MAINTENANCE OF POWER TRANSFORMERS
WHAT CAN MANUFACTURERS DO TO HELP?

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1. Introduction

Over the years Undertakings have lost many highly skilled personnel who were required for the effective maintenance of Power Transformers. This paper outlines some of the improvements made to make certain operations unnecessary, other simpler, to extend the period between inspections and finally, to monitor the transformer such that maintenance is only done when it is really necessary.

2. Improvements to Eliminate Maintenance

One of the main problems seen by Customers is a leak on gasketted joints. Improvements are now made by the use of O-ring gaskets on chords in grooves and the elimination of a main cover gasket by welding the main cover, which during the life of the transformer rarely needs to be removed.

O-ring Gaskets

For many years ABB Powertech Transformers has been successfully using gaskets in grooves for certain critical areas where a leakage would be extremely difficult to repair. A decision was taken to change exclusively to this design for all gasketted joints. The previously used rubber bonded cork gaskets had the disadvantage that they required very even tightening, re-tightening during installation and a further re-tightening after a period in service. However, if these gaskets are tightened too much the elasticity properties of the material are destroyed and is no longer able to expand and contract thereby not providing an effective seal. Many old transformers can be seen using cork gaskets that are leak free but nowadays personnel are not prepared to take the time or have the knowledge to carry out the critical processes.
The O-ring and groove type of gasket offers a leak free joint. Furthermore there is no need for any in-service maintenance of the gasket. When seals are opened for whatever reason, the groove and O-ring lend themselves to a clean replacement and resealing, unlike the cork which often bonded to the mating surfaces and required extensive cleaning of the flanges before resealing. In addition should a leak develop it is normally possible to stop it by re-tightening the bolts.

Welded Main Tank Covers

In conjunction with the O-rings standard practice is to weld the main tank cover. Previously a main tank cover leak would require a major operation to repair. In most cases it involves draining of the oil, lifting of the cover and exposure of the transformer active part to the atmosphere. This operation often takes several days and the added risk of contamination by moisture or other particles while the unit is open. After replacement of the gasket, the transformer needs to be evacuated before oil filling commences.

With a welded cover no maintenance is required. The weld is dye penetrant and pressure tested in the factory. Secondly, it is much easier to repair an oil leak at a weld than a gasket that is leaking. Thirdly the outage time is much less and the possibility of contamination is eliminated.
The design of the transformer cover flanges is such to allow de-welding. On a transformer that has been in service for many years transformer repairers find it easier to gouge the welding than to try to undo cover bolts that are invariably so corroded that they have to be cut off. Should customers however still require a bolted cover with a gasket it can be offered, but would be supplied with a groove made by welding two square strips a defined distance apart and using an O-ring.

3. Improvements to Reduce Maintenance

'Rubber' Bag in Conservator

The concept is used to prevent direct contact between the expanding and contracting oil in

the conservator and the outside atmosphere. There are several ways of doing this:

- To fit a flexible diaphragm across the centre of the conservator with oil on the underside

- To allow the oil in the conservator to enter a rubber bag in the conservator; or

- The normally used method of fitting a rubber bag above the oil in the conservator.

To describe the latter further :
There is a balloon-like bag filled with air inside the conservator. The transformer oil surrounds the bag and is isolated from the atmospheric air by the bag membrane. The rubber bag provides several advantages. Firstly, moisture take-up from outside is minimised. This is important for high dielectric strength of the insulation system. Secondly, a low oxygen content of the oil can be maintained. This leads to a considerable reduced ageing of the cellulose and therefore a low production of internal moisture. Such transformers offer increased loading at a lesser insulation-ageing rate. Thirdly, degassed oil has a better dielectric strength in large-scale gaps and can better suppress partial discharges. For a similar reason as above a degassed insulation system has a far better capability to sustain loading beyond nameplate rating under limited time compared with gas saturated system.

Two questions are often asked regarding this:

a) Is this cheaper than using a silica gel breather? The answer is always 'No' because, as a safety precaution to prevent condensation inside the bag, a silica gel is always fitted to the inlet to the bag.

b) Since there is no moisture ingress can oil treatment be eliminated? Again the answer is 'No' because as insulation degrades moisture develops from within the transformer.

Maintenance Friendly Breathers

Silica gel breathers of transformers are amongst the items that require the most frequent maintenance; are of utmost importance, however often neglected. The reasons for neglect are multiple, but one important one is that breathers are often not maintenance friendly. Easy replacement of the desiccant, good visibility of the charge, robustness and simplicity are but a few of the customer's requirements. It is normal practice to change the silica gel when about 1/3rd of it has changed from blue to pink. To do this meant tipping out the gel from the top, first the good and then the discoloured, so that it all mixed together and had to be completely changed. Improvements that have been incorporated are outlined below.

