2 INSTRUCTIONS

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After the transformer is transported to the place of operation and completely assembled, the following tests should be carried out before transformer putting in operation:

1.1 INSULATION TESTING

After cleaning of all insulators and loosening of all connections to bus bars, lighting arrestors etc., it is necessary to test to test each particular winding to ground and to the other windings by means of Megger of 2500V. The results of measuring shall be compared with results of tests carried out in the factory.

1.2 OIL TESTING

Oil sampling should be taken from the tap for oil testing on the tank and dielectric strength of such oil should be checked.

1.3 CHECKING OF INSTRUMENTS

It is necessary to check whether all protecting and indicating instruments are correctly connected and whether they operate properly. Operational instructions should be followed. The contacts of the oil and winding temperature indicators should be set according to instructions.

1.4 CHECKING THE OPERTION OF THE TAP CHANGER

Before putting in operation, several test switching operations of the tap changer should be made with transformer isolated from network. These switching operations should be extended to the whole tapping range. They serve for testing of mechanical part of the tap changer and driving mechanism.

1.5 IN GENERAL

It is necessary to check as well:

- Buchholz relay
- Oil level of level indicator
- Silica gel breather and oil level in silica gel breather
- Whether all valves and cocks are correctly fitted?
- Whether the connections to cables, busbars and earthing are properly effected?
- Whether there are prescribed clearances between live connections and against ground?
- Whether the gaskets are neatly tightened?
- Whether the pressure relief device is correctly fitted?

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1.6 DEAERATION

If oil is purified in the filter without elimination of gas or if is not poured in the tank without vacuum, it cannot be avoided that air penetrates together with oil into the transformer.

Air contained in oil in a form of small bubbles diminishes the dielectric strength of oil. The bubbles could grow in the windings forming bigger bubbles which could be suddenly released and lifted. If the transformer is under voltage the bubbles passing through places with high electric stresses could cause the flashover or punctures. Therefore, it is recommended that after filling with oil, transformer be left for a few days to eliminate the air.

Moreover, this air could cause a faulty alarm, after reaching a Buchholz relay, and so obstruct the normal operation. It is necessary to de aerate the Buchholz relay as well as coolers and all places intended for de aeration.

1.7 PUTTING INTO OPERATION

It is carried out after all protection devices of transformer are checked for correct connection and proper operation. After the t5ransformer is put under the voltage it should be carefully inspected for some time. After the transformer has been operating 1-2 weeks, sealing screws should be tightened.

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During the operation, transformer is often exposed to high electrical and mechanical stresses. In order to avoid operational disturbances, it is necessary to inspect transformer carefully, first of all, the oil should be tested.

1.1 TRANSFORMER OIL

It is hygroscope and therefore it very easily absorbs moisture. The absorption of moisture could be prevented if the transformer is hermetically separated from the air. By the application of conservator with silica gel breather, the absorption of moisture could be considerably slowed down. By this method it is necessary to check the breather at regular intervals and renew the silica gel when it be completely red in colour. If the oil has been exposed to moisture, it is necessary to check its dielectric strength. Similar oil checking should be carried out in certain time intervals with all large and important transformers.

Any sediment or acid found in oil can be eliminated by filtering In such a case, oil sampling should be taken and dielectric test and chromatographic analysis should be carried out. If it is necessary, windings dielectric test should be carried out.

Sludge comes about when the acids attacking the iron, copper, varnishes, paints, etc., and these materials come into solution and combine together. This sludge eventually precipitates out of solution and forms a heavy tarry substance which adheres to the isolation, the side walls of tank, lodges in ventilating ducts, cooling fans and so on. The sludge could be eliminated by filtering, but if it once started to accumulate this will continue faster and faster. Therefore, it is recommended to change the oil as soon as possible considering the operating conditions. The same applies when the content as acid in oil exceeds permissible value. The change of oil is the best to effect in hot state as in such conditions the oil is low viscosity.

The exchange of oil should be as efficient as possible because the mixture of used and new oil is not recommended. The mixture of used and new oil gets the properties of used oil.

It is also not recommended to mix new oils of different properties. According to the experience, the mixing of new oils of different properties gives the properties of such mixture worse than those of bad quality oil.

If the oil is added after leakage, in which case the mixing quantity is small, it is sufficient that the oil which is added is dry and clean and least of same quality as that in transformer.

The oil which has not been oxidised in a great deal, could be renewed partially. Such a process, however, can be taken in consideration only with great quantity of oil.

1.2 COOLING SYSTEM

Cooling system of transformer with air coolers, as a rule, does not require any maintenance while the oil is correct. If however, sludge has started to accumulate, it could cover the horizontal surfaces of radiator, and coolers should be rinsed with oil. If sludge is not easily removed, it is necessary to use benzene, trichlorethylene or similar liquid then rinsing with oil may be applied.

1.3 ACCESSORIES AND EQUIPMENT

They should be tested yearly. Relays should be cleaned, lubricated and calibrated periodically in accordance with manufacturer`s instructions. It is also necessary to check apparatus, electric cables and conductors, signalising and control devices in control room.

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1.4 BUCHHOLZ RELAY

It is installed in the pipe between tank and conservator. It is intended to signal an inside fault and the loss of insulating liquid by tripping an alarm or shut-off pulse. In the event of partial discharges, creeping currents, local overheating or excessive heat-up due to high any currents developing in metal parts, the insulating materials is subject to decomposition with resultant gas formation. Gases accumulate in the Buchholz relay and displace the insulating oil contained in it.

