIERS

**ALABAMA**

Air Reduction Co.
2825 No. 29th Ave.
N. Birmingham 7, Ala.
Send cylinders to Fairfield, Ala.

**ARKANSAS**

National Cylinder Gas Co.
700 Wheeler Ave.
Ft. Smith, Ark.

**CALIFORNIA**

Air Reduction Pacific Co
Park Ave. & Halleck St.
Emeryville 8, California

Air Reduction Pacific Co.
2423 E. 58th St.
Los Angeles, California

National Cylinder Gas Co.
11705 S. Alameda St.
Los Angeles 2, California

National Cylinder Gas Co.
P.O. Box 427
Wilmington, California

**CONNECTICUT**

National Cylinder Gas Co.
Main Street
South Meriden, Conn.

**FLORIDA**

National Cylinder Gas Co.
P.O. Box 2849
Jacksonville 3, Florida

**GEORGIA**

National Cylinder Gas Co.
471 Peters Street, S.W.
Atlanta, Georgia

**ILLINOIS**

Air Reduction Company
3100 S. Homan Avenue
Chicago 23, Ill.

National Cylinder Gas Co.
1501 W. 44th Street
Chicago, Illinois

National Cylinder Gas Co.
10305 Torrence Ave.
South Chicago, Illinois

National Cylinder Gas Co.
P.O. Box 350
LaGrange, Illinois

National Cylinder Gas Co.
P.O. Box 627
Peoria 1, Illinois

**INDIANA**

National Cylinder Gas Co.
P.O. Box 784
Evansville 1, Indiana

National Cylinder Gas Co.
3209 Madison Ave.
Indianapolis, Indiana

National Cylinder Gas Co.
601 Erie Avenue
Logansport, Indiana

**IOWA**

Air Reduction Co.
2561 State St.
Betterdorf, Ia.

**KANSAS**

National Cylinder Gas Co.
1614-26 State Ave.
Kansas City 2, Kansas

**KENTUCKY**

Air Reduction Co.
550 So. 5th St.
Louisville 1, Ky.

Send cylinders to 1256 Logan St.
Louisville, Ky.

**LOUISIANA**

Air Reduction Co.
1406 So. Rendon St.
New Orleans 2, La.

National Cylinder Gas Co.
569 Felicity St.
New Orleans 9, La.

National Cylinder Gas Co.
P.O. Box 284
Shreveport, Louisiana

**MARYLAND**

Air Reduction Co.
1310 N. Calvert St.
Baltimore 2, Md.
Send cylinders to 4501 E. Fayette St.
Baltimore, Md.

National Cylinder Gas Co.
1700 S. Newkirk Street
Baltimore 24, Maryland

**MASSACHUSETTS**

Air Reduction Co.
122 Mt. Vernon St.
Upham's Corner
Boston, Mass.

National Cylinder Gas Co.
205 Medford Street
Malden 48, Mass.

**MICHIGAN**

Air Reduction Co.
2994 E. Grand Blvd.
Detroit 2, Mich.
Send cylinders to
7991 Hartwick St.
Detroit, Mich.

National Cylinder Gas Co.
P.O. Box 30
Ferndale 20, Michigan

National Cylinder Gas Co.
P.O. Box 35, Roosevelt Sq.
Grand Rapids 9, Mich.

**MINNESOTA**

Air Reduction Co.
1111 Nicollet Ave.
Minneapolis 2, Minn.
Send cylinders to
327 25th St., S.E.
Minneapolis, Minn.

National Cylinder Gas Co.
965 North Lexington Parkway
St. Paul 3, Minnesota

**MISSOURI**

Air Reduction Co.
2701 Warwick Trafficway
Kansas City 8, Mo.
Send cylinders to
1000 W. 26th St.
Kansas City, Mo.

Air Reduction Co.
630 So. 2nd Street
St. Louis, Mo.

National Cylinder Gas Co.
1520 S. Vandeventer Ave.
St. Louis 10, Missouri

**NORTH CAROLINA**

National Cylinder Gas Co.
2414 S. Boulevard
Charlotte 3, N. C.

**NEW JERSEY**

Air Reduction Co
181 Pacific Avenue
Jersey City 4, N. J.

National Cylinder Gas Co.
2136—85th Street
North Bergen, N. J.

**NEW YORK**

Air Reduction Co.
730 Grant Street
Buffalo 13, N. Y.

National Cylinder Gas Co.
South & Front Streets
Hornell, N. Y.

National Cylinder Gas Co.
Buffalo Ave. & 53rd St.
Niagara Falls, N. Y.

**OHIO**

National Cylinder Gas Co.
4620 Este Avenue
Cincinnati 32, Ohio

Air Reduction Co.
1210 W. 69th St.
Cleveland, Ohio

National Cylinder Gas Co.
765 Woodrow Ave.
Columbus 7, Ohio

Air Reduction Co.
P.O. Box 923
Dayton 1, Ohio
Send cylinders to Sellers Rd. at
Springboro Pike
(Moraine City)
Dayton, Ohio

## LIST OF RECOMMENDED NITROGEN SUPPLIERS

National Cylinder Gas Co.
1151 East 222nd St.
Euclid 17, Ohio

National Cylinder Gas Co.
P.O. Box 86
Lowellville, Ohio

OKLAHOMA

National Cylinder Gas Co.
P.O. Box 1534
Oklahoma City 1, Oklahoma

National Cylinder Gas Co.
P.O. Box 168
Tulsa 3, Oklahoma

OREGON

Air Reduction Pacific Co.
430 N.W. 10th Ave.
Portland 9, Oregon
Send cylinders to
2949 N.W. Front Ave.
Portland, Oregon

National Cylinder Gas Co.
2720 North West Yeon Ave.
Portland 10, Oregon

PENNSYLVANIA

National Cylinder Gas Co.
P.O. Box 7
Conshohocken, Pa.

National Cylinder Gas Co.
Davis Island Yards
McKees Rocks, Pa.

Air Reduction Co.
Allegheny Ave. & 17th St.
Philadelphia 40, Pa.
Send cylinders to
Germantown & Allegheny Aves.
Philadelphia, Pa.
or
Bethlehem, Pa.

Air Reduction Co.
2010 Clark Building
Pittsburgh 22, Pa.
Send cylinders to
Midland, Pa.
or
1116 Ridge Ave.
Pittsburgh, Pa.

RHODE ISLAND

Air Reduction Co.
122 Mt. Vernon St.
Upham's Corner
Boston 25, Mass.
Send cylinders to
Central Falls, R. I.

TENNESSEE

National Cylinder Gas Co.
1329 Chestnut Street
Chattanooga 2, Tenn.

National Cylinder Gas Co.
P.O. Box 3545
Memphis, Tenn.

TEXAS

National Cylinder Gas Co.
P.O. Box 5416
Dallas, Texas

National Cylinder Gas Co.
319 N.E. 23rd Street
Ft. Worth 6, Texas

Magnolia Airco Gas Products Co.
2405 Collingsworth Ave.
Houston 6, Texas

National Cylinder Gas Co.
P.O. Box 2106
Houston 1, Texas

National Cylinder Gas Co.
P.O. Box 1557
Lubbock, Texas

VIRGINIA

Air Reduction Co.
P.O. Box 1192
Richmond 9, Va.
Send cylinders to Bickerstaff Rd.
East of Osborne Tpke.
Richmond, Va.

WASHINGTON

Air Reduction Pacific Co.
3623 East Marginal Way
Seattle, Washington

National Cylinder Gas Co.
5510 East Marginal Way
Seattle 4, Washington

WEST VIRGINIA

Air Reduction Co.
94—29th St.
Wheeling, W. Va.

WISCONSIN

National Cylinder Gas Co.
6313—31st Avenue
Kenosha, Wisconsin

Air Reduction Co.
818 W. Winnebago St.
Milwaukee 5, Wisc.
Send cylinders to
3435 No. Buffum St.
Milwaukee, Wisc.

National Cylinder Gas Co.
2615 West Graves Street
Milwaukee 3, Wisconsin

**Westinghouse Electric Corporation**
Sharon Plant, Transformer Divisions, Sharon, Pa.

Printed in U.S.A. (T.P.)

# Instructions for Parallel Operation of Transformers



The theoretically ideal conditions for paralleling transformers are:

1. Identical turns ratios and voltage ratings.
2. Equal percent impedances.
3. Equal ratios of resistance to reactance.
4. Same polarity.
5. Same phase angle shift.
6. Same phase rotation.

## SINGLE PHASE TRANSFORMERS

For single phase transformers only the first four conditions apply as there is no phase rotation or phase angle shift due to voltage transformation.

If the turns ratios are not the same a circulating current will flow even at no load. If the percent impedance or the ratios of resistance to reactance are different there will be no circulating current at no load, but the division of load between the transformers when applied will no longer be proportional to their KVA ratings.

## THREE PHASE TRANSFORMERS

The same conditions hold true for three phase transformers except that in this case the question of phase rotation and phase angle shift must be considered.

**Phase Angle Shift.** Certain transformer connections as the wye-delta or wye-zigzag produce a 30° shift between the line voltages on the primary side and those on the secondary side. Transformers with these connections therefore cannot be paralleled with other transformers not having this shift such as wye-wye, delta-delta, zigzag-delta, or zigzag-zigzag.

**Phase Rotation.** Phase rotation refers to the order in which the terminal voltages reach their maximum values. In paralleling, those terminals whose voltage maximums occur simultaneously are paired.

## POWER TRANSFORMER PRACTICE

The preceding discussion covered the theoretically ideal requirements for paralleling. In actual practice good paralleling is obtained even though the actual transformer conditions deviate by small percentages from the theoretical ones.

Good paralleling is considered as attainable when the percentage impedances of two winding transformers are within 7.5% of each other. For multi-winding and auto-transformers the generally accepted limit is 10%.

Furthermore, in power transformers of normal design the ratio of resistance to reactance is generally sufficiently small to make the requirement of equal ratios of negligible importance in paralleling.

When it is desired to parallel transformers having widely different impedances, reactors or auto-transformers having the proper ratio should be used. If a reactor is used it is placed in series with the transformer whose impedance is lower. It should have a value sufficient to bring the total effective percent impedance of the transformer plus the reactor up to the value of the percent impedance of the second transformer. When an auto-transformer is used, the relative currents supplied by each transformer are determined by the ratio of the two sections of the auto transformer. The auto-transformer adds a voltage to the voltage drop in the transformer with the lower impedances and subtracts a voltage from the voltage drop in the transformer with the higher impedance. Auto-transformers for use in paralleling power transformers are designed especially for each installation. The method of connecting the auto-transformer is shown in a wiring diagram furnished with each installation.

In general, transformers built to the same manufacturing specifications as indicated by the nameplate may be operated in parallel.

In connecting transformers in parallel when the low tension voltage is comparatively low, care should be taken to see that corresponding connecting bars or conductors have approximately the same impedance, otherwise the currents will not divide properly.



Effective April 1978 Supersedes I. L. 47-600-4A, August 1955

WESTINGHOUSE ELECTRIC CORPORATION
MEDIUM POWER TRANSFORMER DIVISION
SHARON, PENNSYLVANIA

# Instructions for WEMCO® and WEMCO CI Insulating Oils

**Westinghouse Electric Corporation**

Medium Power Transformer Division, Sharon, Pa.
I.B. 45-063-100D Effective June 1, 1981
Supersedes I.B. 45-063-100C, June 1978

*SEE IMPORTANT DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITY ON THE NEXT PAGE*

# DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITY

THERE ARE NO UNDERSTANDINGS, AGREEMENTS, REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OTHER THAN THOSE SPECIFICALLY SET OUT BY ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF SELLER. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY PRIOR OR EXISTING AGREEMENT, COMMITMENT OR RELATIONSHIP.

The information, recommendations, descriptions and safety notations in this document are based on Westinghouse's experience and judgment with respect to transformers. THIS INFORMATION SHOULD NOT BE CONSIDERED TO BE ALL INCLUSIVE OR COVERING ALL CONTINGENCIES. If further information is required, the Westinghouse Electric Corporation should be consulted.

NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OR WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE, ARE MADE REGARDING THE INFORMATION, RECOMMENDATIONS, DESCRIPTIONS AND SAFETY NOTATIONS CONTAINED HEREIN. In no event will Westinghouse be responsible to the user in contract, in tort (including negligence), strict liability or otherwise for any special, indirect, incidental or consequential damage or loss whatsoever including but not limited to damage to or loss of use of equipment, plant or power system, cost of capital, loss of profits or revenues, cost of replacement power, additional expenses in the use of existing power facilities, or claims against the user by its customers resulting from the use of the information, recommendations, descriptions and safety notations contained herein.

# SAFETY PAGE

Keep this Instruction Book available to those responsible for the installation, maintenance, operation and repair of the transformer.

The installation, operation and maintenance of a transformer presents numerous potential unsafe conditions, including, but not limited to, the following:

- Improper tap changer operation
- High pressures
- Lethal voltages
- Hazardous chemicals
- Moving machinery
- Heavy components

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow instructions could result in severe personal injury, death, and/or product or property damage.

Additionally, all applicable safety procedures such as OSHA requirements, regional and local safety requirements, safe working practices, and good judgment must be used by personnel when installing, operating, and/or maintaining such equipment.

Safety, as defined in this instruction book, involves two conditions:

1. Personal injury or death

2. Product or property damage (includes damage to the transformer, other property, and reduced transformer life.)

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The safety notations are headed by one of three hazard intensity levels which are defined as follows:

1. **DANGER** - immediate hazard which *will* result in severe personal injury, death, or substantial property damage.

2. **WARNING** - hazard or unsafe practice which *can* result in severe personal injury, death, or substantial property damage.

3. **CAUTION** - hazard or unsafe practice which could result in minor personal injury, or property damage.

## TABLE OF CONTENTS

# WEMCO® C Insulating Oil P.D.S. 55822AG

# WEMCO CI–Inhibited Insulating Oil–
# P.D.S. 55822AV

Wemco C insulating oil and Wemco-C1 oil are developments of the Westinghouse Electric Corporation in cooperation with oil refiners. They are suitable for use in all Westinghouse oil-insulated apparatus. For proper performance of the apparatus, only Westinghouse approved oils should be used.

# Part I–Receiving, Storing and Handling

## SHIPMENT

Wemco C and Wemco Cl oils are shipped in tank cars, drums or cans. Modern tank cars are usually equipped with breathers which bar the admission of moisture and are otherwise well gasketed to protect the oil from moisture. These precautions are necessary because the volume of the oil changes with temperature variations.

When shipped in drums, the drums are provided with screw bungs having gaskets to prevent admission of water.

When shipped in cans, the cans are hermetically sealed immediately after filling and should not be opened until the oil is needed.

## STORING

**Drums.** As soon as a drum of oil has been unloaded, the bung should be examined for damage or leaks.

It is very desirable that oil in drums be stored in a closed room. Outdoor storage of oil is always hazardous to the oil and should be avoided if at all possible. Regardless of storage location all drummed oil should be stored with the bungs down so that the bungs are under positive oil pressure. Do not open the drums until the oil is actually needed. Partially emptied drums must be tightly resealed and stored the same as new drums.

**Cans.** One and five-gallon cans of oil must not be exposed to the weather. Seals should be kept intact until the oil is actually needed. It is not necessary to make dielectric tests on oil in sealed cans.

Screw caps are provided on the cans to use when the oil is only partially removed after the hermetic seal has been broken. By replacing the screw caps, contamination by moisture and dirt will be retarded but the oil must be tested before using.

**Storage Tank.** The storage tank should be mounted on piers so that it will not touch the ground, and will be accessible to all points for inspection for leakage.

In larger storage systems, it is desirable to provide equipment to supply **dry air** for breathing purposes. This is often accomplished by the use of a breather making use of silica gel or aluminum oxide as the drying medium.

The tank should preferably have a convex bottom, allowing the installation of a drain cock at the lowest point for removing any free water or dirt which might settle out. When a cylindrical tank is installed with its axis horizontal, one end should be a little lower than the other, with a drain cock at the lowest point, and the oil supply pipe should enter at the opposite end of the tank. The oil may enter and leave the tank by the same pipe, but this should be at some distance from the bottom to prevent stirring up any settlings when the tank is being filled. It is desirable that the pipe be provided with a swing joint and float, so that it will automatically move with the change in oil level and remain near the surface of the oil.

## FIRE PROTECTION

**CAUTION: While Wemco C or Wemco C1 oil will not take fire unless brought to a high temperature (320°F), it should be remembered that under abnormal conditions such a temperature can be reached, so that proper precaution against fire should be taken. The best way to extinguish burning oil is to smother the flames so that the supply of fresh air is cut off. Chemical fire extinguishers are effective, but water should not be used unless it is applied by a special atomizing spray nozzle.**

## HANDLING

### Sample and Dielectric Test All Oil Before Placing It In Apparatus.

Before putting the oil into equipment see that the tank is free from moisture and foreign material. The presence of impurities, particularly moisture, in the oil or apparatus may lower its dielectric strength to an unusable value. If the oil is supplied in more than one container, each container must be sampled and tested.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore it is recommended that all the oil be passed through a filter to remove solid contaminants and a dehydrater-degasser to remove moisture.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not practicable, protection against moisture must be provided.

All vessels used for transferring the oil should be carefully inspected to see that they are absolutely dry and free from dirt.

Whenever possible it is recommended that all equipment should be allowed to stand for at least eight hours between filling and energizing the apparatus to allow gas bubbles to escape from the oil. This is especially important when filling under vacuum is possible.

**CAUTION: Always use a metal or oil proof hose when handling the oil. A hose made of natural rubber must not be used. Oil may easily become contaminated from the sulfur in the natural rubber, and should not be allowed to come in contact with it.**

When it is necessary to fill equipment with oil, it is essential that the oil be allowed to come to the same temperature as the apparatus. This may require eight hours, or even longer, under extreme temperature conditions. Otherwise, condensation of moisture may lower the dielectric strength of the oil to an unusable value. Cold oil in drums should never be brought into a warmer area and transferred to equipment until it has reached the same temperature as the apparatus.

## FILLING DRUMS

The practice of filling drums with oil is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the oil is likely to become contaminated.

If it is necessary to fill drums for storage, use only those drums which are in good condition and which have been used previously for transformer oil. A good practice is to reserve drums for this purpose by sealing them immediately after being emptied to exclude dirt and water. Before reusing, each drum should be carefully examined to be sure it is clean and free of water.

A new washer should be used with the bung each time the drum is refilled, to ensure a tight seal. These washers may be obtained from the oil refineries and it is recommended that a supply be kept on hand. Natural rubber composition washers should never be used as they would be attacked by the oil.

**WARNING: STATIC ELECTRICITY — Pumping and filtering of oil under certain conditions may cause static electrical charges to build up to the point that a discharge in the gas above the oil is possible. This charge buildup is variable and depends upon several factors but there is always the possibility of it occurring. Therefore, precautionary measures should be taken to prevent static charge buildup as a discharge could cause an explosion in certain gas or vapor mixtures.**

**A thorough purging with nitrogen is recommended for any electrical equipment before oil transfer or filtering is begun.**

# Part II–Oil Characteristics, Sampling and Inspection

## CHARACTERISTICS OF WEMCO "C" OIL

**Advantages**—Wemco "C" Oil, PDS 55822AG, is the Westinghouse trade name for insulating oil which is a refined mineral oil obtained from the fractional distillation of crude petroleum. It is free from moisture, inorganic acid, alkali, sulphur, asphalt, tar, vegetable or animal oils. Wemco "C" offers the following advantages as an insulating oil:

1. High dielectric strength.
2. Low viscosity—provides for good heat transfer.
3. Freedom from inorganic acids, and corrosive sulfur—prevents injury to insulation and materials of construction.
4. Good resistance to emulsification. In case of moisture contamination it quickly settles to the bottom of the tank.
5. Freedom from sludging under normal operating conditions over long periods of time accomplished by proper selection of crudes and refining methods.
6. Because of its low viscosity it enables rapid settling of the arced products in circuit breakers, tap changers, and other arcing contact apparatus.
7. Low pour point allows use under low temperature conditions.
8. The high flash point allows higher operating temperatures.

**Enemies of Transformer Oil.** In order to discuss the problems involved in the maintenance of insulating oil in service and the resultant handling procedures, it is important to realize the factors which can cause damage to insulating oil.

1. **Oxidation**—Oxidation is the most common cause of oil and insulation deterioration. Faulty gaskets and poor welds may permit a unit to breathe air. The oxygen in the air will react with the oil to form organic acids, water and eventually oil sludge. Once sludging has started a clay treatment is required to remove the deterioration products. See **Reclaiming,** page 14.
2. **Contamination**—Moisture is the chief cause of oil contamination. The main source of moisture is from breathing moist air into the transformer thru faulty gaskets or during transformer assembly or inspection with the manhole cover removed. Other solid contaminants in the oil can come from solid insulation, metal parts, etc. Removal of contaminants is discussed in **Reconditioning and Reclaiming,** page 14.
3. **Excessive Temperature**—Excessive heat will accelerate oxidation if any oxygen is present and will also effect the decomposition of the oil itself. Heat also will degrade the other insulating materials and thus generate carbon dioxide and water which then further deteriorates the oil.
4. Minor faults such as corona discharges, sparking and local overheating under the oil level will produce combustible gases and carbon which can be harmful to the operation of the transformer. It is desirable to identify these minor faults and correct them when possible.

**PDS 55822AG Specification Requirement and ASTM Test**

Table I lists the physical properties for insulating oil 55822AG and the appropriate ASTM test numbers for each test procedure.

**TABLE I**

| Property | Specification Value New Oil | Typical Value in Equipment | ASTM No. |
|---|---|---|---|
| Color | 0.5 max. | 1.0 | D1500 |
| Dielectric Strength, 0.100″ gap | 30KV min. | 35KV | D877 |
| 0.040″ gap | 28KV min. | 28KV | D1816 |
| 0.080″ gap | 56KV min. | 56KV | D1816 |

TABLE I (Continued)

| Property | Specification Value New Oil | Typical Value in Equipment | ASTM No. |
|---|---|---|---|
| Neutralization Number | 0.03 mg. max. | 0.03 mg. | D974 |
| Free or Corrosive Sulfur | Noncorrosive | Noncorrosive | D1275 |
| Flash Point | 145°C (293°F) min. | 150°C | D92 |
| Pour Point | -40°C (-40°F) max. | -50°C | D97 |
| Viscosity max. cSt @ 100°C | 3 sec. max. | 3 sec. | D88 |
| max. cSt @ 40°C | 12 sec. max. | 10 sec. | D88 |
| max. cSt @ 0°C | 76 sec. max. | 70 sec. | D88 |
| Moisture Content | 35 ppm max. | 20 ppm | D1533 |
| Specific Gravity @ 60°F | .910 max. | .890 | D1298 |
| Inorganic Chlorides or Sulfates | None | None | D878 |
| Interfacial Tension | 40 dynes min. | 37 dynes | D971 |
| Power Factor, 60 Hz | | | |
| 25°C (77°F) | 0.05% max. | 0.1% | D924 |
| 100°C (212°F) | 0.30% max. | 0.3% | D924 |
| Oxidation Stability | | | |
| Sludge after 72 hours | 0.15% | 0.1% | D2440 |
| Sludge after 164 hours | 0.30% | 0.2% | D2440 |
| Total Acid after 72 hours | 0.5 mg. of KOH | 0.2 mg. of KOH | D2440 |
| Total Acid after 164 hours | 0.6 mg. of KOH | 0.3 mg. of KOH | D2440 |
| Aniline Point | 63-78°C | 75°C | D611 |
| Dielectric Breakdown, Impulse Needle-Negative | 145KV | 150KV | D3300 |

The following properties are typical but are not specification requirements:

| Property | Typical Value |
|---|---|
| Precipitation Number | Zero |
| Reaction | Neutral |
| Specific Heat, Cal/gram °C | 0.488 |
| Coefficient of Expansion 32°F (0°C) | 0.000725 |
| Coefficient of Expansion 212°F (100°C) | 0.000755 |
| Dielectric Constant | 2.2 |
| Weight Per Gallon | 7.5 lbs. |

Curves of interest showing the relationships listed below are on pages 16 thru 19.

Curve 1 - Moisture vs Dielectric Breakdown
Curve 2 - Moisture vs Temperature
Curve 3 - Vapor Pressure vs Temperature, 20-100°C
Curve 4 - Vapor Pressure vs Temperature, 100-200°C
Curve 5 - Vapor Pressure vs Temperature, 200-300°C
Curve 6 - Viscosity vs Temperature
Curve 7 - Moisture Content vs Dew Point

## TESTING OF INSULATING OIL

**Sampling Procedures.** Most of the properties of insulating oil are affected by impurities, particularly water. It is therefore, important that care be exercised in obtaining samples to avoid contamination. It is necessary that all equipment used in obtaining samples and the sample containers be clean and dry.

**Sample Containers.** Sample containers should be glass. An amber glass bottle of at least 16 oz. capacity should be used. Do not use rubber gaskets or rubber stoppers on the bottles. Prior to taking the sample, the bottle should be rinsed with a suitable solvent and thoroughly dried.

**Sampling from Drums.** A sample thief which permits the sample from the bottom of the drum should be used. A convenient thief is shown in Figure 1, page 20; it is 36 inches long by 1¼″ inside diameter with cone shaped caps over the ends and openings ⅜″ diameter at the end. The thief should be rinsed with solvent and thoroughly dried prior to use.

Samples are to be tested for dielectric breakdown on each drum of oil to be added to a transformer. Where large numbers of drums are involved it is permissible to take samples from up to five drums and mix them to make a composite to be tested as one sample. If the breakdown values meet the 30KV minimum all the drums included in the composite may be added to the transformer. If the breakdown does not meet the 30KV minimum value, it is then necessary to test each drum separately.

If equipment is available it is desirable to measure the moisture content at the site.

**Sampling from Tank Car.** For sampling from tank cars a thief employing a trap at the bottom may be used. See Figure 2, page 20. Prior to use this thief also must be rinsed with solvent and thoroughly dried.

**Sampling from Apparatus.** When taking an oil sample from a transformer, it should be withdrawn through the sampling valve at the bottom of the tank. Two of the three quarts of oil should be drawn off and discarded before the sample is taken to assure that the sample obtained is representative of the oil in the transformer.

## FREQUENCY OF TESTING OF OIL AND GAS FROM TRANSFORMERS IN SERVICE

Once a transformer is energized and put into service a periodic test of the oil should be made. In certain specific areas of operation or types of loading, experience will dictate the best frequency cycle. However, in general it is recommended that the following schedule be followed:

| Frequency Inspection | Voltage Class |
|---|---|
| Every year | 288KV and above |
| Every two years | Below 288KV |

This inspection should include at least a field examination of the oil for dielectric breakdown, neutralization number, color and condition. For power transformers a test of the gas in the gas space with a portable combustible gas analyzer, should be included.

## CIRCUIT BREAKERS

The principal causes of deterioration of insulating oil in circuit breakers or other arc producing apparatus, are:

1. Presence of water.
2. Carbonization of the oil (caused by operation of the circuit breaker).

The arcing of the oil in circuit breakers produces small amounts of water, acids, and carbon due to oil decomposition. These acids may in extreme cases form metal soap on plated hardware but this in no way harms the apparatus. Water may also result from the entrance of moist air into the tank. Some of the carbon is deposited on the contact components and at the bottom of the tank while the remainder continues in suspension in the oil.

Carbonization takes place not only when the circuit breaker opens heavy short circuits, but also whenever an arc is formed, even during such light service as the opening of the charging current of the line, and this latter service, repeated, may eventually produce enough carbon to be a source of trouble.

The carbon may reduce the dielectric strength of the oil, lower the surface resistance of the insulation if water is present, and also may lower the resistance to emulsification. The carbon alone may not be detected by the dielectric test, particularly if the oil is free from moisture.

In cold weather, a larger amount of carbon is formed than in warm weather because of the increased viscosity of the oil at low temperatures. Also the carbon is not as readily dispersed through the oil.

## SIGNIFICANCE OF TEST

1. **Dielectric Breakdown ASTM D-877, D-1816**—The dielectric breakdown voltage is an important measurement of the electrical stress which an insulating liquid can withstand without failure. It is measured by applying a voltage between two electrodes under prescribed conditions under the liquid. It also serves as an indication of the presence of contaminants, particularly moisture and conducting particulate matter.

   Dielectric testing should be made as described in the ASTM procedures. ASTM D-877 specifies a test cup equipped with one-inch diameter vertical disc electrodes spaced 0.100 inch apart and is reported as the standard dielectric test value. See Figure 3, page 20.

   ASTM D-1816 specifies a test cup equipped with spherical electrodes spaced either 0.040 or 0.080 inch apart. See Figure 4, page 20. This cup includes a stirrer and is sensitive to small amounts of contaminants and is therefore primarily suitable for use with new oils. This test is made only when specified by those requesting the test. Figure 5, page 21, shows a portable dielectric tester.

2. **Neutralization Number, ASTM D-974**—The neutralization number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of the oil. It measures the acid content of the oil. With service aged oils it can be used as an indicator of the presence of contaminants. The neutralization number is most important in indicating chemical change or deterioration of the oil or in chemical change of additives. It is a guide for determining when oil should be replaced or reclaimed when the results are confirmed or supported by other test data.

3. **Interfacial Tension, ASTM D-971**—The interfacial tension between the insulating oil and water is a measure of the molecular attractive force between the unlike molecules and is expressed in dynes per centimeter. This test provides a means of detecting deterioration. Soluble contaminants or oil-deterioration products generally decrease the interfacial tension value.

4. **Power Factor, ASTM D-924**—The power factor is the ratio of the power dissipated in the oil in watts to the product of the effective voltage and current in voltamperes, when tested with a sinusoidal field under prescribed conditions. A high power factor value is an indication of the presence of contaminants or deterioration products.

5. **Color, ASTM D-1500**—The primary significance of color is to observe a rate of change from previous samples of oil from the same transformer. Noticeable darkening in short periods of time indicate either contamination or deterioration of the oil. A darkening color, with no significant change in neutralization value or viscosity, usually indicates contamination with foreign materials. The color of an insulating oil is determined by means of transmitted light and is expressed by a numerical value based on comparison with a series of color standards.

6. **Pour Point, ASTM D-97**—The pour point is the temperature at which insulating oil will just flow under prescribed conditions. The pour point is useful in determining the type of equipment in which a given oil can be used, but has little significance as far as contamination or deterioration are concerned.

7. **Specific Gravity, ASTM D-1298**—The specific gravity of insulating oil is the ratio of the weights of equal volumes of oil and water at 15.56°C(60°F). The specific gravity may be pertinent in determining the suitability for use in specific application.

8. **Viscosity, ASTM D-88, D-445**—The viscosity of insulating oil is its resistance to uniformly continuous flow without turbulence, inertia or other forces. It is usually measured by timing the flow of a given quantity of oil under

controlled conditions. A marked viscosity increase accompanied by an increasing neutralization number and darkening color, could also indicate deterioration of the oil due to oxidation.

9. **Moisture Content, D-1533**—The presence of free water may be observed by visual examination in the form of separated droplets or as a cloud dispersed throughout the oil. Water in solution is normally determined by physical or chemical means. It is measured in parts per million. Water invariably causes decreased dielectric strength of the oil. Figure 6, page 21, shows an automatic Karl Fischer titrating apparatus.

**Additional Oil Tests.** Additional oil properties are important in defining the specific insulating oil to be used and in screening oil suppliers, but are usually not used in the field or on service aged oils.

1. **Free and Corrosive Sulfur, ASTM D-1275**—This test detects the presence of free sulfur and combined corrosive sulfur by subjecting copper to contact with oil under prescribed conditions.

2. **Inorganic Chlorides and Sulfate, ASTM D-878**—This test indicates the presence of inorganic chlorides and sulfates by precipitation of insoluble salts by means of usual analytical procedures.

3. **Flash Point, ASTM D-92**—The flash point of insulating oil is the temperature to which the material must be heated in order to give off sufficient vapor to form a flammable mixture with air under the conditions of the test.

**Classification of Service Aged Transformer Oils.** It is virtually impossible to attempt to place a rigid interpretation on the condition of a specific oil from one test or one test result and from this to make recommendations. However, certain groups of results will produce patterns which can then be used to establish a picture of the oil condition. Industry experience has developed a classification system of four classes of service-aged transformer oils.

---

**Group I** This group contains oils that are satisfactory for continued use.

**Group II** This group contains oils that require only minor reconditioning to continue in service.

**Group III** This group contains oils that are in poor condition. These should be reclaimed or disposed of depending upon economic consideration.

**Group IV** This group contains oils in such poor condition that it is technically advisable only to dispose of them.

---

Reference here to "reconditioning" and "reclaiming" means:

**Reconditioning** is the removal of water and solids from oil. Typical equipment includes several types of filters, centrifuges and vacuum dehydrators.

**Reclaiming** is the removal of deterioration products and usually is accomplished by use of reclaiming processes involving fullers' earth alone or in combination with certain chemicals.

Table II lists the various recommended values for consideration of an oil in a specific classification.

**TABLE II**

| | **Group I** | **Group II** | **Group III** | **Group IV** |
|---|---|---|---|---|
| | **Oils for Continued Service** | **Oils to be Reconditioned** | **Oils to be Reclaimed** | **Oils to be Scrapped** |
| Dielectric Breakdown, KV | 28 | Less than 28 | Low | Low |
| Neutralization Number mg KOH per gr. of oil | up to .25 | .25-.35 | .35-.5 | .5 and above |
| Interfacial Tension dynes per cm. | 21 | 21 | 18 | 16 |
| Power Factor, 60 hertz 25°C, percent | 1.0 | 1.2 | 2.0 | 5.0 |
| Moisture Content, ppm. | 25 | 35 | above 35 | -- |

No oil should be considered for continuing service if the dielectric strength cannot be brought up to at least 28 KV or if the moisture cannot be held below 35 ppm.

# Part III–Reconditioning and Reclaiming

## RECONDITIONING

Reconditioning involves the removal of water and solid particles from the oil. This is done by using one of several available types of filters, centrifuges, and vacuum dehydrators.

The filters include various kinds of cartridge type filters as well as the common filter press. These filters are capable of removing water, carbon, particulate matter and sludge which is in suspension. Their ability to remove water is dependent upon the dryness of the filter. It is essential that steps be taken to make certain that the filter is dry before the filtration is begun. The best method to determine when a filter in use has become saturated with water and lost its effectiveness is by checking the dielectric strength of the filtered oil or by a continuous indication of the water content of the outgoing oil. If the oil being processed contains a large amount of contamination, it is necessary to change the filter frequently.

The centrifuge is particularly useful when there are large quantities of water or other contamination present. In general it can better remove the larger concentrations, but cannot remove the contaminants as completely as a filter can. Neither the centrifuge or the filter is designed to treat oil chemically.

In some situations it is advantageous to use a combination centrifuge and filter press. The oil is first passed through the centrifuge to remove the large quantity of contamination and then through the filter to remove any remaining contamination. This makes it possible to make use of the best qualities of the two systems.

A vacuum dehydrator provides an efficient method to remove water and also gas from insulating oil. The vacuum dehydrator exposes the oil to high vacuum and heat for a short period of time. Usually some device, such as a nozzle or baffle plates, are included to provide a large oil surface to assist in removing the water and gas from the oil. If solid material is present in the oil, a filter should be used in conjunction with the vacuum dehydrator.

## RECLAIMING

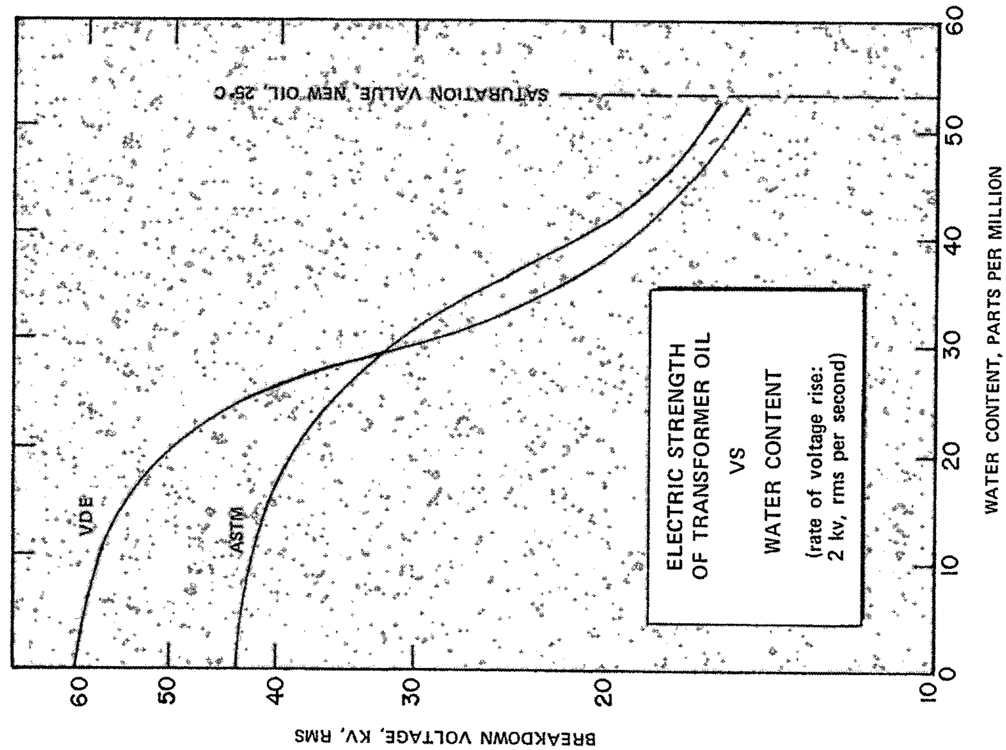
Reclaiming of insulating oil consists of the removal of deterioration products such as sludge and organic acids. The media used for a reclaiming process is fuller's earth, which is a natural occurring clay. The excellent absorbent properties of the fuller's earth will remove the acids and other contaminants. The fuller's earth treatment may be done by percolation through a coarse clay. The percolation may be accomplished either by pressure or by gravity flow. The two methods are the same in principle and commercial equipment is available. In the pressure percolator the oil is forced through the clay by a pump. It has a chamber to hold the clay and is so designed that the oil must pass over the clay. These are capable of processing large volumes in a short time and since the amount of clay is relatively small, it must be changed frequently. In gravity percolation the oil flows through a column of coarse clay by gravity. A typical system would have a tank of oil to be treated at a high level above a cylinder or tank filled with the clay and then below the treating chamber is a tank to receive the filtered material. Once this process is started, it continues with little attention other than periodic sampling. In this system the flow is slow and the volume of clay is relatively large and thus needs to be changed less frequently than with the pressure process. In either of these treatments, checks on the neutralization number of the oil serve to indicate whether the treatment is adequate and whether a change of clay is required.

Another method of clay treatment uses a finely divided clay and a relatively high operating temperature. This method will make the most efficient use of the clay. Commercial apparatus is available for this treatment. It consists of a heated mixing chamber where measured amounts of oil and clay are stirred as they are heated until a desired temperature is reached. The oil-clay mixture then goes into a tank from which it is pumped through a specially designed filter to separate the oil and clay material.

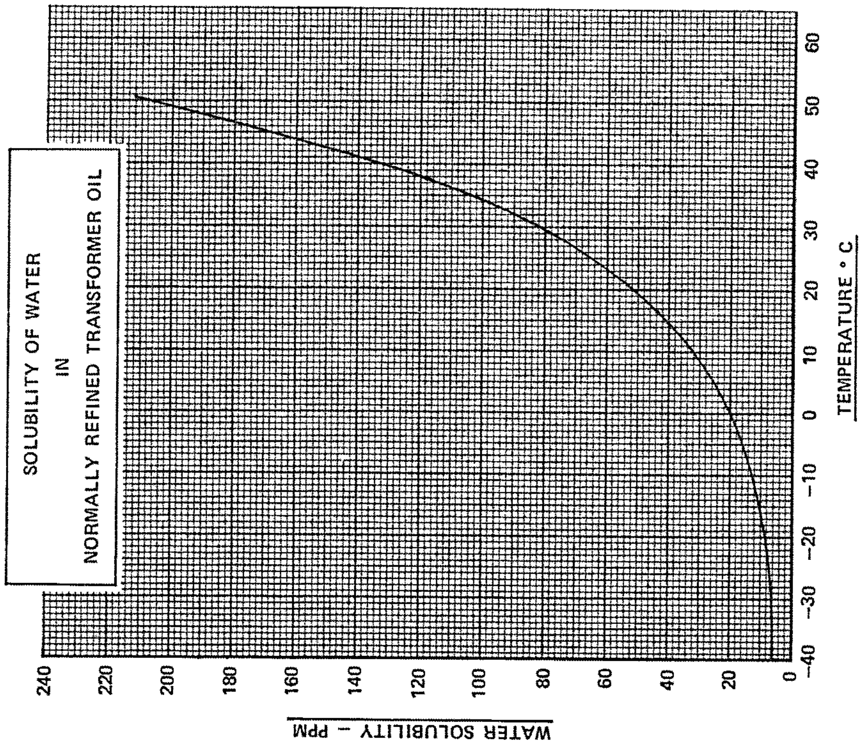
The choice of reclaiming method is based upon the most practical and economical considerations for a particular system and location. In any case, if reclamation is to be performed, the oil should first be put through a filter to remove the free water to prevent wetting of the clay. The oil which has been treated should be put in a container designed to prevent the pickup of moisture.

## ADDITION OF INHIBITOR

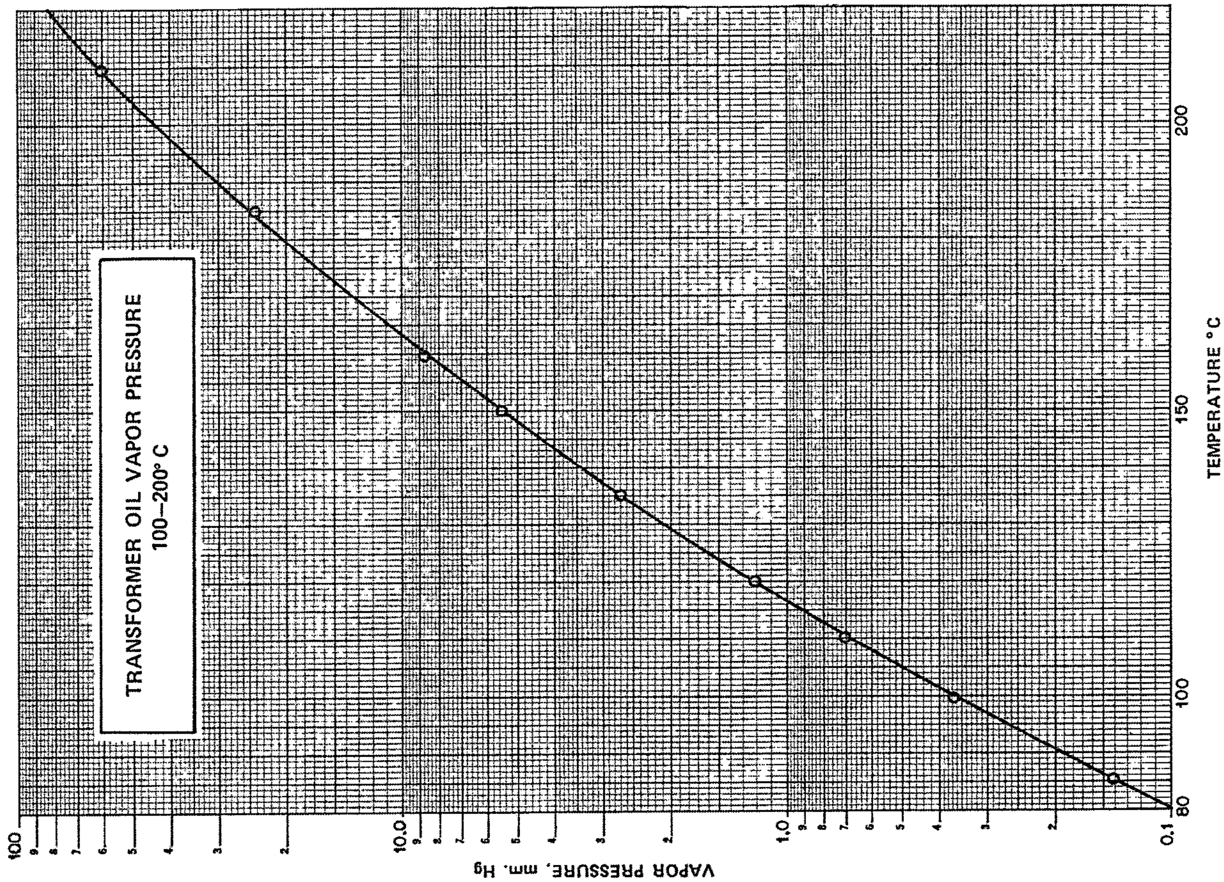
New insulating oil, as normally refined, contains small amounts of natural oxidation inhibitors. These materials retard oxidation until such time as they are all used up. The rate is a function of the amount of oxygen available, contaminants in the oil and the temperature of the filtered oil. Once the inhibitor is used up, the rate of oxidation and deterioration increases. While the reclaiming processes restore the properties of the oil, they do not replace the oxidation inhibitor. Therefore, after any reclaiming operations, a suitable oxidation inhibitor should be added to the oil. It is recommended that 2,6-ditertiary-butyl-paracresol be used in the amount of 0.2 percent by weight of the oil. This material is generally referred to as DBPC. It can be added as a dry powder to the oil and the oil should be heated and agitated to aid in dissolving. If desired a concentrated solution may be prepared by adding the dry solid to the oil while heating and stirring. The solubility is about 30% by weight at normal temperatures and after the desired amount of solid is dissolved in the oil, this concentrate can be added to the remainder of the oil to be inhibited.