Depending on the total mass of the desiccant, the containers are arranged and connected in series to separate the charge so that only one container needs to be recharged at a time when it has been discoloured completely. This reduces maintenance time and desiccant wastage.

To improve the visibility the container housing is made of a transparent and durable material. The smaller range of breathers has a bayonet type of connection that allows easy removal of the desiccant container. Where the charge requirement is above the small unit range, combinations have been developed that have the bayonet type at the end for ease of maintenance. In the case of very large breathers these are made in three canisters connected in series so at maintenance time only one complete canister needs to be re-charged.

Silica gel breathers when used with the rubber bag, of course, require less maintenance.

4. To Make Maintenance as Easy as Possible

Maintenance Friendly Tap changers

Tap changers are also items that require regular maintenance. The maintenance intervals depend primarily on the number of operations, but there are also time-related intervals. These time intervals are in the order of five years depending on the model. There are two types of tap changers used by ABB Powertech Transformers offering high maintainability. One is a bolt-on type known as the UZ range or the in-tank type known as the UC range.

The UZ range is simple, allows ground level access, has excellent overall visibility and requires short outage times.

Compare this with the in tank type where it is necessary to climb on top of the transformer, organise lifting gear and withdraw the diverter switch, frequently also involving the turning of the diverter switch during the removal. For smaller transformers this is a very complex operation.

For larger transformers the in-tank type tapchanger is normally necessary. The UC range requires no shaft disconnection, has a plug-in diverter switch which can be directly withdrawn using the simple lifting lug provided.

‘Maintenance free’ tapchangers

This statement is not completely correct, but for a normal network transformer certainly maintenance is only required every 150 000 operations which normally equates to well over 15 years.

This is achieved by using vacuum switching in the tapchanger thereby eliminating carbonisation of the oil and exchange of contacts.

However it should also be mentioned that the use of a tapchanger oil filter in conjunction with the UC tapchanger described above can increase the maintenance intervals to a similar number of operations and also keeps the oil clean making the servicing much easier and user friendly.

A filter can of course also be used with the UZ type tapchanger but is not generally considered economic due the complete ease of accessibility.

Condition based maintenance

The latest development launched by ABB, and at this time only in the beta stage testing stage is the **T**ransformer **E**lectronic **C**ontrol or **TEC**.
It is Windows based technology and the parameters are processed by a PC terminal and can be used by the operator via easy –to-use software and display. The terminal can be static, for example in the control room, or when desired from a location of your choice through a modem.

Essentially this is a complete controller which has been developed to enhance ‘the value for money’ of the transformer.

Whilst it is still in the final testing stage and features may change slightly, it presently incorporates:

1. Real time measurements of simulated winding temperature, top oil temperature, tap position and current.

2. Complete control of the cooling equipment, in more stages than is normally used (up to 6 instead of 2).

3. Sequential running of fans such that all fans are run to give even usage. In the event of the fans not being required for cooling they are however run periodically automatically.

4. Record of running time of fans for determination of maintenance requirements.

5. Monitoring of tapchanger position and current such that maintenance can be accurately predicted rather than being based on simply time or number of operations.

6. Incorporates programmes for simulation of temperatures and life consumption during overloading.

7. Recording of consumed lifetime according to IEC or IEEE.

8. Automatic tap changing voltage regulation can be incorporated.

9. Documentation can be incorporated such as a complete maintenance manual (How often can you find your copy when you want it?), and videos of tapchanger maintenance.

Add on features include :

10. Monitoring of tapchanger temperature and comparison with transformer temperature for abnormal condition.

11. Continuous monitoring of transformer and tapchanger moisture levels.

12. Monitoring of dissolved gas in oil by use of “Hydran”.

Later editions could also include:

13. Bushing monitoring

14. Additional monitoring of the transformer and tapchanger .

What is so special about this monitor?

Simply that ABB knows the transformer and how it should perform and design information is inputted to the device so the unit is continually monitoring how the transformer is behaving compared with how it is expected to behave.

By simple ‘traffic-light’ LEDS indicating :

Green - normal
Yellow - not as expected
Red - alarm, to be investigated

By screens brought up by clicking on the device on the transformer model such items as

- Running time of fans
- Clocks indicating tapchanger service and contact exchange; and
- predictions of when this is likely to be required both in operations and time.

It can be said that ABB has developed a controlling and monitoring device that offers clear benefits for our customers. Your transformer will now be under full control with the advantages of exact status information, reduced maintenance costs, life time extension, optimised operation and increased availability combined with improved user comfort. Each transformer will have its own fingerprint containing the parameters needed for optimised control. Intelligent solutions on-site, a step into the future with full ABB support and expertise.

5. Conclusion

We hope that this presentation has given some insight in what has been done to eliminate, ease and simplify maintenance and to finally bring maintenance to truly ‘condition based’.

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