FLANDERS

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Electrical Condition Monitoring

OFF-LINE Testing

Polarisation Index / DC Curve
Tan Delta
RFPAM
Partial Discharge
TVA Probe
Surge Comparison Testing
RSO-Repetitive Surge Oscilloscope

ON-LINE Testing

RFPAM
Partial Discharge
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Infrared Thermography

Electrical Condition Monitoring Techniques

Electrical machines and their insulation systems are subjected to mechanical, electrical and thermal stresses. The most significant are as follows:

- Thermal Ageing – Gradual ageing caused by temperatures due to normal operating levels.
- Over-temperature – Unusually high temperature caused from overload, high ambient temperatures and restricted ventilation.
- Over-voltage – Unusually high voltages caused from switching or lightning surges.
- Contamination – This deteriorates electrical insulation by actually conducting current over insulated surfaces, or by attacking the material reducing it's electrical insulating quality and its physical strength. Some forms of contamination are:

    1. Wetness or extreme humidity.
    2. Oil or grease.
    3. Conducting dust and particles.
    4. Chemicals.

To ascertain the integrity of the insulation system of a motor, we can conduct the following tests.

OFF-LINE TESTS

Off-line tests are those that are carried out when it is possible to isolate and disconnect the machine for a long enough period to perform the required tests. These tests are therefore able to collect more information than on-line tests, but can be more expensive due to downtime and labour costs of disconnection / reconnection.

Winding Resistance (Stator & Rotor windings)

During this test, the measurement of the ohmic value between terminals of a winding is carried out. The purpose of the test is to detect shorted turns, bad connections, wrong connections, and open circuits. Acceptable test results consist of the three resistance values (one per phase) to be balanced within 0.5% of the average.

Polarisation Index/DC Curve (Stator & Rotor windings)

DC testing at its simplest yields the insulation resistance. When measuring after two time intervals, we can calculate the polarisation index. When DC is applied over several voltages, we can learn if there is a voltage where leakage is too great. It is then useful to compare such a voltage with the running voltage to earth of the machine.

$$\text{POLARISATION INDEX} = \frac{\text{LEAKAGE CURRENT AFTER 1 MINUTE}}{\text{LEAKAGE CURRENT AFTER 10 MINUTES}}$$

For this test, FLANDERS Electric use the MEGGER MIT1525 insulation tester.

Tan Delta/Dielectric Loss Angle (Stator winding)

This is the classical AC test, which demonstrates the ability of slot insulation to act as a capacitor. It can indicate the state of the resin in the insulation system and the void content. The test should be performed at several applied voltages so that a characteristic curve can be produced. Results obtained from this test can be compared against several criteria to judge the condition of the windings.
With systems below 5kV, we are not primarily concerned with any discharge activity within the insulation system. We are, however, interested in the general state of the insulation itself. A single voltage Tan Delta reading will indicate whether the insulation is damp or has been penetrated by contamination.
With systems above 5kV, the Tan Delta test indicates how much degradation has occurred due to discharge erosion. Discharge commences in areas of high electrical stress where there are voids, and erodes synthetic material such as resin, which binds together the mica used in coil insulation. This erosion causes larger voids and larger discharge levels, which can lead to the eventual breakdown of the insulation system.
For this test, FLANDERS Electric uses the latest SOKEN & DOBLE Tan Delta measuring equipment.

PD Testing (Partial Discharge) Stator winding

Partial discharge measurements have been recognized as an effective, reliable method of assessing stator insulation condition to foreworn of possible machine failures. The measurements are obtained with the machine in normal operation utilising capacitive couplers and thus form an integral part of a condition-based maintenance program.
For this test, FLANDERS Electric uses both the IRIS & DOBLE measuring equipment.

Surge Comparison Testing (Stator & Rotor winding)

A voltage surge is passed through two circuits reputed to be identical. Any variation in the decaying wave pattern indicates a fault, which is highlighted by a separation in the resulting wave. This test is ideally suited to compare circuits in 3-phase, single phase and DC motors of all voltages.
For this test, FLANDERS Electric uses Baker surge comparison equipment.

