TRANSFORMER SERVICE

Advanced diagnostics provide a complete health check for power transformers

Power transformers are mission-critical elements in many industrial, utility and power generation installations. An unexpected failure can result in a lengthy downtime, loss of operating revenue and expensive repairs. Planned or predictive maintenance strategies against transformer failure are well supported by advanced diagnostic techniques, either for fleet screening or investigation of a suspect issue. They offer an efficient, cost-effective way of assessing the overall condition of a transformer fleet so that areas of potential concern can be flagged, further validated and action taken long before a potential failure develops into a serious fault.

Furthermore, if an operator has a transformer that is already causing concern, then diagnostic tests can establish the severity of the problem, locate the fault and help the service team to provide expert advice on what action to take. For example, with more frequent testing it might be possible for the transformer to continue in service, while operating under a safe, reduced load, until a planned service interval is reached.

ABB's transformer diagnostic service utilizes four main techniques – Sweep Frequency Response Analysis (SFRA), Dielectric Frequency Response (DFR), winding resistance measurement and oil sampling.

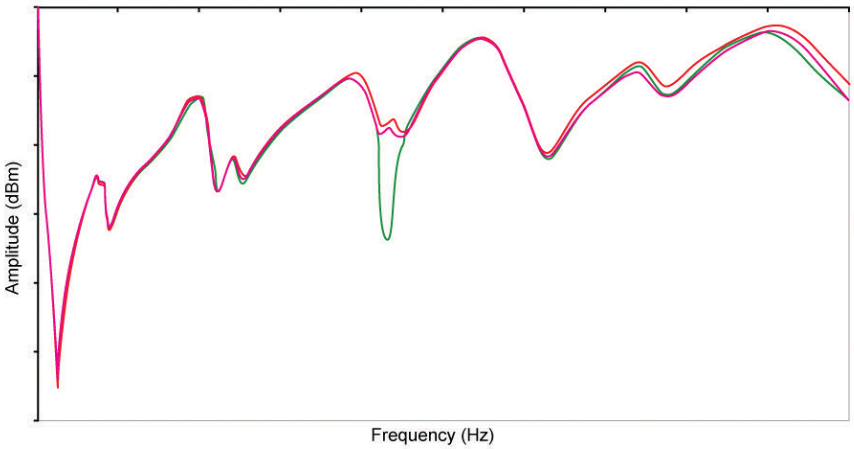
SFRA

The SFRA test is an important tool for identifying potential winding geometry changes. It consists of a low-voltage, offline, measurement of transformer windings' impedance as a function of frequency. The test is performed by injecting a variable frequency AC voltage into each transformer winding and plotting the responding current as a curve.

We recommend that SFRA reference curves be captured in the factory to provide a baseline fingerprint of the windings in an as-new condition. However, for installed transformers, a field test can provide the baseline curves. SFRA testing should be performed periodically during the service life of the transformer, or after a specific incident has caused significant fault currents. An alternative approach is to utilize a type-based comparison between sister transformers with the same design. Under certain conditions, a construction based comparison can be used when comparing measurements between windings in the same transformer.

When interpreted by an expert, comparison of the SFRA test with the transformer's original baseline curves is an excellent method for checking for movement or displacement of windings or winding circuits that could affect its ability to withstand faults. It is much more definitive than low-voltage impedance tests routinely performed on transformers, it helps avoid catastrophic failures and can even locate the exact position of a fault.

Figure 1 shows a typical SFRA analysis in which the pronounced dip in the frequency response curve of one of the transformer phases indicates a potential fault – most probably due to a winding failure or core movement.



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01 Typical SFRA analysis

DFR

Dielectric Frequency Response is used to assess the integrity of a transformer's insulation system. The test determines the volume of moisture and presence of contaminants in the solid insulation, as well as the conductivity and power factor of the oil. This is an extremely useful tool in an overall condition assessment program as standard power factor tests alone do not yield this type of information. The DFR test measures the dielectric properties (capacitance, loss and power factor) of the transformer's insulation as a function of frequency. This offline test utilizes the same type of connections as a standard (Doble) main frequency insulation power factor test. However, by covering a much wider frequency range – typically 1 mHz to 1000 Hz – the test offers increased sensitivity to insulation issues. An important primary use of the DFR test is to determine the moisture content of the cellulose insulation structure of power transformers. It is difficult to obtain a reliable assessment of moisture content by oil sample tests, as the water is constantly transferred between the solid insulation and the oil as the temperature changes. An oil sample has to be taken at relatively high temperatures when the transformer is in equilibrium. But this is a relatively rare state for a transformer and can result in unreliable assessments. A perfect illustration of the advantages of DFR is shown by an exercise during which a customer provided ABB with a list of seven suspect transformers. In each case, oil moisture tests indicated the need for oil processing and drying. With DFR tests we were able to show that only two units actually needed drying. So our recommendation was to dry these two, while keeping the other five under close surveillance. While the customer benefited from significant savings in operational and maintenance costs, preventing unnecessary drying operations on five transformers.

Winding resistance measurement

Winding resistance measurement tests inject a DC current of up to 2 kV through the transformer windings and then measure the voltage drop across that winding – enabling the resistance to be calculated.

The main purpose of this test is to check for significant differences between the windings, which could indicate field damage or deterioration, and also to ensure that the transformer connections are correct and that there are no severe mismatches or open circuits.

Oil sampling

Just as blood tests can provide a doctors with a wealth of information about their patients, a sample of transformer oil can tell engineers a great deal about the condition of a transformer, enabling them to effectively manage the asset for extended life and enhanced reliability. Oil's role in the transformer is to cool and insulate the internal components, and in doing so it bathes every internal component. As a result, the oil contains approximately 70 per cent of the available diagnostic information for the transformer and laboratory analysis can provide an early indication of a developing condition such as tap changer arcing. The best information can be obtained from oil sampling by viewing trends. So it is useful to take a benchmark sample when a transformer has been energized or to perform an oil treatment followed by additional samples taken at regular intervals so that any variation in quality can be measured to monitor developing faults.

Typical tests carried out in the laboratory analysis of the oil sample include:

- Breakdown voltage (dielectric strength)
- Moisture content
- Dissolved gas analysis (DGA)
- Oxidation

The results of these tests impact other variables and affect the condition of the transformer.

Summary

In general, power transformers are very reliable devices and will provide excellent service for many years if maintained and serviced regularly. Failures are usually very serious and result in costly repairs and inconvenient downtime. The new generation of high technology, non-invasive, diagnostic techniques can play a vital role in preserving your assets.

ABB Inc.
Transformer Services
(TRES)

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