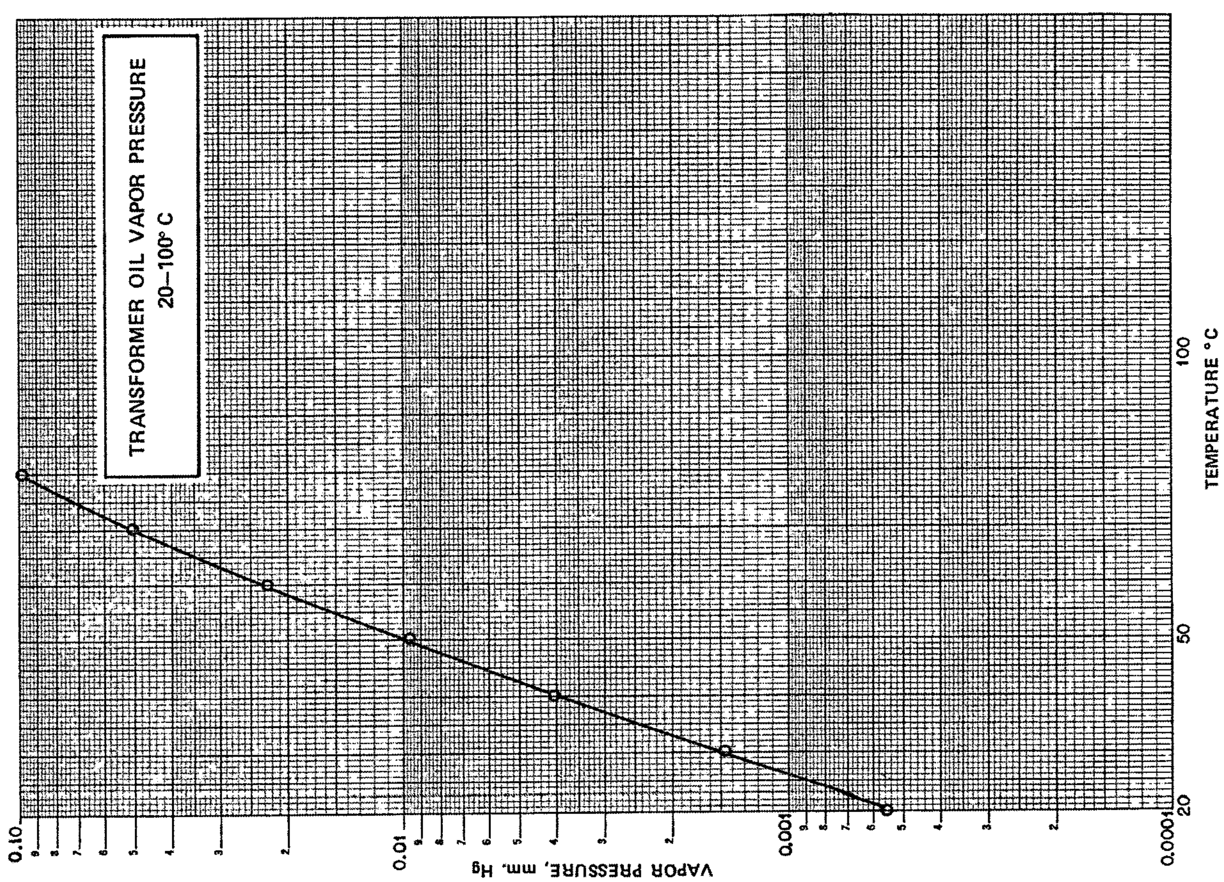

CURVE 1



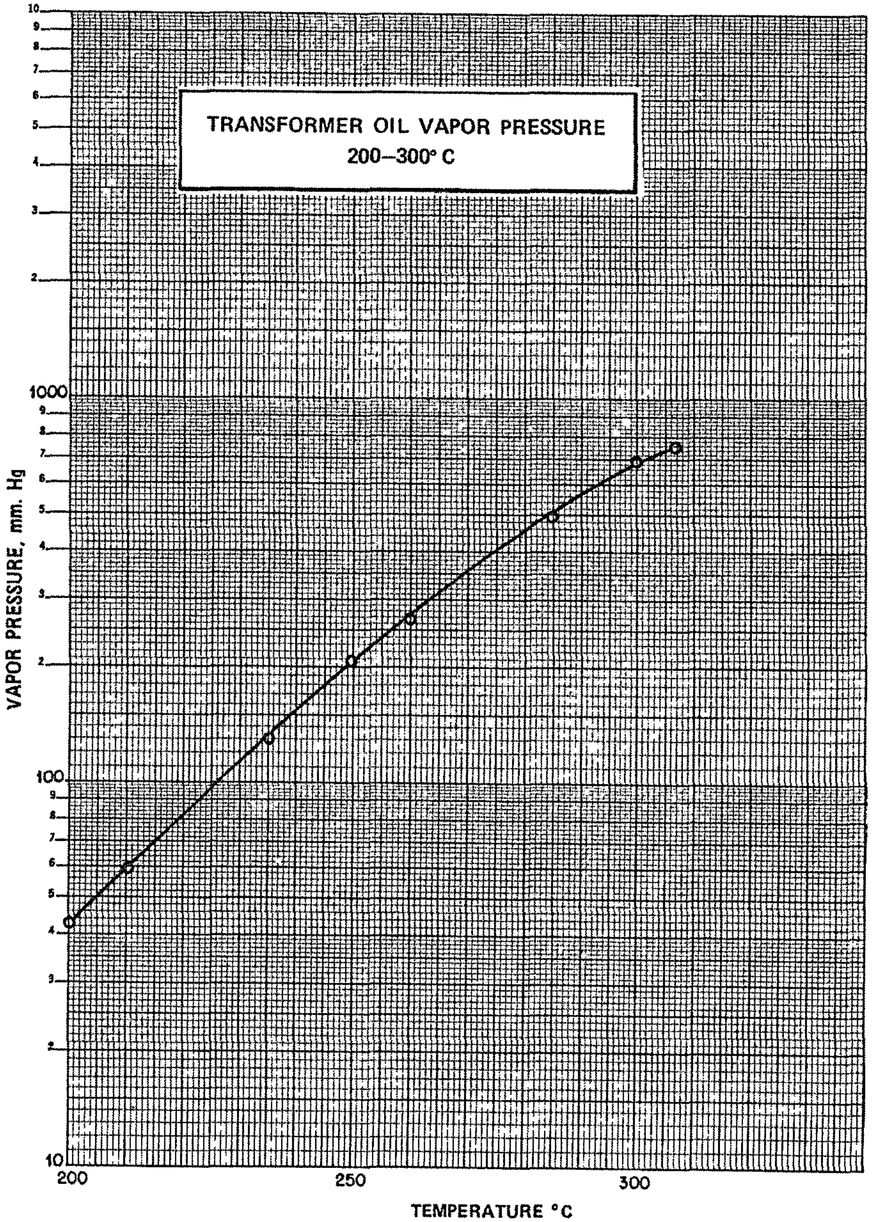

CURVE 2



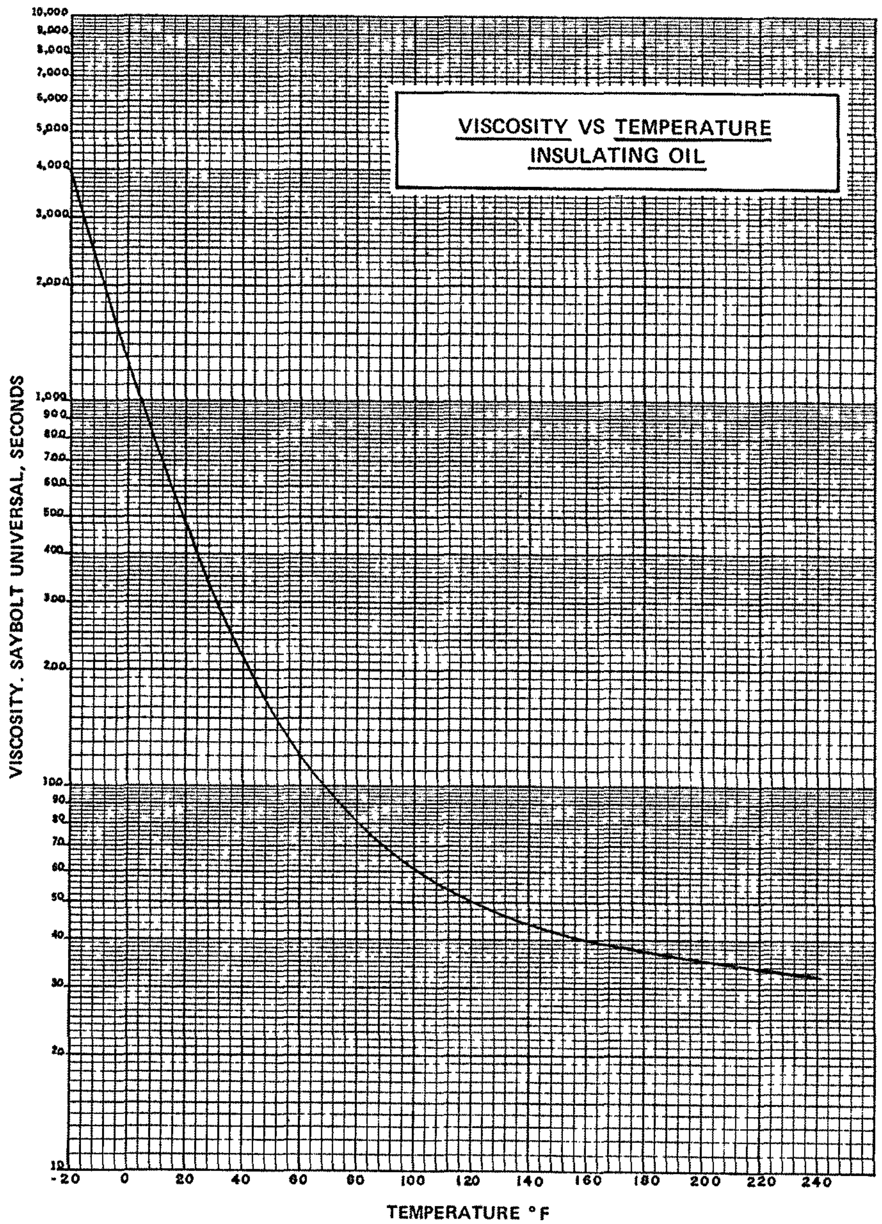

CURVE 4



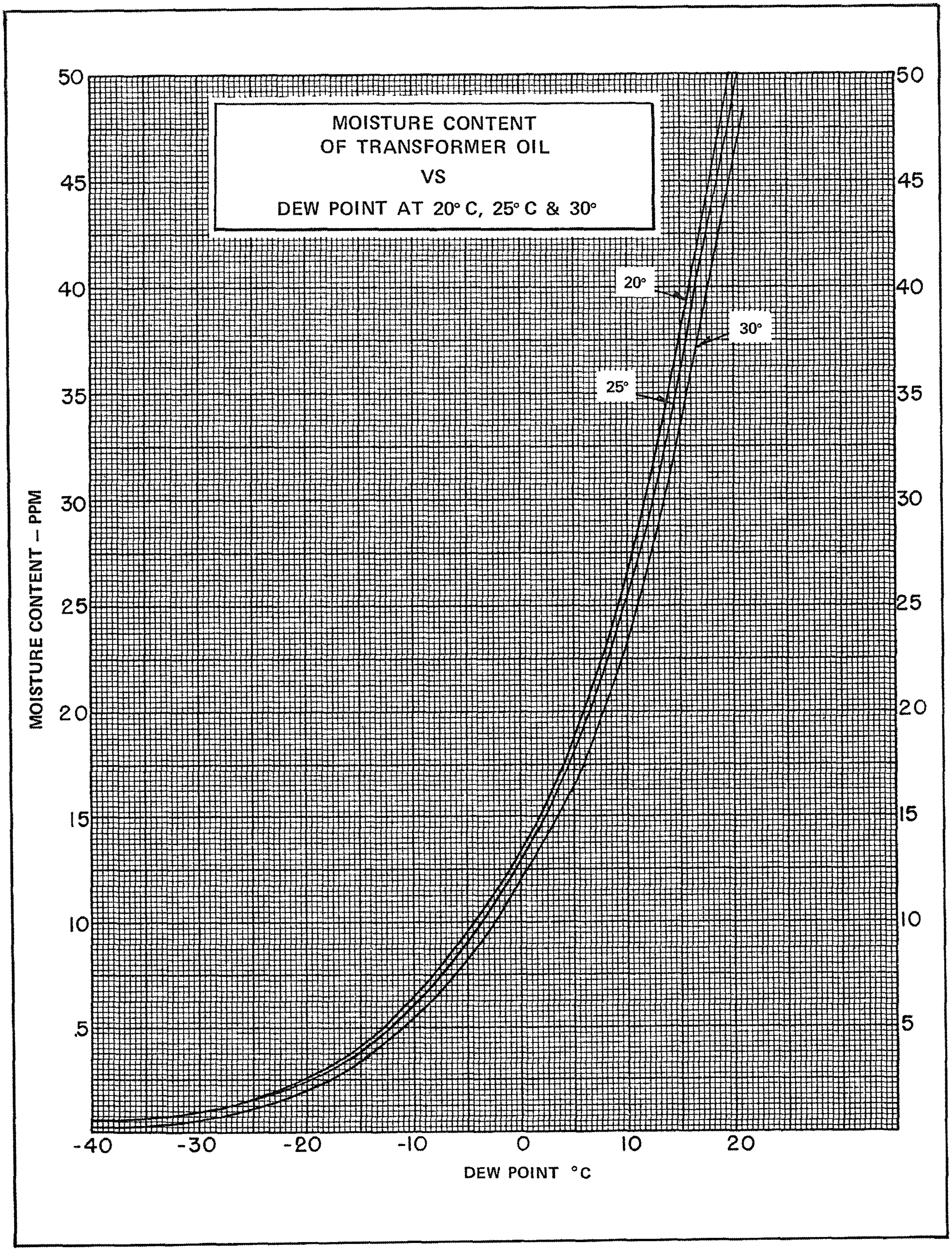

CURVE 3




CURVE 5




CURVE 6


MOISTURE CONTENT
OF TRANSFORMER OIL
VS
DEW POINT AT 20° C, 25° C & 30°
20°
30°
25°
MOISTURE CONTENT — PPM
50
45
40
35
30
25
20
15
10
5
-40
-30
-20
-10
0
10
20
DEW POINT °C

CURVE 7

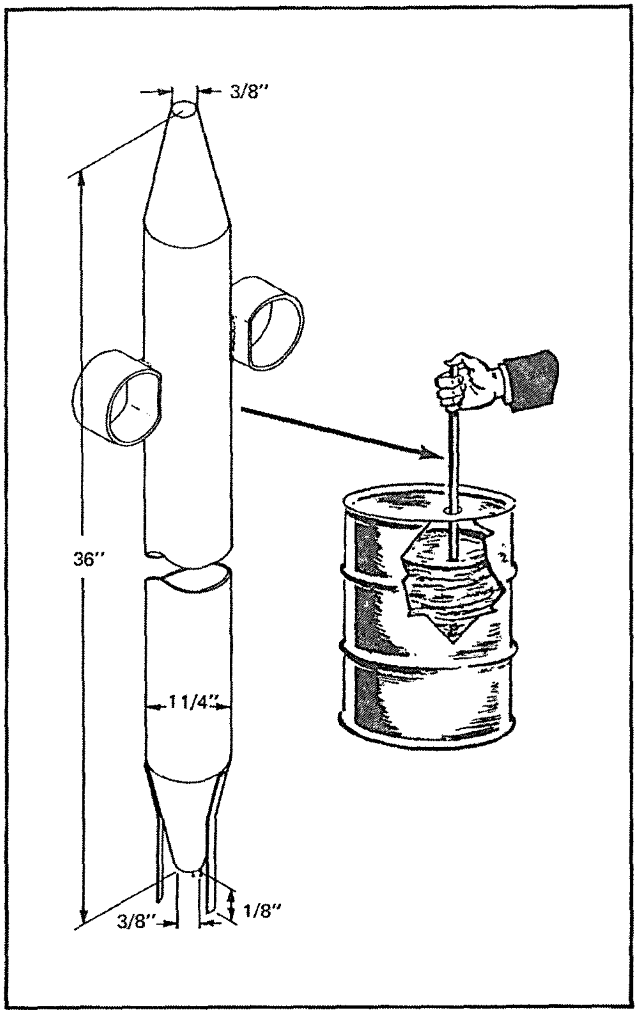



Fig. 1 Drum Thief and Method of Sampling

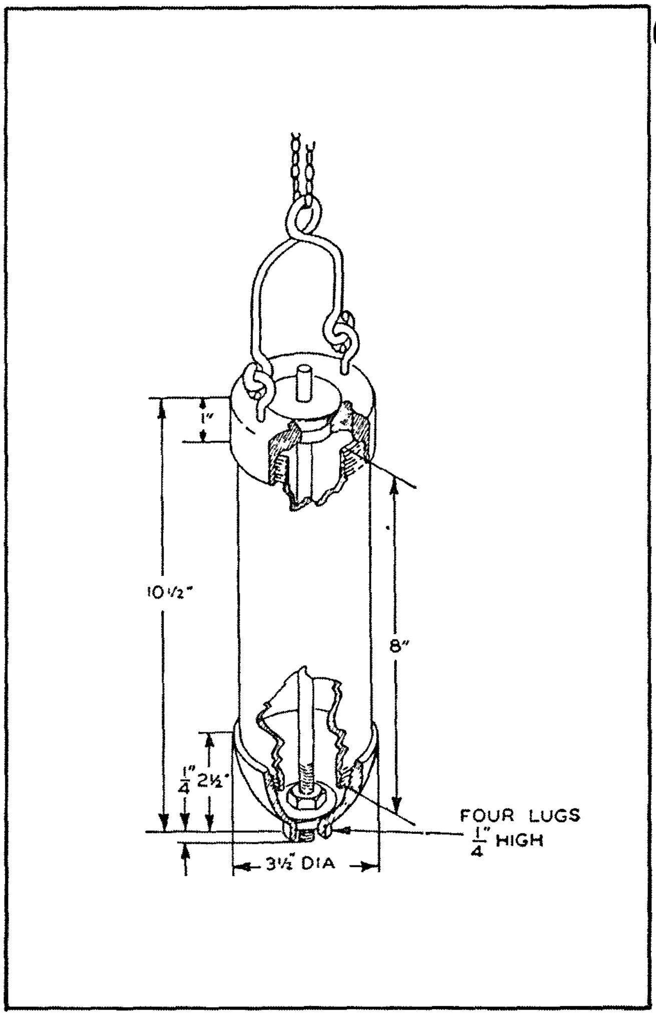



Fig. 2 Tank Car Thief

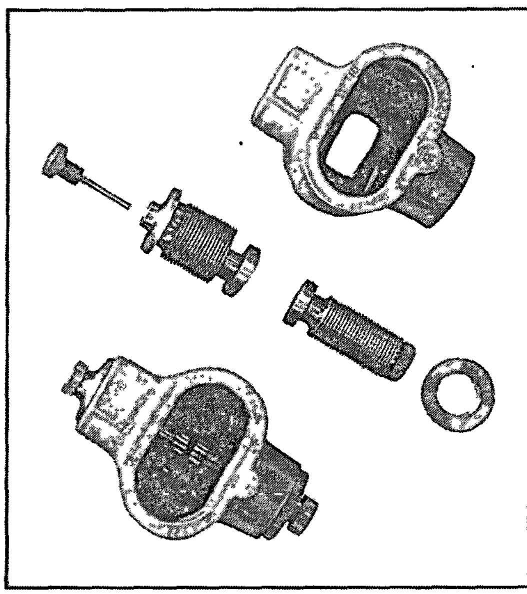


Fig. 3 Oil or Fluid Test Cup for
Dielectric Test (ASTMD-877)

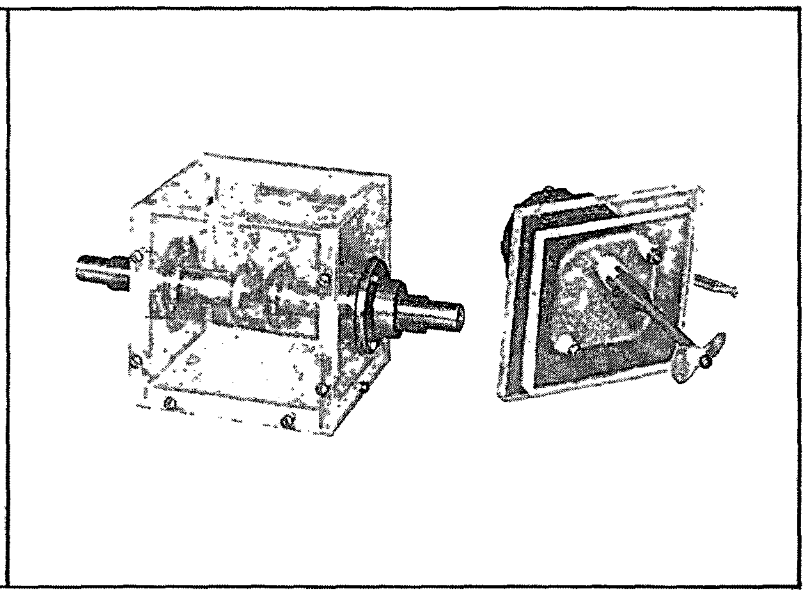


Fig. 4 Oil or Fluid Test Cup for
Dielectric Test (ASTMD-1816)

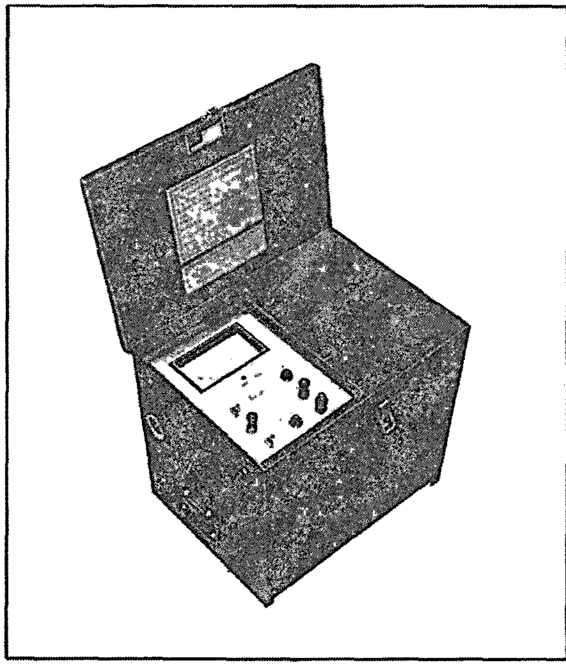


*Fig. 5 Portable Dielectric Tester (Model OC-50)*

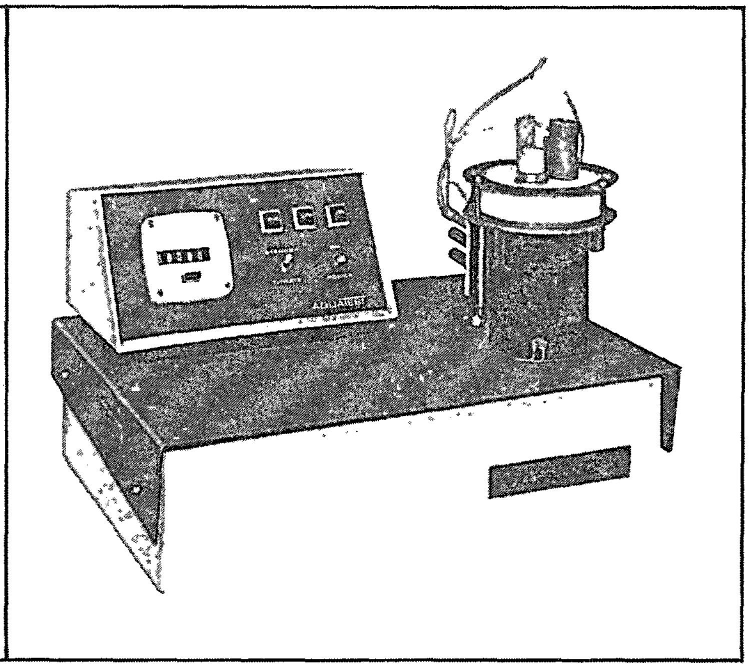


*Fig. 6 Photovolt Automatic Karl Fischer Titrating Apparatus*

# Memorandum

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Westinghouse · Medium Power Transformer Division · Sharon, Pa.

Printed in U.S.A.
(H)

# Gaskets for Oil-Filled Transformers and Tap Changers



| GASKET APPLICATION | | | |
|---|---|---|---|
| Apparatus | Gasket Material | Gasket Cement | Gasket Compression |
| Oil Insulated Transformers | Cork-Neoprene PDS# 45721AH | M#53320LE (S#2790A23H01) | 43% |
| | Nitrile PDS#45351 EQ | None | 25% |
| Tap Changers | Cork-Neoprene PDS# 45721AH Flat Gaskets-No Gasket Stops | M#53320LE (S#2790A23H01) | 43% |
| | Dumbell Nitrile Section S#258A460H01 | None | To 5/16" |

The gaskets used on oil-filled transformers and tap changers are of materials which have proven suitable for that particular apparatus with which they are being used. Experience has shown that the use of the proper material used with the correctly associated apparatus and installed by a standard procedure assures a joint that will be leakproof.

## GASKET INSTALLATION

**A. Preparing Metal Surfaces.** Before applying a gasket to any metal surface care must be taken to assure that the mating surfaces are free of ice, water, oil, grease, rust or dirt by wiping dry. This can be done by using clean rags or any other method that will assure a dry surface. Rust should be removed by sanding or wire brushing. Thin uniform films of primer paint or gasket cement need not be removed. If the gasket is cut in the field, cut the gasket to conform to the surfaces to be sealed. Gasket thickness and percent compression must be in accordance with recommended practice. If the gasket is not a one-piece gasket, scarf the ends of the gasket so that the length of the overlap will be equal to four times the thickness of the gasket material. The mitering should be done with a fine toothed saw and a miter box to assure a clean uniform cut and to obtain full gasket thickness at the lap joint. A hand-type gasket cutter for keystone shaped interlocked joints is available for field work. These interlocked joints must be matched-cut by forming the joint properly and cutting both layers at the same time. Gasket cutting tool (up to 3 inches), S#328B614G01. When ordering precut gaskets, give the complete nameplate reading of the transformer including serial number. Specify exact description of the gaskets required and give their location.

**B. Application of Permanent Cork-Neoprene Gaskets when temperatures are above freezing.** It is recommended that both sides of the gasket be cemented to the gasket surfaces. Apply cement M#53320LE as follows:

1. Apply cement to both gasket and joint surfaces and let dry at least ten minutes but not more than 60 minutes.

2. Assemble gasket and press firmly into place.

3. Coat other side as per (1).

4. Assemble joint.

*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.*

Effective December, 1979   Supersedes I.L. 48-069-1C, June 1979

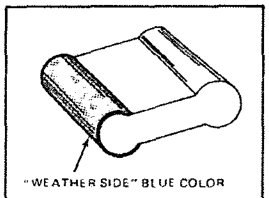
**C. Application of Permanent Cork-Neoprene Gaskets when temperatures are below freezing.** To keep the gasket from getting too hard and to keep the cement fluid, the gaskets and cement should be kept at a temperature of 35°F or higher up to the time of actual application of cement and compression of gaskets. This will mean that the cement and gaskets will usually have to be kept warmer than this in freezing weather. It will not be necessary to coat the gasket groove with cement M#53320LE providing the gasket is assembled with the mating parts before the cement is completely set up. By following these instructions you can be sure that the gasket will not be too hard to compress properly and the cement will adhere to the metal surfaces, assuring an oil-tight seal.

**D. Inspection Opening Gaskets.** Cork-neoprene gaskets for inspection openings may be sealed on one side only to permit the removal of the inspection cover without destroying the gasket. It is recommended that the gasket be sealed to the stationary member of large openings and to the cover of small openings and load tap changer oil compartment doors. The gasket is sealed to one member by applying a uniform coating of gasket cement M#53320LE to one side of the gasket and to the surface to which the gasket is cemented. It is suggested that the surface of the gasket not cemented be coated with a silicone lubricant, to prevent the vulcanizing of the gasket material to the steel plate. This will permit the removal of the cover without destroying the gasket.

Prior to replacing a cover of an inspection opening, the gasket should be examined to make certain that it has not been damaged and that it has sufficient thickness to reseal the joint.

**E. Application of Rectangular Nitrile Gaskets.** These gaskets do not require cementing for sealing. However, to facilitate assembly, particularly on vertical flanges, it is helpful to use cement M#53320LE to hold the gasket in its recess while the joint is being assembled. For inspection openings, a thin coating of silicone lubricant will permit easier disassembly.

**F. Application of Dumbell Nitrile Gaskets.** These gaskets, applied to openings of tap changer compartments, do not require cementing. They are always to be installed with the blue "weather side" of the gasket exposed to the atmosphere. Tighten until the rounded edges of the gaskets are compressed to the 5/16 inch thickness of the center web.




*Dumbell Nitrile Gasket*

**NOTE: It is very important that all openings in the transformer tank and tap changer be tightly closed before putting a unit into operation. This is necessary whether the unit is for indoor or outdoor operation. For all liquid filled tap changers and regulators; the bushing flanges, main cover, manhole covers, etc. must be oil and gas tight.**

## LEAKAGE TESTS

Liquid filled transformers should be tested for pressure tightness prior to putting in service. The permissible internal pressure that may be used can be determined from the nameplate on the transformer. Internal test pressures of ten pounds per square inch may be used to check the tightness of gasketed joints for transformers whose nameplates indicate that the transformer may be filled under complete vacuum. All other transformers should be tested with an internal pressure of five pounds per square inch.

The following precautions should be observed when making the pressure test:

1. **Inertaire transformers:**–Close the valves or disconnect the piping and plug the entrances into the tank before testing.

2. **Open air breathers, dehydrating breathers, and breathing regulators:**–Close openings to this equipment before testing.

3. **Mechanical relief device:**–The relief device must be replaced by a steel plate when the test pressure is likely to exceed the tripping pressure of the relief device. For additional instructions, refer to the instruction leaflet for relief device.

4. **Relief diaphragm:**–A relief diaphragm must be replaced by a steel diaphragm when the test pressure is likely to exceed the rupturing pressure of the relief diaphragm. For additional instructions, refer to the instruction leaflet for relief diaphragm.

# For Standard Outside Finish, Oil Insulated Transformer Tanks



The STANDARD outside finish for Westinghouse oil insulated transformers is a system that satisfactorily withstands widely diverse atmospheric conditions. The colors of the primer and finish coats are different so as to obtain a contrast between adjacent coats, insuring that each coat is continuous and of sufficient thickness.

The transformer tanks and accessories, being constructed of steel, are susceptible to rusting. Therefore, to prevent rusting of exposed steel surfaces, careful attention is given to the following steps:

1. All exposed steel surfaces must be thoroughly cleaned and prepared for the application of the protective coats of paint since the proper preparation of the surfaces to be finished is an important factor in securing a satisfactory and lasting finish.

Regardless of how good the paint may be, it will fail as a protector if applied over a wet, dirty, rusty, or greasy surface. Rust and scale will absorb and hold moisture. Therefore, in order to obtain a durable finish, it is absolutely essential that no moisture be sealed in by the application of paint. For large areas, a clean dry surface with sufficient roughness for good adhesion of the priming coat is obtained by shot or sand blasting the exposed surfaces of the transformer tank.

2. The careful application of a high grade, durable quality paint.

The factors that determine the quality of any paint are the pigment and vehicle. The pigment gives the color and body of the paint and the vehicle holds the pigment particles in place and forms a continuous film. Although attention is generally centered upon the selection of the pigment, tests show that the vehicle of a paint is the first of these two components to deteriorate. Therefore, a paint of high quality is used to obtain a satisfactory finish.

## STANDARD FINISH

**Tank.** The Westinghouse standard finish for power transformer tanks is essentially a three-coat system.

The primer coat (M#33230AP) is composed of an alkyd type vehicle and pigments, primarily zinc chromate and iron oxide.

The two finish coats (M#33220AP) are composed of resins and pigments to withstand the elements and to provide good appearance when new, and after weathering has taken place. The standard finish coat is light gray in color (ANSI #70).

**Radiators.** As a base for the finish, Widefin radiators are chemically cleaned and phosphatized. The standard finish for the Widefin radiators is a coating of polyester powder applied electrostatically and oven cured at a high temperature.

The polyester powder coat (ANSI#70 color) may be overcoated with special colors (liquid base) to provide a wide range of colors if necessary.

## APPLICATION DATA

**Tank.** The two liquid paints used for the tank are water borne paints and may be applied satisfactorily by spraying, brushing, or roller coating only. Thin sparingly for brush or spray work and use only tap water for thinning.

The primer and finish coats may be air dried or force dried. Air drying will require 30 minutes to 2 hours depending on atmospheric conditions. Force drying is recommended (1 hour at 125°C) in order to secure a harder coat quicker.

**Radiators.** The radiator is coated with a thermoset polyester powder that has excellent outdoor durability.



Effective February, 1979 Supersedes I. L. 48-069-15A, January, 1965

A small can of paint is furnished with the transformer to patch and/or touch up any marred area.

Aerosol paint dispensers (12 oz.) are available for small repair jobs on tanks and radiators in the shop or field. Small containers of paint may also be secured. These are identified as follows:

| | |
|---|---|
| Prime Coat (M#33230AP) | Air Dry Water Borne Paint B-5-616 |
| Finish Coat For Tanks (M#33220AP) | Air Dry Water Borne Paint B-6-3002 |
| Radiator Touch-Up (M#32220BR) | Air Dry Oil Base Paint B-6-364, ANSI#70 |
| Aerosol Touch-Up S#1326C50H06 | Air Dry Oil Base Paint B-6-364, ANSI#70 |

Larger quantities of Westinghouse paints can be obtained through the nearest Westinghouse Sales Office.

**IMPORTANT: Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.**

To do this, clean the damaged portion by means of scraper or sandpaper, apply a coat of primer paint and allow proper drying time, then apply a coat of finish paint.

**NOTE: For small marred spots which do not penetrate the paint film to the parent metal, only the finish paint is necessary. Due to the indefinite life of the primer, the finish paint should be applied as soon as possible.**

**Westinghouse Electric Corporation**
Medium Power Transformer Division, Sharon, Pa.

Printed in U.S.A.
(W E)

EQUIPMENT • PROCEDURE

# INSTRUCTIONS

# REMOVING AND REPLACING WELDED-ON COVERS AND TANKS

## REMOVING THE WELD

There are times when it becomes necessary to remove a welded-on cover from a transformer tank or the top section from the bottom section of a form-fit tank. This may be done by either chipping out the joining weld or cutting out the weld with a gas cutting torch. The equipment required and a suggested procedure to remove the weld is described below.

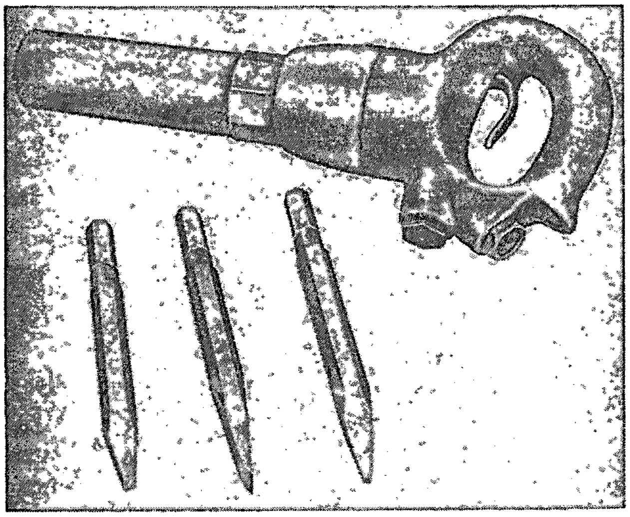


FIG. 1. Recommended Equipment

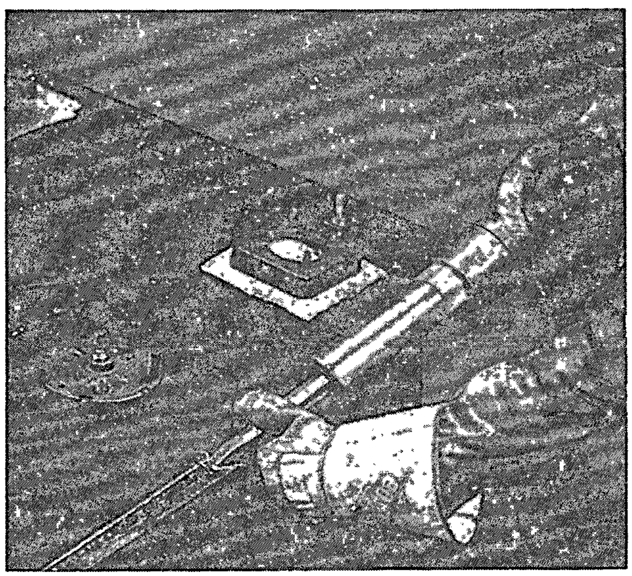


FIG. 2. Removal Procedure

## CHIPPING OUT A WELD

**Equipment.** The equipment recommended to remove a weld by chipping is:

**1.** A heavy pneumatic chipping hammer.

**2.** Three-eighths and 1/8 inch diamond-pointed chisels. The chisels should be forged tools, hardened and tempered so that the edges will not turn or spall. The cutting edges of the diamond-pointed chisels should be ground straight with no chamfer.

**3.** Flat chisels. The flat chisel should have the flat side relieved 1/64", approximately 1/8" back from the cutting edge. This prevents the chisel from "digging-in" and allows the operator better control of its cutting.

**4.** Gloves and safety glasses should be worn by the operator for his personal protection.

**Procedure.** It is important to cover any openings into the tank, to avoid entry of chips. To remove a weld by chipping, apply machine oil or grease to the surface of the weld to lubricate the cutting. A 3/8 inch diamond-point chisel is used in the pneumatic hammer and the chisel is held so that the diamond is pointed into the root of the joint. The chisel should cut 1/8" back of the vertical edge of the weld and along the face of the horizontal

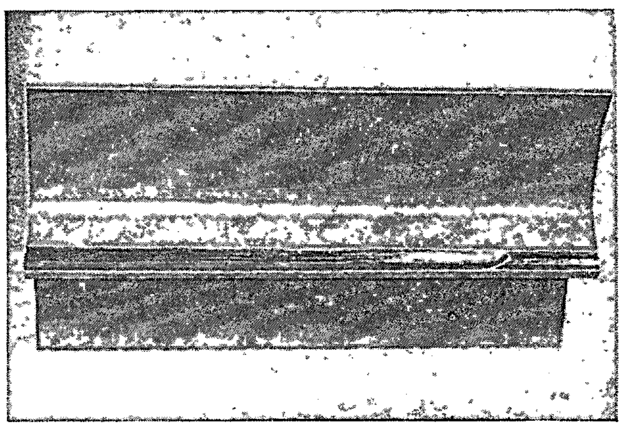


FIG. 3. Weld Partially Removed

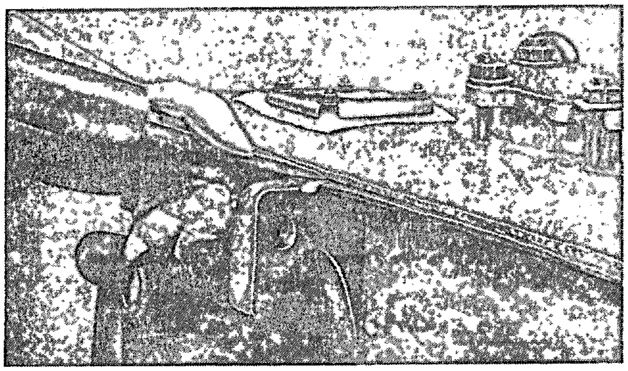


FIG. 4. Carefully Breaking the Seal

flange to remove as much of the weld as possible. Should the weld not be completely removed in one pass with the 3/8 inch diamond-point chisel, more oil or grease should be spread over the remaining weld and the flat chisel used to cut the weld flush with the horizontal and vertical surfaces of the joint. The small diamond-point chisel should then be used to remove any remaining weld metal from the root of the joint.

The flat chisel is then driven directly into the root of the joint to crack the seal, as shown in Fig. 4. To prevent the chisel from being driven between the joint and deforming the plates, it is moved slowly along the joint. A lifting force upon the cover or the top section will help to break the seal.

### WELD REMOVAL BY GAS CUTTING

**Equipment.** The equipment recommended to remove a weld by gas cutting is:

**1.** A heavy duty gas cutting torch, preferably of the oxy-acetylene type.

**2.** Heavy duty flame cutting tips or Airco #6 or #8, Style 183 or Oxweld #19, Style 1511 gouging tips.

**3.** A number of C-clamps.

**4.** A heavy machinist's or pneumatic hammer and a flat chisel to break the weld seal.

**5.** Protective equipment such as gloves and colored goggles for safety protection of the operator, nitrogen to purge the transformer tank and hand operated carbon dioxide fire extinguishers.

**Procedure.** To remove a weld by gas cutting the following procedure is suggested. Connect a bottle of dry nitrogen to the filling plug opening and flush the gas space with nitrogen. Keep nitrogen flowing into the gas space while the weld is being removed to blanket the core and coils and to prevent combustible gases collecting within the transformer case.

The cutting or gouging tip is assembled to the cutting torch. The gas pressures should be adjusted to the recommended pressures for the size tip used. Usually 60 to 80 psi oxygen pressure and 5 to 6 psi acetylene pressure. The torch is lighted and the flame adjusted to give a neutral flame. Heat the weld at one corner of the tank to a white heat, then simultaneously set the torch in motion along the weld and release the cutting oxygen. Move the torch axially along the weld with an oscillating motion, forward slowly an inch or two, then backward quickly about one-half inch, to permit the flame to fan out and wash the molten weld metal from the root of the joint. Continue along the weld in this manner, gauging the depth of the cut so that the entire cross-section of the weld is removed in one pass.

Apply C-clamps to clamp the side or sides from which the weld has been removed to prevent the joint opening prior to complete weld removal.

After the weld has been removed completely around the tank, remove the C-clamps and drive the flat chisel directly into the root of the joint to break any remaining weld seal, as shown in Fig. 4.

### REPLACING A WELDED-ON COVER

To replace a welded-on cover that has previously been removed as described above, the following is recommended:

**Preparing the Cover for Replacement.**

**1.** Chip or grind any irregularities around the cover edge left during the weld removal operation when the cover was removed from the case. The cover edge should be square and expose clean metal.

**2.** Clean the underside of the cover three inches back from the cover edge to a smooth surface. A disc grinder is recommended for this operation.

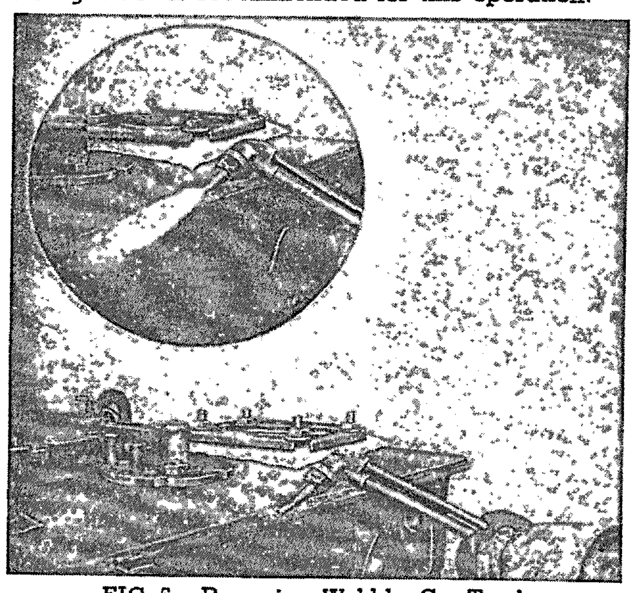


FIG. 5. Removing Weld by Gas Torch

3. Remove and wipe all foreign material from the cover, especially from the underside to prevent dirt falling into the transformer when the cover is placed in position on the transformer case.