Winding Resistance Test (Rotor Winding)

A reduction in winding resistance may indicate shorting of conductors. An increase in winding resistance may indicate a poor connection. In measuring the rotor resistance by the voltage drop method, it is essential that voltage contacts for the voltmeter are placed directly on the collector rings or exposed leads of the rotor winding.

Winding Impedance (Rotor winding)

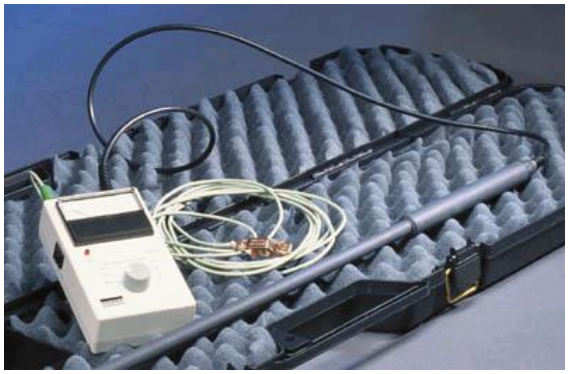
The presence of short-circuited turns in the windings of large generator rotors may be detected by impedance measurements. These measurements are usually obtained by applying 110v at power frequency across the collector rings and measuring the input current and voltage at standstill. At constant input levels, voltages are measured across the field coils of individual poles. With the field coils connected in series, similar coils should have a comparable voltage drop.

RSO-Repetitive Surge Oscilloscope

The instrument simultaneously injects fast rise time low voltage repetitive surges on each collector ring. The reflected wave forms are displayed on a dual trace scope. If there are no anomalies the reflected wave forms will be identical. The wave forms will be different if shorted turns are present.

TVA Probe

The electromagnetic corona probe method of testing stator-winding insulation provides test data that can be used to evaluate the condition of the insulation system. The peak pulse meter, displays high frequency pulses picked up by the probe when corona (partial discharge) activity is evident in the voids of the insulation while the stator is under test at full rated voltage and with the rotor removed from the stator. The probe is maneuvered along each slot and readings taken from the peak pulse meter in milli-amperes. The probe can detect the slots, which are subject to the highest discharge, and pinpoint the area along the slot where most activity is present, allowing the possibility of a repair to be assessed.



ON-LINE TESTS

On-line tests are those which are carried out with the machine under normal operating conditions. Whilst these tests are less invasive and do not require any downtime, they can only offer limited information on motor condition. However, they can be useful if the information collected is carefully analysed and trended over time to detect any change in condition. These tests are particularly useful for those machines where disconnection is difficult or not feasible due to production or other requirements.

PD Testing (Partial Discharge) Stator winding

Partial discharge measurements have been recognized as an effective, reliable method of assessing stator insulation condition to foreworn of possible machine failures. The measurements are obtained with the machine in normal operation utilising capacitive couplers and thus form an integral part of a condition-based maintenance program.

For ease of testing on-line Dowding & Mills have the resources to permanently fit capacitive couplers to the machine to be tested. Once the couplers are fitted, routine testing can be conducted with no disruption to machine operation.

For this test, FLANDERS Electric uses both the IRIS & DOBLE measuring equipment.

Current Spectrum Analysis

The purpose of the test is to analyse the motor's current spectrum and is valid on any 3-phase machine above 10 kW. Clip-on current transformers allow the tests to be carried out non-invasively while the motor is under normal operational conditions. The clip-on current transformer can be placed either on the main phase cables or on a secondary circuit such as the ammeter circuit.

The tests will determine the condition of the motor in respect of rotor cage faults such as:

- Cracked or broken rotor bars and end rings
- High resistance joints (i.e. brazing problems)
- Casting porosities or blow-holes in aluminium die cast rotors
- Rotor winding problems in slip-ring induction motors

This test can identify broken rotor bars before they progress to failure, which may lead to destruction of the stator windings.