When a specific amount of gas has collected, a float will actuate a contact. In the manner, the operating personal can detect possible faults early enough to take suitable measures to prevent extension of damage.

If high-energy arc discharging occurs inside the unit under protection, a very rapid decomposition of the insulation material results. The generated pressure surge of the insulation oil travels through the pipe into the Buchholz relay. At a specific flow rate, the generated flow actuates a magnetically held damper and triggers a signal.

The same signal contacts are actuated by a float coupled with damper when leakage in the pipe to drop to the response level.

When the relay has been activated during operation the following should attended to:

After the relay has signalised alarm, through the window in the casing check the colour and quantity of accumulated gas. The gas collected in casing of the relay should be tested.

If it is necessary, transformer active part should be taken out of the tank, tested and repaired.

The air collected in the casing usually derives from air bubbles created when transformer is filled with oil. In such a cases, signals activated by de aeration do not last for long period.

When transformer is cut out under influence of gas relay, creation of gas in transformer is also stopped. Several minutes should pass before the checking the gas relay. Gas should be checked according to close 1.

Punctures without lasting effect in transformer often do not cause continuos defect though the gas relay has been activated. It is recommended, therefore, that the transformer is connected without load after the relay casing has been filled with oil. If the relay is activated immediately it means that transformer should be put definitely out of operation and opened for check-up, it is not recommended to put the transformer in operation again as this may result in further faults.

The Buchholz relays are not sensitive to external influences. No servicing is needed during operation. On routine inspections of protection devices, test the function of Buchholz relay and check the alarm and cut-off devices connected to them. Check the Buchholz relay for leaks and proper seat of sealing element. Any detected fault has to be remedied at once.

TANK COVER, GASKETS AND VALVE should be from time to time checked and repaired when necessary.

1.5 BUSHINGS

Surface contamination is caused by natural deposits (such us early morning dew, salt fog in sea coast areas) and industrial pollution. Such contamination has often resulted in noisy substations, damage of insulating surfaces, partial discharge, tracking flashover, and loss of power.

If it is possible to prevent insulators from flashing over by periodic hand wiping (de-energised), periodic washing, or periodic dry cleaning using such techniques as dry powder blasting with an insulated "hot stick" or periodic coating with grease compounds (energised or de-energised).

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POWER TRANSFORMER AND ASSOCIATED EQUIPMENT MAINTENANCE INSPECTION AND TESTING INTERVALS

Recommended Frequency of testing for Energised Transformers

Interval	Visual inspection and/or Tests
Daily (or every shift)	Transformer load currents and voltages. Ambient, top oil, winding temperature. Listen for unusual noises. Protective relay indicating targets. Record and reset Observe cooling fans. Observe all switch gear indicating lights and all heater ammeters.
Weekly	Leaks. Oil level in tank and in oil-filled bushings (if so equipped). Feel cooling tubes; note temperature change.
Monthly	Inspection of all bushings, and for leaks from tanks, fittings and cooling tubes. General condition, tap-changer; note and record number of operations. Protection alarms (temperature and pressure), check for proper operation. Dehydrating breather; free from moisture restriction.
Quarterly	Oil tests. Pressure relief device - see if it has tripped. External inspection of switch gear parts by opening doors. Gas-in-oil analysis.
Semi-Annually	Bushings - visual check for cracks. unscrewed hardware, leaning at bad angle. Grounding system - inspect for loose, broken or corroded connections.
Annually	Bushing cleaning in polluted environment. Inspect switchgear cable termination for cleanliness and tracking. Inspect transformer cables for deformation, closeness to grounded metal parts. Protective relay trip check, test calibration.
2 years	Bushing cleaning in non-polluted areas. Power factor test on oil-filled bushings.

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POWER TRANSFORMER AND ASSOCIATED EQUIPMENT RECCOMENDED FREQUENCY OF MAINTENANCE FOR SHEDULED TRANSFOREMER SHUTDOWN

Interval	Visual inspection and/or Tests
Annual (optimal)	Switch gear inspection, vacuum cleaning, lubrication of circuit breaker mechanisms. Inspect. through cover holes - especially bushings, also for moisture, rust, sludge deposits. Lighting and surge protective devices, visual inspections, cleaning and repair. Auxiliary cooling fans – checking and testing. Functional trip testing of air circuit breakers. Power factor of oil and air circuit breakers and bushings. Tap changer - external inspection of accessible parts for seal leakage, corrosion, wear and looseness Minor repairs - tighten bolts, replace gaskets, repair weak welded joints, etc. Basic electrical tests including power factor and mg ohm meter series.
3 years	Complete series of transformer electrical tests. Tap changer – electrical tests (power factor and dc resistance); each step of tap changer. Inspect pressure relief device for proper operation. Switch gear complete cleaning, inspection and lubrication of all associated devices including CB, wiring, buses, disconnect devices and insulators. All "annual" items not considered at one or two year interval.
6 years (minimum)	Insulated cables dc high potential testing - fault detection. Undercover transformer inspection - lowering of oil level, detailed inspection of all accessible internal mechanical and electrical parts, especially tap changer contacts, loose bracing and connections Applicable to heavy duty equipment, such as arc furnas units. Inspection should be made under clean conditions.

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