**Preparing the Case Flange to Receive the Cover.**

1. Place a blanket of clean paper or cloth over the entire transformer a few inches below the case flange. This blanket should be attached and continuously sealed with wide masking tape around the entire interior of the case. This is necessary to prevent any foreign material falling into the transformer.

2. Remove any raised irregularities from the top surface of the flange by chipping or grinding. A sanding disc will do the job very effectively, or a grinder may be used; in either case, it should be used so that the material removed from the flange will be thrown away from the transformer case rather than into it. This surface must be smooth to permit the cover to fit tightly and uniformly around the case.

3. Gently brush cuttings and debris collected on the blanket over the transformer to the center of the blanket. Remove this debris, then carefully pull the sealing tape from the case walls to free the blanket. Make certain that the edges of the blanket are kept above the center of the blanket at all times so that any foreign material on the blanket will not roll into the transformer.

**Applying the Asbestos Sealing Gasket to the Case Flange.**

1. Brush a ½″ wide coating of #7386 red cement 1½″ to 2″ back from the edge of the flange completely around the case. Care must be observed to prevent any cement extending onto the weld area as it will cause weld porosity.

2. Place a ⅛″ diameter asbestos rope #3879 completely around the case flange in the center of the freshly applied cement. There must not be any openings in the gasket. Use a good butt joint, or allow one end to extend a little in back of the other.

**Positioning the Cover and Preparing for Welding.**

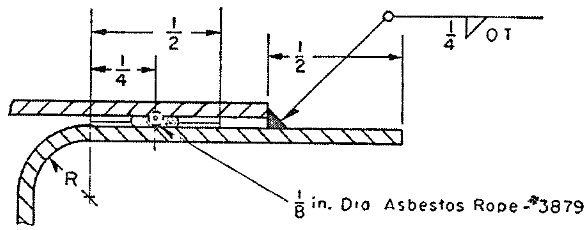
1. Lower the cover onto the case flange so that it is in its approximate final position without sliding across the asbestos gasket. Normally the flange will extend approximately ½″ beyond the cover edge.

2. Clamp the cover and flange tightly together around its entire periphery with C-clamps. Place the C-clamps near the edge of the cover so that the welding operator can weld under the clamps. The cover edge should be tight against the flange before any welding is done at that point.

**Welding the Cover to the Flange.**

1. Cover all openings in the cover.

2. Apply a ⅛″ fillet sealing weld around the cover starting at one corner of the case and welding around it. Use Westinghouse $5/32$″ diameter DH-coated electrodes (#972 076 for 50# packages). This is an American Welding Society Type E-6020 electrode and is recommended for horizontal fillets or downhand welding. It is recommended for this weld because of its high penetrating properties. Either a-c or d-c (reverse polarity preferred) current may be used with a current setting of 155 to 175 amperes.




1. APPLY A ½ IN. WIDE COATING OF #7386 CEMENT TO THE TANK FLANGE.
2. PLACE THE GASKET (ASBESTOS ROPE) IN THE CENTER OF THE STRIP OF CEMENT.
3. CLAMP COVER AND FLANGE TIGHTLY TOGETHER BEFORE WELDING.
4. BE SURE THERE IS NO OPEN SPACE NOT FILLED WITH GASKET MATERIAL.

FIG. 6. Method of Joining Cover to Flange

3. Remove the C-clamps from the cover and flange.

4. Remove the slag from the weld bead and wire brush.

5. Weave a ¼″ fillet weld over the ⅛″ fillet weld using Westinghouse $5/32$″ diameter FP electrodes and a welding current of 150 to 160 amperes. This electrode (S#1528 912 in 50# packages) is also a coated electrode. It is an American Welding Society Type E-6012 and may be used with a-c or d-c (straight polarity preferred) current.

6. Clean the slag from the weld and brush.

Paint the weld, the flange and the edge of the cover with primer and touch-up paint.

## FORM-FIT TANK TOP SECTIONS

To replace the top section of a form-fit tank that has been previously removed as described above, the following is recommended:

**Preparing the Top Section for Replacement.**

1. Chip or grind any remaining irregularities left along the bottom face and edge of the flange

of the top section. The flange edge should be square and expose clean metal. The bottom side of the flange should be smooth.

**2.** Wipe all foreign material from the flange.

**Preparing the Flange of the Bottom Section to Receive the Top Section.**

**1.** Wrap and attach with masking tape an 8″ to 12″ wide strip of heavy paper or cloth around the iron directly above the flange.

**2.** Remove any irregularities from the top surface of the flange by chipping or grinding. When grinding, one should use the grinder so that the material removed is thrown away from the transformer rather than against the iron core. Brush and wipe all foreign material from the flange with a dry cloth. This surface must be smooth to permit the top section to fit tightly and uniformly around the case.

**3.** Remove the 8″ to 12″ wide protecting material previously placed around the iron.

**Applying the Sealing Gasket to the Flange of the Bottom Section.**

**1.** Brush a 1½″ wide coating of #7386 red cement 2″ back from the edge of the flange of the bottom section. Care must be observed to prevent any cement extending onto the weld area as it will cause weld porosity.

**2.** Place the sealing gasket #1598 upon the freshly applied cement with the tape edges outward, completely around the flange. There must not be any openings in the gasket. Use a good butt joint or allow one end to extend a little in back of the other.

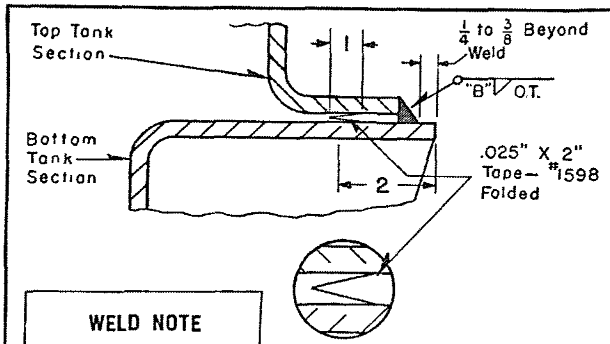
**Positioning the Top Section and Preparing for Welding.**

**1.** Lower the top section slowly over the transformer assembly until it is seated on the flange of the bottom section.

**2.** Clamp the flanges of the top and bottom sections together tightly around its entire periphery with C-clamps. Place the C-clamps near the edge of the flange so that the welding operator can weld behind the C-clamps. The two flanges must be tight together before any welding is done at a given point.

**Welding the Top Section to the Bottom Section.**

**1.** Apply a ⅛″ fillet sealing weld around the top section starting at one corner of the case and weld around it. Use Westinghouse 5/32″ diameter DH-coated electrodes S#972 076 for 50# packages.




WELD NOTE

| Top Tank Section Thickness | Weld Size "B" |
|---|---|
| ¼ | ¼ |
| 5/16 | ¼ |
| ⅜ | 5/16 |
| 7/16 + ½ | ⅜ |

1. BRUSH A 1½″ WIDE COATING OF #7386 CEMENT ON THE FLANGE OF THE BOTTOM TANK SECTION 2″ BACK FROM THE TANK EDGE.
2. FOLD THE 2″ WIDE ASBESTOS TAPE ALONG ITS CENTER AND PLACE ON THE FRESHLY APPLIED CEMENT WITH THE TAPE EDGES OUTWARD.
3. CLAMP FLANGES TOGETHER TIGHTLY BEFORE WELDING.
4. BE SURE THERE IS NO OPEN SPACE NOT FILLED WITH GASKET MATERIAL.

FIG. 7. Joining of Flanges, "Form-Fit" Tank

This is an American Welding Society Type E-6020 electrode and is recommended for horizontal fillets or downhand welding. It is recommended for this weld because of its high penetrating properties. Either a-c or d-c (reverse polarity preferred) current may be used with a current setting of 155 to 175 amperes.

**2.** Remove the C-clamps from the cover and flange.

**3.** Remove the slag from the weld bead and wire-brush.

**4.** Weave a ¼″ fillet weld over the ⅛″ fillet weld for top sections made of ¼″ and 5/16″ thick plate, a 5/16″ weld for ⅜″ thick top sections and a ⅜″ weld for 7/16″ or ½″ thick top sections. Deposit this weld with Westinghouse 3/16″ diameter FP electrodes and a welding current of 190 to 210 amperes. This electrode is a coated electrode S#1528 913 in 50# packages. It is an American Welding Society Type E-6012 and may be used with a-c or d-c (straight polarity preferred) current.

**5.** Clean the slag from the weld and brush.

**6.** Paint the weld and the flanges with primer and touch-up paint.

## WELD AT BOTTOM OF TANK WALL

Many transformer designs will have a bottom weld between the tank wall and the tank bottom. This arrangement, which is not of the form-fit design, is illustrated in Fig. 8. It is necessary to remove this

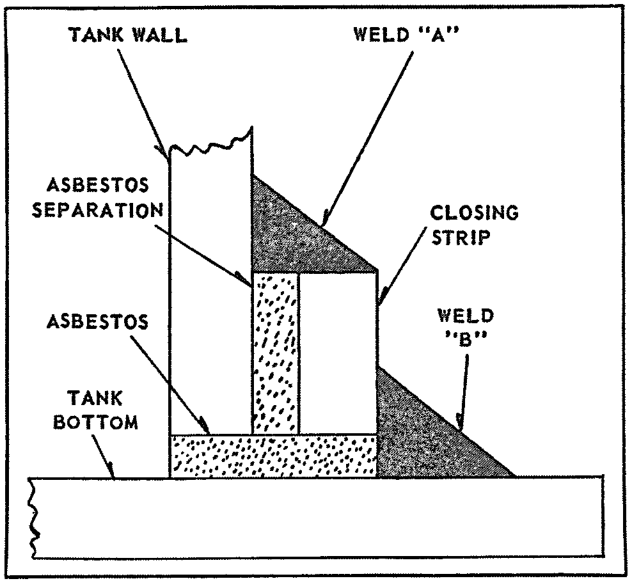



FIG. 8. Weld between Tank Wall and Tank Bottom

weld to lift the tank away from the bottom so that the core and coil assembly can be removed. Because of limited space beneath the coolers it is recommended that the weld be removed by gas cutting.

**Removing a Weld at the Bottom of the Tank.**

The procedure for the removal of a bottom weld is similar to removing a welded-on cover by gas cutting except as follows:

1. Weld "A" of Fig. 8 must be removed, not weld "B". This is to prevent the gas flame from reaching the oil that has dripped from the core and coil assembly and collected on the tank bottom.

2. Remove the weld completely as well as approximately 1/8" of the closing strip to insure adequate separation between the closing strip and the tank wall.

3. Use on Oxweld #13, Style 1511 tip, directing the flame in the direction of the weld as shown in Fig. 5.

4. Remove the tank from the bottom by lifting after all the internal connections between the core and coil assembly and tank are removed.

**Replacing Tank and Weld.**

1. Before replacing the tank on the base, remove irregularities from the tank surface and the inside of the closing strip by grinding.

2. After replacing the tank, close up the clearance between the tank wall and closing strip. This is to be done by calking with 3/16" diameter asbestos rope #3879 all around the tank. Care should be taken that there are no asbestos fibers protruding that might produce a defective weld.

3. Proceed with welding the tank wall to the closing strip using the same method as specified in welding the cover to the flange, except that clamping is not required.

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
Printed in U.S.A.

# Instructions for Repairing Tank Leaks



This instruction leaflet is intended to give general instructions concerning recommended practices for repairing a weld leak in power transformers or their auxiliaries. Variations of these instructions may be desirable for special repair tasks, but normally the weld leak may be successfully sealed if these instructions are followed.

TRANSFORMER CASES AND FITTINGS

Transformer cases and their fittings are fabricated from 3/16" to 1/2" thick welding quality low carbon steel, which are joined by manual, semi-automatic and automatic welding, using a manual shielded arc, submerged arc and inert arc process.

To repair a weld leak in a case seam or around one of the fittings the following is recommended:

1. De-energize the transformer. Check the liquid level in relation to the area to be welded. It should be 4" or more above the area to be welded. Should the area to be welded be above the liquid level or if the liquid has been removed from the case, blanket the transformer with dry nitrogen.

2. If the liquid has not been removed, pull a vacuum of several pounds per square inch above the liquid to stop the liquid leak. This may be done with a vacuum pump or by sealing all fittings on the case and draining sufficient oil to obtain the necessary vacuum.

NOTE: Vacuum is not always required, especially when a sweating leak is to be repaired and the case wall is relatively thick.

3. Peen the weld leak closed, if possible, with the ball end of a ball-peen hammer or with a blunt or round-nosed chisel.

4. Grind or scrape the paint from the area to be welded and prepare a suitable point for attaching the ground lead to the arc welding machine.

5. Select a 1/8" diameter all purpose, coated electrode, American Welding Society type E-6012 (Westinghouse type FP). Either a-c or d-c welding current may be used. When d-c current is used, straight polarity is preferred, that is the electrode is negative.

The welding machine is adjusted to supply the desired welding current. Some value between 115 to 125 amperes should be used, depending upon the welding operator's ability and the individual task at hand.

6. Apply a string bead sealing weld over the weld defect in a single, quick pass. This weld should be deposited horizontally or vertically depending upon circumstances. If the weld is deposited vertically, it is recommended that it be made downward to drive any liquid seepage ahead of the weld.

Successive beads are deposited adjacent and over the first sealing bead, or a single pass may be weaved across it to complete the weld. If the beads are deposited vertically, deposit these beads from the top down if any liquid seepage is present; otherwise they may be deposited upward if preferred. Remove the slag from the deposited weld before depositing each successive weld bead or pass

Liquid interferes with the welding operation and the quality of the deposited metal. It should be wiped off with a dry cloth. All welds should be deposited in a sequence as above to prevent any liquid seepage interfering with the welding operation other than the final sealing at the lowest point of the weld leak.

7. Clean the repaired area and check with a suitable leak detector to be sure the leak has been stopped.

Effective March, 1966 Supersedes I.L. 48-069-20C, November, 1962

8. After testing for leaks, reclean the area and apply touch-up paint, as outlined in I.L. 48-069-15, "Standard Outside Finish for Westinghouse Oil Insulated Transformers".

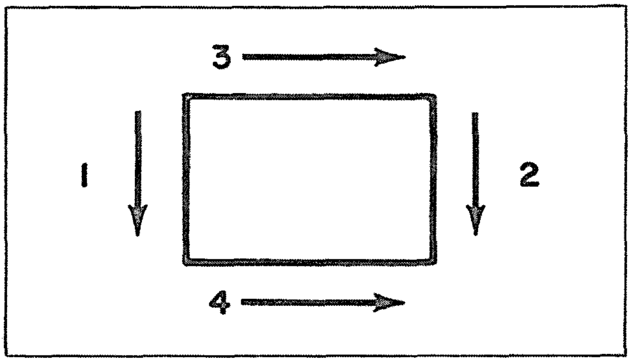



*Fig. 1. Welding Sequence for Patch*

ALTERNATE METHOD USING A PATCH

A patch may be welded to the transformer case to repair a leak as an alternate to the method above. The recommended method is as follows:

1. De-energize the transformer and pull a vacuum, peen the weld, clean the weld area, check the liquid level, select the 1/8" type E-6012 electrodes and adjust the welding machine as above.

2. Fit a patch of 3/16" or 1/4" thick steel over the area to be sealed. Tack this patch in place, then weld it to the transformer case by welding the sides first, vertically downward, then horizontally across the top of the patch and finally horizontally across the bottom. This welding sequence is recommended to prevent any liquid interfering with or contaminating the weld. (See Figure 1.)

3. Clean the repaired area and check with a suitable leak detector to be sure the leak has been stopped.

4. After testing for leaks, reclean the area and apply touch-up paint as outlined in I.L. 48-069-15, "Standard Outside Finish for Westinghouse Oil Insulated Transformers."

TUBULAR COOLERS

The Westinghouse swaged tube cooler consists of a number of 2" diameter x 18 gauge (approximately .050 thick) wall thickness riser tubes with swaged ends inserted into, and arc welded to, two 2-3/8" diameter x .093" wall thickness header tubes for assemblies of eight riser tubes or less and 2-3/8" diameter x .125" wall thickness header tubes for assemblies of nine or ten riser tubes. The wall thickness of the swaged end of the riser tube at the point it is welded to the header tube is approximately .070".

Tube cooler assemblies without swaged riser tubes are made from 1-1/2" extra-heavy pipe or 9/64" or 5/16" wall thickness tubing welded to 2" extra-heavy-pipe headers.

To repair a weld leak in a tube cooler assembly or in the weld attaching the headers to the case the following is recommended:

1. De-energize the transformer and pull a vacuum above the liquid to stop the liquid leak. This is essential when repairing the swaged tube coolers.

2. Peen the weld leak closed if possible with blunt or round-nosed chisels.

3. Scrape the paint from the area to be welded and prepare a suitable point for attaching the ground lead to the arc welding machine. Remove any liquid on the surface to be welded.

4. If a leak occurs in the weld at the swaged end or where a brace is welded to a header use a 3/32" diameter coated electrode with low penetration characteristics, American Welding Society type E-6013. It may be used either d-c (straight polarity preferred) or a-c. The recommended welding current is 50 to 60 amperes.

5. Seal the leak with a single, quick weld bead. Apply the bead horizontally, vertically or overhead as the occasion demands. If vertically, weld downward. When

sealing a weld joining the header to the case, start at the top of the header and weld downward around its periphery to the bottom of the header. Always weld so that any oil seepage will flow away from the weld rather than into it.

Weld beads must be small and made quickly to prevent burning through the tube walls. An arrangement of mirrors may aid in repairing a weld that can be reached, but is not in the welding operator's direct line of vision.

6. Clean the repaired area and check with a suitable leak detector to be sure the leak has been stopped.

7. After testing for leaks, reclean the area and apply touch-up paint as outlined in I.L. 48-069-15, "Standard Outside Finish for Westinghouse Oil Insulated Transformers".

8. If a leak occurs in the tube (usually a flash weld seam) or where a brace is welded to the riser tube, drain the liquid and blanket with nitrogen. Then the repair should be made by gas welding. After repair has been made repeat steps 6 and 7.

FIN-TYPE RADIATORS

The Westinghouse fin-type radiators consist of different numbers of fin elements welded to each other and to a formed header. The elements are made from two sheets of .057" thick mild steel continuously welded along their outer edges and with intermediate seams between the individual lobes.

Field repair of a seam between lobes or replacement of an element is not recommended. The radiator should be returned to the factory for repair.

To repair weld leaks around the header flange, along the outer edge of the elements or in the weld where the elements join the header or each other, the following procedure is recommended:

1. Close the radiator valves between the radiator and the transformer case.

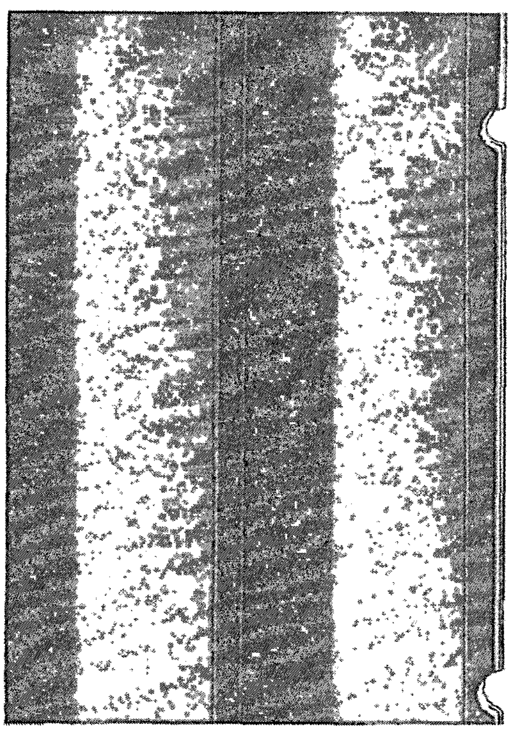


*Fig. 2. Radiator Section Prepared for Welding*

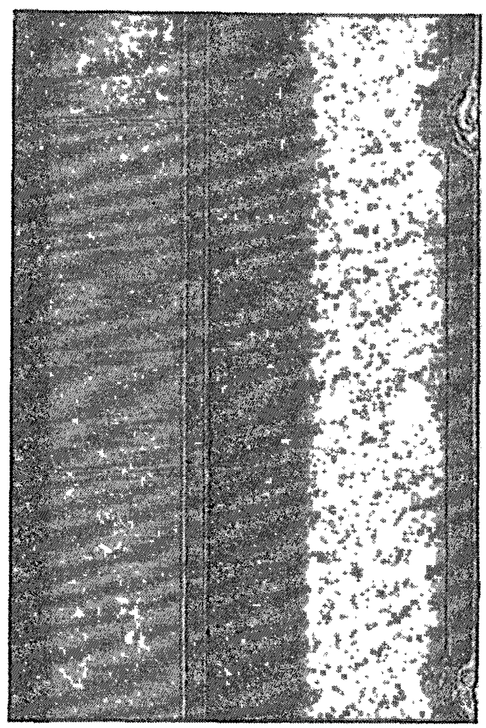


*Fig. 3. Radiator Section After Welding*

Drain the liquid from the radiator and remove the radiator from transformer case.

2. Grind or scrape the paint from the area to be repaired. Also remove any liquid, dirt or foreign matter.

3. If the weld to be repaired is around the header flange use 1/8" diameter type E-6012 electrodes with current settings between 115 to 125 amperes. Weld horizontally around the flange.

4. A slightly reducing oxygen-acetylene welding flame is recommended for repairing a weld along the edge of an element, a weld joining the elements to each other, or a weld joining the elements to the header. The recommended procedure for repairing a leak along the edge of an element is outlined below:

a. Heat the full length of the seam with the oxy-acetylene torch to drive out all trapped oil.

b. Find the exact location of the leak by means of a suitable leak detector.

c. When the exact location of the leak has been determined, notch the edge of the element as shown in Figure 2 at points two to three inches on either side of the leak. These notches may be cut with a hack saw, a file, or a small grinder.

d. Start by filling one of the notches. Next, fill in the second notch. Finally fuse the edges of the element between the notches moving forward with a slightly weaving motion. Be sure to tie this weld into both filled notches. Use 1/16" soft iron gas welding rod as filler material.

Figure 3 shows the repaired element before touching up the repaired area.

5. Clean the repaired area and check with a suitable leak detector to be sure the leak has been stopped.

6. After testing for leaks, reclean the area and apply touch-up paint as outlined in I.L. 48-069-15, "Standard Outside Finish for Westinghouse Oil Insulated Transformers."

7. Reinstall the radiator.

## YUKON COOLERS

"Yukon" Coolers are formed by corrugating sections of the tank wall and are integral with the tank wall. The thickness of these coolers is usually 5/16" which corresponds to the wall thickness of network transformers on which they are primarily used. Since they are the same thickness as the tank wall and consist mostly of flat surfaces, the procedure for repairing weld leaks is the same as given under the information on the first page of this leaflet under "Transformer Cases and Fittings."

# Instructions for Type WCA De-energized Tap Changer



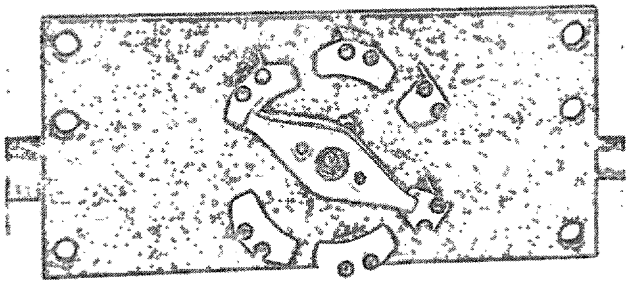


**Fig. 1** *WCA Tap Changer Contact Assembly*

The Type WCA De-energized Tap Changer is a device for changing transformer tap connections from outside the transformer tank when the transformer is completely de-energized.

**CAUTION: The Type WCA Tap Changer must not be operated with the transformer energized. The transformer must not be energized unless the tap changer is locked on an operating position. Failure to observe these rules may result in damage to equipment and personal injury or loss of life.**

The transformer instruction plate has a tabulation of all operating positions of the de-energized tap changer showing available voltage and current ratings.

## DESCRIPTION

The complete WCA installation is made of three parts: (1) the tap changer deck, (2) the drive shaft, (3) the operating mechanism.

Figure 1 and Figure 2 show the contact assembly and the overall assembly of the WCA single phase deck. Figure 3 shows a three phase assembly mounted on the core and coil assembly

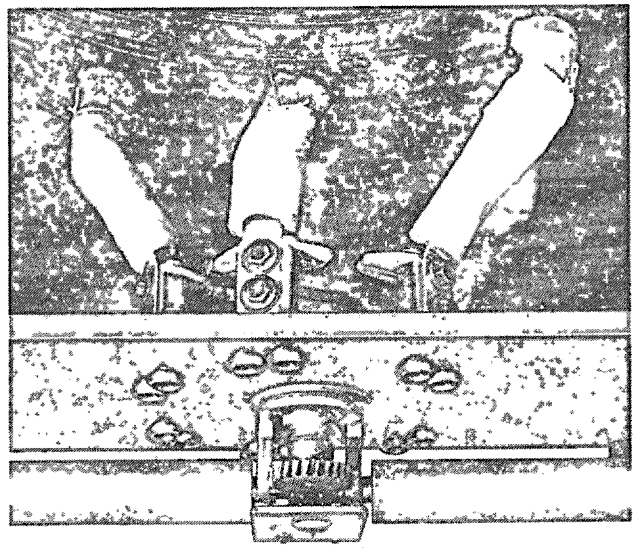


**Fig. 2** *WCA Tap Changer Deck Assembly*

with drive shaft connections between phases and the drive shaft to the operating mechanism at the right end. Figure 4 shows the operating mechanism and position indicator which is mounted externally. Figure 5 shows diagramatically how these components form a complete assembly.

The tap changer deck contains the tin-plated stationary contacts which are electrically connected to the transformer taps, the silver tipped moving contact assembly which completes the tap connections, and the mechanical gearing to relate the moving contact position to the drive shaft. These parts are all assembled on a Micarta board which is mounted adjacent to the coil assembly within the transformer tank. A three phase transformer has a deck for each phase. The large discs shown in Figure 3 for electrical shielding of tap changer components are used when voltage stress analysis shows that their use will decrease the size of the transformer tank and the amount of insulating oil required.



Effective January, 1979 Supersedes I.L. 48-064-44, February, 1978

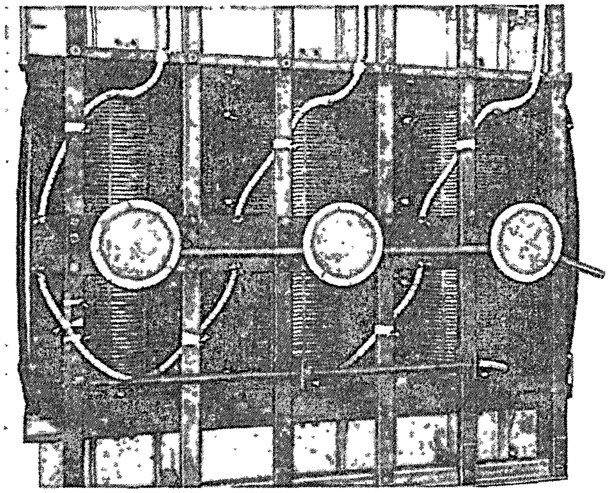


Fig. 3 *WCA Mounted on Transformer Core and Coils*

The drive shaft consists of Micarta tubes connecting the phase decks, and telescoping Micarta tube drive shafts from one end phase to the tank wall. Each interphase tube is restrained at one end and has a slip joint at the other end. The telescoping shafts provide a slip joint to the tank wall. All shaft end connections are ball joints. These provisions allow for all dimensional variations due to temperature, pressure, and manufacturing tolerances. One complete revolution of the drive shaft makes a one position movement of the WCA contacts.

The operating mechanism consists of an operating handle, a position indicator, and a packing gland plus a secondary O-ring oil seal. The operating handle is pinned to the shaft, and carries the geneva pinion which operates the position indicator geneva gear. The mechanism shaft extends through the WCA boss into the transformer tank and terminates in the ball joint for the WCA drive shaft.

The main oil seal is a spring loaded packing. In addition, there is a secondary O-ring seal. The geneva gear position indicator has pinion slots blocked to limit operation to the desired number of positions. The complete operating mechanism assembly is bolted and gasketed to the WCA boss on the tank wall.

It may at times be necessary to separate the operating handle and position indicator from the packing gland so that they can be mounted remote from the WCA boss. In these cases, a bevel gear assembly is substituted for the handle and indicator described above, and external shafting is run to the required location for the operating handle and position indicator.

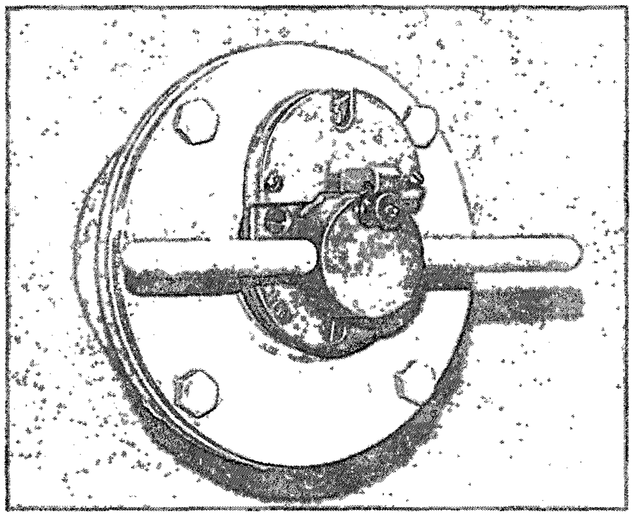


Fig. 4 *WCA Operating Mechanism and Position Indicator*

## RECEIVING, HANDLING, INSTALLATION

The WCA tap changer is installed and tested at the factory and is received as an integral part of the transformer. No servicing is required at the time of installation except visual inspection for shipping damage. The integrity of the internal parts will automatically be checked during the transformer installation tests for ratio and resistance.

Before the transformer is energized, the WCA tap changer should be operated to the position shown on the instruction plate which matches the transformer voltage with the system operating voltage. The tap changer should be padlocked on this position by inserting the shackle of the padlock between the locking pin and the lug just above the center of the operating handle.

## OPERATION

**CAUTION: Never operate the WCA tap changer while the transformer is energized. To do so will certainly cause burning on the contacts, and may cause personal injury, loss of life or extensive damage.**

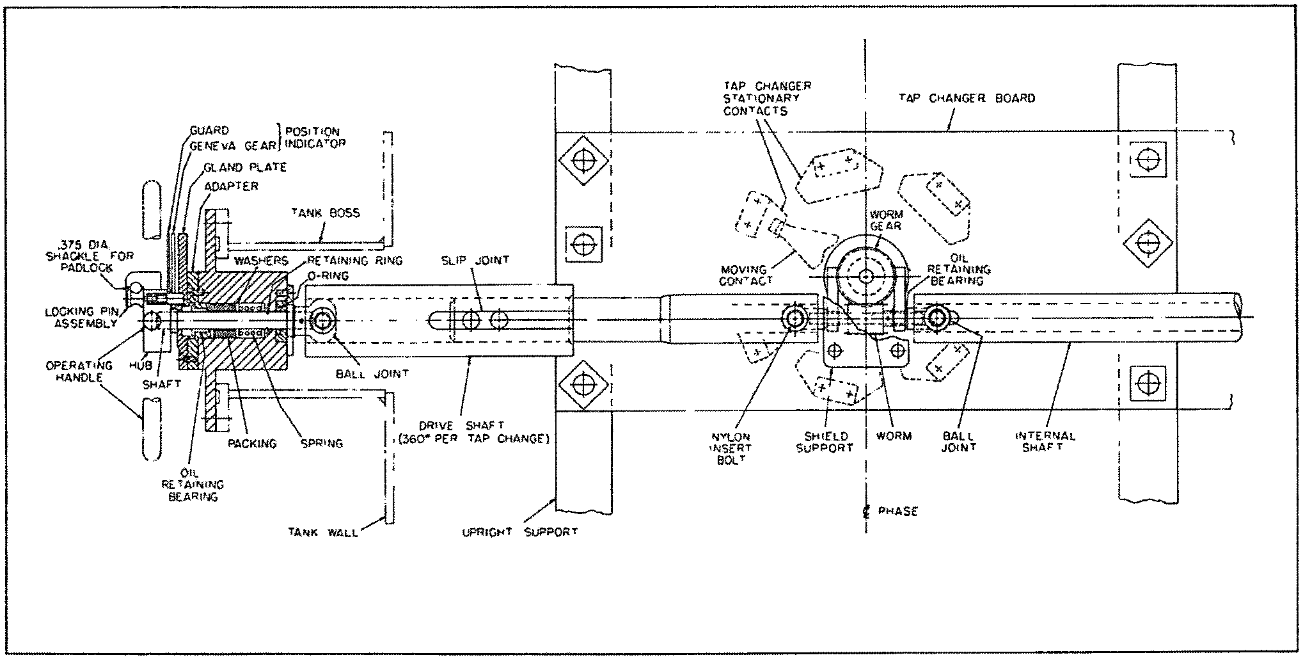



**Fig. 5** *Diagram of WCA Tap Changer Assembly*

To operate the WCA tap changer one position:

1. De-energize the transformer.

2. Pull out on the locking pin, located just above the center of the handle, approximately 1/4 inch.

3. Turn the handle a small amount, 5 or 10 degrees. Release the locking pin. Complete one full revolution of the handle. Let the locking pin drop into locked position.

The direction of rotation of the operating handle is determined by the internal construction of the transformer core and coil assembly. After one revolution of the handle, check the position number on the position indicator. Then make additional operations in the same or opposite directions as required until the desired new operating position is reached.

On the limit positions, the mechanical stops will thwart operation into an open position. The stop reflects on the handle as a positive blocking force, rather than just the increase in torque normally felt as the WCA contacts make. Should this condition be encountered, simply rotate the handle in the other direction to the desired operating position.

## MAINTENANCE

The WCA tap changer is designed to operate without maintenance. Internal parts are protected by the transformer oil. External shafts are stainless steel operating in bronze bushings.

It is recommended that the tap changer periodically be operated one or two positions and back so as to wipe the contact surfaces. This may be done when the transformer is de-energized for some other reason.

The same general statements apply also when the operating handle is remote from the WCA tank boss. In this case, however, gear boxes are involved and the gear teeth need protection. It is recommended that, at least annually, the inspection plates be removed from the gear boxes and the gear teeth be lubricated with a coating and sealing type compound such as Molykote Silicone Lubricant M-77.

## OVERHAUL AND REPAIR

Overhaul or repair is not normally needed during the life of the transformer on which the WCA tap changer is installed. It is built, however, so that it is possible for a trained mechanic familiar with transformer equipment to make repairs using conventional tools.

**CAUTION: Before making any repairs to the WCA tap changer or its operating mechanism, de-energize the transformer to prevent accidentally changing taps or losing oil with the transformer energized with resulting danger to equipment and personnel.**

External parts can be repaired without draining the oil from the transformer tank. Because of the secondary O-ring oil seal, this includes the main shaft packing assembly.

Any internal repairs will require draining oil from the transformer to a level below the WCA tank boss to permit removing the mechanism as a unit from the boss. This would include replacing the mechanism shaft, replacing the secondary O-ring oil seal, or replacing the boss gasket.

In any repair operation:

1. De-energize the transformer.

2. Note the position shown on the position indicator.

3. If the position indicator is mechanically disconnected from the tap changer do not rotate the tap changer drive while the indicator is disconnected.

4. When reconnecting the position indicator, be sure the position is the same as noted before disconnection.

5. After any mechanical disconnection of the drive between tap changer and position indicator, transformer ratio tests must be made on all WCA positions before re-energizing the transformer.

6. After any oil is drained from the transformer tank, the tank must be refilled in accordance with the leaflet "Instructions for Shipment, Installation, and Storage of Oil-Filled Power Transformers."

If, in spite of all precautions, the position indicator gets out of synchronism with the tap changer, as determined by the ratio tests of paragraph 5 above, use the ratio test to determine the position on which the tap changer is actually setting, remove the shield in front of the position geneva by removing the two brass screws, remove the position geneva and rotate it to the proper position, and replace the shield. **The ratio tests should be repeated for all positions before energizing the transformer.**

**NOTE: If the ratio test indicates an open circuit, it probably means that the drive shaft is 180° out of synchronism. This cannot be corrected as above. The mechanical shaft connection opened during the repairs must be reopened and the shaft alignment corrected there.**

If repair of the tap changer deck assembly is required, the operating mechanism must be removed from the tank wall and the entire core and coil assembly removed from the tank. This is a major procedure, preferably performed in a transformer service shop.

## RENEWAL PARTS

Renewal Parts may be ordered from the nearest Westinghouse Sales Office by giving a description of the parts wanted and the transformer rating and serial number shown on the transformer instruction plate.

**Westinghouse Electric Corporation**
Medium Power Transformer Division, Sharon, Pa. 16146

Printed in U.S.A. (W.P.D.)

# Instructions for INERTAIRE®
# Equipment Types RN and RNE



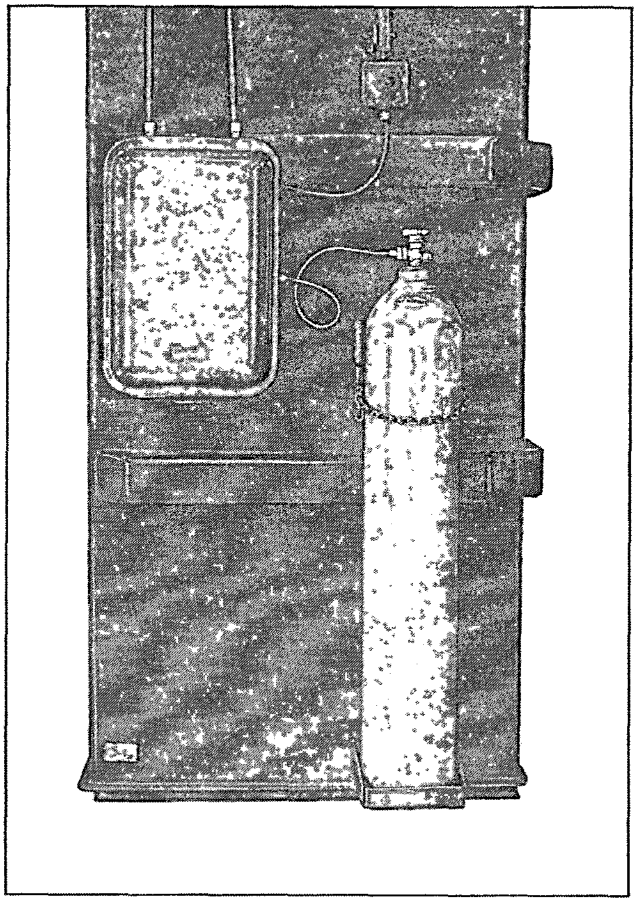


*Fig. 1. Typical Installation of Inertaire Equipment, Type RNE*

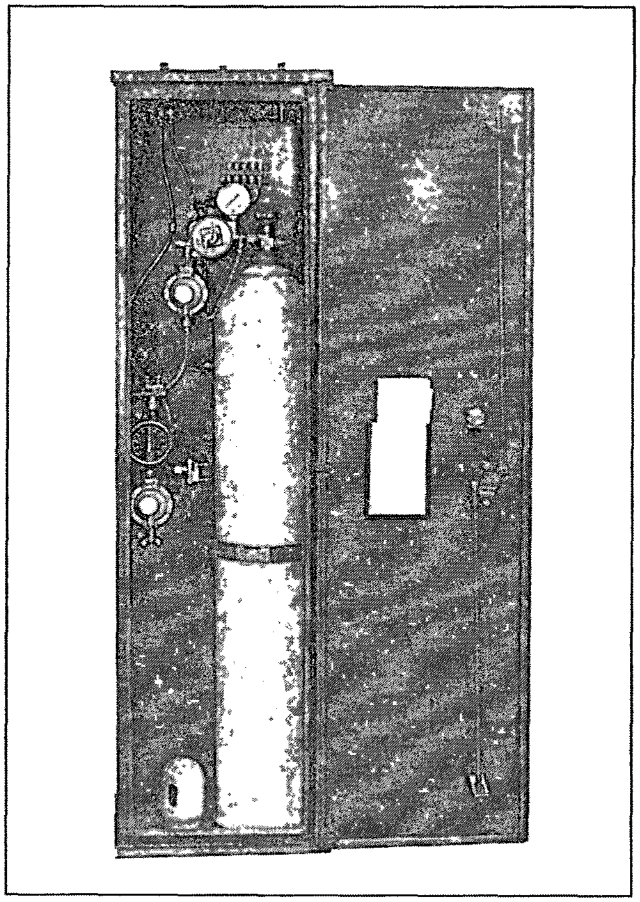


*Fig. 2. Inertaire Equipment and Cabinet, Type RN*

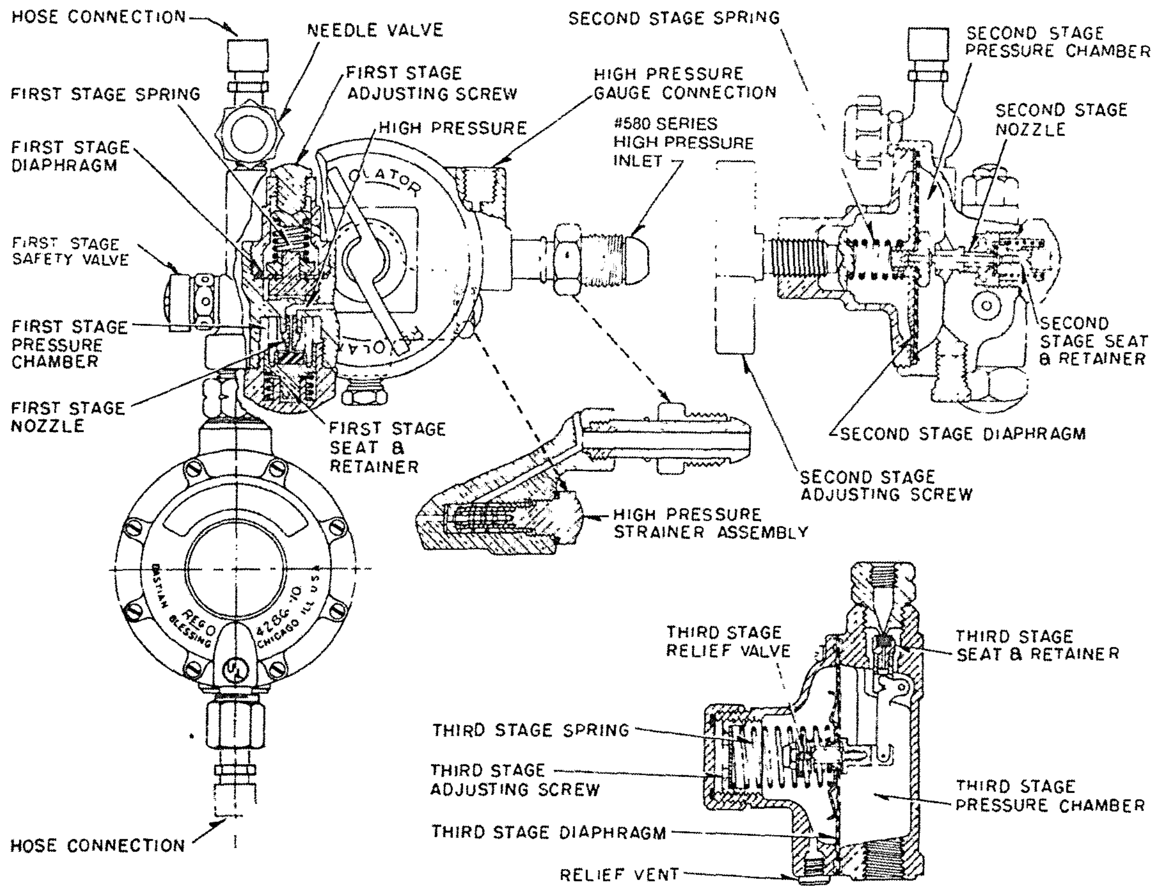
INERTAIRE is the Westinghouse system for removing oxygen and moisture from the air being drawn into a transformer tank when decreasing temperature would create a partial vacuum within the tank. With the oxygen and moisture removed, the remaining inert gases are almost wholly nitrogen. Subsequent development has evolved means for feeding dry nitrogen at low pressure into the transformer tank from high pressure nitrogen cylinders, instead of depending on removing oxygen and moisture from the air drawn in during breathing.

