Operation and Maintenance of Water-Cooled Transformers

INSTRUCTIONS

OPERATION

General—Entrapped air is a potential source of trouble in all transformers. In general therefore it is desirable to fill transformers with oil under full vacuum. This is done for transformers shipped in oil from the factory except in a very few cases where it is not considered as essential.

The filling of transformers with oil in the field should be done under a full vacuum provided the transformer tanks are designed for this condition. If the transformer tanks have been designed for full vacuum and it is imperative to get the maximum impulse strength immediately the transformers should be filled with oil under full vacuum by placing them in an auxiliary tank. Transformers with round wire coils should always be filled with oil under full vacuum, because of the higher stress across coil groups. For definite information on tank strengths the factory should be consulted.

In those cases where the transformers are not filled under full vacuum, full voltage should not be applied to the windings for several hours after the oil has been put into the case. This time is necessary to allow the air bubbles to escape.

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. After full voltage has been applied successfully, the transformer should preferably be operated in that way for a few hours without 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.

Oil Sampling—There is always a chance that moisture may get into the oil after the transformer is installed so that sample of oil should be drawn from the bottom of the tank at least once in every three months and tested for dielectric strength. Customers who do not have facilities for testing oil can send samples to the Westinghouse Electric & Manufacturing Company at East Pittsburgh, Pa. Bottles and containers as illustrated in Fig. 1 can be supplied by any of our district offices in lots of six, for this purpose, at a nominal charge. These bottles are vacuum dried and sealed. A container is provided allowing shipment by Parcel Post, which is usually very desirable.

Customers who are not equipped to make their own tests are urged to avail themselves of this service.

Water Circulation—Open the main valve as soon as voltage is applied. If there are two or more sets of cooling coils in parallel, adjust the valves of all sections for equal rates of flow. This can be judged approximately by comparing the size of the discharge streams from different sections, or by means of the flow indicators when used in each section. It can be determined best, however, by noting the difference in temperature between ingoing and outgoing water from each section, after the transformer has reached steady temperature conditions under load. A careful measure should be taken of the total amount of water flowing through all sections and the total rate of flow adjusted to that called for on the diagram plate. The rate of flow should be checked from time to time, and if it is found to be diminished, the cause should be looked for and remedied. One common cause of reduction of flow is the clogging of, or scale deposits on the inside of the cooling coils. The water used should be as free from impurities as possible in order to avoid these deposits. Salt water should never be used in cooling coils.

For low water temperatures, the water rate may be reduced for light loads. When this is done, a careful check must be made on the oil temperature to make sure that it does not exceed 80° C.

Where water-cooled transformers are exposed to low temperatures, the cooling coil connections should be lagged to prevent freezing.

Temperature Readings—Thermometers should be read daily or more often. If, at rated load or less, the oil temperature reaches 65° C. for an oil-immersed water-cooled transformer, it is advisable to check operating conditions.

If the oil temperature in oil-immersed, water-cooled transformers should exceed 65°C. at rated load or less, either the cooling coils need cleaning, an insufficient amount of cooling water is being used, or the temperature of the cooling water is higher than 25°C. The oil temperature in oil-immersed, water-cooled transformers should not be allowed to exceed 75°C. even for short periods of time. A lower oil temperature is recommended for oil-immersed, water-cooled transformers on account of the greater difference between the temperatures of the windin gsand of the oil than in oil-immersed self-cooled transformers.

MAINTENANCE

Care of Water-Cooling Coils in Case of Shut-Down—Whenever a water-cooled transformer is shut down in cold weather precaution must be taken to prevent freezing of water in the cooling coils. The best method is to blow or drain out the water. If the coil is not gravity drained, it is advisable to fill it with transformer oil.

A water-cooled transformer with gravity drained cooling coils may retain a slight amount of water in the coils after they are drained, due to slight disalignment of coils or foundation from a level position. It is recommended that self-draining coils be blown out after draining, as an extra precaution.

Scale in Cooling Coils—Occasionally the quality of water used for cooling purposes is such that it will gradually form a deposit inside the cooling coils. This deposit is a poor heat conductor and will make itself known by increased temperature in the transformer oil and also probably by a decreased flow of water. If the oil in a water-cooled transformer begins to show a higher temperature than it should without apparent reason, the cooling coils should be examined at once for deposit. The deposit may be mostly particles thrown down by dirty water, or it may be a coating or scale that is generally hard to remove. A deposit of dirt can generally be removed by blowing through the coil with steam at a fairly high pressure. In many cases scale can be removed by passing through the coils a ten per cent solution of hydrochloic acid. Some kinds of oil will deposit a coating on the outside of the cooling coils and cause an increase in the oil temperature. An inspection will disclose any trouble of this kind. The oil furnished with Westinghouse transformers will not form such a deposit under normal operating conditions.