A secondary test can also be carried out to determine:

- Stationary or rotating air gap irregularities
- Bent shaft, thermal bow
- Unbalanced magnetic pull
- Mechanical unbalance
- Bearing problems

Infra-Red Thermography

When an item of electrical equipment develops a fault, almost invariably it gets hot. This has always been a fact of life for the maintenance engineer; with checking the temperature rise a normal maintenance procedure. In the past it has been impossible to check more than a few pieces of equipment by these means quickly and safely, but this situation has been transformed by the recent developments in Thermal Imaging Cameras.

The equipment works on the principle that all bodies at normal temperatures and operation radiate electromagnetic energy. If this energy is focused and detected, a thermal image can be generated electronically. This is similar to the image one would see on a video camera, except that in this instance the differing colour shades are representative of differing temperatures. This immediately makes it possible to carry out rapid global temperature surveys of both electrical and mechanical equipment whilst this equipment is under normal operating conditions.

The main advantages of thermal imaging are:

- The surveys are conducted under normal operating conditions.
- Many installations can be surveyed within a short period.
- Faulty equipment can be discovered at an early stage reducing the chance of breakdown.

Early detection of faults makes it possible to plan outages and improve maintenance and repair schedules.

Mechanical Condition Monitoring Techniques

Vibration Analysis

FLANDERS Electric use the VB7 Portable Data Collector / Machinery Analyzer and Ascent analysis software.

The VB7 is a small, lightweight package that collects field data, such as vibration information and process variables, with a frequency range of 10 CPM to 4,518,000 CPM (0.18 Hz to 75.3 kHz). It also includes true zoom, screen capture and print capabilities. Advanced analysis features include phase measurement, time synchronous averaging and "Startup / Coastdown" capabilities.

⇒ Providing fast, accurate fault identification through a powerful array of automated fault diagnosis tools.

⇒ Supplying the most comprehensive array of alarm definitions through a simple, automated setup function. Proper use of multiple alarms extends maintenance intervals without increasing risk, thus saving you maintenance costs.

⇒ The ability to integrate data from a variety of condition monitoring technologies such as oil analysis data, infra-red thermographic images and process data. Results from other applications can also be displayed using the unique ActiveX (latest object linking and embedding technologies from Microsoft) display pane.

⇒ Having over 30 standard reports as well as a custom report generator, therefore allowing us to tailor a report to suit your particular needs and requirements.

Typical faults that vibration analysis can detect are:

- Imbalance
- Looseness
- Journal bearing wear
- Resonance
- Cavitation and Recirculation
- Misalignment
- Defects in rolling element bearings
- Gear defects (e.g. gear wear, gear looseness)
- Electrical defects in some electrical rotating machines

Dynamic Balancing

FLANDERS Electric can provide on-site, single and two-plane dynamic balancing of the following;

- Cooling fans.
- Drive shafts.
- Roller drives.
- Rotors.
- Armatures.

Laser Alignment

FLANDERS Electric can rectify misalignment problems whilst on-site using state-of-the-art laser alignment equipment. Misalignment of plant and machinery can be a costly exercise if not corrected; units that require alignment are as follows;

- Motor-pump drives
- Motor-gearbox drives
- Motor-fan drives
- Line shafts
- Drive shafts
- Hydraulic drives

Oil Sampling and Wear Debris Analysis

FLANDERS Electric use an independent oil analysis laboratory to conduct oil and wear debris analysis from samples collected whilst on-site. The laboratory routinely tests for:

- Up to 16 different metals by Inductively Coupled Plasma Atomic Emission Spectrometry
- Water, Oxidation, Nitration, Sulphation and Glycol by Fourier Transform Infra Red
- PQ Index
- Base Number
- Acid Number
- Particle Counting

More advanced tests available are:

- Filter Patch Test – involves isolating the debris from the oil for examination under a microscope. The results are reported in terms of various particle types observed, such as ferrous, non-ferrous, abrasive, etc.

- Microscopic Particle Examination – ascertains the true nature of the wear occurring in the oil compartment.

For more information concerning the above-mentioned services, please contact the following FLANDERS Electric Service Centre.

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