Westinghouse Types RN and RNE Inertaire equipment maintain a cushion of inert dry gas above the oil of transformers or similar oil-filled equipment.

The nitrogen is supplied from a steel cylinder which is initially filled to a pressure of 2000 pounds per square inch. A pressure reducing valve automatically feeds nitrogen into the transformer whenever the transformer pressure falls below 1/2 pound per square inch gauge.

A relief valve assembly incorporated in the final stage of the reducing valve conserves the nitrogen in the gas space by permitting it to escape to the atmosphere only when the pressure in the transformer, due to the expansion of the oil with temperature, exceeds the predetermined value of 6-1/2 pounds per square inch gauge. A sampling valve connected to the gas space provides means for taking a sample of the gas to determine its oxygen content.

Effective May 1977 Supersedes I.L. 48-063-36B, April 1976




The standard thread connection on the high pressure inlet of the RN and RNE Regulator is the C.G.A. Standard #584 (.960-14-RH-EXT) to mate with cylinder valve outlet #581 ( 965-1N-RH-INT).

**NOTE:** The thread connection and pressure settings described in this I.L. is standard for the Type RN and RNE Inertaire system. See nameplate in the cabinet for special modifications supplied by customer request.

*Fig. 3. Regulator and Secondary Relief Valve Assembly (Type RN and RNE Inertaire Equipment)*

# DESCRIPTION

## Regulator and High Pressure Gauge

A three-stage reducing valve is used to reduce the nitrogen cylinder pressure of 2000 psi to 1/2 psi feed in pressure. The physical appearance of the reducing valve may be that shown in either Figure 3 or Figure 3A. Both models have the equivalent features and are interchangeable.

The first stage is compensated to give constant pressure and flow to the second stage regardless of drop in cylinder pressure. In passing through the first stage the pressure is reduced from 2000 psi to approximately 100 psi.

The second stage further reduces the pressure to approximately 5 to 10 psi before the gas enters the third and final stage reducer where the pressure is reduced to 1/2 psi. The nitrogen is fed into the transformer gas space at this final pressure when the pressure in the gas space falls below 1/2 psi.

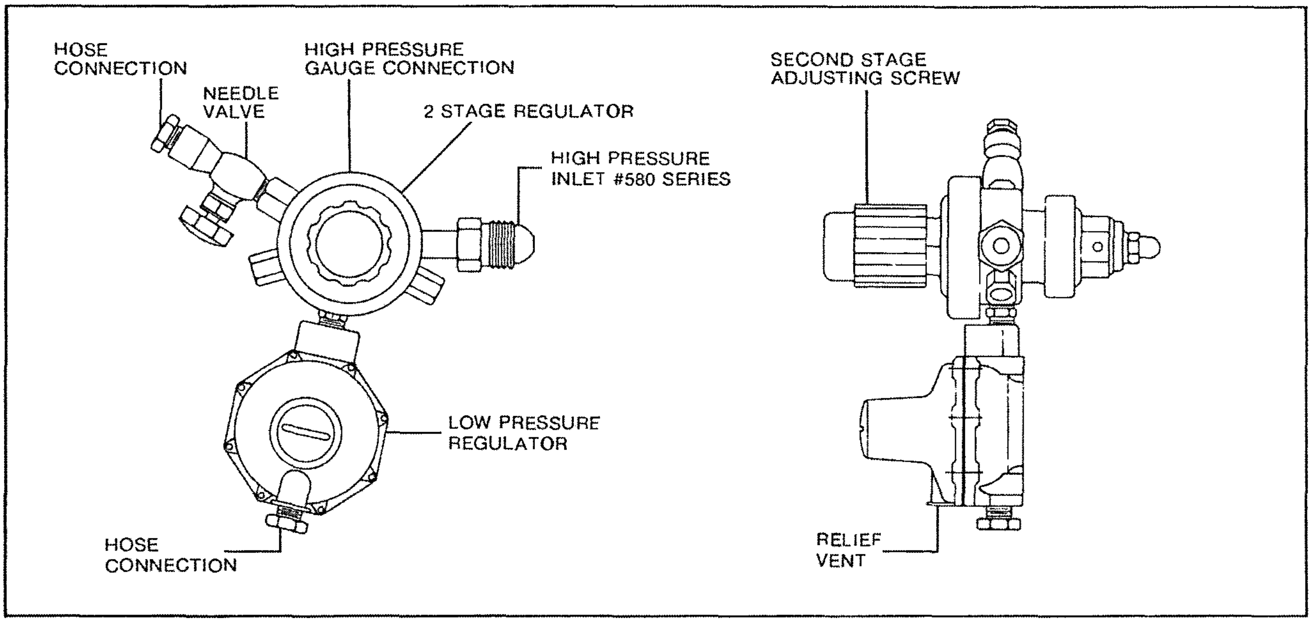



*Fig. 3A. Regulator and Secondary Relief Valve Assembly (Type RN and RNE Inertaire Equipment)*

A high pressure safety is provided in the event of excessive heat near the cylinder causing the cylinder pressure to increase to a dangerous value. The high pressure safety consists of a diaphragm backed by rose metal. When excessive heat occurs, the rose metal backing the diaphragm melts, leaving the diaphragm unsupported. The diaphragm then ruptures, permitting the gas to escape to the atmosphere through several holes arranged to distribute the thrust in all directions.

The test needle valve with a hose connection is located at the outlet of the second stage. The connection provides a relatively low pressure source (3 to 10 psig) for checking the relief pressure of a relief valve incorporated as part of the third stage. This connection may also be used for purging the gas space.

The pressure at this connection can be adjusted by turning the adjusting screw (or T-handle) clockwise to raise the pressure or counterclockwise to lower the pressure on second stage.

---

**NOTE: After using this connection, adjustment should be reset to provide approximately 5 pounds per square inch gauge pressure, (but never less than 3 pounds per square inch gauge), since 5 pounds per square inch gauge pressure gives the best performance in the following stage.**

---

The third stage of the regulator is the lower portion of the device. It is adjusted at the factory to feed nitrogen into the gas space when the pressure in the transformer falls below 1/2 pound per square inch gauge, and to seal off the gas space from the nitrogen supply when this pressure rises above 1/2 pound per square inch gauge. This setting should not be disturbed under any circumstances.

A primary relief valve installed on the sump (Fig. 4) acts to prevent the transformer from exceeding 6-1/2 psig. This is a spring loaded diaphram valve which opens slightly, permitting gas to escape to the atmosphere. As soon as the pressure falls below 6-1/2 psig the valve closes, preventing further loss of gas.

A secondary or backup relief valve is incorporated within the third stage of the pressure regulator (Fig. 3 or 3A), which acts to prevent the transformer pressure from exceeding 8 psig.

**IMPORTANT: The regulator is a precision instrument and adjustment other than the one mentioned in the previous Note should not be attempted. If the valve does not operate correctly, notify the nearest Westinghouse Office and send the valve to the Westinghouse Electric Corporation, Sharon, Pa., for repair. Repair of regulator and high pressure gauges should not be attempted in the field.**

A 3000 pound per square inch pressure gauge is connected to the high pressure chamber of the reducing valve, and indicates the nitrogen pressure in the cylinder. Switches are provided with electrical contacts which close when the cylinder pressure falls to 200 pounds per square inch gauge, warning the operator that only 10 percent of the full cylinder of nitrogen is left. (See Fig. 8). *The switch ratings are given in Table No. 1.* The regulator will continue to function, however, until the cylinder is empty.

COMPOUND PRESSURE GAUGE AND SWITCHES. A compound pressure gauge, Fig. 4, mounted on the sump, is used to indicate pressure in the transformer gas space. It has a range of -10 to +10 psig. The sump is equipped with two alarm micro-switches, one to operate at abnormal high pressure and the other to operate at vacuum should it occur. Refer to Fig. 8. The standard pressure switches are supplied with normally open or normally closed contacts. The switches are set 8-1/2 psig on the pressure side and 1-1/2 psig on the vacuum side. The switch ratings are given in Table No. 1.

The differential of the switches is approximately 3/4 psig. That is, if the high alarm operates, the pressure must fall only 3/4 psig before the switch is reset; if the low alarm operates, the pressure must increase 3/4 psig for the switch to reset.

It should be noted that the vacuum switch will never operate except in case the nitrogen cylinder is allowed to become empty. The pressure switch will not operate unless the relief valve should fail to perform its function, or the pressure builds up faster than it can be relieved by the relief valve due to a fault in the transformer.

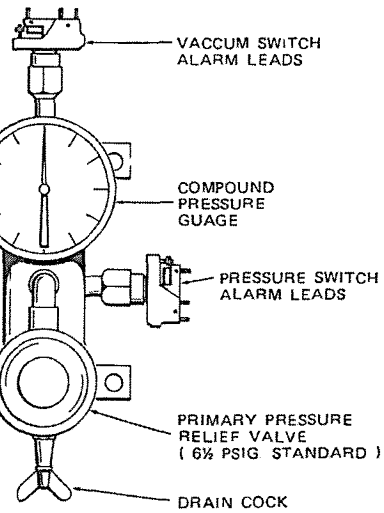



*Fig. 4. Sump, Compound Pressure Gauge, Switches and Diaphragm Type Breathing Relief Valve*

SHUT-OFF VALVE. Always close the shut-off valve before evacuating transformer. This valve has two hose connections and is located above the regulator (see Figure 5, page 5). Opening or closing this valve, connects the gas space above the transformer oil level to the sump assembly and the test valve on the outlet of the first stage of the reducing valve. The operating positions are as follows:

1. Shut-off (clockwise to limit). This shuts off the gas space and connects the relief valve through the hose to the needle test valve. This position is used to seal the gas space, and also for testing the operating pressure of the test valve.

2. Operating (counterclockwise to limit). In this position, the gas space is connected to the relief through the oil sump, and the connection to the needle test valve is closed.

SAMPLING VALVE. The sampling valve is a needle valve connected to the gas space above the oil through a pipe attached to the tank wall.

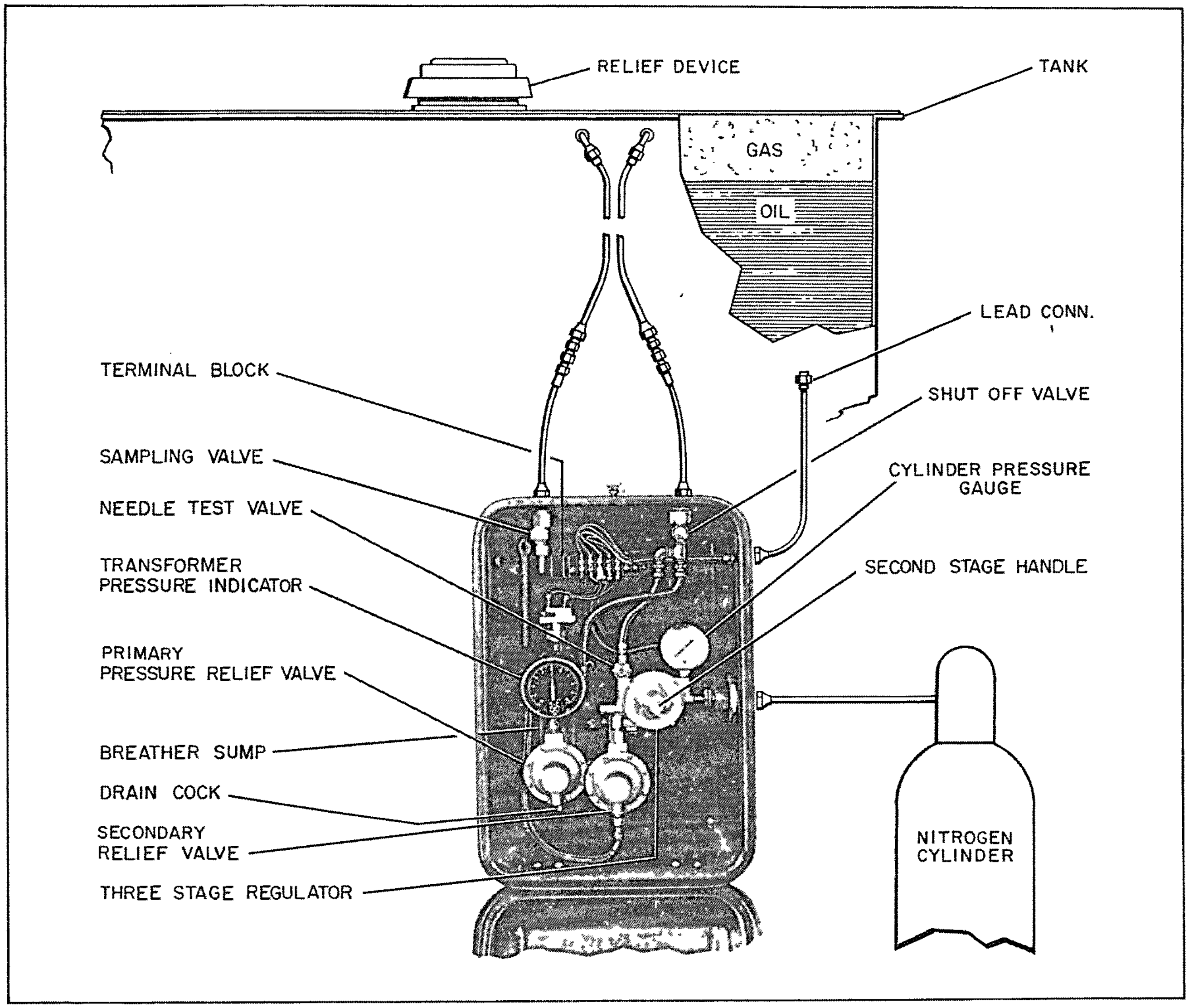



*Fig. 5 Inertaire Equipment Arrangement — Type RNE*

It is used for obtaining samples of the gas from the gas space for oxygen content analysis. When sampling for oxygen content, sufficient gas should be allowed to flow to clear the line before taking the sample. This valve may be also used as an exhaust valve when purging the oxygen from the gas space.

## INSTALLATION (Type RNE)

Inertaire equipment is shipped assembled in cabinet and mounted on tanks when clearance permits. One Nitrogen cylinder, two short low pressure hoses, one high pressure hose, and the alarm cable are shipped detail or in the cabinet.

If the cabinet is not mounted on the transformer tank, the mounting should be made as follows: Remove the three vibration dampeners from the cabinet and mount them on the three pads provided on the transformer tank wall. Set the three holes in the cabinet bracket over the studs and tighten the nuts.

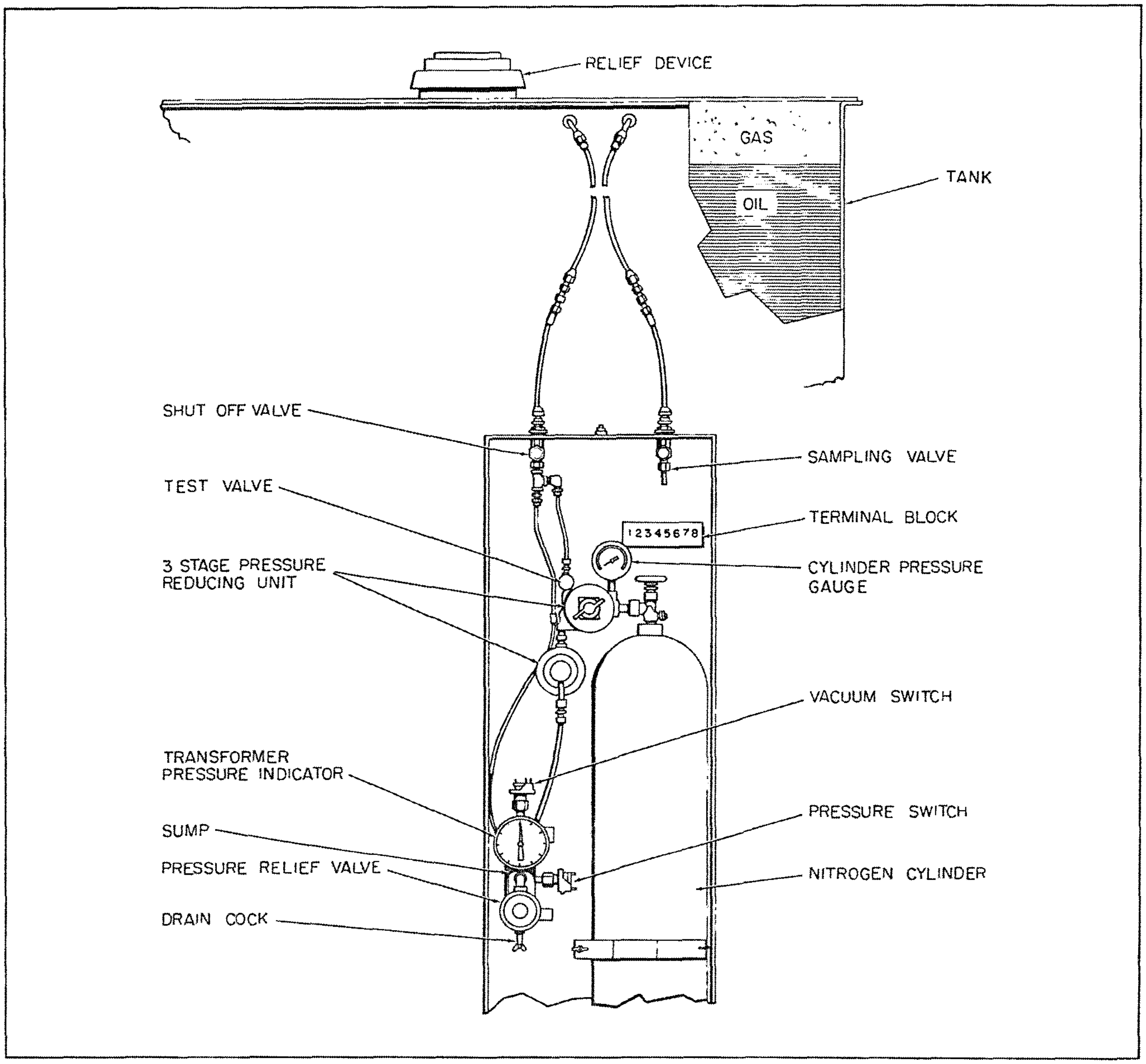



*Fig. 6. Inertaire Equipment Arrangement — Type RN*

Connect the low pressure hose between the fittings on top of the cabinet and the Inertaire piping by means of the union type connections. Care must be taken to make a gas tight seal. A small amount of clean thread cement on the threads will sometimes assist.

Place nitrogen cylinder into the cylinder support and securely clamp or chain the cylinder.

Before connecting up the high pressure flexible tubing be sure cylinder valve and tubing is free of any dirt. Open the cylinder valve slightly so that any dirt lodged in its passages may be blown out.

Next screw the union of the flexible hose onto the valve finger tight and then open the cylinder valve very little letting the gas leak by the threads to blow off any fine dirt that might be on the union seat, in the threads or inside the tubing. Remove the plug from the side of the cabinet and screw the union of the flexible hose into the mounting bracket. Tighten the union nuts with a wrench until the leakage stops and open cylinder valve full.

**NOTE: Pipes on transformer tank should be free of oil before connecting low pressure hose between cabinet and pipe.**

## INSTALLATION (Type RN)

### Mounting

Inertaire equipment usually is shipped separate from the transformer tank and consists of: (1) the reducing valve; (2) one operating nitrogen cylinder; (3) two short flexible hose assemblies which connect between the cabinet and the tank; (4) three anti-vibration mounting pieces; (5) the cabinet with all other parts of the equipment mounted in it; (6) flexible alarm leads.

In mounting the cabinet on the transformer, the three vibration dampeners (Fig. 7) are to be mounted on the three pads on the transformer tank wall. Next, remove the cap nut on the center stud of the vibration dampeners and set the holes in the cabinet brackets over the studs. Replace the cap nuts.

The flexible hose should be connected at the top of the cabinet by means of the union type connections. Care should be taken to make a gas-tight connection. A small amount of clean thread cement placed on the threads will sometimes assist.

Hang the reducing valve from the cover and connect snythetic tubing between test valve and shut-off valve. Also connect third stage outlet to oil sump assembly with synthetic tubing.

Remove cylinder valve protecting cap from cylinder and place cylinder in cabinet. The cylinder and place cylinder in cabinet. The cyl-

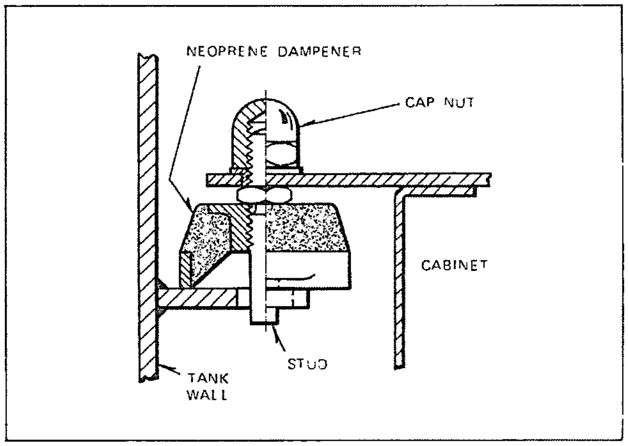



*Fig. 7. Vibration Dampeners*

inder valve protecting cap should be kept in cabinet for use when cylinder is sent away for refill. Before connecting reducing valve high pressure union to cylinder valve, be sure cylinder valve is free of any dirt. Open the cylinder valve slightly so that any dirt lodged in its passages may be blown out.

**NOTE: Do not have valve opening pointed toward any one as a small object blown from the valve with such high pressure might cause serious injury.**

When connecting the reducing valve to the cylinder valve, screw the union on with the fingers and then open the cylinder valve very little letting gas leak by the threads to blow off any fine dirt that might be on the union seat or in the threads. Tighten union nut with a wrench until this leakage stops and open cylinder valve full.

**NOTE: When opening the cylinder valve:**

**1. Always open the valve very slowly. The sudden shock of high pressure admitted to the reducing valve is likely to injure the high pressure gauge or the regulator seat.**

**2. Always back-seat the valve with as much force as would be used in closing the valve.**

### Operation Sequence for Service (RN and RNE)

These steps are important to avoid rupturing second stage diaphragm of regulator.

1. Close nitrogen cylinder valve.
2. Close shut-off valve clockwise to limit.
3. Turn second stage adjusting T-handle counterclockwise until handle is loose.
4. Open test needle valve by turning counterclockwise to limit.
5. SLOWLY open nitrogen cylinder valve to limit.
6. Turn second stage adjusting T-handle or adjusting screw clockwise until 5 psi is indicated on the compound pressure gauge.
7. Close test needle valve by turning clockwise to limit.
8. Turn shut-off valve to operating position; counterclockwise to limit.

---

**CAUTION: Always follow the above steps when replacing nitrogen cylinder.**

---

### Deoxygenation

Inertaire transformers may be installed with air in the gas space for simplicity of installation. However, for the efficient usage of Inertaire equipment, the transformer should be purged with nitrogen. If it is the customer's practice to purge transformers to obtain initial increased protection to the transformers, he should pull proper vacuum on transformer and relieve vacuum with dry nitrogen to positive pressure. The oxygen content will then be less than 3% as required. Refer to I. L. 48-063-9, "Preparing Transformer for Operation with Nitrogen Gas" for the proper procedure.

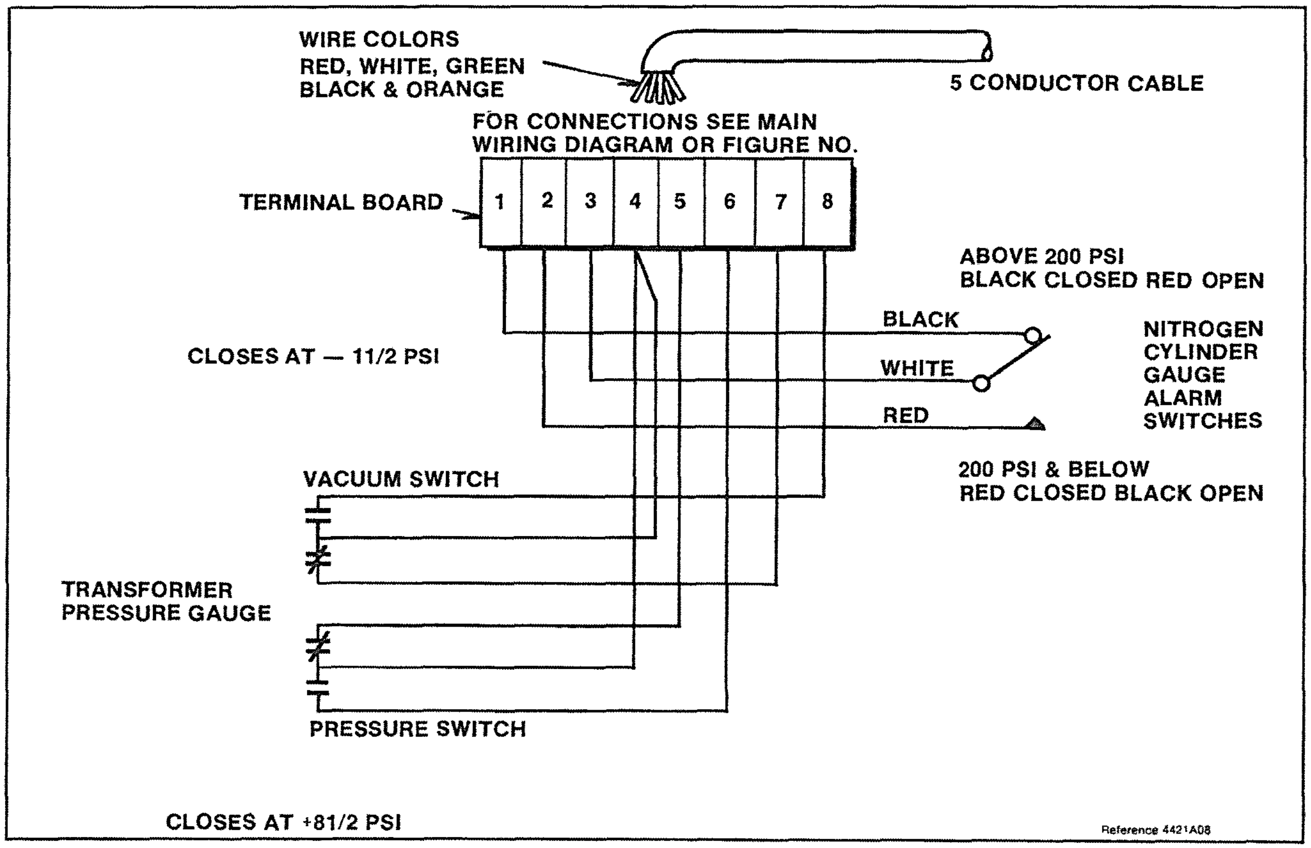



*Fig. 8. Connection Diagram of Alarm Switches (Types RN and RNE)*

### Tank Leak Test

If an oil pressure test cannot be conveniently made to check the tightness of the tank and fittings the following tests should be made, as any small nitrogen leak will result in abnormal operation of the Inertaire system.

A 5 psi nitrogen pressure test should be made on the transformer tanks and Inertaire equipment. Open the drain valve on the bottom of the Inertaire sump. The nitrogen will blow out the oil if there is any, in the sump. Close the sump drain valve, close the shut-off valve at the top of the cabinet, and slowly increase nitrogen pressure on the compound gauge to 5 psi by the T-handle on the second stage of the regulator. Check all hose connections, valve packing glands and the connection to the cylinder.

Allow the transformer to stand several hours under pressure. If pressure falls off (with no change in temperature) a leak is present and it must be found and corrected.

**CAUTION: Extreme care should be observed, when purging the gas space with nitrogen from a high pressure container, not to seal the transformer off tight until the gas in the gas space has reached ambient temperature. The expansion of nitrogen from a very high pressure (1500 to 2000 pounds per square inch) to atmospheric pressure results in the nitrogen entering the gas space at a very low temperature. Unless the gas is free to expand as it warms up to ambient temperature, the pressure within the tank may increase to such a value as to operate the relief device. If no relief device is provided, the pressure may distort the tank.**

### Checking the Relief Pressure of Relief Valve

Having completed the test for leaks, the relief pressure of the relief valve should be checked. This is done by first isolating the gas space from the Inertaire equipment (turn shut-off valve clockwise to the limit). With the test valve set for a very small gas flow build the pressure up slowly in the relief valve. Gas will escape from the relief valve when the proper pressure is reached. It should relieve any pressure above 6-1/2 psi for standard RN and RNE inertaire.

**IMPORTANT: This pressure must not exceed 6-1/2 ± 1/2. The relief valve for Inertaire is sealed and no attempt should be made to adjust the pressure setting. The nearest Westinghouse office should be notified if the valve does not operate correctly.**

**IMPORTANT: When checking circuits through the instruments it is necessary to follow Table No. 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing microswitches or switches of similar capacities.**

**TABLE NO. 1**

| Voltage | Non-Inductive Load-Amps. | Inductive Load Amps. L/R = .026* |
|---|---|---|
| 125 A-C | 10 | 10 |
| 250 A-C | 5 | 5 |
| 125 A-C | 0 5 | 0 05 |
| 250 D-C | 0.25 | 0 025 |

*Equal to or less than 026 If greater refer to factory for adjusted rating

## MAINTENANCE

Westinghouse Inertaire transformers are designed to require very little maintenance and attention on the part of the customer. Since the tank is nearly always under a positive pressure of at least 1/2 pound per square inch gauge, there is a small likelihood of the oxygen or moisture content becoming high.

The amount of nitrogen used by the transformer and the frequency of cylinder replacement will depend on the tightness of the tank as well as the load cycle. In order to be sure that the equipment is operating correctly and that there are no leaks in the system, it is recommended that the following readings be taken during the first month of operation:

1. Weekly oxygen analysis to determine whether unit is operating properly. Additional purging should be done should the unit approach an oxygen content of 5 percent as this is considered to be the safe upper limit which will prevent explosions in the gas space.

If the flue gas analyzer is not obtainable, the use of Fyrite Oxygen Indicator S#1408196 is recommended. This may be purchased from Westinghouse Electric Corporation, Sharon Plant. Complete instructions for determining the oxygen content is supplied with each analyzer.

2. For the first week, take daily readings of nitrogen cylinder pressure, transformer tank pressure as indicated by the pressure gauge, transformer oil temperature and ambient temperature. Weekly readings of the above will suffice for the remainder of the month.

After the first month of observations has shown that the equipment is functioning properly, no further readings are necessary except that check-analysis of the oxygen content should be made in about three months. During normal operation, the oxygen content should remain below 1 percent.

**Nitrogen Cylinders**

Since the nitrogen used in Inertaire equipment will last a relatively long time, it is not feasible to rent cylinders from a nitrogen supplier. The cylinders which are used with the equipment are shipped to the customer with the transformer and becomes the property of the customer. These cylinders are painted gray so that they may be easily identified.

Westinghouse cylinders for regular use with Inertaire equipment may be identified as follows:

a. Each Westinghouse cylinder is painted gray and is identified "Westinghouse Nitrogen."

b. Each cylinder is originally shipped from the Sharon Plant with the transformer.

When the pressure in the operating cylinder drops between 150 and 200 pounds per square inch, it should be replaced with a full cylinder of nitrogen. The nitrogen used on Inertaire transformers must be dry. Commercial nitrogen is not always free from moisture, therefore, only nitrogen which meets the requirements of Westinghouse 52107AA should be used. **Do not use any other grade of nitrogen or any other gas.**

The regulator is left supported from the cover while the cylinder is being refilled.

During the time the nitrogen cylinder regulator is not connected to the nitrogen cylinder, the union on the reducing valve should be closed by a plug supplied for this purpose. The reducing valve plug is located on the bracket on the door. If the plug is not used, lowered pressure in the tank may cause the reducing valve to open, permitting more or less free breathing through the reducing valve. These cylinders can be properly refilled only by the listed suppliers.

Since it is usual for nitrogen suppliers to exchange cylinders, it is suggested that the customer's requisition for normal operating gas read as follows: "Refill cylinder, Serial No. 000000 with Westinghouse Inertaire Nitrogen, PDS #52107AA and return same cylinder to purchaser." The serial number will be found on the side of the gray operating cylinder.

Drain the oil sump once a year to prevent any appreciable oil coming in contact with the regulator.

Check the relief pressure of the relief valve to determine if any change has occurred since last inspection. Refer to paragraphs under Installation for guidance.

## NITROGEN SUPPLIERS

If nitrogen per **Westinghouse Spec. P.S. 52107AA** is not available locally, information for nearest distributor may be obtained from the sources listed below.

Airco Distributor Products
150 East 42nd St.
New York City, N.Y. 10017

National Cylinder Gas Co.
840 N. Michigan Ave.
Chicago, Ill. 60611

Air Products & Chemicals Inc.
P.O. Box 565
Creighton, Pa. 15030

Burdett Oxygen Co. Inc.
3400 Lakeside Ave.
Cleveland, Ohio 44114

Linde Co.
270 Park Ave.
New York City, N.Y. 10017

Stuart Oxygen Co.
351 California St.
San Francisco, California 94104

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Westinghouse · Medium Power Transformer Division · Sharon, Pa.

Printed in U.S.A.

# Instructions for Westinghouse Radiators



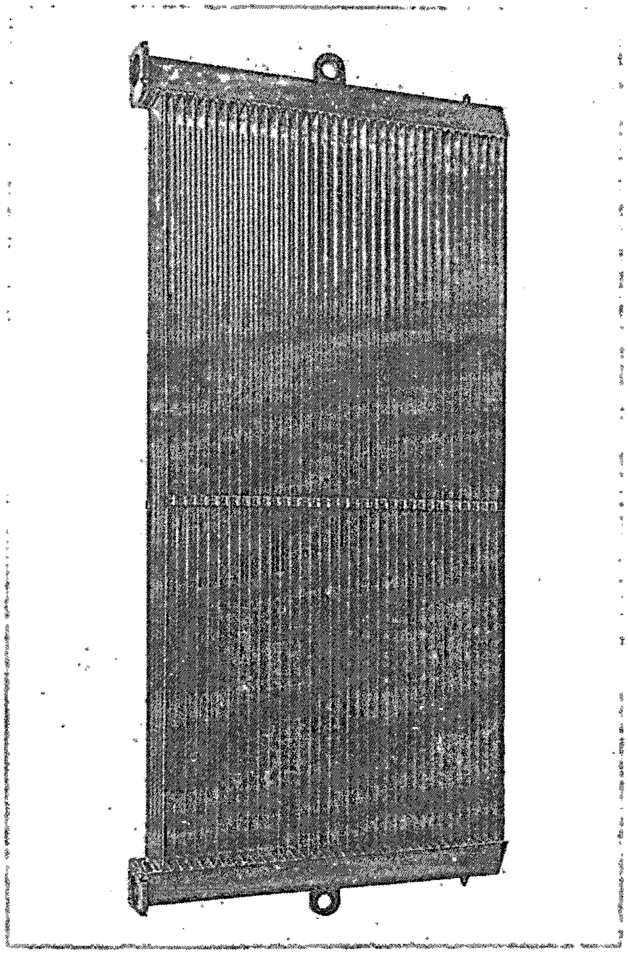


Fig. 1 *Westinghouse 36-Fin Radiator*

THE WESTINGHOUSE RADIATOR is a highly efficient cooling unit which is designed for use on large self-cooled transformers where high cooling capacities are required. It is detachable and may be removed for shipment, which reduces shipping clearances and relieves tank wall stresses which might develop due to sudden shocks in transportation.

DESCRIPTION

The radiator is of all-welded sheet metal construction with vertical cooling sections through which the oil circulates and is cooled. A formed metal header welded to each end of the assembly of sections, complete the structure and provides connections for the fittings which attach the radiator to the tank. The radiator lengths vary from eight to fourteen feet in one foot steps.

The individual fin sections are made from two preformed sheets of steel. The sheets are formed and trimmed so that when the two sheets are mated together they form several oil passages across the width of the fin. The sheets are welded together by an automatic resistance welding machine along the edges and between the individual lobes.

The ends of the fin sections are then flanged and trimmed. This flange over-laps the flange on the adjacent fin and they are mash seam welded together and then planished to give a smooth joint. The flanged connection between fins is curved which eliminates horizontal surfaces between fins and insures complete drainage. See Fig. 2.

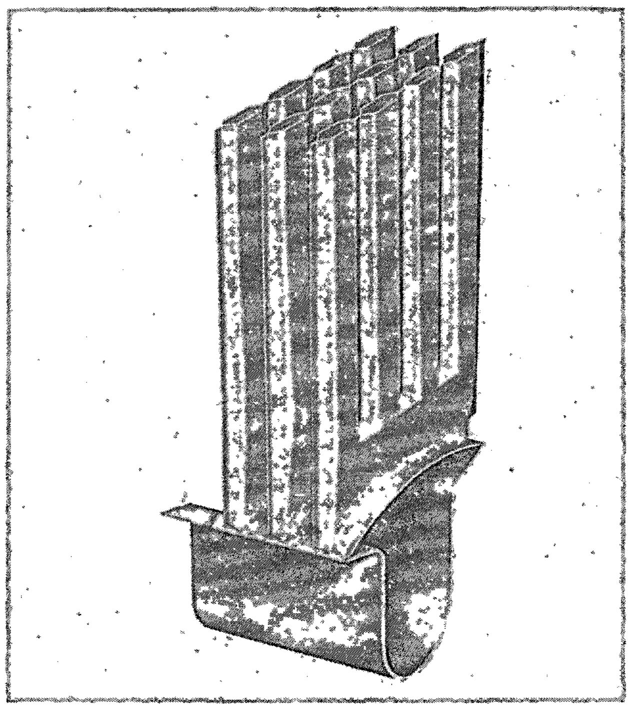


Fig. 2 Radiator Section Showing Joints Formed with Mash-Seam Welder

Effective September, 1966. Supersedes I.L. 48-063-32, October, 1962

The formed headers are then welded to the formed ends of the fin assembly, thus completing the structure and providing means of attaching the radiator to the transformer tank.

After pressure testing, the radiator is cleaned and phosphatized followed by a coat of epoxy primer and finish coat of paint. Each coat of paint is applied by the flow coat method and then baked in an oven.

## INSTALLATION

Receiving, Handling and Storing. The usual practice is to ship all radiators with all openings on the tank and radiators protected with blind flanges. The blind flanges are for shipment only. Cadmium plated bolts, nuts and lock washers are furnished for permanent mounting.

**IMPORTANT: Do not remove the blind flanges until ready to install the radiators. Dirt and moisture must be kept out of the radiators.**

Unpacking. When unpacking, lifting or handling the radiators, care must be taken to prevent scratching the paint or damaging the radiator elements. An ample supply of grey touch-up paint is furnished to repaint any minor scratches. This paint should be applied as the radiators are being prepared for mounting.

**CAUTION: The radiators should be handled at all times by the lifting hooks on headers only. Do not use ropes or cables around fins.**

Installing Radiators. It will be found most convenient to place the radiator across suitable supports when preparing it for mounting to the tank.

First, remove the blind flanges from a radiator and dispose of the bag of silica gel. The radiators are sealed against entrance of moisture in the factory. If they are stored outdoors in cold weather there can be some condensation of moisture from the air inside the radiator in excess of what the bag of silica gel could handle. It is therefore good practice to check for this condition and flush out with transformer oil when necessary. Then, clean header flange face to make sure all dirt, loose paint, etc. has been removed.

Second, remove the blind flanges from a set of valves on the transformer tank and inspect the gaskets to make sure they are not damaged. This is a permanent type Nitrile gasket and it is not necessary to use a new gasket or gasket cement for proper sealing.

Now lift the prepared radiator by the lifting eye in the top header and swing it into position over the valves.

Lifting of the radiator can be accomplished by using an overhead crane, an A-frame with block and tackle or by block and tackle to the station superstructure.

The end spacer strips on the 36-fin and 54-fin radiator may cause some difficulty if they are not bolted into position before the radiator assembly is drawn down tightly to the tank. Caution must then be exercised to insure a good metal-to-metal contact between the header and the tank valve body.

| LENGTH FEET | 18-FIN | | 27-FIN | | 36-FIN | | 54-FIN | |
|---|---|---|---|---|---|---|---|---|
| | DRY WEIGHT | GALS. OIL | DRY WEIGHT | GALS. OIL | DRY WEIGHT | GALS. OIL | DRY WEIGHT | GALS. OIL |
| 8 | 750 | 33 | 1090 | 48 | 1440 | 64 | 2120 | 95 |
| 9 | 830 | 36 | 1210 | 52 | 1590 | 70 | 2350 | 104 |
| 10 | 910 | 39 | 1330 | 57 | 1750 | 76 | 2590 | 113 |
| 11 | 990 | 42 | 1450 | 61 | 1910 | 82 | 2820 | 122 |
| 12 | 1070 | 45 | 1560 | 66 | 2060 | 88 | 3060 | 131 |
| 13 | 1140 | 48 | 1680 | 71 | 2220 | 94 | 3290 | 141 |
| 14 | 1220 | 51 | 1800 | 75 | 2370 | 100 | 3520 | 150 |

WEIGHT OF RADIATORS

The 54 fin radiators must be supported by tie rods running from the bottom header to transformer tank cover. When installing the 54 fin radiators, the outer end of the bottom header must be supported from the ground so that it will remain level until the tie rods have been installed and tightened. Do not attempt to level bottom header by means of tightening the tie rods.

Filling of Radiators. To fill a radiator, turn the bottom valve to the open position as indicated on the operating arm and thus allow the liquid from the main tank to flow into the radiator. Secure the valve in this open position by means of the thumb screw. Next open the top valve and allow the entrapped air to escape. Care must be taken that the terminal boards or bridge work of the transformer are not exposed above the liquid in this operation. If there is danger of exposing the terminal boards or bridge, liquid should be added to replace that required to fill each radiator. After all radiators have been filled the normal liquid level should be restored as soon as possible or within a couple of hours.

Radiator Removal. Should it become necessary to remove a radiator, first close the valves top and bottom. Lock the operating arm in the closed position with the thumb screw. Finger tightness will provide sufficient pressure to seat the valve. Next, drain the liquid from the radiator by removing the 3/4 inch drain plug from the bottom header and the 3/4 inch vent plug from the top. After the liquid has been removed from the radiator, proceed to dismantle. If the radiator is to be left off for any length of time the transformer valves should be gasketed and covered with blind flanges. The openings in the radiators should also be gasketed and flanged to keep out dirt and moisture.

## MAINTENANCE

The only maintenance required for the radiators consists of repainting or touch-up, to keep the surface free from rust. The radiator element wall is of a necessity thin in section for proper cooling, and being of steel construction, is susceptible to rust and possible rupture, unless protected by a good paint finish. The open element construction permits thorough cleaning of all surfaces for repaint or touch-up. This ease of accessibility insures a better finish, longer radiator life and the least possible cost of maintenance. Standard finish paint for transformer tanks can be applied as touch-up paint.

If the packing gland at the valve operating arm leaks and requires tightening it is necessary to remove the external arm (remove one screw) to get access to the gland nut.

If leaks should develop in the longitudinal seam welds, refer to I. L. 48-069-20 for instructions on how to repair. In the event a leak occurs where the fins join the header, care must be taken when repairing this type of leak since the fin material is 17 gauge thick and improper repairing methods may cause a more severe leak. The following procedure is recommended for repairing this type of leak: (1) Drain oil out of radiator and leave radiator mounted if leak is accessible. (2) Use oxy-acetylene torch and normal brazing rod or mild steel rod or a silver solder (45% Ag) with Handy Harmon paste flux. If silver solder is used, it is mandatory that the area around the leak be clean before making repair. (3) Pressure test radiator at 15 psig for 1 hr. to insure leak has been repaired. (4) Epoxy is not recommended for repairing leaks because it is only temporary and it makes repairing as outlined above essentially impossible.

# Instructions for Radiator and Pump Valves



## Direct Action Radiator Valve

Westinghouse Direct Action Radiator Valves are of the flapper type. Generally valves are supplied on transformers with radiator cooling to allow removal of the radiator equipment without draining the unit. The cooling equipment may be removed for shipment, in which case the radiator valves are closed and blind flanges put over the openings.