It is vital to the life of a water-cooled transformer that water be kept flowing continuously through the cooling coils during operation. If the water is shut off, the temperature of the transformer will rise very rapidly and will soon reach the danger point. All Westinghouse water-cooled transformers are equipped with thermometers having alarm contacts. These contacts should be wired up to alarm systems that will give warnings in case the transformer temperature rises too high.

Testing for Cooling Coil Leaks—Cooling coils are tested for leaks at the factory with water under a pressure of 500 pounds per square inch. If there is any suspicion that a cooling coil may have been damaged during shipment, it should be tested before being put into service. To do this, connect a pressure pump, valve, and pressure gauge to one end of the coil in the order given. Pump water into the coil, or transformer oil should be used if the coil is already

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installed in the transformer case, and when full, close up the open end tightly with a cap, being careful to leave no air pocket. Bring the pressure up to about 100 or 150 pounds per square inch by means of the pump and close the valve tightly. If all connections are tight and there are no leaks in the coil, the pressure should hold practically constant for five minutes. If the pressure begins to drop immediately after the valve is closed and keeps dropping steadily, there is a leak somewhere. If there is a minute hole in the coil the liquid will come through in the form of drops or a very feeble stream. Care should be taken not to mistake a leak in the valve or connections for a leak in the coil.

Another method that may be used is to close up one end of the coil tightly, immerse in water or oil and apply an air pressure of from 20 to 100 pounds per square inch. If there is a leak in the coil, it will be indicated by the appearance of air bubbles on the surface of the liquid.

Inspection—Transformers require less care and attention than almost any other kind of electrical power apparatus. This, however, is not a reason for neglecting them. The conditions under which they operate will determine to some extent the frequency with which they should be inspected. A regular program of inspection should be established and rigidly carried out.

The oil should be tested for dielectric strength and the presence of sludge. If there is an indication of moisture or sludge formation, the oil should be tested further and treated as described in the Instruction Booklet on Oil. If tests show the oil to be in bad condition an inspection should be made on the inside of the tank for possible cause of the trouble. However, if the oil tests satisfactorily the case should not be opened but a careful inspection of all accessories should be made to see that

FIG. 1—OIL TESTING SERVICE

they are functioning properly. Transformers equipped with the Inertaire device cannot have sludge formation since oxygen is excluded. The record of deoxidizing compound, or nitrogen gas consumption should be studied and if excessive the case should be tested for leaks as described in the Instruction Booklet on Inertaire.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined the transformer should be taken out of service and given a thorough inspection.

Any symptoms such as unusual noises, high or low oil levels, rupturing of relief diaphragm, etc. should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions such as overloads, frequent short circuits, or special units such as furnace transformers should be inspected internally at least once a year. This can usually be done adequately by lowering the oil level and inspecting with a light through the manhole.

Repainting—It is desirable to repaint the transformer at intervals to maintain the finish in good condition. Local climatic conditions cover such a wide range that definite recommendations as to frequency of repainting are not possible. Repainting by flowing is preferable because it tends to wash off foreign matter and produces a uniform coating. See leaflet "Standard Finish for Transformers."

Equipment has been developed for flow coating, cleaning and handling transformer and parts in the field. The customer should write to the Company for details.

Spare Transformers—A spare transformer should be given the same routine checks as are given to transformers continuously in service. The internal parts should be kept free from the condensation and accumulation of moisture. To obtain the maximum advantage from the spare unit it should be kept ready for instant service.

REPAIRING

With proper care, modern transformers seldom give trouble; but, nevertheless, repairs are occasionally necessary.

No general instructions will be given here for repairs of transformers. The customer should write to the Company, describing the nature of the trouble and the extent and character of the damage, and information and instructions for repair will be promptly and freely given.

RENEWAL PARTS

Renewal parts are covered in R.P. Booklet #150 which may be obtained on request if not already available.

In writing with reference to any transformer, always give the full name plate reading, as this furnishes accurate information for identification.

All coils and leads are numbered, round fibre tags being used for this purpose. In referring to coils or leads, always give the number, being careful not to confuse coil tags and lead tags.

Westinghouse Electric & Manufacturing Company

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