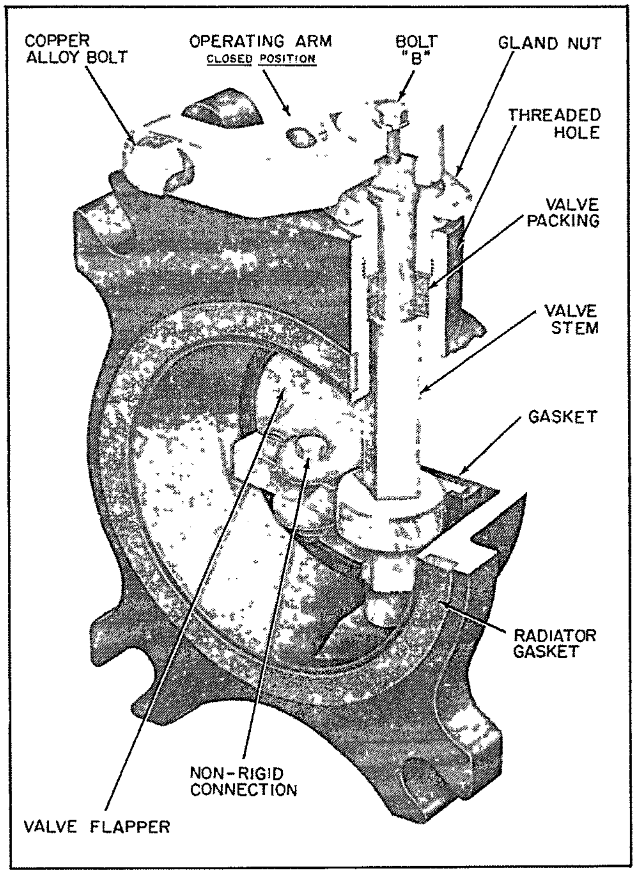



**Fig. 1** *Direct Action Radiator Valve in Closed Position*

### DESCRIPTION

Direct Action Radiator Valve. (Fig. 1) This valve is made up of the body, flapper spring, flapper arm, valve stem, operating arm, gland nut, valve packing and miscellaneous hardware. The valve body is made of forged steel with the outer face grooved for a bolted gasketed joint. The body is welded onto the tank wall before assembly of the internal parts. The flapper has a cast aluminum body with a molded-on oil resistant synthetic rubber gasket.

The valve stem is sealed to the valve body with packing which is compressed by the gland nut. If leaks occur at the valve stem, they can generally be stopped by tightening the gland nut.

### OPERATION

The radiator valve is shown in the closed position in Fig. 1. To open the valve the copper alloy bolt is removed and the valve handle moved approximately 90$^{\circ}$ counterclockwise. The copper alloy bolt is then tightened into the threaded hole shown in Fig. 1. The operating arm of the radiator is marked to indicate the closed direction.

**NOTE: It is essential that the flapper operating arm of the radiator and cooler valves be securely fastened in the open position to eliminate vibration and wear on the internal parts.**

### RENEWAL PARTS

If renewal parts are required, order them from the nearest Westinghouse Sales Office, giving a description of parts wanted, with the transformer serial number and rating as found on the transformer instruction plate.

---

## Direct Action Pump Valve

Westinghouse Direct Action Pump Valves are of the flapper type. Generally pump valves are supplied on transformers with forced oil cooling to allow removal of the forced oil cooling

Effective February, 1977 Supersedes I.L. 48-063-12, January, 1964

equipment without draining the unit. The cooling equipment may be removed for shipment, in which case the pump valves are closed and blind flanges put over the openings.

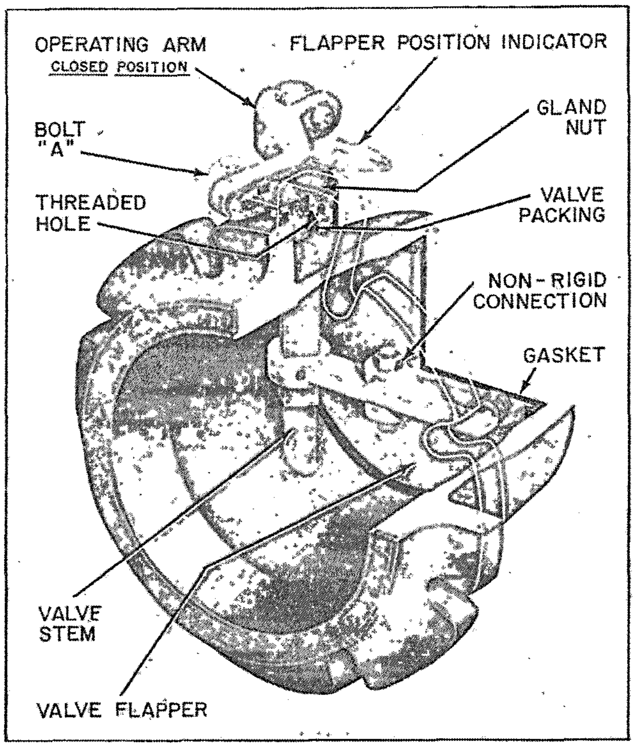



**Fig. 2** *Direct Action Pump Valve in Closed Position*

## DESCRIPTION

Direct Action Pump Valve. (Fig. 2) This valve is made up of the body, flapper, spring, flapper arm, valve stem, operating arm, gland nut, valve packing and miscellaneous hardware.

The valve body is made of forged steel with the outer face grooved for a bolted gasketed joint. The body is welded onto the tank wall before assembly of the internal parts. The flapper has a cast aluminum body with a molded-on oil resistant synthetic rubber gasket.

The valve stem is sealed to the valve body with packing which is compressed by the gland nut. If leaks occur at the valve stem, they can generally be stopped by tightening the gland nut.

The Direct Action Pump Valve is shown in the closed position in Fig. 2. The flapper position indicator points across the pipe when the valve is closed showing that the flapper is across the pipe preventing flow. To open the cooler valve, bolt "A" is removed and the arm rotated approximately 90° clockwise and then flipped 180° to allow bolt "A" to enter threaded hole as shown in Fig. 2. The bolt is then tightened firmly into the threaded hole.

**NOTE: It is essential that the flapper operating arm of the Direct Action Pump Valves be securely fastened in the open position to eliminate vibration and wear on the internal parts.**

## RENEWAL PARTS

If renewal parts are required, order them from the nearest Westinghouse Sales Office, giving a description of parts wanted, with the transformer serial number and rating as found on the transformer instruction plate.

## Cam Action Radiator Valve

The use of radiator valves eliminates the necessity for draining oil from transformers when installing or removing radiators. The valve should be left open during normal transformer operation. It is

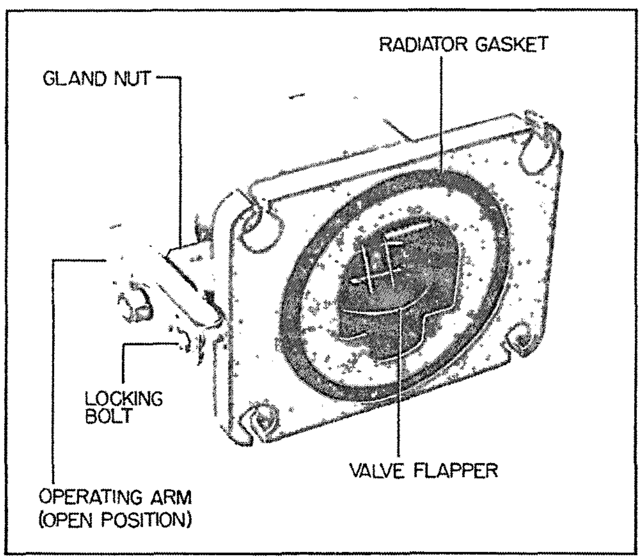



**Fig. 3** *Cam Action Radiator Valve in Open Position*

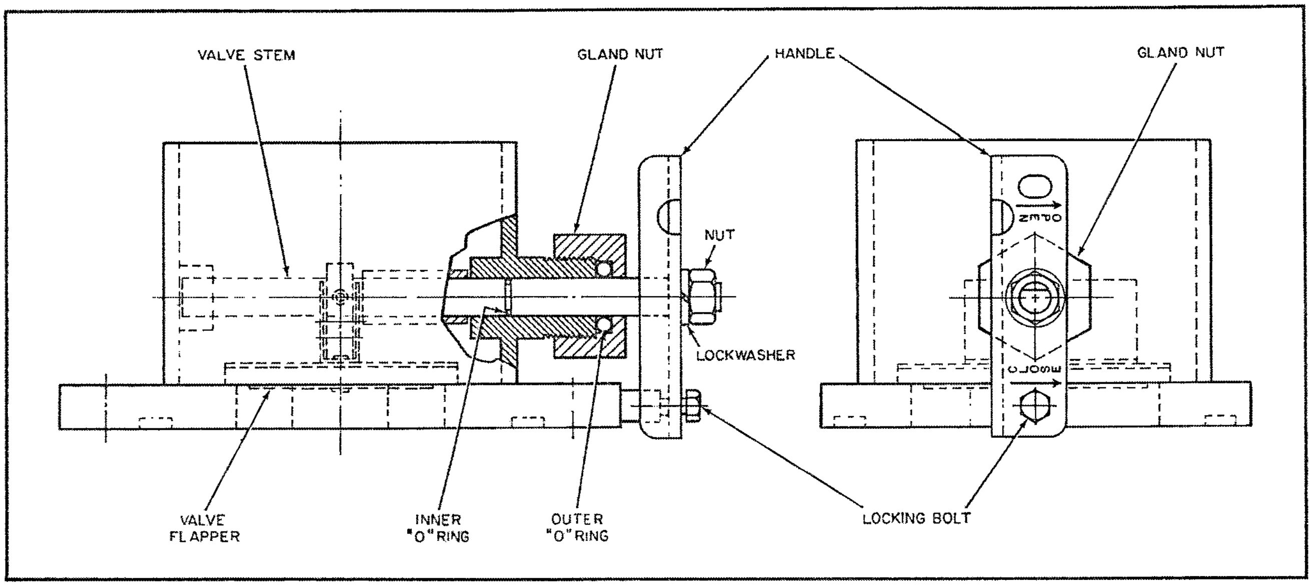



**Fig. 4** *Location of Replaceable Outer "O" Ring on Cam Action Radiator Valve*

closed only during shipment of the transformer or radiator removal. The valve opening is covered by a blind flange when the radiators are removed for shipment or when vacuum filling a transformer without radiators in place. In the open position the flapper offers little resistance to the flow of oil through the opening.

The valve, Fig. 3, is completely assembled and welded to the tank. Thru bolts, of 3/4 inch diameter, are used to hold the blind flange or radiator against the valve face. Grooves are located on the valve face side for location of a nitrile ring gasket.

Double "O" ring gaskets are located around the operating shaft to make it pressure tight as shown in Fig. 4. The steel disc flapper has a resilient flat gasket which seals against the inside of the flange in the closed position. The valve flapper is opened and closed by positive toggle and cam action which prevents excessive force from being applied to the operating mechanism.

## OPERATION

The handle is located along the side of the valve housing and is locked in position by means of a steel bolt which permits locking in either open or closed position. Markings on the handle indicate the flapper position. The valve is closed when the word "CLOSE" on the valve handle is located adjacent to the locking bolt. The valve is open when the word "OPEN" on the valve handle is located adjacent to the locking bolt. The "OPEN" end of the handle is further identified by a 1/2 inch hole on the bend. The handle rotates 180° between the open and closed positions. The arrow adjacent to the words "OPEN" and "CLOSE" show the direction of rotation to move to that position. Stops prevent operation beyond either end of the 180° movement. The valve should be operated toward "CLOSE" until the internal cam toggles into position. It should be operated toward "OPEN" as far as the stop will permit. The locking bolt must be inserted through the hole in the end of the handle in either position to prevent accidental operation. **It is important to lock the handle in the proper position because accidental closing could shut off oil flow through the radiator and cause overheating of the transformer while accidental opening could cause loss of oil from the transformer.** The locking bolt also secures the flapper against the stop in the open position to prevent vibration caused by oil flow.

The valve flapper is not intended to provide a permanent vacuum tight shut-off. The valve provides a closure between the main transformer tank and the radiator or other attachment and permits removal of the radiator or other attachment without draining the main unit.

**IMPORTANT: When a radiator or other attachment is being removed, the valve must be in the "CLOSE" position and a blind flange must be mounted over the exposed face of the valve. The blind flange will assure a vacuum tight seal during vacuum processing and eliminates the possibility of small amounts of oil seepage due to internal pressures.**

**The blind flange which is mounted on each valve during shipment should be retained for future use.**

**During factory processing and shipment a small amount of oil may accumulate between the blind flange and the flapper. This is noted by a nameplate on each blind flange and is not a condition of concern.**

## MAINTENANCE

Maintenance is not normally required. An inspection should be made at least once a year to detect any abnormal condition. The packing around the shaft consists of a double "O" ring seal. (See Fig. 4) The outer seal is squeezed to a predetermined compression by the gland nut and is limited by an internal shoulder which is machined in the nut. If the gland nut should loosen, it should be retightened against the shoulder but not forced beyond that point. The inner seal is intended as a secondary seal to limit seepage such that the outer seal can be replaced without draining the transformer. If an oil leak should ever develop around the valve shaft and retightening the gland does not stop the leak, the outer "O" ring should be replaced as follows:

a) Remove the hex nut and lockwasher from the end of the handle. (Reference Fig. 4)

b) Pull the handle from the shaft.

c) Remove the gland nut (1-3/4 inches across the flat of the hex).

d) Remove the outer "O" ring.

e) Install a new outer "O" ring. (Nitrile "O" ring, Shor-A-Durometer hardness 70, ANSI B 141.9, size Standard #312).

f) Re-install the gland nut. Tighten the nut until the internal shoulder in the nut is seated against the face of the threaded bearing assembly. Do Not Force Beyond This Point.

g) Replace the handle on the shaft. The shaft and handle are keyed so that there is only one assembly position with the bent-over flange toward the valve body.

h) Replace the lockwasher and nut and tighten to hold the handle on the shaft.

## RENEWAL PARTS

If renewal parts are required, order from the nearest Westinghouse Sales Office, giving a description of the parts wanted, with the transformer serial number and rating as found on the transformer instruction plate.

**Westinghouse Electric Corporation**
Sharon Transformer Division, Sharon, PA. 16146

Printed in U.S.A.

# Instructions for Forced-Air Cooling Equipment Unit Fan Assembly

I.L. 48-063-13B

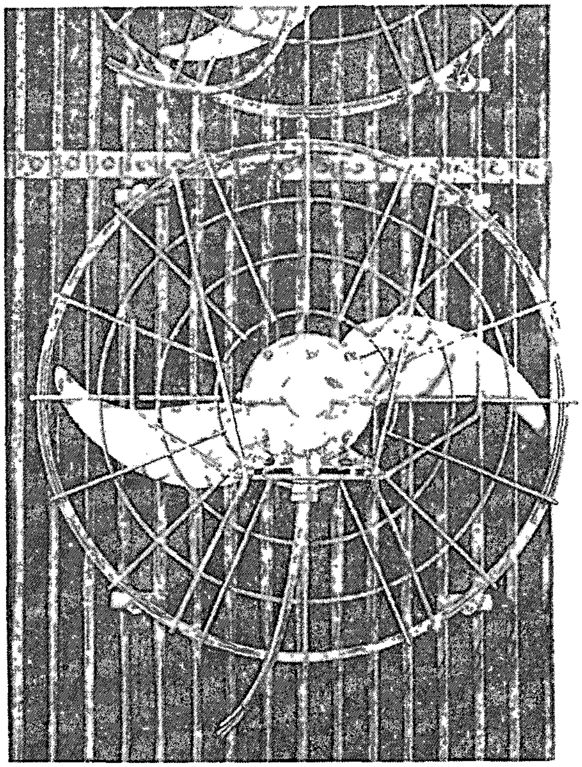


**Fig. 1** *Fin Type Radiator Forced-Air Equipment*

Westinghouse manufactures two types of cooling equipment for use on OA/FA and OA/FOA (oil-insulated air-cooled, forced air-cooled, forced oil-forced air-cooled) transformers: The banked fin type radiators and the flattened tube type assembly. The control equipment and fan assemblies are the same for both types. An occasional inspection and lubricating of the fan motors is required after installation as described later.

Standard unit fan assemblies are furnished with single phase or three phase motors. The single phase motors are capacitor-start, capacitor-run, with the capacitor mounted in a housing attached to the motor. Both the single and three phase motors are equipped with self resetting "Thermoguard" overload protection.

Transformers shipped to a destination having a 3 phase auxiliary power supply may have single phase fans evenly distributed on the 3 phase supply.

Rotation of the fan blade is counterclockwise when looking at the motor from the lead end. Vent holes are provided on the underside of the motor to drain any condensation that may form in the motor. These vents are covered during shipment with a small adhesive decal which should be removed before operating the motors.

## BANKED FIN TYPE RADIATOR FORCED-AIR EQUIPMENT

The radiator bank assembly consists of a number of fin type radiators mounted side by side in a group. A number of fans are mounted on the side of the first radiator in the group so air can be forced horizontally between the fins of each radiator in the bank. The Westinghouse fin type radiator with its preformed cooling elements arranged in parallel rows provides a group of continuous ducts. The flow of air from the fans is directed through this duct system, thereby greatly increasing the normal convection characteristics. One fan of such an arrangement is shown in Figure 1.

The fans are connected together electrically by one of two different methods:

(1) The individual fan cords may be plugged into special neoprene molded blocks which are located between fans and interconnected with neoprene cable. This molded wire harness type of assembly provides a good, weathertight assembly and will permit connecting or disconnecting individual fans without disconnecting power to the other fans. When plugging these molded items together it is recommended that the mating pieces be coated with a light film of silicone grease to overcome the friction between the rubber components. The male part must be fully inserted so that the O-ring portion in the female connector will lock into the groove on the male connector and form a good, weathertight joint.

(2) The individual fan cords may be plugged into special receptacles located in a vertical run of conduit. It is possible to connect or disconnect individual fans without disconnecting power to the rest of the fans.

Effective September, 1975 Supersedes I.L. 48-063-13A, December, 1962

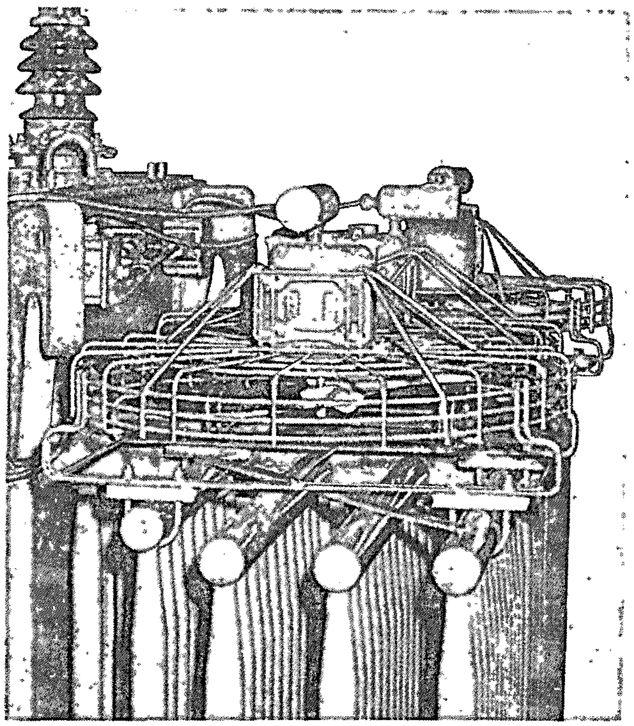


**Fig. 2** *Typical Fan Assembly used on Tube Coolers*

## FLATTENED TUBE TYPE FORCED AIR EQUIPMENT

The flat tube cooler assembly consists of a number of vertical, flattened steel tubes arranged in parallel, welded to headers at top and bottom. These headers may be welded to the transformer tank wall in groups to form a bank of tube coolers, or groups of 3 or 4 may be welded to small headers which in turn may be flanged and bolted to a valve for removal during shipment.

Fan assemblies will normally be mounted above tube coolers, to blow air downward on the warmest surfaces; but they can be mounted on the side or underneath, if necessary, to meet special requirements. Note that in any case the motor vent holes must be in the lower side of the motor as it is mounted.

When flat tube coolers are grouped and bolted to flanged valves (tubular radiators), the fans will normally be mounted on the side, as on the fin type radiators, to blow air horizontally through the bank.

## INSTALLATION

The fin type radiators and the large tubular radiator assemblies are removed for shipment due to railroad clearance limitations. Before installing the cooling equipment, a careful study of the outline drawing and transformer should be made. The fans will be shipped properly located and attached to one or more radiators, depending upon the number of banks.

All shipments of assembled fans and motors are made with the fan shaft restrained to prevent movement during shipment. Be sure all shipping straps and tie downs are removed and that the fan turns freely before it is put in operation. Remove decals from the vent holes on the bottom side of the motor to permit condensation to drain out.

## MAINTENANCE

### Lubrication:

The motors have either ball or sleeve bearings which are designed to operate for long periods of time without lubrication. As a general rule motors which operate more than 50% of the time, or are subjected to climatic conditions as they exist in the southern half of the United States should be lubricated more frequently. Excessive lubrication, however, can be an invitation to trouble.

### Motors with Flip Lid Oilers:

These motors have sleeve bearings with a large oil reservoir containing a self-wicking material having superior oil-storage properties. The bearings have circumferential oil grooves which assure a forced oil lubrication across the entire bearing length.

The following rules will provide a guide for bearing re-lubrication. (1) Motors mounted with the shaft horizontal should be lubricated every one to three years, (2) Motors mounted with the shaft vertical should be lubricated annually.

When lubricating add 30 to 40 drops (22 drops $\approx$1cc) of Electric Motor Oil or SAE No. 10 automotive oil to each bearing.

### Motors with Pressure Grease Fittings:

These motors are designed with a grease fitting and a relief fitting at both bearings to prevent over greasing. The motors have ball bearings with a seal on the winding side of the bearing and a shield on the opposite side. These motors should be regreased every one to two years depending on duty cycle and operating conditions.

For greasing this type of motor use a high grade of grease, such as Esso Beacon 325 (MILG3278). This grease can be obtained from the Lima Motor Division through the nearest Westinghouse office.

Motors with Sealed Ball Bearings:

These motors have neither type of lubrication fitting described above. The bearings have been permanently lubricated and sealed at the factory and require *no* lubrication.

Painting

Good practice dictates that apparatus should be kept protected with paint. The entire air blast assembly, *except the propeller*, should be painted at regular intervals.

Inspection

A regular, thorough inspection should be made of the equipment to insure the best service.

## RENEWAL PARTS

When ordering renewal parts, send a complete description of the particular part and the transformer serial number to the nearest Westinghouse office.

Westinghouse

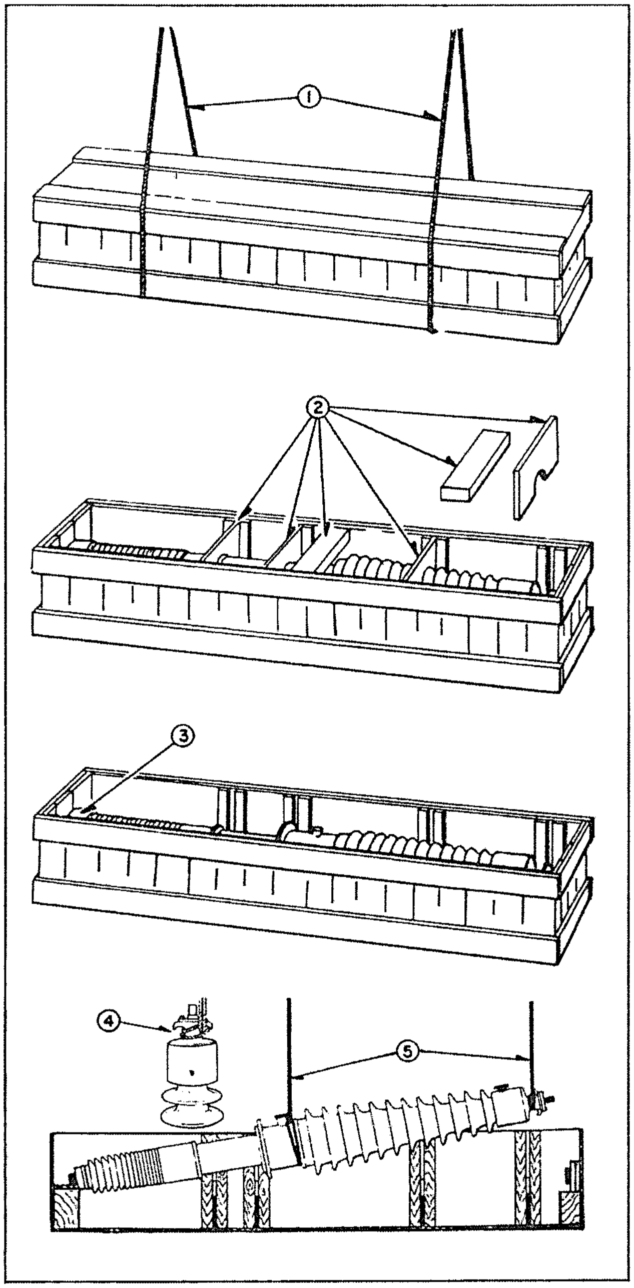
**THE LEADER OF THE TRANSFORMER INDUSTRY**

Westinghouse • Sharon Transformer Division • Sharon, Pennsylvania

Printed in U S A

# Instructions for Outdoor Condenser Bushings, Type O, Shipped in Boxes

I L. 33-155-5A



Examine the shipment immediately for damage in transit. If damaged, file claim with the carrier and notify the nearest Westinghouse Sales Office.

## UNPACKING AND HANDLING

The following numbered steps refer to the corresponding numbers on the illustration:

(1) Lift the box with slings as shown.

(2) Remove the cover and spacers from the box. Use a nail puller where possible. Lift out the top halves of the centering collars.

(3) Remove the blocking from the ends of the bushing to free the bushing. Do not allow porcelain casings to be struck by tools or against the box while handling as these parts are easily damaged.

(4) Attach a rope or steel cable around the top of the bushing under the lifting lugs as shown.

(5) When lifting from a horizontal packing case, it is desirable to use a double hoist with one lift at the flange and one looped under the lifting lugs. Do not lift by the porcelain or pivot the bushing on the lower porcelain. Keep the lower end of the bushing on felt or wood, braced to prevent slipping and with porcelain away from the floor.

## STORING

The bushing may be removed from the box for inspection and storage in a clean safe place, or it may be stored in the box to avoid damage. The bushing should be stored in a vertical position or with the cap end at least 10 inches higher than the opposite end.

**Westinghouse Electric Corporation**

POWER CIRCUIT BREAKER DEPT., TRAFFORD, PA.
SHARON TRANSFORMER DIVISION, SHARON, PA.

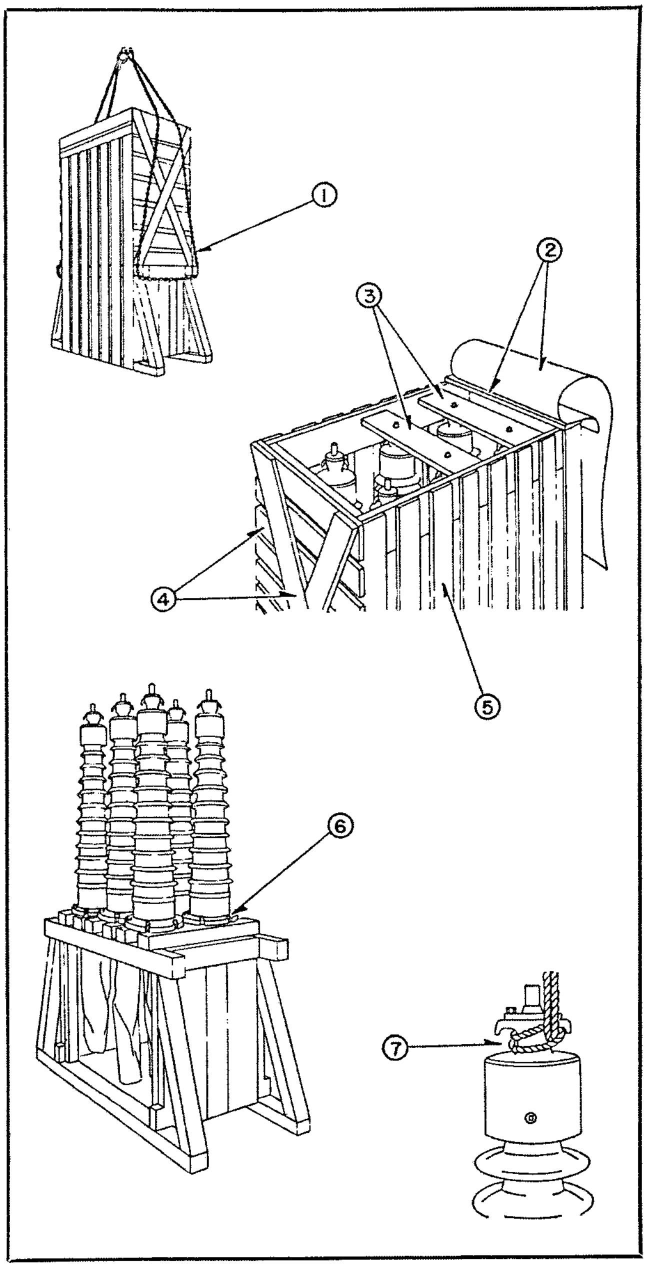
Effective July, 1973 Supersedes I. L. 33-155-5, March, 1961 Printed in U.S.A. (W.E.)

UNPACKING • HANDLING • STORING

# INSTRUCTIONS

## OUTDOOR CONDENSER BUSHINGS TYPE "O"

### SHIPPED VERTICAL IN CRATES




Examine the shipment immediately for damage in transit. If damaged, file claim at once with the transportation company and notify the nearest Westinghouse Sales Office.

### UNPACKING AND HANDLING

The following numbered steps refer to the corresponding numbers on the illustration:

**1.** Lift the crate with slings as shown.

**2.** Remove the waterproof cover and the top boards from the crate. Use a nail puller where possible.

**3.** Remove the supports from around the tops of the bushings. Do not allow porcelain casings to be struck by tools or against the crate while handling as these parts are easily damaged.

**4.** Remove the diagonal braces and the horizontal boards from the ends of the crate.

**5.** Remove the vertical boards from the sides of the crate.

**6.** Working on one bushing at a time, remove the four bolts securing the flange to the skid.

**7.** Attach a rope or steel cable around the top of the bushing under the lifting lugs as shown and lift the bushing from the skid. Do not lift by the porcelain. Keep the bushing vertical while lifting to avoid damage to the porcelain on adjacent bushings. See that the lower end of the bushing does not strike the skid.

### STORING

Leave the bushings packed in the crate. Store in a clean place where the bushings will not be damaged. Horizontal storage is not recommended.

WESTINGHOUSE ELECTRIC CORPORATION

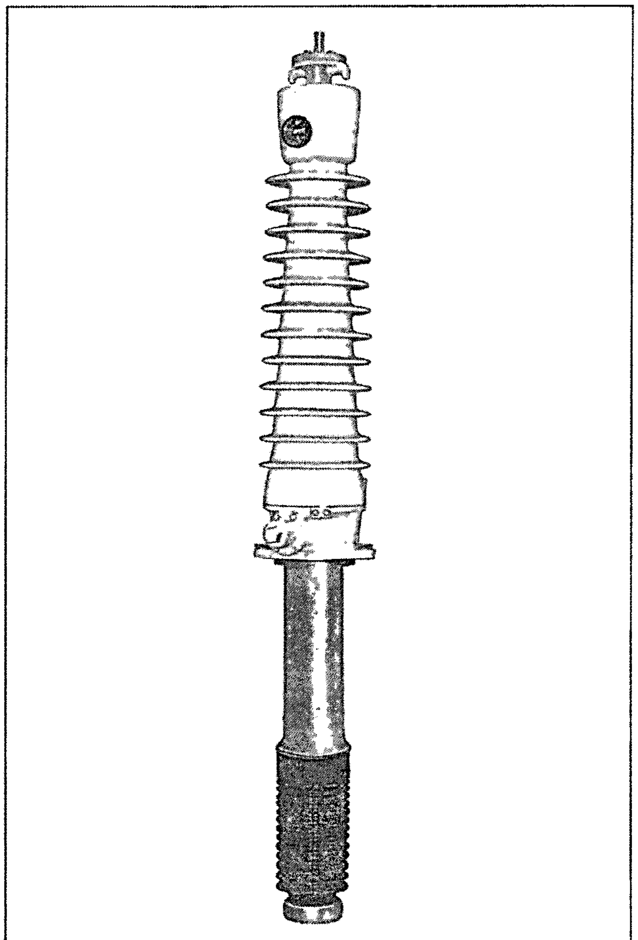
POWER CIRCUIT BREAKER DEPT. • TRAFFORD, PA.
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

SUPERSEDES I.L. 33-155-3 Dated April, 1949

AUGUST, 1967
Printed in U.S.A.

# Instructions for Type "O-AL" 115 KV and Above Outdoor Condenser Bushings





THE TYPE "O-AL" (ALUMINUM) CONDENSER BUSHINGS are designed for oil circuit breaker and transformer applications.

Westinghouse bushings for circuit breakers are made by the Circuit Breaker Division at Trafford, Pennsylvania, while transformer bushings are made by the Transformer Division at Sharon, Pennsylvania and Muncie, Indiana. For this reason identical and interchangeable bushings will be identified by different drawing numbers or different style numbers. They also will be identified by identical "Key" numbers.

A key number has been assigned to most of the outdoor bushings for the purpose of identifying the principal mounting dimensions, internal dimensions, and nominal current ratings. Superseding key numbers are catalog numbers. Bushings of the same catalog number are exactly identical. The catalog number is used to relate to standards, correlate between circuit breaker and transformer (IC) bushings, and compare to other manufacturers bushings. For specifics concerning identification of replacement bushings refer to T.D. 33-360.

These bushings (Type "O-AL") have an oil-impregnated kraft paper condenser inside an oil-filled chamber as shown in Fig. 6. This chamber consists of an expansion bowl, an upper porcelain weather casing, a metal mounting flange, a lower porcelain and a bottom terminal. All parts are held under pressure by a spring assembly. The entire chamber is sealed. All joints above oil level are sealed by welding. Joints between porcelain and metal parts are made with cork-neoprene sealing gaskets encircled by asbestos-neoprene gaskets and held in compression by the springs in the expansion bowl.

The expansion bowls are constructed as shown in Fig. 7. All joints are welded. Heating of parts is prevented by use of non-magnetic materials and insulating against short circuiting paths in the magnetic field.

The upper porcelain weather casing and the lower porcelain are held in place by compression on their ends. Springs of the proper number and dimensions to provide the desired pressure are supplied in the bushings to meet all test requirements and the maximum operating and shipping requirements of the equipment for which the bushings are designed.

The flange is provided with a voltage tap receptacle and oil valve as shown in insets D and E in Fig. 6. This I.L. does not apply to the 69 kv type "O" where the voltage tap receptacle is replaced by a power factor tap, or type "O" above 69 kv which have ungrounded voltage taps.

The bushing is filled with degassed Wemco "C" oil. Sufficient gas space is left in the expansion bowl to prevent excessive pressures from being

Effective January, 1977 Supersedes I.L. 48-061-68A, November, 1975

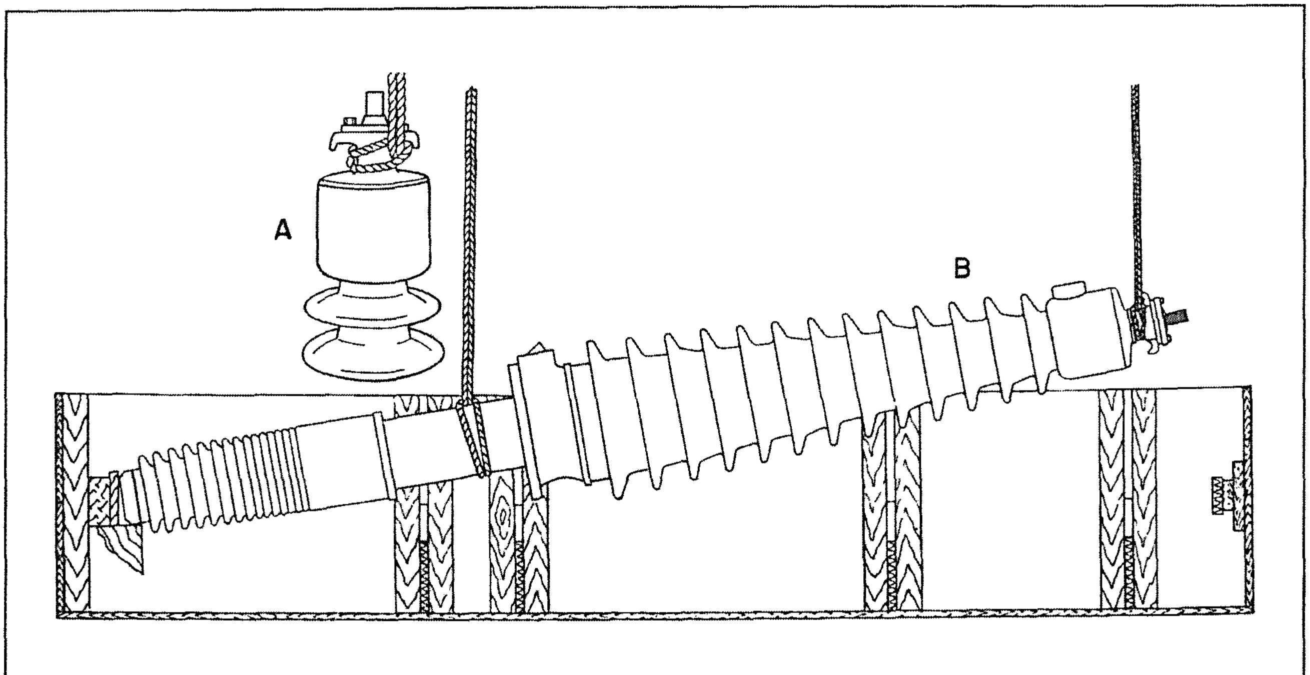



Fig. 1. *Lifting Bushing (A) from Vertical Position, (B) from Horizontal Position*

built up by the thermal expansion of the oil. The oil is not exposed to light and the expansion space is filled under low pressure with nitrogen so that there is no oxidation of the oil. The oil level reads correctly on the magnetic oil gauge when the bushing is vertical. The reading on the dial will be at a higher or lower level if the bushing is inclined from the vertical position.

## RECEIVING, LIFTING AND STORAGE

### Receiving

Bushings will be shipped by three different methods determined by voltages. Ratings of 161 kv and below are generally shipped in the breaker. 230 kv bushings are shipped 6 in a skid (refer to I.L. 33-155-3) while 345 kv bushings are shipped 1 per crate in a horizontal position (I.L. 33-155-5). Transformer bushings are normally shipped in wirebound or box crates.

General instructions for unpacking and handling are fastened to the outside of the crate.

### Lifting

The type "O-AL" bushings can be lifted from a horizontal to a vertical position and lifted in a vertical position by a rope or steel cable looped around the top nut under the lifting lugs. See A, Fig. 1.

When lifting from the blocking in a horizontal packing case it is desirable to use a double hoist with one lift at the flange and one looped around the top under the lifting lugs. See B, Fig. 1. When up-ending the bushing keep the lower end on felt or wood, braced to protect threads and prevent slipping and keep procelain away from the floor.

A recommended method of suspending the bushing at the proper angle for installing is illustrated in Fig. 2.

### Storing

Bushings should be stored, preferably in a rack and in a vertical position or with the top end at least 18 inches higher than the bottom end, in a

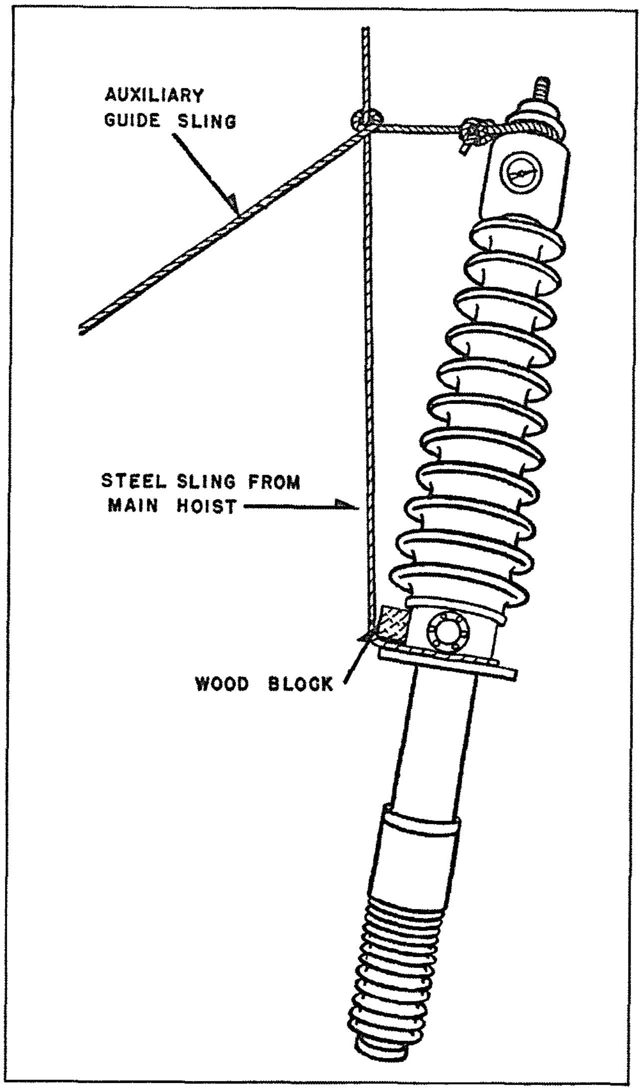



**Fig. 2.** *Method of Suspending Bushing at Angle for Installation*

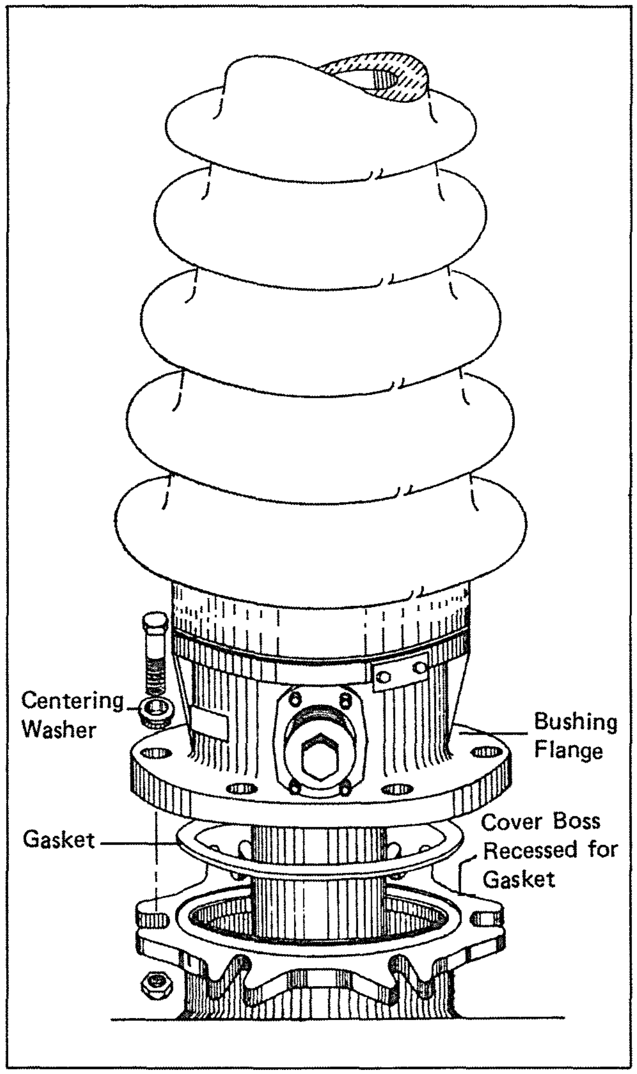



**Fig. 3-A.** *Installing Bushing on Transformer*

place where they will not be damaged mechanically. No special precautions need to be taken as to moisture or temperature. A check of oil height, and of power factor and capacitance should be made before putting the bushings into service after prolonged storage.

## INSTALLATION

Before installing in the apparatus, wipe the bushing clean of all dust, grease or particles of packing material using cloths wrung out of 1, 1, 1, trichloroethane or transformer oil, and finish with a dry cloth.

### Installing Transformer Bushings

Transformer bushings are provided with static shields to cover the threads and sharp corners of bottom terminals. These should always be securely in place on the bushing before it is put into the transformer.

It is recommended that 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.

Transformer cover bosses (See Fig. 3A) are flat with a recess to retain the gasket and limits its compression. The side of the gasket in the recess should be covered with gasket cement 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.

Spare bushings furnished for a given transformer are supplied without cable leads if they are duplicates of the bushings to be replaced. In this case the cable inside the transformer will fit the bushing without alteration. If replacement bushings require new cables, they will be furnished as a length of cable attached to a stud

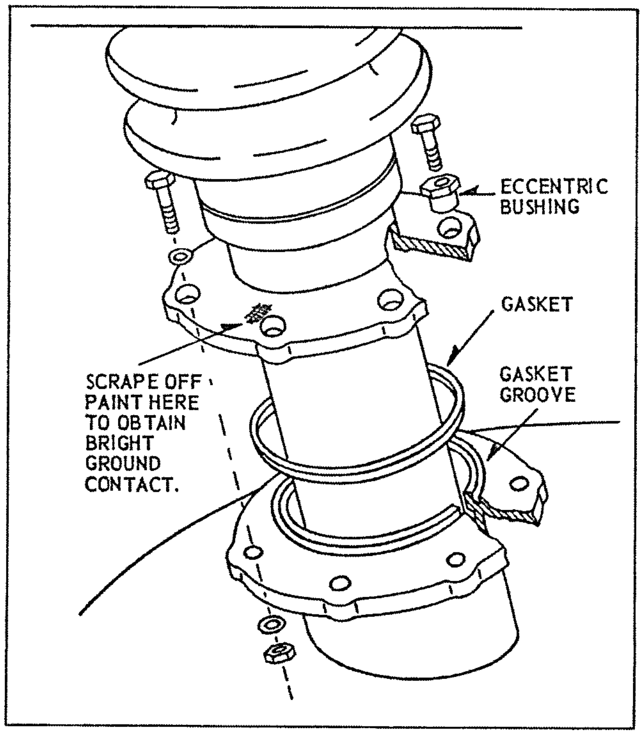



**Fig. 3-B.** *Installing Bushing on Circuit Breaker*

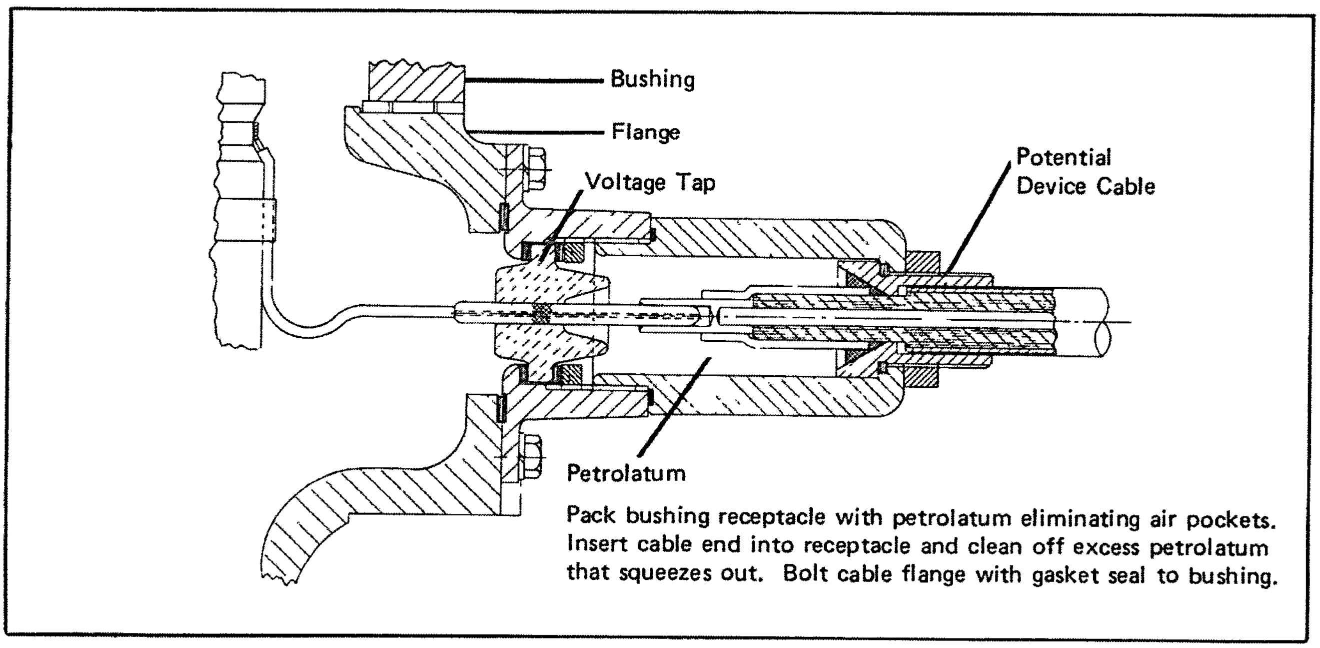



**Fig. 4.** *Voltage Tap Receptacle with Potential Device Cable Connected*

terminal. In order to install such a bushing it will be necessary to cut off the old cable and splice the new cable to the old one. The splice should be brazed or crimped. The spliced joint should preferably be within the condenser tube, provided there is sufficient clearance. The location of the splice may be obtained by measuring the length of the bushing above the bushing cover boss and the length of the cable to the surface of the cover boss. Add two inches to this measurement to give the proper slack in the cable.

Bushings on transformers are supplied with draw-through leads unless the current exceeds the value set by safe thermal considerations, 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 securely 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 a 3/8 bolt screwed into 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 then is 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 screw driver 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.

### Installing Breaker Bushings

See Fig. 3-B. Circuit breaker cover bosses for bushings are flat with a machined groove in the flat surface to retain the bushing gasket. Cement gasket into tank groove and apply vaseline between gasket and the bushing. The vaseline will permit shifting the bushing without damage to the gasket. Eccentric bushings are used on flange bolts to shift bushing for contact adjustment. Have all bolts tight for final assembly.

**IMPORTANT: See that outside connections do not throw strains on the bushing in excess of those specified by standards.**

### Voltage Tap

Type "O-AL" bushings 115 kv and above are furnished with a voltage tap located at the flange. See Fig. 6-E. The voltage tap receptacle is filled with petrolatum when the potential device is attached. See Fig. 4. The voltage tap is grounded by its cap unless it is connected to a potential device.

### Potential Device Connection

Type "O-AL" bushings are furnished with a two layer potential tap for use with PBA-2 bushing potential devices.

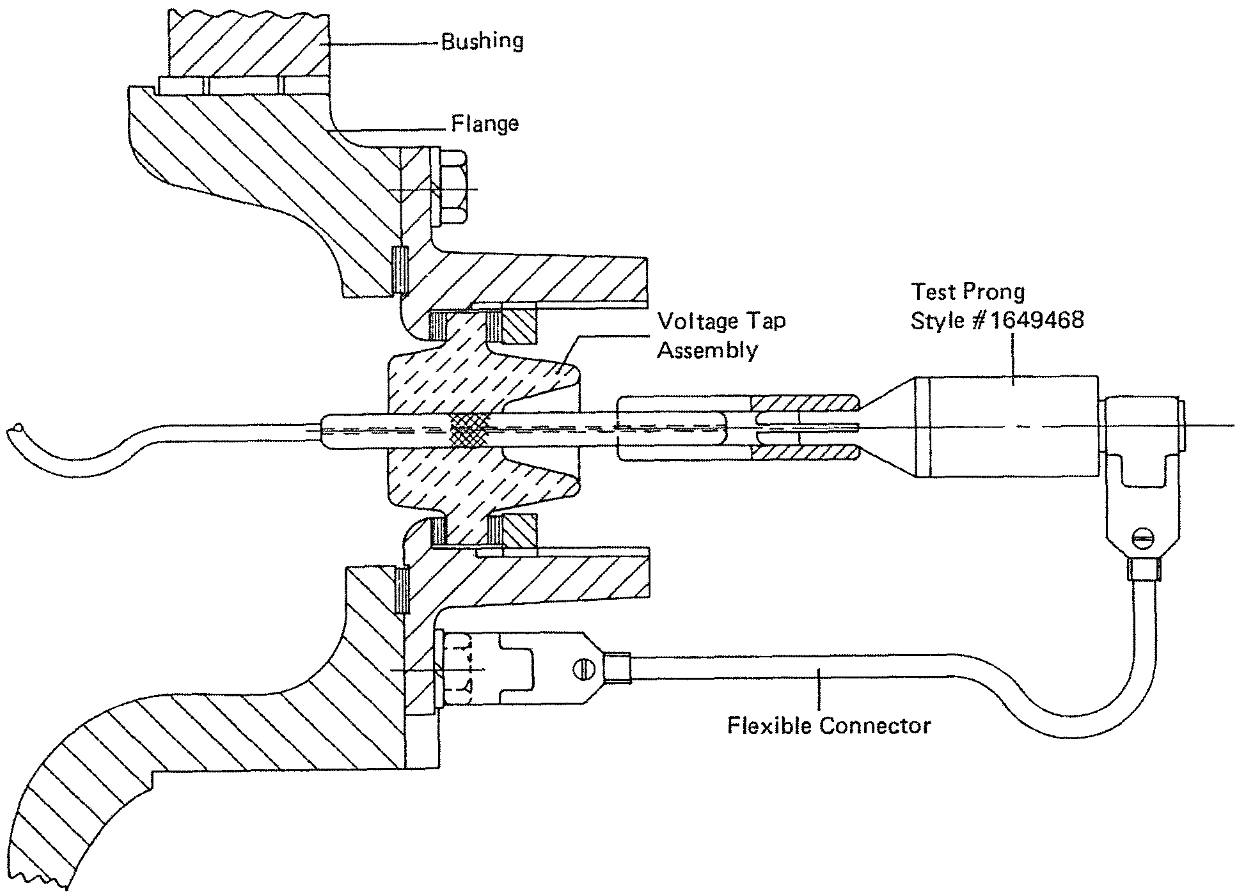
To connect Potential Devices Cable (See Fig. 4) remove the cap from the bushing tap receptacle. Pack the receptacle with petrolatum and screw the cable termination in place.

## MAINTENANCE

### General Maintenance of Bushing

1. Clean all exposed surfaces including weather casing and magnetic oil gauge face at regular intervals. Touch up paint on bowl or flange if necessary.

2. Watch oil gauge. Any abnormal change in oil level indicates a leak in the bushing and should be investigated. The magnetic oil gauge needle should be horizontal when the bushing is vertical and the average temperature of the bushing is approximately 20 to 25$^{o}$C (68 to 77$^{o}$F).




TEST PRONG FOR MAKING UNGROUNDED P.F. TESTS THROUGH VOLTAGE TAP ON TYPE "O-AL" BUSHINGS INSTRUCTIONS———— AFTER BUSHING IS DISCONNECTED FROM HIGH VOLTAGE LINE AND GROUNDED.

THE PROCEDURE FOR USING THE TEST PRONG IS·

1. REMOVE CAP PLUG FROM VOLTAGE TAP SOCKET.
2. CONNECT THE TERMINAL END OF THE TEST PRONG TO GROUND WITH A FLEXIBLE CONNECTOR AS A SAFETY MEASURE, SO ANY ELECTROSTATIC CHARGE LEFT ON THE BUSHING AFTER IT HAS BEEN REMOVED FROM SERVICE WILL BE DISCHARGED TO GROUND WHEN THE TEST PRONG IS INSERTED IN THE VOLTAGE CAP.
3. INSERT THE PRONG TO MAKE CONTACT WITH THE POTENTIAL TAP STUD.
4. DISCONNECT THE TEST PRONG FROM GROUND AND CONNECT IT TO THE PROPER POWER FACTOR TEST LEAD.
5. PROCEED TO MAKE A POWER FACTOR TEST IN THE CONVENTIONAL MANNER USED FOR TESTING UNGROUNDED SPECIMENS.
6. AFTER COMPLETING THE POWER FACTOR TEST, REMOVE THE TEST PRONG AND SCREW IN THE GROUNDING CAP IN A WEATHERPROOF MANNER. PETROLATUM MAY BE LEFT IN PLACE, BUT THERE SHOULD BE AT LEAST 20 PERCENT AIRSPACE FOR EXPANSION.

**Fig. 5.** *Test Prong for Making Ungrounded Power Factor Tests through Tap on Type "O-AL" Bushings*

Power Factor and Capacitance Tests

Where Power Factor testing schedules have been adapted make power factor and capacitance tests the first year and recheck every second year. External damage or the collection of dirt on insulating surfaces may make other occasional tests desirable.

**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, such as the interrupter.**

Power Factor Tests and capacitance measurements can be made by the "Ungrounded Specimen Method" by connecting to the potential tap (See Fig. 5). This eliminates the necessity for disconnecting the transformer winding, grid, or the line lead from the bushing. Ground the insulated test prong to dissipate any charge that may be left when contact is made to the potential tap. The power factor and capacitance between the tap and central conductor, and between the tap and the flange can then be measured. After tests, replace the grounding cap plug.

For more complete information and limits on power factor tests see Westinghouse Bushing Manual, T.D. 33-360.

Oil Tests

The type "O-AL" bushing is hermetically sealed with the oil not exposed to light or oxygen, uses no materials harmful to the oil, and has no spots of high voltage concentration. It is therefore strongly recommended that no samples of oil for oil test be taken unless power factor test casts suspicion on the bushing. Sampling removes internal gas pressure and to refill means unsoldering the sealed plug in the cap allowing oxygen to enter.

When inspection or power factor test indicates that samples should be taken, draw the sample from the valve at the flange.

**IMPORTANT: If low dielectric oil is found, make a thorough investigation for tightness. Air or nitrogen, if used in testing, should be known to be dry, and not used at over 15 pounds pressure per square inch.**

Summary

Required maintenance is "keep outside clean, watch oil gauge, examine for loose connection, broken porcelain, oil leaks, and make power factor tests and capacitance measurements periodically."

## BUSHING REPAIR

Bushings of this type will rarely have to be rebuilt. Occasionally, due to an accident, a bushing may be damaged. If the power factor is greater than one percent, a new condenser should be wound. In such cases Westinghouse has adequate facilities for repairing bushings and best results will generally be obtained by returning them to the factory. If, however, it is desired to dismantle a bushing, the factory will issue instructions for dismantling.

If a new condenser is required return the bushing to Westinghouse Electric Corporation (circuit breaker bushings to Trafford and transformer bushings to Sharon), as special equipment is necessary for evacuating, degassing oil and impregnating to insure the best results.

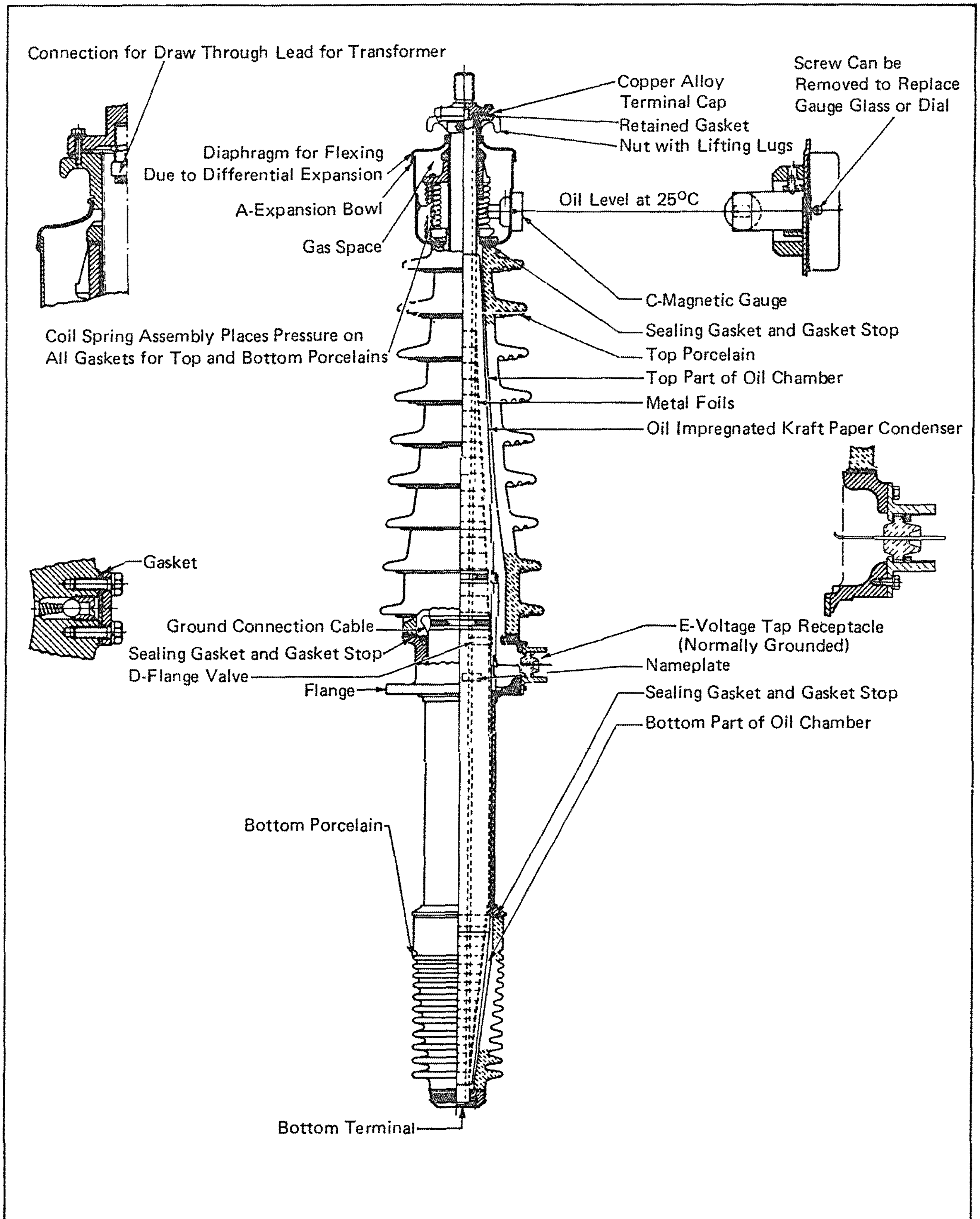



**Fig. 6.** *Sectional View–Aluminum Condenser Bushing, Type "O-AL"*

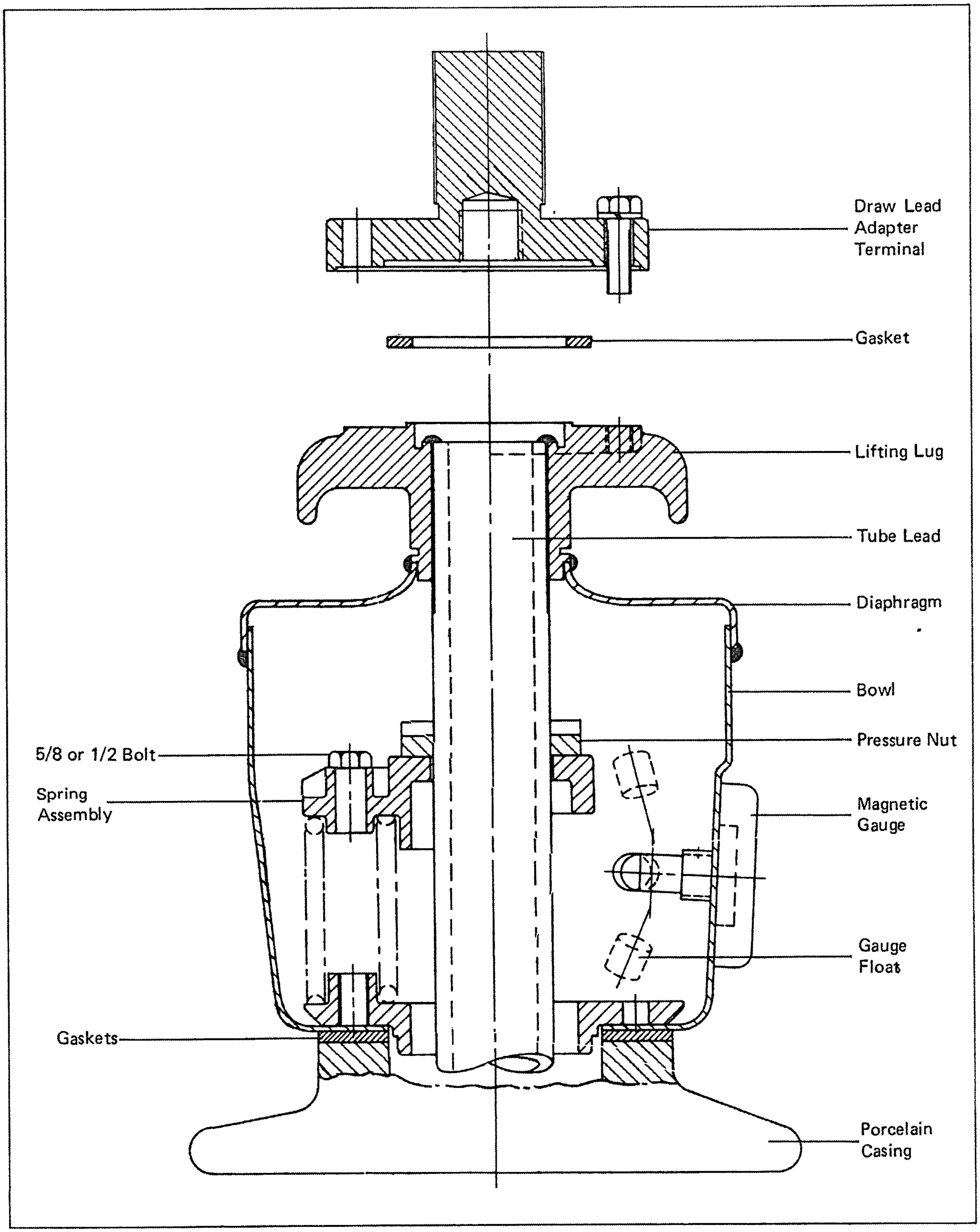



Fig. 7. *Sectional View–Bushing Expansion Bowl*

# Memorandum

# Memorandum

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Westinghouse • Sharon Transformer Division • Sharon, Pennsylvania

Printed in U.S.A. (W.P.D.)

# Instructions for Porcelain Bushings, Type RJ Nema Standard

I. L. 48-061-64

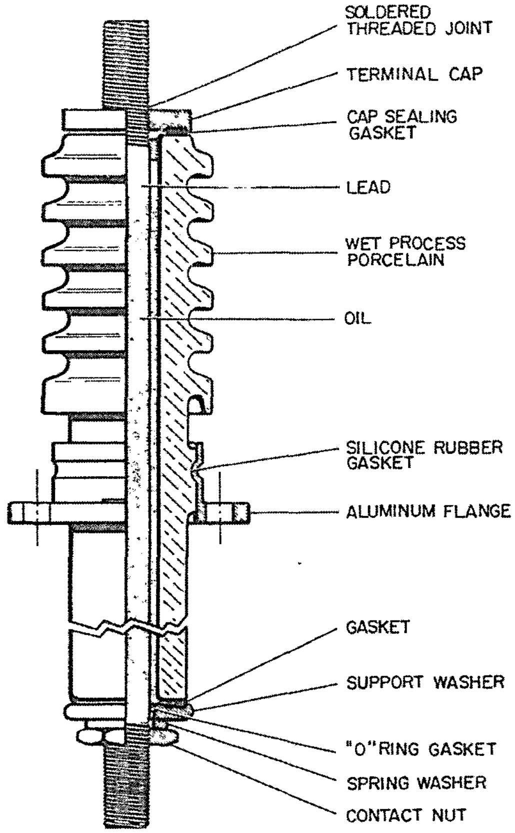



*Fig. 1. Type RJ Bottom Connected Bushing.*

The Westinghouse Bushing, Type "RJ", conforms to Nema Standard dimensions and is used for voltages 15 KV and lower, and for nominal current ratings of 1200 and 2000 amperes. This bushing is made of a single piece, wet process procelain with a one-piece forged aluminum flange rolled into a groove in the porcelain over a silicone rubber gasket. The space between the conductor and the inside of the porcelain is filled with oil to reduce corona and improve other electrical characteristics of the 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.

## HANDLING AND STORING

Care must be taken in handling the bushing to avoid mechanical damage. Bushings should be stored in a clean, dry place.

## INSTALLATION

These 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 nitrile reuseable gasket to seal between the bushing flange and the boss. When the mounting nuts are tightened, the flange and boss are drawn together to make a metal-to-metal gasket stop.

## FIELD TESTING

Visual inspection of these bushings should be made periodically to detect cracked or broken porcelains or oil leaks, and to clean the porcelains.

## RENEWAL PARTS

If Renewal Parts are required, order from the nearest Westinghouse Sales Office. Supply the style number given on the bushing nameplate and the transformer serial number and rating as stamped on the transformer instruction plate.

I.P. 2517

**Westinghouse Electric Corporation**

POWER TRANSFORMER DIVISION
SHARON, PA. • MUNCIE, IND. • S. BOSTON, VA.

Effective December, 1970

Printed in U.S.A (W.E.)

# Instructions for Type IVL Intermediate Class Lightning Arrester

I.L. 38-211-1

## INTRODUCTION

IVL Intermediate Class Lightning Arresters are designed for protection of high voltage transmission line equipment, indoors or outdoors, from 0 to 10,000 feet altitude. IVL arresters are rated 3 thru 120 KV, and meet all NEMA, ANSI, and IEC Standards for intermediate class arresters.

## DESCRIPTION

Each arrester pole consists of one or more porcelain clad units, (picture) and required attachments. Multi unit poles have all metal top units. Style numbers listed are for gray color, however, brown is available on request. Listed information is applicable to both colors. A master nameplate located on the bottom casting of all poles, identifies the arrester pole by style number; and gives pole voltage rating, and location of individual units in the pole. It also identifies the grading ring if one is required. For multi unit poles, a separate unit nameplate is located on the bottom casting of upper units. THE POLE VOLTAGE RATING IS THE MAXIMUM CONTINUOUS SIXTY HERTZ RMS VOLTAGE WHICH MAY BE APPLIED ACROSS THE ARRESTER FROM LINE TO GROUND. If this rated voltage is exceeded, the arrester may be damaged.

## RECEIVING, HANDLING, & STORING

The IVL arrester has been designed to withstand shipping shocks, and each unit is shipped in a protective container.

### Receipt

On receipt, inspect containers for any visible signs of damage. Unpack the units carefully and examine for breakage or other damage, especially to the porcelain. Check parts with the packing list. If damage or shortages exist, save the container and packing materials, notify the carrier, and promptly inform the nearest Westinghouse sales office.

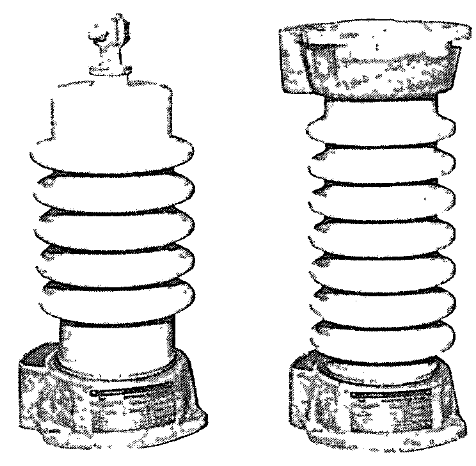
Each arrester pole should include: one or more arrester units which add up to the pole voltage rating; one line terminal; one ground terminal bracket; terminal connectors; and hardware to connect units together, and to attach the line terminal. On porcelain top units, the line terminal is built in. Arresters rated 84 thru 120 KV will also include a grading ring. Hardware for mounting the bottom unit to a base is not provided.

Insulating base units and discharge counters are available for separate purchase.

## INSTALLATION

CAUTION:

1. WHEN INSTALLING 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 PORTS 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 (see page 2).



*Porcelain Top* *Metal Top*
*Type IVL Arrester Units*

Effective September, 1975

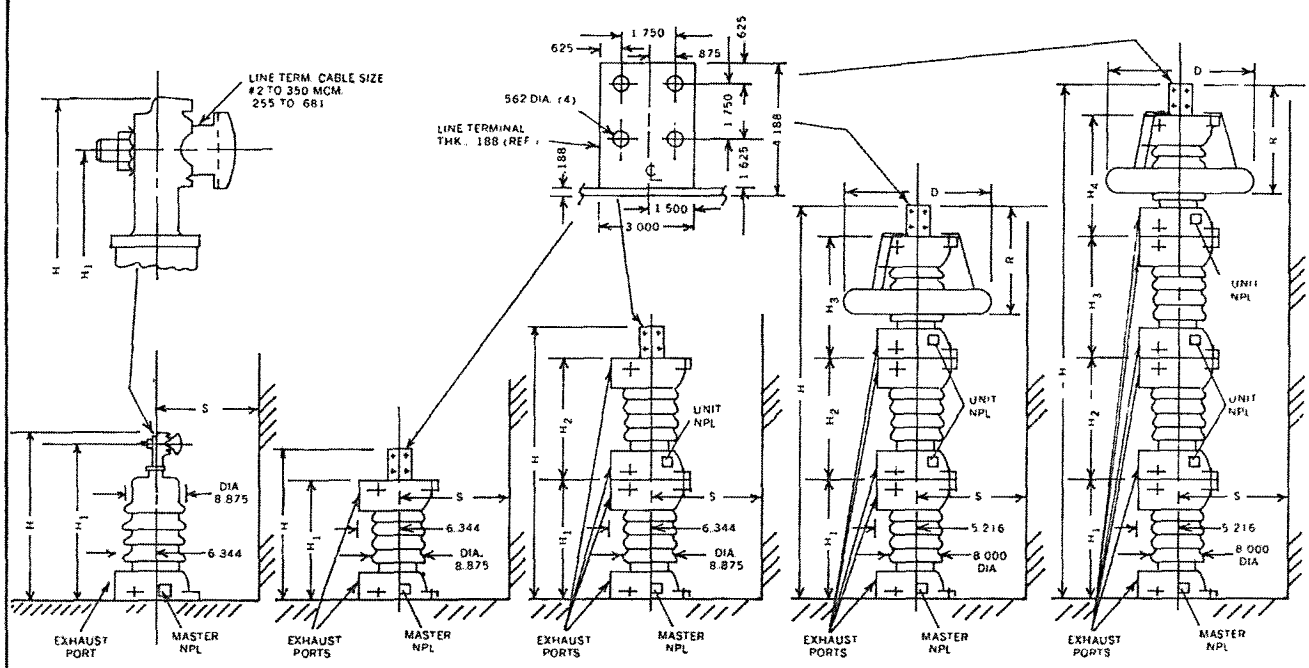
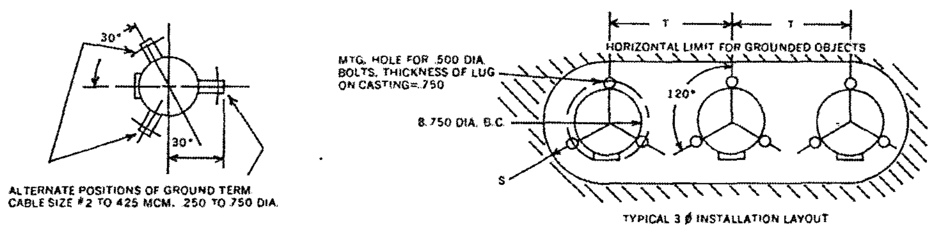



*Fig. 1* *Fig. 2* *Fig 3* *Fig. 4* *Fig 5*




## SERIAL NUMBER EXAMPLE

**Arrester Serial Number 75M5001—On Master Nameplate**
**On Multi Unit Poles**

| Unit Position | Unit Serial Number | Location |
|---|---|---|
| Bottom | 75M50011 | Master nameplate |
| Second | 75M50012 | Master and unit nameplates |
| Third | 75M50013 | Master and unit nameplates |
| Fourth | 75M50014 | Master and unit nameplates |

*Note that serial numbers for all units in a pole are identical except the last digit*

| 3-15 KV PORCELAIN TOP (FIG. 1) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Dimensions (Inches) | | | | | | |
| Style | KV Rating | H | $H_1$ | S | T | Creep | Weight (pounds) |
| 5554A50A03 | 3 | 14.50 | 13.56 | 5.5 | 9.0 | 12.25 | 31 |
| 5554A50A04 | 4.5 | 14.50 | 13.56 | 5.5 | 9.0 | 12.25 | 32 |
| 5554A50A06 | 6 | 14.50 | 13.56 | 5.5 | 9.0 | 12.25 | 32.5 |
| 5554A50A07 | 7.5 | 18.50 | 17.56 | 5.5 | 9.0 | 17.95 | 38 |
| 5554A50A09 | 9 | 18.50 | 17.56 | 5.5 | 9.0 | 17.95 | 39 |
| 5554A50A10 | 10 | 22.50 | 21.56 | 6.0 | 9.0 | 25.35 | 45 |
| 5554A50A12 | 12 | 22.50 | 21.56 | 6.5 | 9.0 | 25.35 | 46 |
| 5554A50A15 | 15 | 22.50 | 21.56 | 7.0 | 10.0 | 25.35 | 47 |
| 5554A50A18 | 18 | 26.50 | 25.562 | 8.0 | 11.0 | 32.750 | 53 |
| 5554A50A21 | 21 | 26.50 | 25.562 | 9.0 | 12.0 | 32.750 | 54 |
| 5554A50A24 | 24 | 28.50 | 27.562 | 10.0 | 13.0 | 36.450 | 57 |
| 5554A50A27 | 27 | 32.50 | 31.562 | 11.0 | 14.0 | 43.850 | 63 |
| 5554A50A30 | 30 | 32.50 | 31.562 | 12.0 | 15.0 | 43.850 | 64 |

| 3-120 KV METAL TOP | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dimensions (Inches) | | | | | | | | | | | | |
| Style | KV Rating | Figure Number | H | $H_1$ | $H_2$ | $H_3$ | $H_4$ | D dia. | R | S | T | Creep | Weight (pounds) |
| 5554A51A03 | 3 | 2 | 18.44 | 14.25 | | | | | | 7.5 | 11.5 | 10.4 | 43 |
| 5554A51A04 | 4.5 | 2 | 18.44 | 14.25 | | | | | | 7.5 | 11.5 | 10.4 | 43.5 |
| 5554A51A06 | 6 | 2 | 18.44 | 14.25 | | | | | | 8.5 | 12.5 | 10.4 | 44 |
| 5554A51A07 | 7.5 | 2 | 20.69 | 16.50 | | | | | | 8.5 | 12.5 | 14.4 | 48 |
| 5554A51A09 | 9 | 2 | 20.69 | 16.50 | | | | | | 9.5 | 13.5 | 14.4 | 49 |
| 5554A51A10 | 10 | 2 | 20.69 | 16.50 | | | | | | 9.5 | 13.5 | 14.4 | 49.5 |
| 5554A51A12 | 12 | 2 | 20.69 | 16.50 | | | | | | 10.5 | 14.5 | 14.4 | 50 |
| 5554A51A15 | 15 | 2 | 21.94 | 17.75 | | | | | | 11.5 | 15.5 | 17.3 | 53 |
| 5554A51A18 | 18 | 2 | 27.31 | 23.12 | | | | | | 12.5 | 16.5 | 27.8 | 63 |
| 5554A51A21 | 21 | 2 | 27.31 | 23.12 | | | | | | 13.5 | 17.5 | 27.8 | 64 |
| 5554A51A24 | 24 | 2 | 28.94 | 24.75 | | | | | | 14.5 | 18.5 | 31.1 | 67 |
| 5554A51A27 | 27 | 2 | 32.94 | 28.75 | | | | | | 15.5 | 19.5 | 38.5 | 75 |
| 5554A51A30 | 30 | 2 | 32.94 | 28.75 | | | | | | 16.5 | 20.5 | 38.5 | 76 |
| 5554A51A36 | 36 | 2 | 37.94 | 33.75 | | | | | | 18.5 | 22.5 | 46.9 | 86 |
| 5554A51A39 | 39 | 2 | 41.94 | 37.75 | | | | | | 19.5 | 23.5 | 54.3 | 94 |
| 5554A51A45 | 45 | 3 | 52.06 | 23.12 | 24.75 | | | | | 20.5 | 24.5 | 59.0 | 127 |
| 5554A51A48 | 48 | 3 | 53.69 | 24.75 | 24.75 | | | | | 21.5 | 25.5 | 62.2 | 131 |
| 5554A51A60 | 60 | 3 | 61.69 | 28.75 | 28.75 | | | | | 25.5 | 29.5 | 77.0 | 148 |
| 5554A51A72 | 72 | 3 | 71.69 | 33.75 | 33.75 | | | | | 29.5 | 33.5 | 93.8 | 168 |
| 5554A51A78 | 78 | 3 | 79.69 | 37.75 | 37.75 | | | | | 31.5 | 35.5 | 108.6 | 183 |
| 5554A51A84 | 84 | 4 | 86.44 | 24.75 | 28.75 | 28.75 | | 30.00 | 16.00 | 43.0 | 58.0 | 108.1 | 233 |
| 5554A51A90 | 90 | 4 | 90.44 | 28.75 | 28.75 | 28.75 | | 30.00 | 16.00 | 45.0 | 60.0 | 115.5 | 241 |
| 5554A51A96 | 96 | 4 | 95.44 | 28.75 | 28.75 | 33.75 | | 30.00 | 16.00 | 47.0 | 62.0 | 123.9 | 251 |
| 5554A51A98 | 108 | 4 | 105.44 | 33.75 | 33.75 | 33.75 | | 30.00 | 16.00 | 51.0 | 66.0 | 140.7 | 272 |
| 5554A51A99 | 120 | 5 | 119.19 | 28.75 | 28.75 | 28.75 | 28.75 | 30.00 | 16.00 | 55.0 | 70.0 | 154.0 | 314 |

## General

To give the highest degree of protection, the arresters should be located near the protected apparatus, using leads of the shortest possible length. Each arrester pole should be connected to the same ground as the protected apparatus.

A suitable foundation in accordance with the outline drawing for the arrester should be provided.

For operation above 6000 feet altitude, add 3% to clearance dimensions S and T for each 1000 feet.

Line connections should be made in such a way that no excessive mechanical strain is placed on the arrester. The cantilever strength of the IVL arrester is 5,000 foot pounds, and should not be exceeded under any combination of forces such as conductor side pull, and wind or earthquake loading.

## Installation Procedure

1. If an insulating base is used, bolt it to the foundation. 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 to 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 emaining 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.
5. For metal top arresters, bolt the line terminal assembly to the top unit. When a grading ring is used, put the ring on top of the line terminal assembly, then lift this assembly by the line terminal flag, and attach to the top unit.

## TESTING

Each unit is tested at the factory for 60 Hertz sparkover, grading current at rated voltage, radio influence, and to detect leaks. Units should not be opened in the field because entrance of moisture can cause permanent damage to internal components.

No simple field tests will check complete characteristics of an arrester unit. This requires extensive laboratory facilities.

If an arrester is suspected of having been damaged in service, the only field tests that should be attempted are sixty Hertz sparkover, RIV tests, Doble tests, or Megger tests. Such tests will not determine the condition of the valve elements. For more information refer to NEMA Bulletin 70, Guide for Field Testing of Lightning Arresters.

The IVL arrester uses non-linear grading resistors which may be damaged if the applied voltage exceeds the rating for more than a few cycles. Due to this fact, for 60 Hertz tests, raise voltage at a uniform rate to sparkover within 5 seconds, and then switch off within 10 cycles.

Doble or Megger tests on units of the same rating may give different readings. If one unit shows considerable deviation from the rest, its condition may be open to question. It is more significant to make periodic readings and note the trends of the readings. Contamination on the porcelain surface may cause faulty or misleading readings. Only clean, dry arresters should be tested.

## MAINTENANCE

The IVL 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.

## CORRESPONDENCE

Direct inquiries pertaining to the lightning arrester to the nearest Westinghouse sales office giving all information stated on the master nameplate.

**Westinghouse Electric Corporation**

Distribution Apparatus Division, Bloomington, Indiana 47401

Printed in U.S.A.

# Instructions for Type CPL Station Class Lightning Arrester

I.L. 38-131-3

## INTRODUCTION

CPL Station Class Lightning Arresters are designed for protection of high voltage transmission line equipment, indoors or outdoors, from 0 to 10,000 feet altitude. CPL arresters are rated 24 thru 312 KV, and meet all NEMA, USASI and IEC Standards.

All CPL arresters incorporate a directional pressure relief system to vent high pressures caused by arrester failure. For safe operation of this system, EXHAUST PORTS SHOULD BE DIRECTED AWAY FROM PROTECTED EQUIPMENT AND OTHER ARRESTER POLES.

## DESCRIPTION

Each arrester pole consists of one or more porcelain clad units, (picture) and required attachments. Style numbers listed are for gray color, however, brown is available on request. Listed information is applicable to both colors. A master nameplate located on the bottom casting of all poles, identifies the arrester pole by style number; and gives pole voltage rating, and location of individual units in the pole It also identifies the grading ring if one is required. For two unit poles, a separate unit nameplate is located on the bottom casting of the top unit. THE POLE VOLTAGE RATING IS THE MAXIMUM SIXTY HERTZ RMS VOLTAGE WHICH MAY BE APPLIED ACROSS THE ARRESTER FROM LINE TO GROUND. If this rated voltage is exceeded, the arrester may be damaged.

CPL ARRESTER UNITS ARE NOT INTERCHANGEABLE WITH ANY OTHER TYPE STATION ARRESTERS. It is sometimes possible to change pole voltage rating in the field. In all cases, before changing an arrester's rating, consult the nearest Westinghouse district office.

## RECEIVING, HANDLING, & STORING

The CPL arrester has been designed to withstand shipping shocks, and each unit is shipped in a protective container, with 24 thru 144 KV units shipped and stored upright. 168 thru 192 KV units may be shipped and stored horizontal.

### Receipt

On receipt, inspect containers for any visible signs of damage. Unpack the units carefully and examine for breakage or other damage, especially to the porcelain. If damage exists, save the container and packing materials and notify the carrier. Check parts with the packing list. Shortages should be checked with the carrier, and if not the carrier's fault, with our nearest Sales Office.

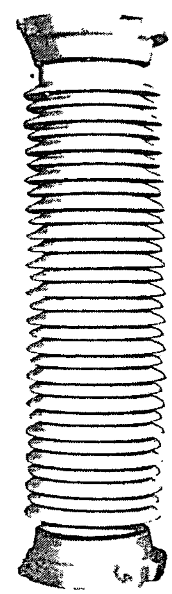
Each arrester pole should include: one or more arrester units which add up to the pole voltage rating, one line terminal bracket, one ground terminal bracket; four eye bolt terminal connectors; and hardware to connect units together, and to attach the line terminal. Arresters rated 168 thru 312 KV will also include a grading ring. Hardware for mounting the bottom unit to a base is not provided.

Insulating base units, shunts, discharge counters, Blitzwatchers, and extra heavy line terminal brackets for suspension mounting are available for separate purchase.

## INSTALLATION

CAUTION:

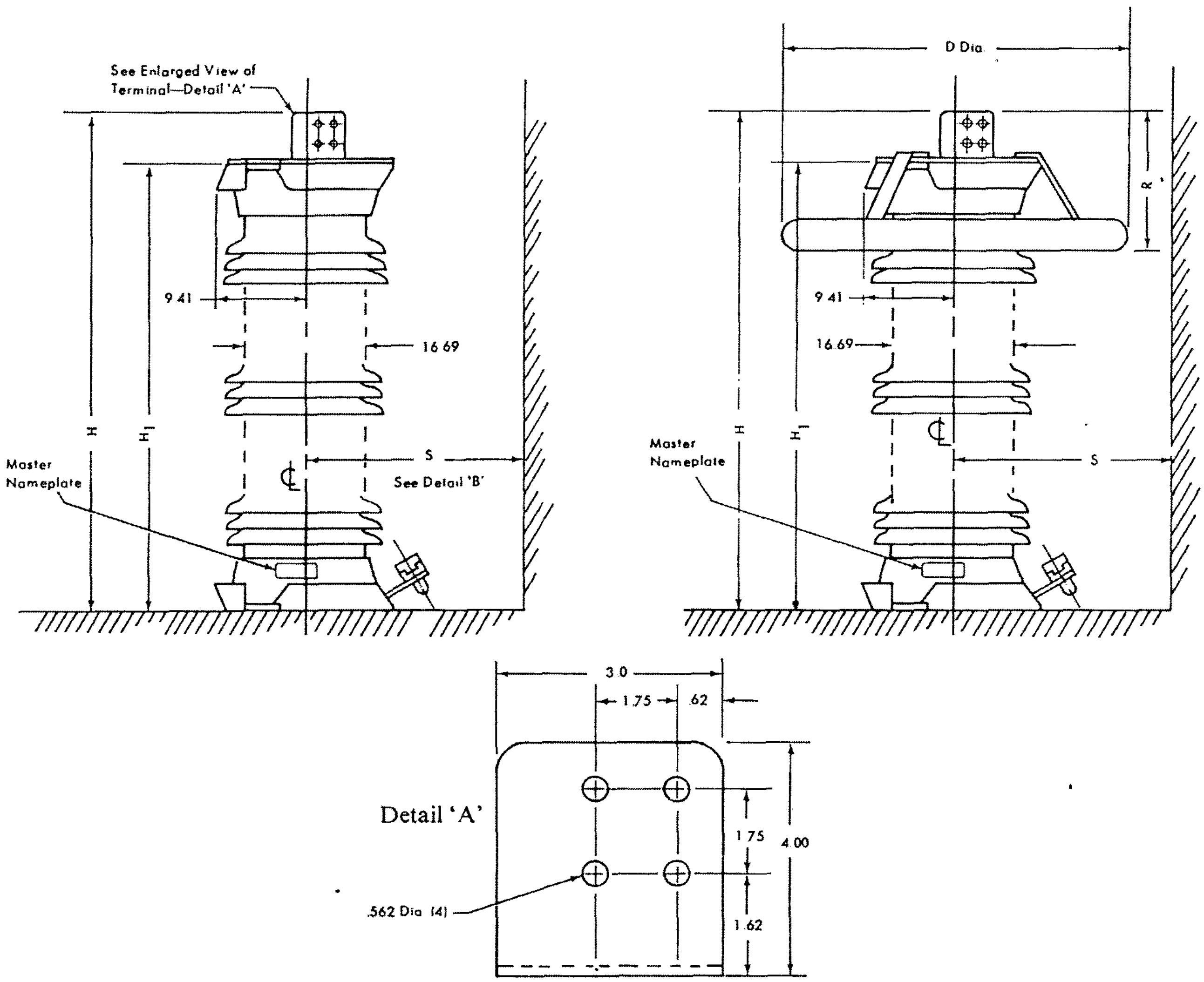
1. WHEN INSTALLING ARRESTER, ALL MOUNTING FEET MUST BE FLUSH BEFORE TIGHTENING BOLTS. SHIM IF NECESSARY.
2. THE ARRESTER SHOULD NOT BE CLIMBED FOR ANY REASON.
3. THE LINE TERMINAL MUST NOT BE USED TO LIFT THE ARRESTER.
4. ARRESTER EXHAUST PORTS SHOULD BE DIRECTED AWAY FROM PROTECTED EQUIPMENT AND OTHER ARRESTER POLES.



*Type CPL Arrester Unit*

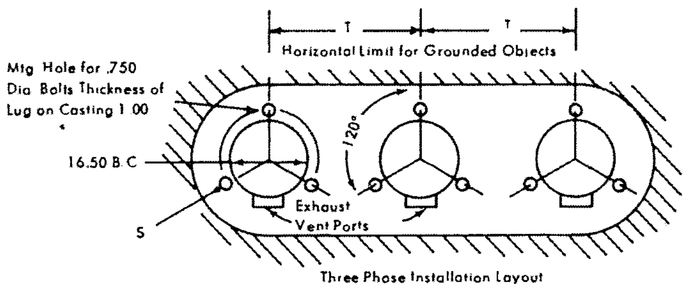
Effective January, 1974 Supersedes I L 38-131-1A

## SINGLE UNIT POLES

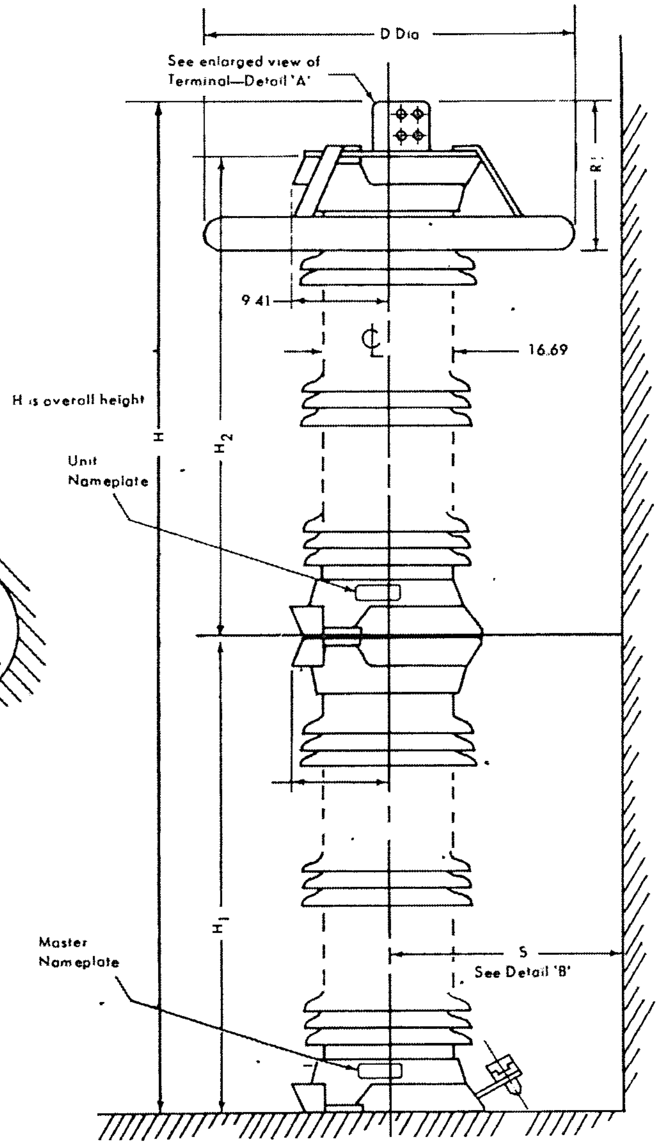



| Style No. | KV Rating | DIMENSIONS (Inches) | | | | | | | Weight (Pounds) |
|---|---|---|---|---|---|---|---|---|---|
| | | H1 | H | D dia. | R | S | T | Creep | |
| 5040A02A41 | 24 | 22.75 | 27.12 | | | 15 | 24 | 24.8 | 220 |
| 5040A03A61 | 36 | 30.11 | 34.50 | | | 18 | 27 | 51.1 | 270 |
| 5040A04A81 | 48 | 30.11 | 34.50 | | | 21 | 30 | 51.1 | 275 |
| | | | | | | | | | |
| 3891A06A01 | 60 | 35.38 | 38.75 | | | 23 | 32 | 67.3 | 327 |
| 3891A07A21 | 72 | 38.45 | 42.83 | | | 27 | 36 | 79.9 | 373 |
| 3891A09A01 | 90 | 52.38 | 56.75 | | | 31 | 40 | 119.4 | 476 |
| 3891A09A61 | 96 | 52.38 | 56.75 | | | 33 | 42 | 119.4 | 482 |
| | | | | | | | | | |
| 3891A10A81 | 108 | 61.03 | 65.41 | | | 36 | 45 | 146.5 | 563 |
| 3891A12A01 | 120 | 61.03 | 65.41 | | | 39 | 48 | 146.5 | 580 |
| 3891A13A21 | 132 | 65.62 | 70.00 | | | 43 | 52 | 161.2 | 609 |
| 3891A14A41 | 144 | 69.56 | 73.94 | | | 47 | 56 | 174.2 | 655 |
| | | | | | | | | | |
| 3891A16A81 | 168 | 85.92 | 90.30 | 40.0 | 14.12 | 65 | 84 | 224.4 | 799 |
| 3891A18A01 | 180 | 85.92 | 90.30 | 40.0 | 14.12 | 68 | 87 | 224.4 | 800 |
| 3891A19A21 | 192 | 92.03 | 96.41 | 40.0 | 14.12 | 72 | 91 | 240.0 | 845 |

## TWO UNIT POLES




Detail 'B'




| Style No. | KV Rating | DIMENSIONS (Inches) | | | | | | | | Weight (Pounds) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $H_1$ | $H_2$ | H | D Dia. | R | S | T | Creep | |
| 3891A22A82 | 228 | 61.03 | 61.03 | 126.44 | 40.0 | 14.12 | 83 | 102 | 293.0 | 1090 |
| 3891A24A02 | 240 | 61.03 | 61.03 | 126.44 | 40.0 | 14.12 | 87 | 106 | 293.0 | 1090 |
| | | | | | | | | | | |
| 3891A25A82 | 258 | 65.62 | 65.62 | 135.62 | 40.0 | 14.12 | 93 | 112 | 322.4 | 1248 |
| 3891A26A42 | 264 | 65.62 | 65.62 | 135.62 | 40.0 | 14.12 | 95 | 114 | 322.4 | 1248 |
| | | | | | | | | | | |
| 3891A27A62 | 276 | 69.56 | 69.56 | 143.62 | 40.0 | 14.12 | 99 | 118 | 348.4 | 1340 |
| 3891A28A82 | 288 | 69.56 | 69.56 | 143.62 | 40.0 | 14.12 | 104 | 124 | 348.4 | 1340 |
| | | | | | | | | | | |
| 3891A30A02 | 300 | 75.88 | 75.88 | 156.12 | 40.0 | 14.12 | 107 | 127 | 373.6 | 1420 |
| 3891A31A22 | 312 | 75.88 | 75.88 | 156.12 | 40.0 | 14.12 | 110 | 130 | 373.6 | 1420 |

## General

To give the highest degree of protection, the arresters should be located near the protected apparatus, using leads of the shortest possible length. Each arrester pole should be connected to the same ground as the protected apparatus.

A suitable foundation in accordance with the outline drawing for the arrester should be provided.

For operation above 6000 feet altitude, add 3% to clearance dimensions S and T (Detail B) for each 1000 feet.

Line connections should be made in such a way that no excessive mechanical strain is placed on the arrester. The cantilever strength of the CPL arrester is 17,000 foot pounds, and should not be exceeded under any combination of forces such as conductor side pull, and wind or earthquake loading.

## Installation Procedure

1. If an insulating base is used, bolt it to the foundation. If the insulating base is installed, but not used for recording or measuring equipment, shunt the base with cable shunt.
2. The bottom arrester unit (see master nameplate) is bolted to the insulating base, or to the foundation if no base is used. Include the ground terminal assembly under one of the mounting bolts—above the mounting foot. Each unit may be lifted by the top casting.
3. After the bottom unit and associated parts are firmly anchored, install remaining units as indicated on the master nameplate.
4. Terminals.
   Four standard terminal connectors; suitable for use with copper or aluminum, are supplied with each pole. Bolt two to the line terminal bracket, to form the line terminal assembly, and two to the ground terminal bracket. These terminals accept cable .250 to .750 inch diameter.
5. Bolt the line terminal assembly to the top unit. When a grading ring is used, put the ring on top of the line terminal assembly, then lift this assembly by the line terminal flag, and attach to the top unit.

## TESTING

Each unit is tested at the factory for 60 Hertz sparkover, switching surge sparkover, grading current at rated voltage, radio influence, and to detect leaks. Units should not be opened in the field because entrance of moisture can cause permanent damage to internal components.

No simple field tests will check complete characteristics of an arrester unit. This requires extensive laboratory facilities.

If an arrester is suspected of having been damaged in service, the only field tests that should be attempted are sixty Hertz sparkover, RIV tests, Doble tests, or Megger tests. Such tests will not determine the condition of the valve elements. For more information refer to NEMA Bulletin 70, Guide for Field Testing of Lightning Arresters.

The CPL arrester uses non-linear grading resistors which may be damaged if the applied voltage exceeds the rating for even a short time. Due to this fact, for 60 Hertz tests, raise voltage at a uniform rate to sparkover within 10 seconds, and then switch off within 10 cycles

Doble or Megger tests on units of the same rating may give different readings. If one unit shows considerable deviation from the rest, its condition may be open to question. It is more significant to make periodic readings and note the trends of the readings. Contamination on the porcelain surface may cause faulty or misleading readings. Only clean, dry arresters should be tested.

## MAINTENANCE

The 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.

## CORRESPONDENCE

Direct inquiries pertaining to the lightning arrester to the nearest Westinghouse sales office giving all information stated on the master nameplate.

**Westinghouse Electric Corporation**

Distribution Apparatus Division, Bloomington, Indiana 47401

Printed in U.S.A.

DESCRIPTION INSTALLATION

# INSTRUCTIONS

## TEMPERATURE INDICATORS
### Hot Oil Dial Type
**Submersible No Switches and One Switch Direct Mounted**

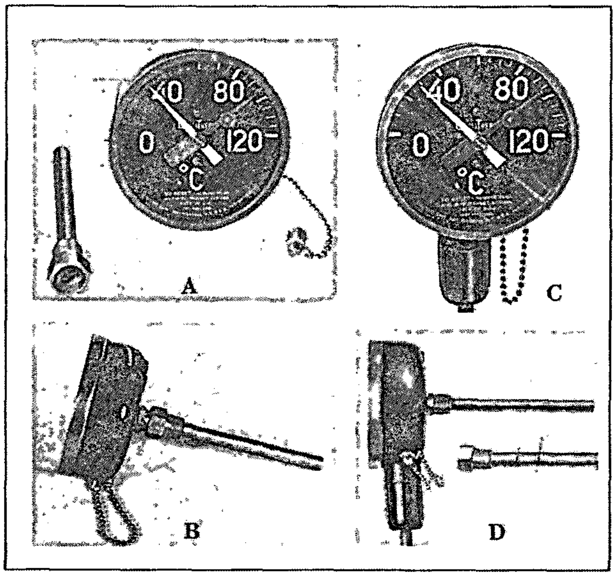



FIG. 1. (A) Front and (B) Side View of Indicator Without Alarm Connections; (C) Front and (D) Side View of Indicator With Alarm Connections.

TEMPERATURE INDICATORS, designed for application on Westinghouse transformers or related apparatus to indicate liquid temperatures, are self-contained, weatherproof and submersible instruments of the dial type, operated by means of bimetallic elements immersed in the liquid.

They are usually shipped mounted on the transformer cases, require no maintenance, and are suitable for oil or Inerteen.

## DESCRIPTION

The indicator is a dial type precision instrument whose needle is directly coupled to a bimetallic, spiral actuating element in the stem, which fits closely into a well. The well is of thin-walled construction and screws into a fitting on the transformer case, making an oil-tight connection.

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

The dial is calibrated in degrees centigrade and is easily read because of the contrasting black face with yellow characters, graduations, and indicating pointer.

A maximum indicating pointer, red in color, is used to indicate the maximum temperature reached between readings. This hand is reset by wiping a magnet across the face of the dial. The

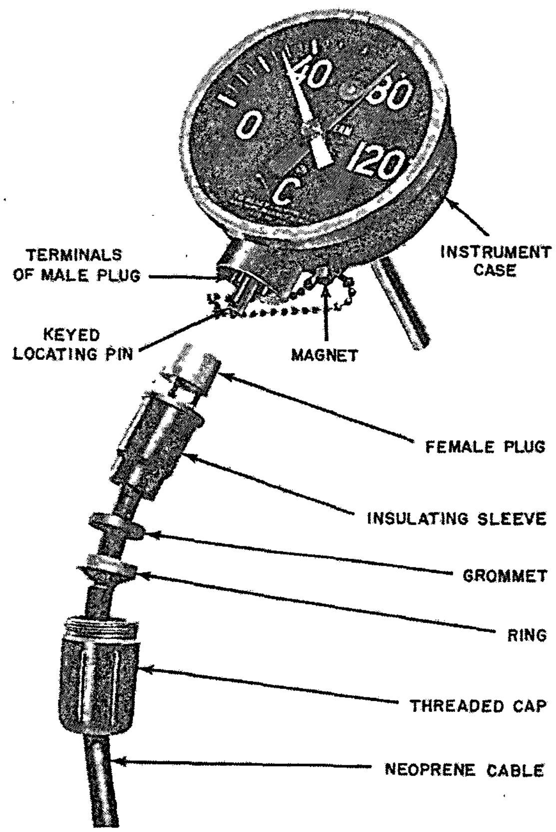



FIG 2. Triple Seal Connection Details.

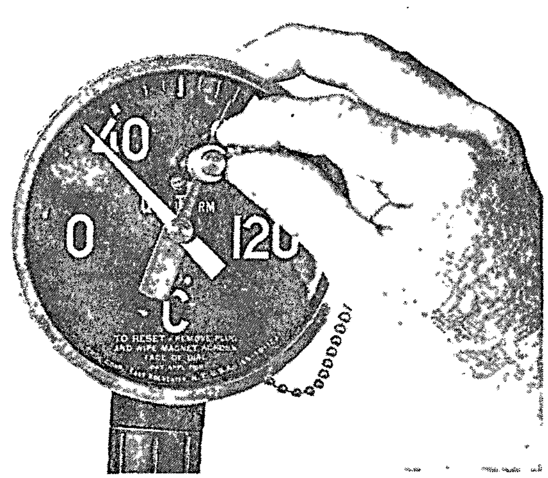


FIG. 3. Method of Resetting Maximum Indicating Pointer.

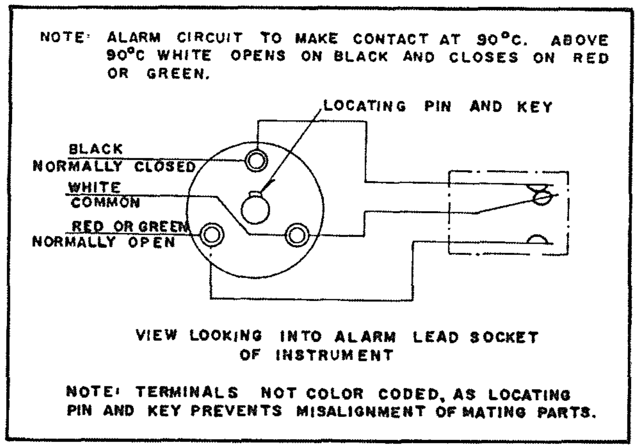



FIG. 4. Connection Diagram for Alarm Contact Leads.

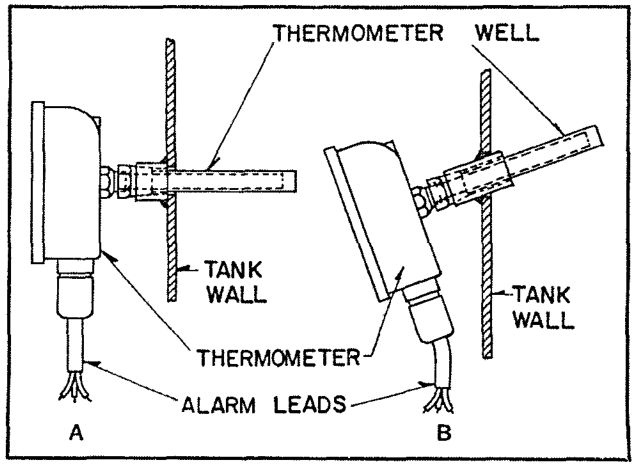



FIG. 5. Indicator Mounted (A) Vertical and (B) Tilted Downward.

magnet must be held with the poles in the proper position so as to attract the maximum indicating pointer. The magnet is attached to a small chain on the instrument case to prevent misplacing after using and is self-supporting in a metallic socket on the under side of this case. The method of resetting the maximum indicating pointer is shown in Fig 3.

There are two types of indicators available—one without alarm connections shown in Fig. 1, A and B, and one with alarm connections shown in Fig. 1, C and D. When alarm connections are required, the latter one will be supplied with the new triple seal connection, the details of which are shown in Fig. 2. This connector consists of:

1. Three protruding terminals molded in the case and a locating pin and key to prevent making incorrect connections.

2. A rubber insulator which has three terminal jacks to mate with the terminals in the case and a hole slot and key through the rubber insulator. The ends of the lead wires are soldered into one end of the terminal jacks.

3. A bushing to hold the insulator and enclose the soldered joint.

4. A grommet to make a seal between the rubber covered cable and the bushing.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of the connector tight in the case. This retaining nut is screwed into place.

The micro-switch in the indicator with alarm connections is factory set to operate at 90° C. The switch is adjustable over a range of 65° C to 100°C. The switch opens at $7\frac{1}{2}° \pm 2\frac{1}{2}°$ C less than the closing temperature. The ratings for this switch are given in Table No. 1 while the connection diagram is shown in Fig. 4.

**Field Test.** Remove the indicator from its well and submerge the stem up to the brass fitting in a closely temperature-controlled, well agitated oil bath. Check the temperature by placing a thermocouple or other accurate temperature measuring device on the stem about two inches from the end. The indicator should be accurate within ±2 degrees C, allowing a minimum of 15 minutes for the indicator to come up to temperature. To adjust the switch to a different value in the indicator with adjustable alarm, remove the sealing plug at the top of the case. Make the proper adjustment of the switch through the opening in the case, and then reseal the case with the sealing plug.

**Important. When changing the alarm setting on those temperature indicators with adjustable contacts, be sure to use a non-setting sealing compound on the threads of the sealing plug. Plastic Lead Seal #8138-3 is recommended. Loose or improperly sealed plugs will allow moisture to collect in the indicators, and cause eventual shorting of electrical circuits or deterioration of dial markings.**

## INSTALLATION

The indicators are usually shipped mounted in place. To install them when shipped as a separate item, remove the pipe plug from the mounting coupling. Treat threads on the well-to-wall connection with Westinghouse thread cement (Style No. 1150 419, pint can or Style No. 471-880, quart can) and screw the well securely in place, making an oil-tight connection. Then screw the indicator in place, being careful that the dial is in a reading position. The indicator can be removed from the well in the tank wall without the loss of liquid.

**Table No. 1**

| VOLTAGE | NON-INDUCTIVE LOAD—AMPS. | INDUCTIVE LOAD AMPS. L/R—.026* |
|---|---|---|
| 125 A-C | 10 | 10 |
| 250 A-C | 5 | 5 |
| 125 D-C | 0.5 | 0.05 |
| 250 D-C | 0.25 | 0.025 |

*Equal to or less than .026. If greater, refer to factory for adjusted rating

The instrument may be mounted at eye level (A, Fig. 5) or can be mounted at a higher level and tilted so that it can be read easily when mounted high (B, Fig. 5).

**Important: When checking circuits through this instrument it is necessary to follow Table No. 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing micro-switches of similar capacities.**

## RENEWAL PARTS

If it becomes necessary to repair the instrument, contact the nearest Westinghouse Office. Complete instructions will then be given by the District Engineering & Service Division for the return of the instrument to the factory at Sharon, Pa., to have it repaired and placed in first class condition.

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
Printed in U.S.A

# Instructions for Winding Temperature Indicator, Hot Spot Dial Type, Non-Submersible Three or Four Switch, Remote Indicating

I.L. 48-062-11

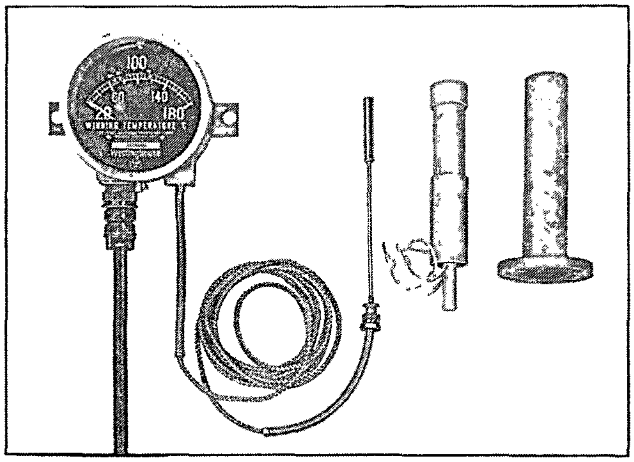



**Fig. 1** *Front View of 3-Switch Indicator Showing Twist-Lock Bezel*

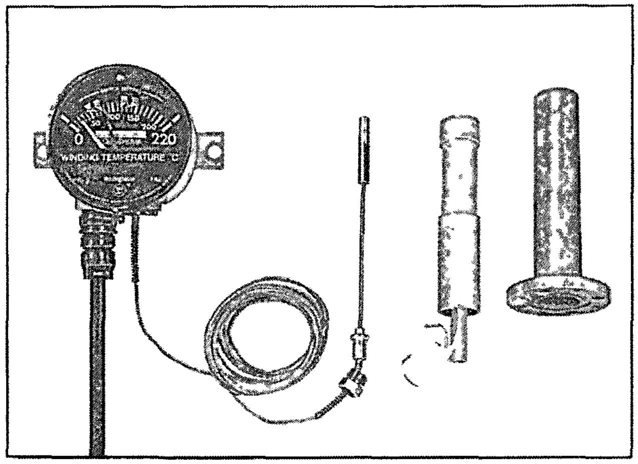



**Fig. 2** *Front View of 4-Switch Indicator Showing Screw-Clamp Bezel*

THE REMOTE WINDING TEMPERATURE INDICATOR, designed for operation on Westinghouse Power Transformers and related apparatus, is used for automatic control of cooling fans by winding temperature and for winding temperature alarm. It is a dial type indicator operated by a Bourdon tube system. The indicator is mounted near eye level and the Bourdon tube is connected to the sensing bulb by a length of flexible, shielded capillary tubing. It is self-contained and weatherproof, designed for outdoor service.

The winding hot spot temperature rise above top oil is duplicated by a heating coil in a well in the hot oil, with the thermometer sensing bulb located in the center of the heating coil. Current through the heating coil is proportional to winding current, so the indicator is accurate at any load.

The indicator has two switches for automatic control of two stages of cooling equipment, plus one or two alarm switches.

## RECEIVING

### Shipment

The indicator is usually shipped in place on the transformer and requires no adjustment or maintenance.

If the indicator is shipped as a separate item, to be installed in the field, it should be carefully unpacked and installed as shown in Figure 3. **Particular care should be used not to bend the capillary tube at sharp angles or flex it unnecessarily during installation or in service.**

## DESCRIPTION

The Westinghouse winding temperature indicator system includes a temperature indicator and a heating coil assembly. A typical mounting arrangement is shown in Figure 3 and a typical circuit diagram is shown in Figure 4.




Effective January 1980 Supersedes I.L. 46-717-11B, July 1962

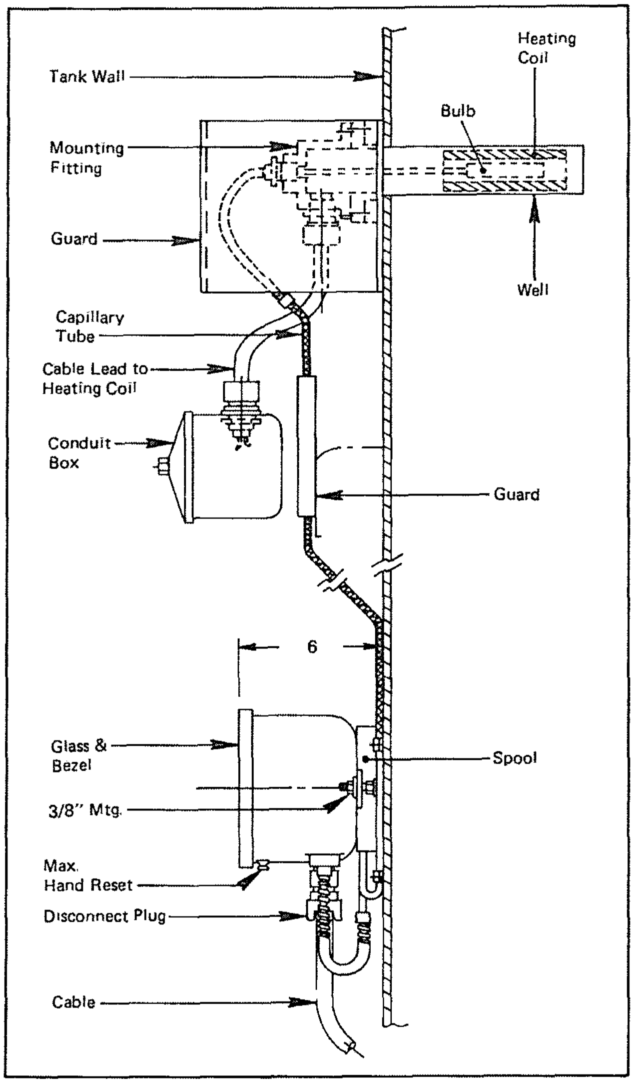



Fig. 3 *Typical Mounting Arrangement on Transformer Tank Wall*

## Heating Coil Assembly

The heating coil is mounted in a well located in the hot oil, below minimum oil level. The well is gasketed and bolted to a boss which is welded to the tank wall, making an oil tight connection. The heating coil slips into this well and is held in place by a mounting fitting which is gasketed and bolted to the flange of the well. Current through the heating coil comes from a current transformer - e.g., on a bushing - so the current is proportional to transformer load. Calibration is accomplished either by changing taps on the current transformer or by using a tapped autotransformer in the main control cabinet. Connections

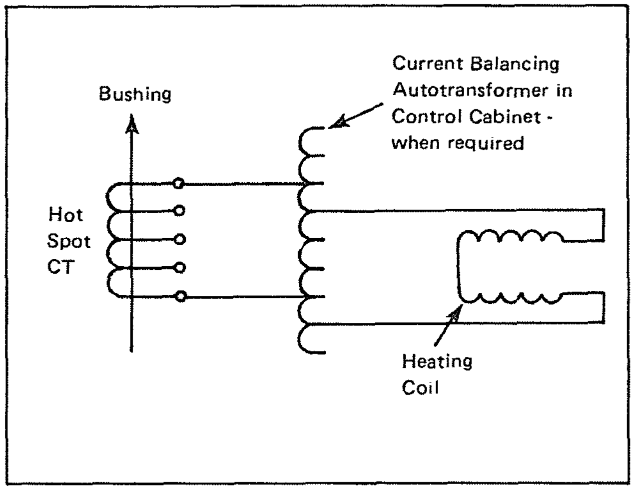



Fig. 4 *Schematic Diagram of Typical Heating Coil Circuit*

to the heating coil are made via a neoprene covered cable which enters the bottom of the mounting fitting.

**CAUTION: The secondary circuit of an energized current transformer must never be opened. Always short circuit the CT before disconnecting the heating coil.**

**NOTE: Do not add any solid or liquid material to the heating coil or well; that would destroy the calibration of the indicator.**

## Indicator

The indicator consists of a Bourdon tube connected through a capillary tube to a sensing bulb, which fits closely into the center of the heating coil described above. See Figure 3. The sensing bulb goes through the front opening in the mounting fitting, gasketed and held with a threaded fitting.

The capillary tube bend is protected against accidental damage by a guard where the bulb enters the well. The long capillary tube is protected by a flexible covering; it may also be protected by a metal channel in the vertical run between the well and the indicator. The capillary tube is supported at intervals so that long bends or spans are not free to vibrate, as this may cause failure of the tube. In many installations, excess capillary tubing may be coiled in a spool mounted directly behind the indicator at the tank wall.

The indicator dial is calibrated in degrees Centigrade and is easily read because of the contrasting black face with yellow characters, graduations and indicating pointer. The dial range is 20-180°C for the three-switch indicator and 0-220°C for the four-switch indicator.

Switch settings are shown by small pointers on the dial scale. A red maximum hand indicates the highest temperature reached since it was last reset. This hand can be easily reset by either unscrewing the reset cap and pulling down on the chain, or by pressing up on the reset button.

## Switches

The control and alarm switch connections are made through a disconnect plug on the bottom of the instrument case. The male half of the connector is sealed in the case, and the internal circuit diagram is shown by a decal on the side of the case. The female half of the connector is on a neoprene-jacketed flexible cable, wired into the transformer control circuits as shown on the transformer wiring diagram.

If the indicator should be removed from the transformer for shipment, the connection pins on the instrument will be covered by a plastic cap; the cable on the tank will be looped and tied and the plug connector will be protected by plastic.

There are three or four switches in this type of temperature indicator. Switch No. 1 is normally set at the factory to close at 70°C. Switch No. 2 would be set at 75°C. Switch No. 3, the alarm switch, is normally set at 117°C. If there is a fourth switch, its normal setting is 125°C. All switches will reopen when the temperature falls 6° to 10° below their closing temperature. Figure 5 shows the color coding at the cable end of the switch circuits.

The above switch settings are nominal values; these will be supplied unless other values are specified by the customer. The switch settings on this instrument may be easily changed in service to meet changing power system requirements in one of two ways, depending on the style of its bezel.

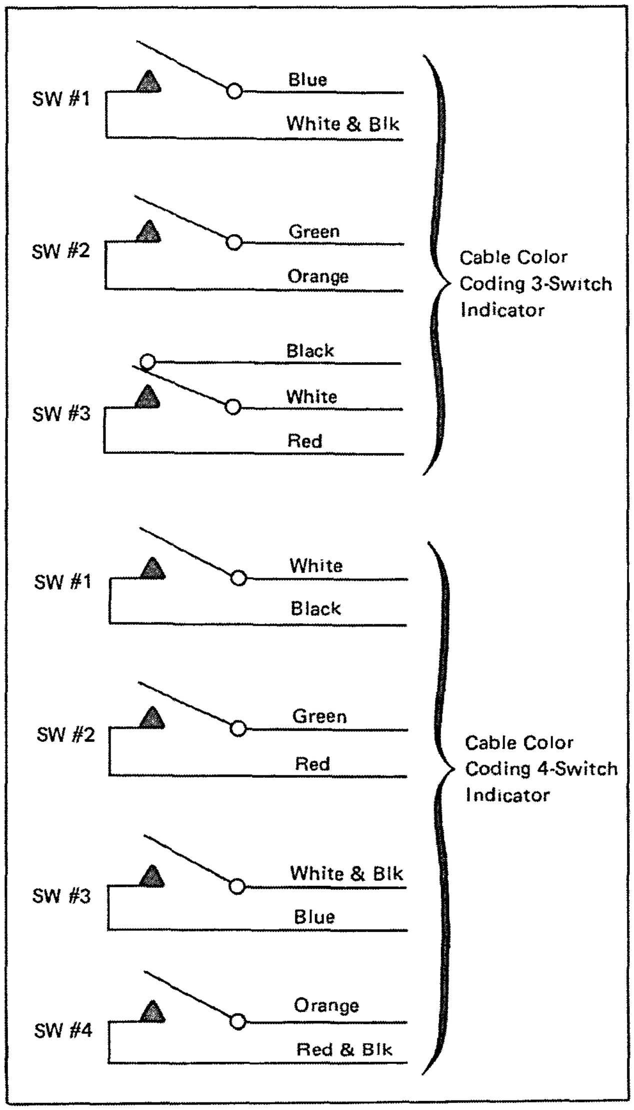



**Fig. 5** *Connection Diagram*

(a) If the glass is held in place by a clamping ring with a screw at the bottom of the dial: loosen the screw, remove glass and ring, loosen the screw in the dial slot which indicates switch setting and move it to the desired setting. Tighten the screw and reassemble glass and clamping ring.

(b) If the bezel is not split at the bottom and is not held in place by a screw, it is a twist-lock design: turn the bezel counterclockwise approximately 1/8 turn, remove glass and bezel, loosen knob at the dial slot which indicates switch setting and move it to the desired setting. Tighten the knob and reassemble glass and bezel.

These instruments are weatherproof but are not sealed; they will breathe through the vents provided in the bottom of the case.

## FIELD TEST

The indicator should not require calibration; however, it may be checked as follows:

Disconnect plug connector, remove bulb from the well, and remove capillary tube from tank wall. Submerge the bulb up to the brass fitting in a closely temperature controlled, well agitated oil bath. Hold oil temperature constant for at least 15 minutes. The indicator should be accurate within approximately 2% of full scale. It will hold its calibration unless the bulb or capillary tube is damaged and there is a loss of fluid.

**Table No. 1 - Switch Interrupting Ratings**

| Voltage | Non-Inductive Amperes | Inductive Load* Amperes |
|---|---|---|
| 125 AC | 10 | 10 |
| 250 AC | 5 | 5 |
| 48 DC | 1.0 | 0.10 |
| 125 DC | 0.5 | 0.05 |
| 250 DC | 0.25 | 0.025 |

* Ratio $\frac{L\ (\text{henrys})}{R\ (\text{ohms})} \leqq 0.026$

**IMPORTANT: When checking switch circuits through this instrument it is necessary to observe Table No. 1. Do not use a low voltage bell ringer. An indicating light device is recognized as best for checking circuits through instruments containing switches of similar rating.**

**NOTE: The instrument and heating coil system are calibrated with all of the transformer cooling equipment in operation. It will be less accurate when some of the fans or pumps are idle, as when the transformer is lightly loaded.**

If it is necessary to repair the instrument, contact the nearest Westinghouse Office. Complete instructions will be given for the return of the instrument to the factory at Sharon, Pa. to have it repaired or replaced.

**Westinghouse Electric Corporation**
Medium Power Transformer Division
Sharon, Pennsylvania 16146

Printed in U.S.A.
(T.P.)

# Instructions for Automatic Resetting Relief Device



The Automatic Resetting Relief Device, mounted on the transformer cover, is designed to relieve dangerous pressures which may build up within the transformer tank. When a predetermined pressure is exceeded, a pressure reaction lifts the diaphragm and vents the transformer tank.

Occasionally a fault under oil may result in a primary explosion. The wave front of pressure created is not as steep as that of a secondary explosion of hydrogen or acetylene and air above the oil, nor the results as violent. The abnormal pressure following an arc is often great enough to rupture the tank if a Relief Device has not been provided.

## DESCRIPTION

The construction of the Automatic Resetting Relief Device is shown in Figures 1 and 2. Its operating parts consist of a dome-shaped diaphragm, compression springs, gaskets, and protective cover.

The sturdy parts allow the Relief Device to operate numerous times without damage.

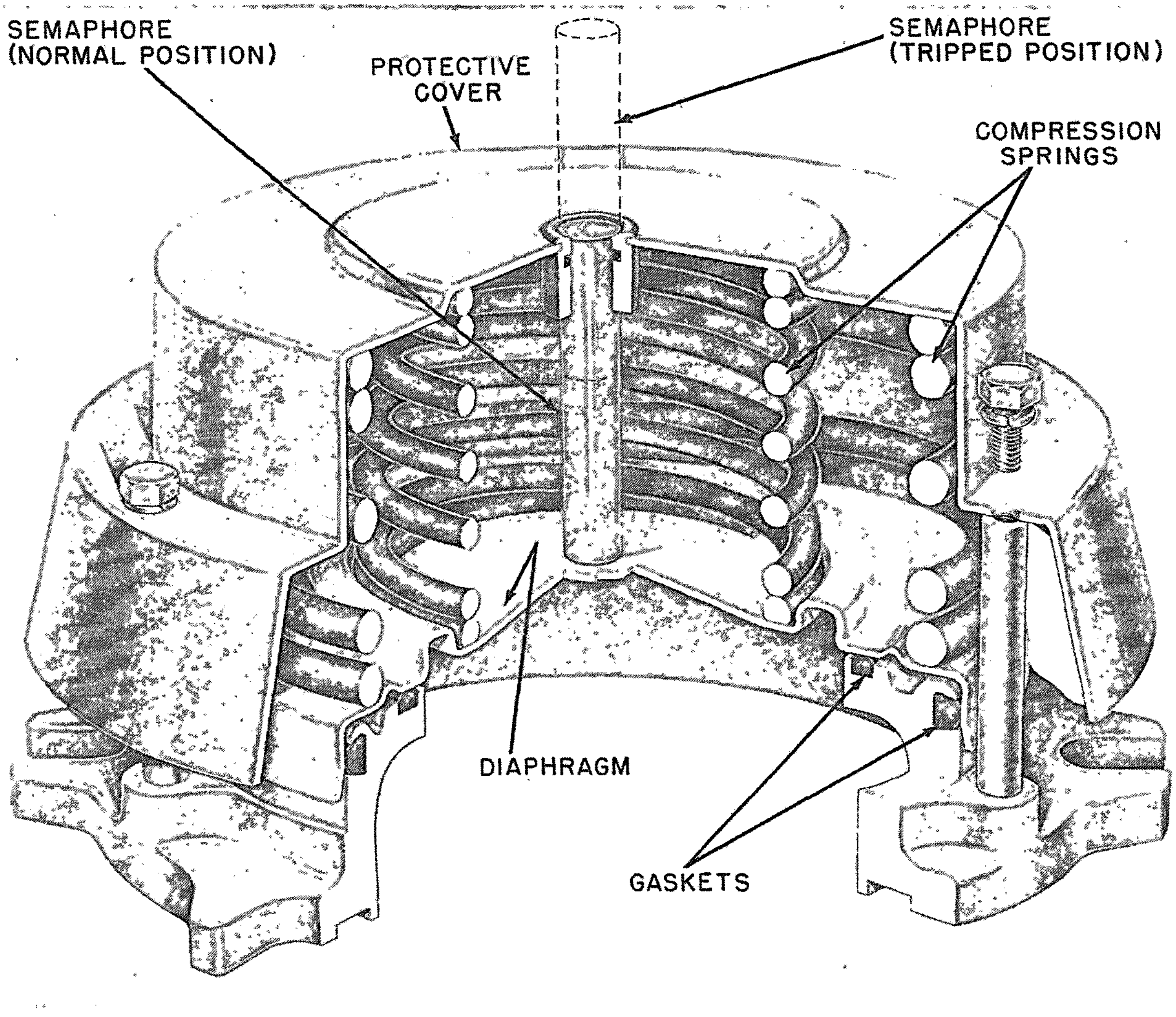



**Fig. 1** *Relief Device in Sealed Position*

Effective July, 1975 supersedes I.L. 48-065-4C, January, 1969

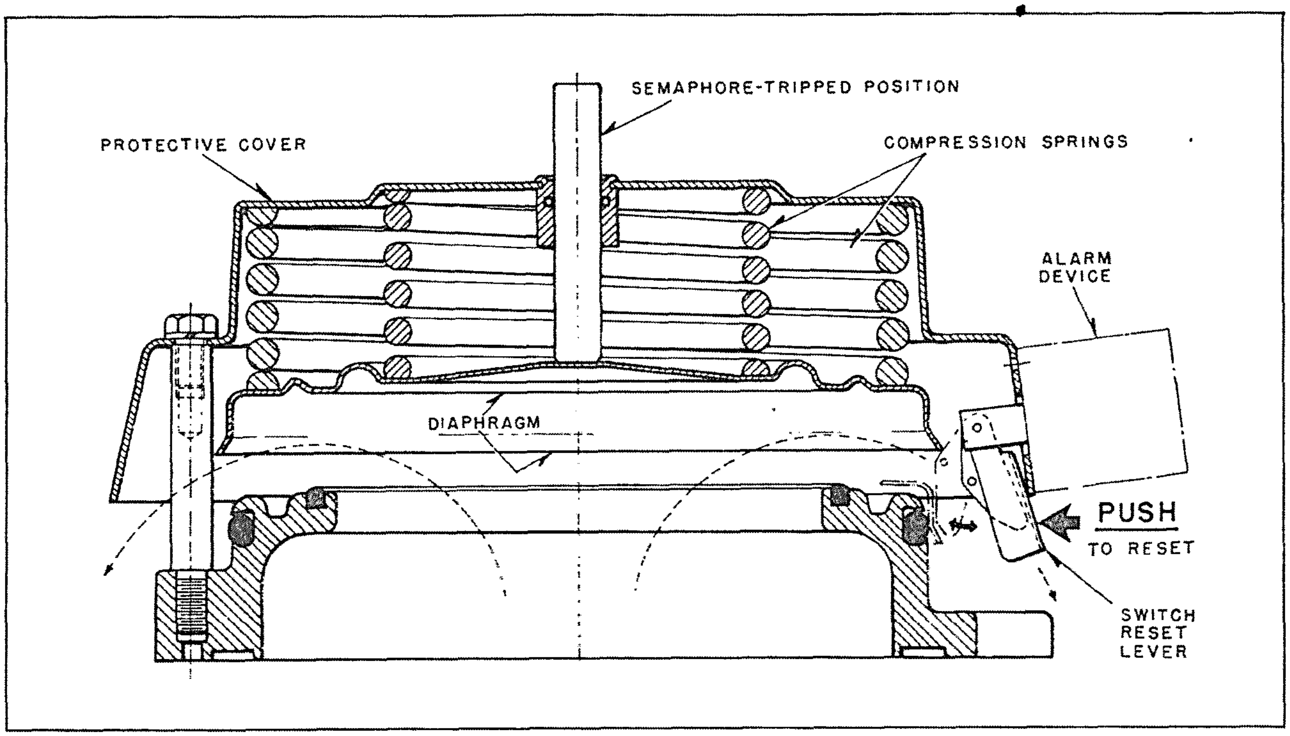



**Fig. 2** *Relief Device in Maximum Venting Position*

## SIGNALS

The Relief Device is equipped with a lightweight, plastic semaphore which rests upon the diaphragm before operation. (Figure 1) When the diaphragm rises during operation, it lifts the semaphore into view and indicates the Relief Device has operated. Alarm contacts can also be supplied to indicate the unit has operated.

When electrical alarm contacts are ordered, the alarm device is mounted on the side of the cover. The alarm device incorporates a double throw microswitch. The button of this switch is depressed to open a normally closed circuit for the untripped position of Relief Device. When Relief Device operates, movement of the diaphragm releases the button on the switch and the switch transfers back to the normally closed circuit. (Figure 2) Closing this circuit actuates the alarm. (Figure 3) The switch ratings appear in Table 1.

## OPERATION

The mechanism is shown in the sealed position in Figure 1. Figure 2 shows maximum venting position.

When the pressure in the tank rises above normal to tripping pressure of 10±1 psi, the diaphragm lifts slightly, exhausting into the space between the outer ring and the body of the Relief Device. The tank pressure thus spreads over the entire diaphragm area, which is twice the area of the center section, causing the device to open rapidly and remain open until the pressure within the tank falls well below the tripping pressure. This differential between tripping and closing pressures assures positive sealing upon closure.

The Relief Device resets itself and reseals when the pressure in the gas space has fallen to approximately one-half the tripping pressure.

The Relief Device hasn't any moving parts during normal transformer conditions. Operation of the Relief Device occurs only under excess pressure. Diaphragm travel, which is limited by compression springs in the protective cover, serves to lift the semaphore and operate the alarm device if one is attached.

After operation it is unnecessary to reset the Relief Device but the semaphore and alarm device should be reset as soon as convenient.

Resetting is accomplished by pushing the semaphore down until it is flush with the top of the cover. The alarm switch is reset by pushing in the switch reset lever to its limit (see Figure 2.)

## IMPORTANT

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.

Relays, solenoids, and motors are inductive loads. When an inductive circuit is opened, a voltage is inducted in the circuit tending to maintain current flow. The resultant arcing causes severe contact duty and may result in failure of the contacts to interrupt current.

When checking circuits through this device, it is necessary to follow Table 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing microswitches or similar switches.

**Table 1**
**Switch Interrupting Ratings**

| Voltage | Non-Inductive Load-Amps. | Inductive Load-Amps. L/R = .026* |
|---|---|---|
| 125 A-C | 10 | 10 |
| 250 A-C | 5 | 5 |
| 125 D-C | 0.5 | 0.05 |
| 250 D-C | 0.25 | 0.025 |

* Equal to or less than .026. If greater, refer to factory for adjusted rating.

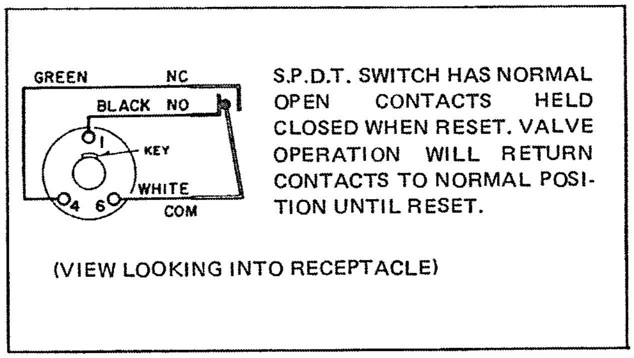



**Fig. 3** *Alarm Device Wiring Diagram*

## MAINTENANCE

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 is to be replaced, remove the old gasket and clean out the gasket recess in the relief device. Replace with a nitrile gasket S#4340D99H03. No cement is required.

Keep spare gasket on hand. For additional parts, order from the nearest Westinghouse Office, giving the serial and stock order number of the complete transformer as stamped on the nameplate.

## CAUTION

Should disassembly of the Relief Device be necessary, caution must be exercised when removing the protective cover because the springs are under compression.

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Westinghouse • Sharon Transformer Division • Sharon, Pennsylvania

Printed in U.S.A. (W.P.D.)

DESCRIPTION INSTALLATION

# INSTRUCTIONS

## LIQUID LEVEL INDICATORS
### Magnetic Type

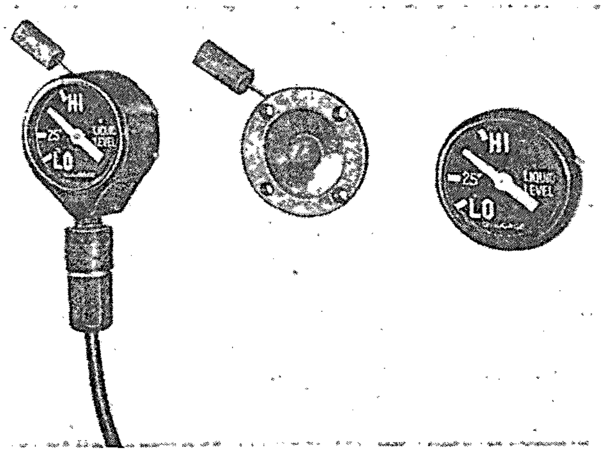



FIG. 1. Bezel with Alarm (left); Body with Float and Rod at Back (center); Bezel without Alarm Contacts.

MAGNETIC TYPE LIQUID LEVEL INDICATORS, designed for application on Westinghouse transformers or related apparatus, are self-contained, indicating, weatherproof, submersible, shockproof, float operated instruments suitable for use with oil or Inerteen.

Liquid level indicators with alarm contacts are available in either of two sizes. These contacts will operate a bell circuit, light, or small relay system. Liquid level indicators are usually shipped mounted on the transformer case, or equipment, and require no maintenance.

### DESCRIPTION

These indicators are precision instruments composed of two main parts, the bezel and the body. See Figure 1. The bezel or outer assembly, includes the calibrated dial and indicating needle. It is hermetically sealed and should not be subjected to a vacuum since the internal pressure might break the glass. The dial is black with yellow markings for high visibility. The yellow indicating needle is directly mounted on the forward end of a shaft, the other end of which carries a powerful actuating magnet. The bezel-when in place, covers and protects the mounting screws with which the body is attached to the flange or boss on the transformer tank or equipment.

The body is sealed against oil leakage and encloses a second powerful magnet opposite the magnet in the bezel. The magnet in the body is mounted on a shaft coupled to the float arm. See Figure 2. In operation the motion of the float arm rotates the body magnet which in turn positively displaces the bezel magnet to which the indicating needle is attached.

In indicators having alarm contacts, a microswitch enclosed in the bezel is actuated at a predetermined position by the motion of the needle shaft. Microswitch ratings are given in Table 1.

**Important:** When checking circuits through this instrument, it is necessary to follow Table 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing microswitches with ratings similar to those of these devices.

While complete instruments with or without alarm 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

**TABLE NO. 1**

| VOLTAGE | NON-INDUCTIVE LOAD—AMPS. | INDUCTIVE LOAD AMPS.* |
|---|---|---|
| 125 AC | 10 | 10 |
| 250 AC | 5 | 5 |
| 125 DC | 0.5 | 0.05 |
| 250 DC | 0.25 | 0.025 |

* L/R equal to or less than .026".
L = Inductive in henrys
R = Resistance in ohms

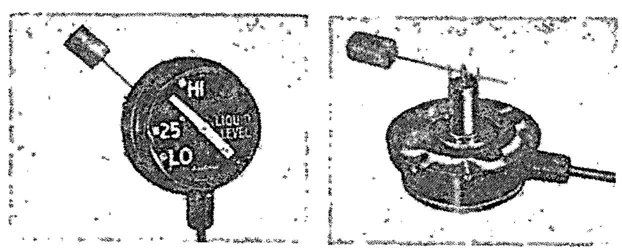



FIG. 2. Front and Rear of Medium Size Gauge with Float

Supersedes I.L. 46-714-3E

FEBRUARY, 1964

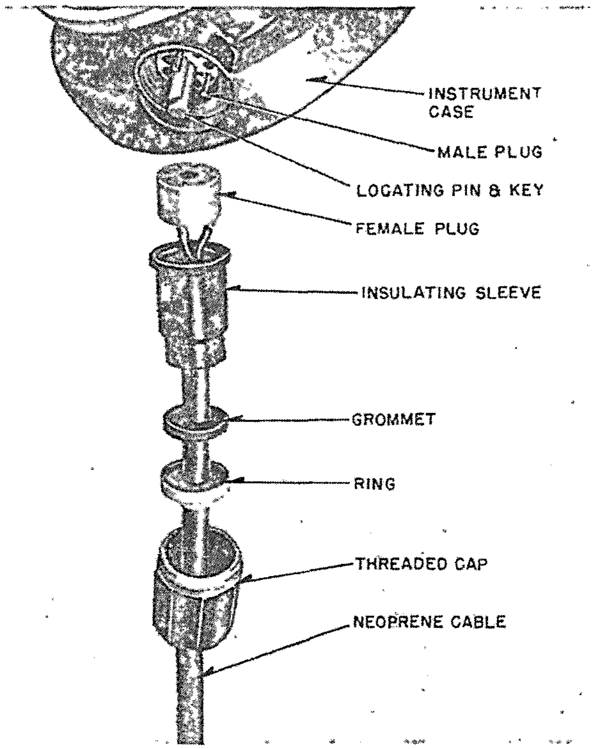



FIG. 3. Triple Seal Connector

must be used in the body of an instrument when alarm contacts are used in the bezel.

Alarm leads are brought through the under side of the bezel by means of a triple seal connector, Figure 3, which consists of the following:

**1.** The male terminals are moulded into the case together with a keyed locating pin which prevents making incorrect connections.

**2.** The rubber female plug has terminals to mate with the terminals in the case and a keyed hole to match the locating pin. The ends of the leads are tinned and crimped into the terminals of the female plug.

**3.** An insulating sleeve to press the female plug against the male plug.

**4.** A grommet to make a seal between the rubber cable and the bushing.

**5.** A ring to compress the grommet against the cable.

**6.** A threaded cap to hold the component parts of the connector tight in the case.

The connection diagram for this liquid level indicator is shown in Figure 4.

For indicators 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 the Table No. 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 or excessive breathing may be produced in Inertaire units causing a high rate of loss of nitrogen, or the low level alarm may be caused to operate unnecessarily due to the incorrect amount of liquid in the tank. If any part of the instrument is damaged, the bezel may be replaced without disturbing the rest of the instrument and without loss of oil.

## INSTALLATION

Instruments are usually shipped in place. 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 red gasket cement (S# 1150419, black can or S# 471880, white can). Allow to dry for 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. Put the bezel in place and tighten the holding screws on the sides. If alarm contacts are used make proper connections to the conduit box.

**Important:** When checking circuits through this instrument it is necessary to follow Table No. 1.

## RENEWAL PARTS

If repairs to the instrument are necessary, contact the nearest Westinghouse Office.

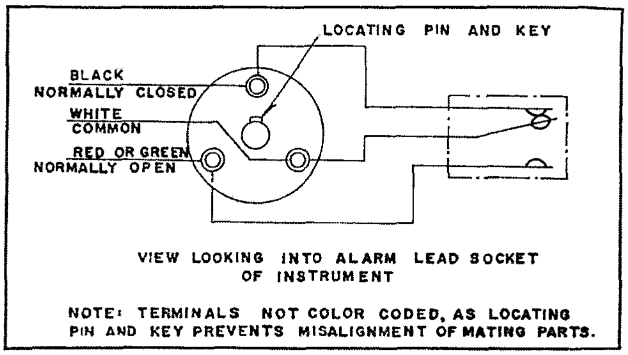



FIG. 4. Connection Diagram for Alarm Leads

## TABLE NO. 2

| 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 |

# Instructions for Junction Block, Cast Resin Type for Oil Apparatus



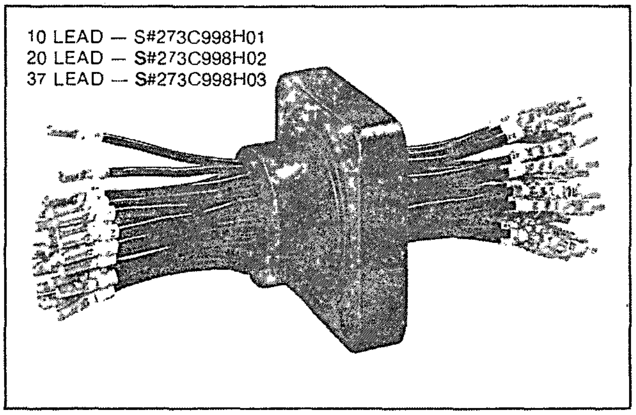



*Fig. 1 Junction Block (37 lead)*

The Westinghouse Cast Resin Junction Block used for oil apparatus only, brings current and/ or potential transformer leads through the tank wall or cover.

The device consists of 10, 20, or 37 leads passing through a solid cast resin flange. The leads are provided with an internal metal seal which bonds the wire strands. This seal is then encapsulated in the resin flange.

Each lead of the junction block is insulated and provided with a captive screw disconnect terminal S#593A907H02 on the air end of the lead, and a crimp connector S#16D3067H11 on the liquid end of the lead. Identification markers on each end of each lead make it unnecessary to ring out the wire before making the connection.

## External Wiring Connection Procedure

(1) Bring ends of external wires into the block housing. Spread out and position the wires with regard to terminal markings so as to obtain a neat, orderly assembly when complete. Cut each wire as needed to the correct length.

(2) Pick out the correct lead by means of the numerical marker.

(3) Slip the insulating sleeve back onto the insulated wire.

(4) On wires being attached to the liquid end of the junction block leads (internal), trim the insulation on the wires back 7/16 inches. Insert wires in the crimp connectors and crimp with E.T.C. Model No. RHT 1050 hand crimper. Pneumatic Tool Model No. 69010
using Amp. Hd. No. 300583 may also be used.

(5) On wires being attached to the air end of the junction block leads (external), trim the insulation back 7/16 inches. Insert wires into the barrel of the screw type connector (S#593A907H01) shipped detail, and crimp using E.T.C. Model No. RHT 1050 hand crimper. Pneumatic Tool Model No. 69010 using Amp. Hd. No. 300583 may also be used.

**NOTE: For junction blocks supplied with special request insulated connector S#591B301H13, use Amp Tool Model No. 59239-4.**

(6) Connect the captive screw terminals.

(7) Slip insulating sleeve back over both halves of all connections.

Unused leads or connectors should have the connectors left on and the insulating sleeve drawn down over the connectors.

Terminals which must be grounded during test, may be disconnected from their normal connection and connected to a captive screw terminal crimped onto a ground wire. If more than one lead must be connected to ground at one time, use #15 or #16 cable as ground lead and make as many stubs as needed for connectors by doubling sections of the cable back on itself (See Fig. 4).

**NOTE:** Limited flexing of leads is permitted during installation of junction blocks when ambient temperature conditions are below 20 degrees Fahrenheit to avoid the possibility of cracking the wire insulation. If installation flexing of leads must be done below 20 degrees Fahrenheit, the use of a heat lamp to keep the leads warm during connecting operations is recommended. Once installed, the junction block is capable of sustaining temperatures of +230 degrees Fahrenheit to −65 degrees Fahrenheit.

Effective April, 1973 Supersedes I. L. 47-069-9B, October, 1972

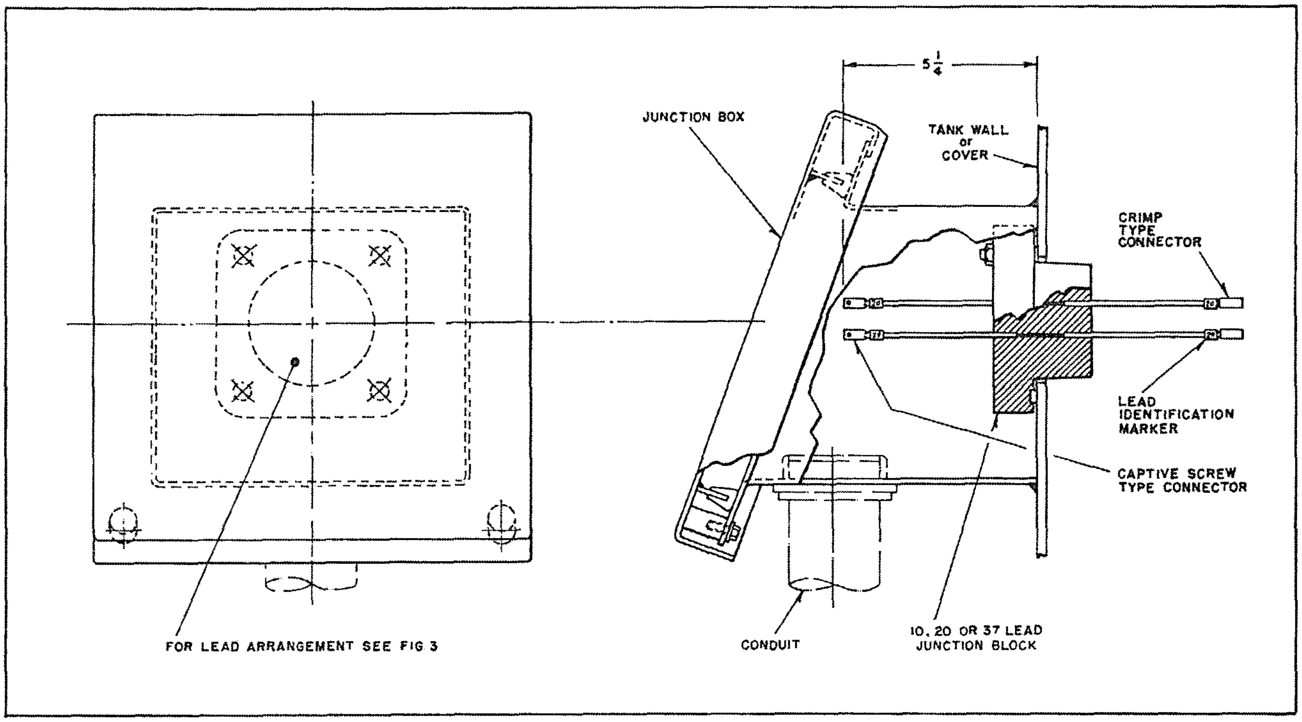



*Fig. 2 Junction Block Housing*

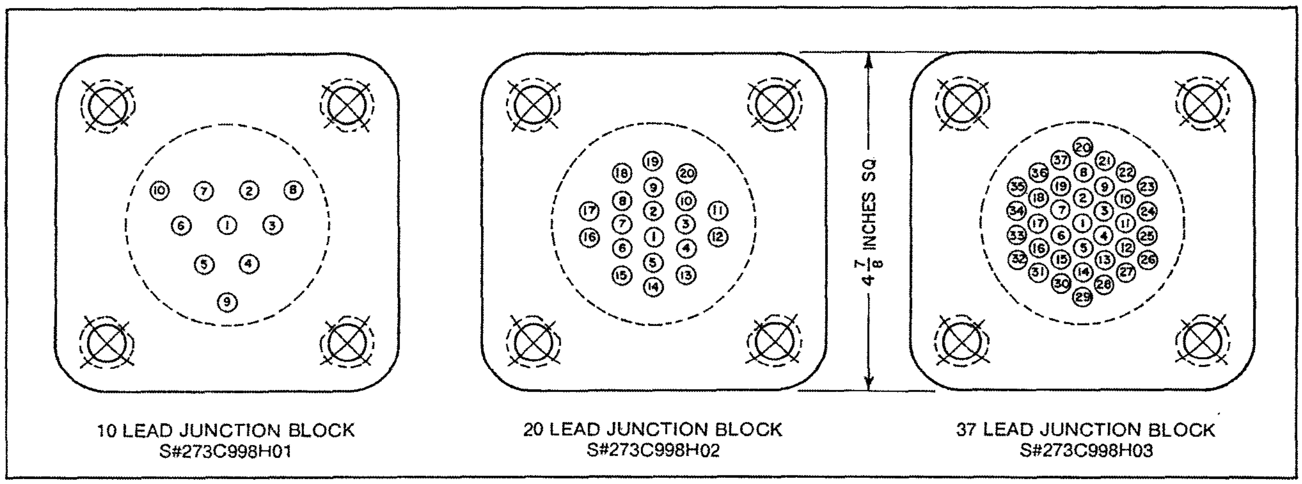



*Fig. 3 Lead Arrangement of Junction Blocks (front view)*

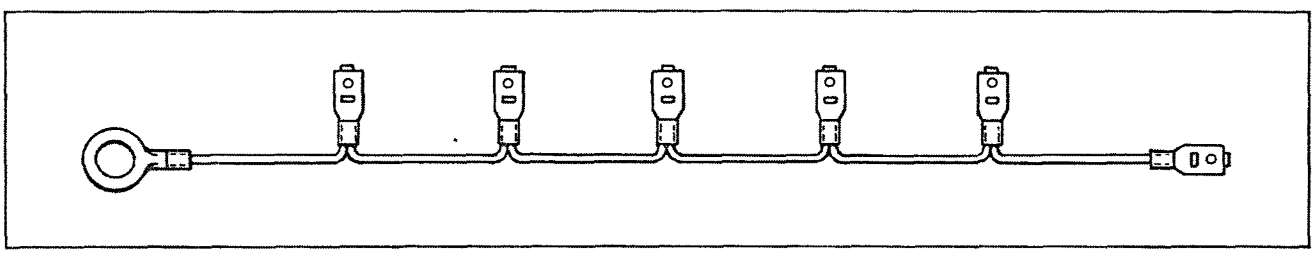


*Fig. 4 Hook-up for Ground Connections*

# Instructions for Accuracy Standards for Current Transformers



## ACCURACY CLASSES FOR METERING SERVICE

The accuracy classification of current transformers for metering service includes a correlation between ratio correction factor and phase angle so as to show the overall effect on watthour meter registration. The classification is based on the requirement that the transformer correction factor (the correction for overall error due to both ratio error and phase angle) be within the limits specified in Table 3. For any particular accuracy class the ratio correction factor and phase angle must fall within the parallelograms of Fig. 2 for 100% and 10% current respectively to keep the transformer correction factor within the limits specified in Table 3.

**Table 1**
METERING ACCURACY CLASSIFICATION

The line numbers are ASA standard accuracy classes for metering (60 cycles).

| LINE NUMBER | ACCURACY AT BURDEN | | | |
|---|---|---|---|---|
| | B-0.1 | B-0.2 | B-0.5 | B-2.0* |
| 1 | 0.3 | 0.3 | 0.3 | 0.3 |
| 2 | 0.3 | 0.3 | 0.3 | 0.6 |
| 3 | 0.3 | 0.3 | 0.3 | 1.2 |
| 4 | 0.3 | 0.3 | 0.3 | ... |
| 5 | 0.3 | 0.3 | 0.6 | 0.6 |
| 6 | 0.3 | 0.3 | 0.6 | 1.2 |
| 7 | 0.3 | 0.3 | 0.6 | ... |
| 8 | 0.3 | 0.3 | 1.2 | 1.2 |
| 9 | 0.3 | 0.3 | 1.2 | ... |
| 10 | 0.3 | 0.3 | ... | .. |
| 11 | 0.3 | 0.6 | 0.6 | 0.6 |
| 12 | 0.3 | 0.6 | 0.6 | 1.2 |
| 13 | 0.3 | 0.6 | 0.6 | . |
| 14 | 0.3 | 0.6 | 1.2 | 1.2 |
| 15 | 0.3 | 0.6 | 1.2 | ... |
| 16 | 0.3 | 0.6 | .. | . |
| 17 | 0.3 | 1.2 | 1.2 | 1.2 |
| 18 | 0.3 | 1.2 | 1.2 | |
| 19 | 0.3 | 1.2 | ... | ... |
| 20 | 0.3 | ... | ... | ... |
| 21 | 0.6 | 0.6 | 0.6 | 0.6 |
| 22 | 0.6 | 0.6 | 0.6 | 1.2 |
| 23 | 0.6 | 0.6 | 0.6 | ... |
| 24 | 0.6 | 0.6 | 1.2 | 1.2 |
| 25 | 0.6 | 0.6 | 1.2 | . . |
| 26 | 0.6 | 0.6 | ... | . |
| 27 | 0.6 | 1.2 | 1.2 | 1.2 |
| 28 | 0.6 | 1.2 | 1.2 | . |
| 29 | 0.6 | 1.2 | ... | ... |
| 30 | 0.6 | ... | ... | .. |
| 31 | 1.2 | 1.2 | 1.2 | 1.2 |
| 32 | 1.2 | 1.2 | 1.2 | ... |
| 33 | 1.2 | 1.2 | ... | .. |
| 34 | 1.2 | ... | ... | ... |
| 35 | 0.5 | 0.5 | ... | ... |

* Not ASA standard metering burden.
NOTE: A single line in the table defines the accuracy classes at four burdens.

For example, the overall correction will never exceed .3% at 100% rated current for a transformer in the 0.3 accuracy class. If the ratio correction factor is 1.003 the maximum allowable phase angle, from Fig. 2, is + 15.6 minutes. The transformer correction factor is:

$$\begin{aligned} TCF &= RCF - \frac{\beta}{2600} \\ &= 1.003 - \frac{15.6}{2600} \\ &= .997 \end{aligned}$$

The corresponding ratio correction factor and phase angle for any point inside the 0.3 class parallelogram for 100% rated current will always give a transformer correciton factor between .997 and 1.003.

## ACCURACY CLASSES FOR RELAYING SERVICE

Two classes of error are permissible, 2.5% or 10%, as the operator chooses. The accuracy may then be designated, for instance, as 2.5 H 100. The 2.5 means 2.5% maximum error; the 100 means that the transformer can supply at least 100 volts to the burden without exceeding the error. The 100 volts can be the product of a high burden and a high current. Examples are:

A high burden, 4 ohms at 25 amperes (5 times normal) gives 100 volts; a low burden, 1 ohm at 100 amperes (20 times normal) gives 100 volts, or any intermediate burden and current, 2 ohms at 50 amperes which also gives 100 volts.

Effective January, 1963 Supersedes I.L. 44-060-1, March, 1955

The application engineer uses the standard in this way:

If the actual burden is 3 ohms, and he must have accuracy up to 60 amperes (12 times normal), the necessary voltage is 3 x 60 = 180. Therefore, a 200 class transformer is required.

**Table 2**

RELAYING ACCURACY CLASSIFICATION

| LINE NUMBER | % ERROR CLASS 10H | 2.5H | LINE NUMBER | % ERROR CLASS 10H | 2.5H |
|---|---|---|---|---|---|
| A | 10 | .. | J | 100 | 100 |
| B | 10 | 10 | K | 200 | 50 |
| C | 20 | . | L | 200 | 100 |
| D | 20 | 10 | M | 200 | 200 |
| E | 20 | 20 | N | 400 | 100 |
| F | 50 | .. | O | 400 | 200 |
| G | 50 | 50 | P | 400 | 400 |
| H | 100 | .. | Q | 800 | 200 |
| I | 100 | 50 | R | 800 | 400 |
| | | | S | 800 | 800 |

NOTE: The numbers in the table are the ASA standard (60-cycle) H volts classification.

He can choose either 2.5% or 10% as required for the application; he would specify either 2.5 H 200 or 10 H 200 class accuracy.

This standard does not apply below 5 times nor above 20 times normal secondary current.

## THERMAL SHORT TIME CURRENT RATING

The thermal short-time current rating is the RMS symmetrical primary current that may be carried for 1 second. The thermal rating for any time up to 5 seconds may be determined from the 1 second rating by dividing by the square root of the specified number of seconds.

## MECHANICAL SHORT TIME CURRENT RATING

The mechanical short-time current rating is the RMS value of the a-c component of a completely displaced primary current wave which the transformer is capable of withstanding with the secondary short circuited.

## CONTINUOUS THERMAL-CURRENT RATING FACTOR FOR CURRENT TRANSFORMERS

This is the factor by which the rated primary current is multiplied to obtain the maximum allowable continuous primary current based on temperature rise and a 30 C ambient temperature application. Curves of Fig. 1 may be used to determine the percentage of rated primary current that can be carried at any ambient.

All Westinghouse transformers that are suitable for operation at full rated current in a 55 C ambient are so marked. A sample nameplate marking is as follows:

Standard Ambient
55 C
RF 30 C = 1.33

This information shows at a glance that the transformer can be operated at full rated current in a 55 C ambient. In addition the rating factor shows that the transformer can be operated at 1.33 times rated current in a 30 C ambient.

The rating factor on the nameplate applies only for 30 C ambient. To find the multiplier at any ambient, refer to the curves of Fig. 1. For example, if a transformer with a rating factor of 2.0 is to be applied in a 50 C ambient (from the curve for 2.0 rating factor), the transformer can carry 1.6 times rated primary current continuously in this ambient.

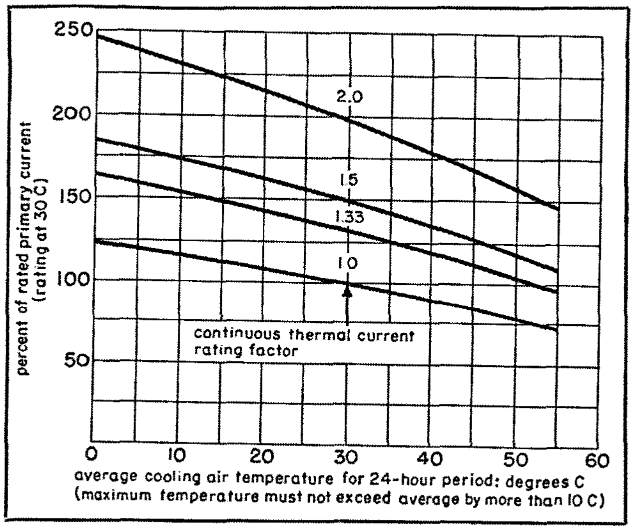



FIG. 1. Basic Loading Characteristics

## NAMEPLATE MARKING

According to ASA Standard C57.13, Par. 13-17.750 the manufacturer shall specify on the nameplate a reference to a data sheet or instruction book which will give such information as thermal short-time and mechanical short-time current ratings, accuracy classifications, application data, or any other information of general use in the application of current transformers. Therefore, on the trans-

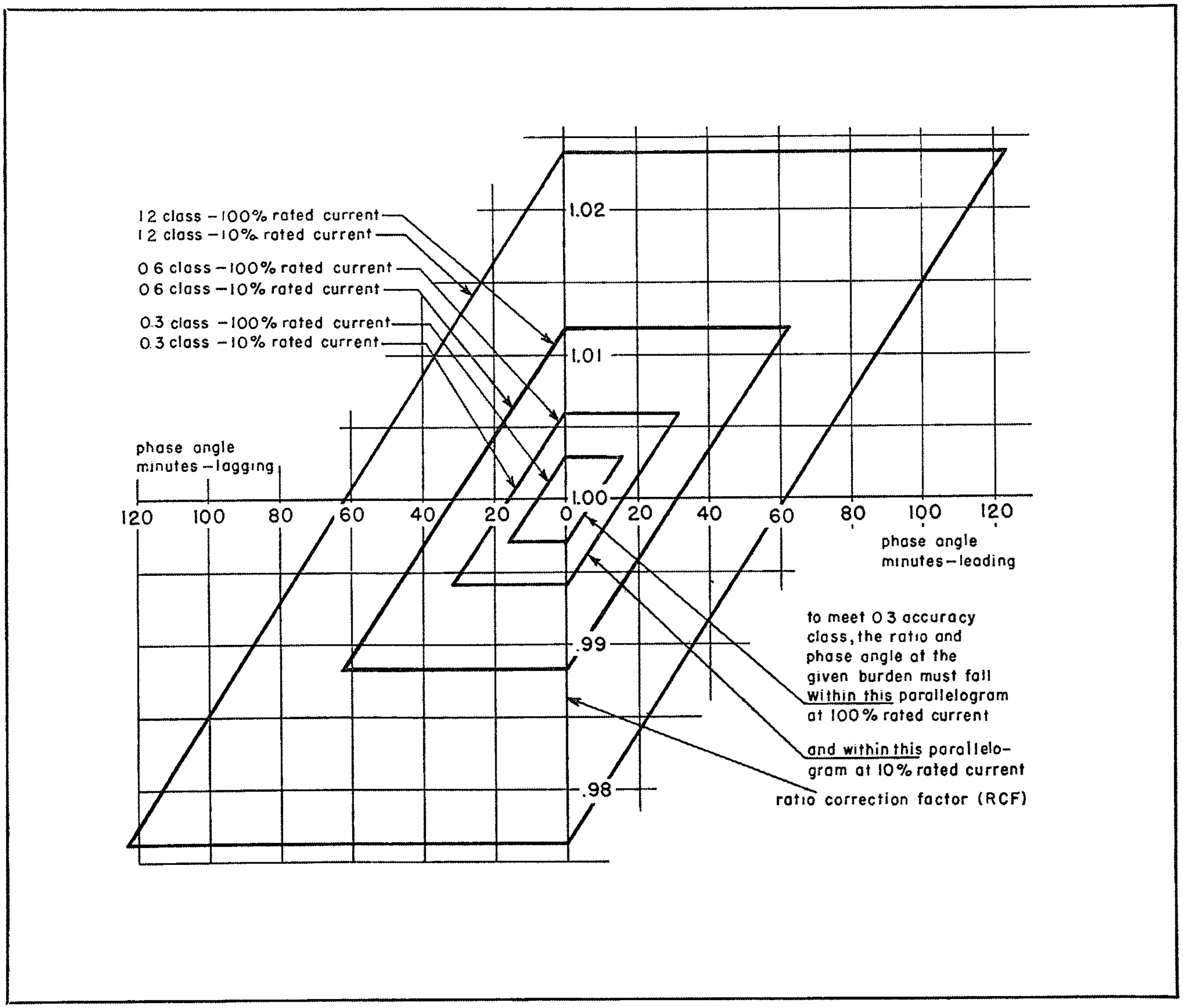



FIG. 2. Equivalent Parallelogram

**Table 3**

**LIMITS OF TRANSFORMER CORRECTION FACTOR (TCF)**

| ACCURACY CLASS | 100% RATED CURRENT | | 10% RATED CURRENT | | LIMITS OF POWER FACTOR OF METERED LOAD (LAGGING) | |
|---|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. |
| 1.2 | .988 | 1.012 | .976 | 1.024 | 0.6 | 1.0 |
| 0.6 | .994 | 1.006 | .988 | 1.012 | 0.6 | 1.0 |
| 0.3 | .997 | 1.003 | .994 | 1.006 | 0.6 | 1.0 |
| 0.5 | .995 ❙ | 1.005 ❙ | .995 | 1.005 | 0.6 | 1.0 |

❙ These values also apply to 150 percent rated current.

former nameplate a line number from Table 1 specifies metering accuracy; a line number from Table 2 specifies relaying accuracy; and two numbers followed by M and T designate respectively the mechanical and thermal limits in number of times rated current. An example designation is:

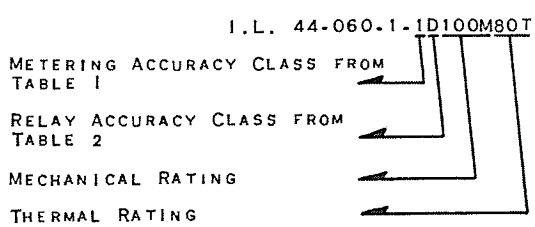


**Table 4**

STANDARD BURDENS FOR STANDARD 5-AMPERE SECONDARY CURRENT TRANSFORMERS

| STANDARD BURDEN CHARACTERISTICS | | | IMPEDANCE, POWER FACTOR AND VOLT-AMPERE STANDARD SECONDARY BURDENS | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | FOR 60-CYCLE AND 5-AMPERE SECONDARY CURRENT | | | FOR 25-CYCLE AND 5-AMPERE SECONDARY CURRENT | | |
| BURDEN DESIGNATION | RESISTANCE: OHMS | INDUCTANCE: MILLIHENRYS | IMPEDANCE: OHMS | VOLT-AMPERES[a] | POWER FACTOR | IMPEDANCE: OHMS | VOLT-AMPERES[a] | POWER FACTOR |
| B-0.1 | 0.09 | 0.116 | 0.1 | 2.5 | 0.9 | 0.0918 | 2.3 | 0.98 |
| B-0.2 | 0.18 | 0.232 | 0.2 | 5.0 | 0.9 | 0.1836 | 4.6 | 0.98 |
| B-0.5 | 0.45 | 0.580 | 0.5 | 12.5 | 0.9 | 0.4590 | 11.5 | 0.98 |
| B-1 | 0.5 | 2.3 | 1.0 | 25 | 0.5 | 0.617 | 15.4 | 0.81 |
| B-2 | 1.0 | 4.6 | 2.0 | 50 | 0.5 | 1.234 | 30.8 | 0.81 |
| B-4 | 2.0 | 9.2 | 4.0 | 100 | 0.5 | 2.468 | 61.6 | 0.81 |
| B-8 | 4.0 | 18.4 | 8.0 | 200 | 0.5 | 4.936 | 123.2 | 0.81 |

[a] The burden may also be designated by means of the volt-ampere characteristic: 25 volt-amperes at 5 amperes or 50 volt-amperes at 5 amperes.

NOTE: Burdens for other frequencies shall have the same values of resistance and inductance as those given in this table.
Standard burdens for metering applications are B-0.1, B-0.2 and B-0.5.
Standard burdens for relaying applications are B-1, B-2, B-4 and B-8.

NOTE: For current transformers having nonstandard secondary current, corresponding nonstandard burdens where needed may be derived from the standard burdens in proportion to the square of the ratio of the 5-ampere current to the nonstandard current.

TRANSFORMER RENEWAL PARTS DATA

| INSTR. BOOK | |
|---|---|
| Contr. No. | date Recd. |
| 23646 | 9-16-81 |
| BPA Book No. | Copy |
| IB- 7-1 | |
| Item | BPA Equip. No. (SER) |
| 7 | T-1635 |

WESTINGHOUSE ELECTRIC CORP., SHARON, PA. 16146

TRANSFORMER RENEWAL PARTS DATA

CUSTOMER BONNEVILLE P

1 - TRANSF 3 PHASE 25000 KVA

CLASS OA/FA/FOA OR OA/FA/FA

115 H.V. KV

| GENERAL ORDER | CUSTOMER ORDER | SHOP ORDER |
|---|---|---|
| PO88519 | AC7981BP23646 | RCS2416 |

THE FOLLOWING PARTS ARE MOST SUBJECT TO WEAR IN ORDINARY OPERATION:

| NAME OF PART | PART NUMBER | UNIT QTY |
|---|---|---|
| BREAKER | 8610D13H07 | 1 |
| BREAKER | 8610D13H12 | 1 |
| BREAKER | 8610D13H03 | 1 |
| BREAKER | 8610D13H12 | 1 |
| CONTACTOR (CAT-A201K1CW) | 276A134G08 | 1 |
| CONTACTOR (CAT-A201K1CW) | 276A134G08 | 1 |
| PB RELAY | 464C283H04 | 1 |
| PB RELAY | 464C283H04 | 1 |
| SWITCH ASSEMBLY - FOA CONTROL PANEL | 231C296M03 | 1 |
| TOGGLE SWITCH (DP-DT) | 464C476H09 | 2 |
| TOGGLE SWITCH (DP-DT) | 464C476H06 | 1 |
| NLTC PACKING | 272C560H02 | 1 |
| NLTC O RING (.6ID X 1.2OD 71070CA) | 00 | 1 |
| WCA TAP CHANGER MOUNTING GASKET | 4340D99H01 | 1 |
| JUNCTION BOX TERMINAL BLOCK | 273C998G02 | 1 |
| JUNCTION BOX TERMINAL BLOCK GASKET | 4340D99H75 | 1 |
| FLUID GAGE | 7663077M03 | 1 |
| FLUID GAGE MOUNTING GASKET | 4340D99H55 | 1 |
| HOT OIL THERMOMETER | 8707D96H01 | 1 |
| HOT SPOT ASSEMBLY | 1355C18C02 | 1 |
| INDICATOR | 8707D98H01 | 1 |
| HEATING COIL | 469C356G03 | 1 |
| HEATING COIL GASKET | 4340D99H68 | 1 |
| WELL GASKET | 4340D99H58 | 1 |
| HIGH VOLTAGE BUSHING ASSEMBLY | 6783D33G01 | 3 |
| HV BUSHING MOUNTING GASKET | 4340D99H05 | 3 |
| HV BUSHING CAP GASKET | 4340D99H31 | 3 |
| LOW VOLTAGE BUSHING ASSEMBLY | 234C116G05 | 4 |
| LV BUSHING MOUNTING GASKET | 4340D99H11 | 4 |

DATE 09/02/81

WESTINGHOUSE ELECTRIC CORP., SHARON, PA. 16146

TRANSFORMER RENEWAL PARTS DATA

CUSTOMER BONNEVILLE P

1 - TRANSF 3 PHASE 25000 KVA

CLASS OA/FA/FOA OR OA/FA/FA

115 H.V. KV

| GENERAL ORDER | CUSTOMER ORDER | SHOP ORDER |
|---|---|---|
| P088519 | AC7981BP23646 | RCS2416 |

THE FOLLOWING PARTS ARE MOST SUBJECT TO WEAR IN ORDINARY OPERATION:

| NAME OF PART | PART NUMBER | UNIT QTY |
|---|---|---|
| 20 INCH MANHOLE COVER GASKET | 4340D99H60 | 1 |
| 24 INCH MANHOLE COVER GASKET | 4340D99H61 | 1 |
| RELIEF DEVICE ASSEMBLY | 2430123G02 | 1 |
| RELIEF DEVICE MOUNTING GASKET | 4340D99H52 | 1 |
| GASKET CEMENT | 2790A23H01 | 3 |
| INERTAIRE ASSEMBLY | 7739D73G02 | 1 |
| SUMP-GAUGE-SWITCH ASSEMBLY | 224C648C13 | 1 |
| BREATHER SUMP | 780C851G01 | 1 |
| PRESSURE VACUMM GAUGE | 5868954H01 | 1 |
| VACUMM SWITCH | 1330C86H06 | 1 |
| PRESSURE SWITCH | 1330C86H16 | 1 |
| PRESSURE REDUCTION UNIT | 1331C07G02 | 1 |
| PRESSURE RELIEF VALVE | 16D4465H04 | 1 |
| FLEXIBLE HOSE CONNECTION | 4297A87H02 | 1 |
| NITROGEN CYLINDER | 462C297H01 | 1 |
| LIGHTNING ARRESTER (H.V.) | 3891A09A01 | 3 |
| LIGHTNING ARRESTER (L.V.) | 5554A51A12 | 3 |
| FAN ASSEMBLY | 8659D08G19 | 4 |
| MOTOR | 1960C76H01 | 4 |
| PROPELLER | 8657D79H01 | 8 |
| CAPACITOR | 2782A68H01 | 4 |
| BELDEN PLUG MALE | 8958D08H05 | 4 |
| FAN JUNCTION BLOCK | 8658C09H01 | 4 |
| FAN JUNCTION BLOCK PLUG | 2790A12H02 | 8 |

WESTINGHOUSE ELECTRIC CORP., SHARON, PA. 16146

TRANSFORMER RENEWAL PARTS DATA

CUSTOMER BONNEVILLE P

1 - TRANSF 3 PHASE 25000 KVA

CLASS OA/FA/FOA OR OA/FA/FA

115 H.V. KV

| GENERAL ORDER | CUSTOMER ORDER | SHOP ORDER |
|---|---|---|
| PO88519 | AC7981BP23646 | RCS2416 |

THE FOLLOWING PARTS ARE MOST SUBJECT TO WEAR IN ORDINARY OPERATION:

| NAME OF PART | PART NUMBER | UNIT QTY |
|---|---|---|

REFERENCE D-949704

WESTINGHOUSE ELECTRIC CORP., SHARON, PA. 16146

TRANSFORMER · SPARE PARTS DATA

CUSTOMER BONNEVILLE P

1 - TRANSF 3 PHASE 25000 KVA

CLASS OA/FA/FOA OR OA/FA/FA

115 H.V. KV

| GENERAL ORDER | CUSTOMER ORDER | SHOP ORDER |
|---|---|---|
| PO88519 | AC7981BP23646 | RCS2416 |

***** RECOMMENDATIONS FOR STOCK - 1 SET FOR 1 TRANSFORMER ****

+PRICES SUBJECT TO CHANGE WITHOUT NOTICE

| NAME OF PART | PART NUMBER | RECOMD QTY | UNIT PRICE |
|---|---|---|---|
| NLTC PACKING | 272C560H02 | 1 | |
| NLTC O RING (.6ID X 1.2OD 7107OCA) | 00 | 1 | |
| WCA TAP CHANGER MOUNTING GASKET | 4340D99H01 | 1 | |
| JUNCTION BOX TERMINAL BLOCK GASKET | 4340D99H75 | 1 | |
| FLUID GAGE MOUNTING GASKET | 4340D99H55 | 1 | |
| HEATING COIL GASKET | 4340D99H68 | 1 | |
| WELL GASKET | 4340D99H58 | 1 | |
| HV BUSHING MOUNTING GASKET | 4340D99H05 | 1 | |
| HV BUSHING CAP GASKET | 4340D99H31 | 1 | |
| LV BUSHING MOUNTING GASKET | 4340D99H11 | 1 | |
| 20 INCH MANHOLE COVER GASKET | 4340D99H60 | 1 | |
| 24 INCH MANHOLE COVER GASKET | 4340D99H61 | 1 | |
| RELIEF DEVICE MOUNTING GASKET | 4340D99H52 | 1 | |
| GASKET CEMENT | 2790A23H01 | 1 | |
| MOTOR | 1960C76H01 | 1 | |