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Electric Motor Testing – "The New Kid on the PdM Block"

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Figure 1

While vibration analysis and infrared thermography have been widely used for years as part of predictive maintenance programs, Electric Motor Testing (EMT) is a relative new-comer to condition monitoring. In reality though, the tests utilized by modern EMT systems have been around for years.

What is EMT?

EMT in its simplest form is a process of determining the health of an electric motor and its associated circuits through the use of specific electrical testing equipment. Testing equipment used in the past might include: VOM, ammeter, megohmeter, LRC bridge, low resistance bridge, oscilloscope or a monolithic rotor bar tester, to name a few. This approach to EMT has been going on for nearly a century. So why have I referred to EMT as "the new kid on the block?"

Beginning about 15 years ago, several manufacturers began to incorporate several of these individual pieces of testing equipment into one or two pieces of portable, computer-supported testing equipment. These portable testers can be used to quickly and accurately capture motor circuit data that can be measured, quantified, stored and analyzed to help anticipate and identify fault conditions that can lead to the premature failure or loss of an asset. EMT equipment can also serve as a motor database allowing a user to track motors, trend parameters, and search for specific criteria. The captured data can then be presented in several different formats for reporting the motor information. The combination of all of the above pieces of testing equipment into portable test equipment was the key to enabling efficiency and accuracy in order to help increase asset reliability.

Electric Motor Testing can be further defined as de-energized offline (static) testing and energized online (dynamic) testing. Each of these tests provides unique data that can be correlated with other technologies, or with each other, to identify failure modes in their infancy. Let's look at these two types of testing a little closer.

Offline Testing

Offline testing is done by applying a voltage, with very low amperage, at different frequencies, to a de-energized motor circuit. Several different parameters can be measured without any damage to the circuit or motor. These test signals are typically applied at the motor control center (MCC) bucket (see Figure 1) feeding a motor and its associated asset (pump, gearbox, fan, etc.) It is sometimes necessary to test at a secondary disconnect or the motor junction box in order to isolate the source of a problem between the control circuit and the motor.

The following parameters are measured and can be trended to determine the health of the motor and motor circuit:

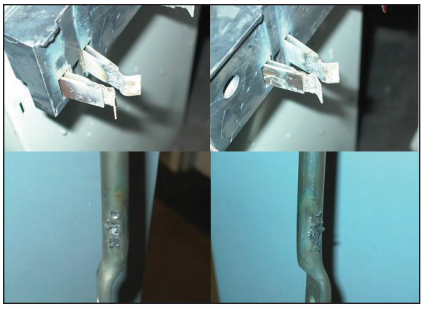

Figure 2

Resistive imbalance is measured to identify any high resistance connections in the motor circuit or motor. These results can typically be correlated to infrared results but can "see" connections to which infrared wouldn't have access.

Resistance to ground is checked to confirm the condition of the insulation in the feeder cables and the insulation of the motor stator windings. It is much more economical to perform a proactive clean, dip and bake of a motor than a reactive rebuild after failure of the insulation system.

Inductive imbalance is trended to identify rotor bar problems. Rotor bar issues such as porosity, breakage or connection to the end ring effect motor efficiencies and often lead to catastrophic failure.

Capacitive imbalance is trended to watch for the cleanliness of the motor windings. Increases in capacitive imbalance would suggest performance of a clean, dip and bake to lengthen the life of the motor.

Rotor Influence Check (RIC) is another offline test, which is used to determine eccentricity of the rotor to the stator and rotor health. This is done by rotating the shaft of the motor through a series of decreed increments depending on the number of poles the motor has and measuring the influence of the magnetic field on the stator windings. The RIC is usually performed as a baseline check.

Online testing

Online testing is done by connecting current transformers (CT) and potential transformers (PT) on each phase of an operating motor at the MCC. All sizes and voltages of motors can be tested utilizing EMT equipment. High voltage systems are checked by connecting the EMT CTs and PTs to the motor circuit CTs. This allows high voltage systems to be tested at 120-volt levels without signal parameter loss. Online testing allows identification of many of the same failure modes as offline testing, as well as a few more. This can also be done without interrupting production. Data is trended and compared to previous testing or existing IEEE or NEMA standards.

The following parameters are measured and trended online to determine the health of the motor and motor circuit:

Power Analysis is done to analyze current and voltage imbalances and levels. In addition, harmonic distortion can be identified. This information is used to check incoming power quality and the effects of the motor on the electrical system.

High/Low Resolution establishes pole pass side band amplitudes which indicate the condition of the rotor bars.

Eccentricity measures the non-uniformity of the air gap between the rotor and stator. This can indicate bearing or alignment issues.

Demodulation filters out the 60Hz carrier frequency and reveals hidden signals representing repetitive load variations caused by mechanical faults in bearings, gears and pump drive trains.

Where is the Value?

Let's give some examples of motor circuit problems identified by EMT to offer an idea about the effectiveness of this technology. In one case, during a routine, online

Figure 3

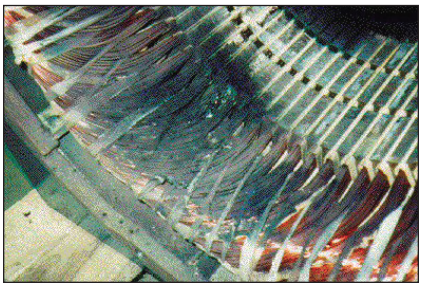

Figure 4

inspection, a motor circuit was found to be in a single-phased condition. Further troubleshooting revealed an unsatisfactory bus connection at the MCC bucket. Figure 2 (previous page) shows pitting on the bus stabs and bus bar severely pitted from arcing. In another situation, during a routine offline EMT test an unusually low resistance to ground was detected. As seen in Figure 3, the motor lead connections inside the motor junction box had arced through the insulating tape and were making contact with the junction box cover. Each of these examples is not related to the motor itself but to the motor circuit. However, if undetected, each one would have lead to a catastrophic failure. Now let's look at one more example where a problem with the motor itself was discovered. A quarterly inspection revealed a high impedance imbalance and a high current imbalance during online testing. To confirm an anomaly, an offline test was scheduled. A resistive imbalance confirmed the findings. Figure 4 shows a short in the end turn of a stator winding in the motor.

How often should EMT be scheduled?

Industry best practices suggest online testing be completed quarterly and offline testing be conducted once or twice a year depending on the environment in which the motors are operating. Harsh environments with dust or high moisture can benefit from more frequent testing. These environments may also dictate slight modifications to existing recognized alarm levels; however, the user must understand that motor life expectancy is going to be reduced when motors operate outside design.

EMT as part of a total motor management program

EMT analysis is a tremendous predictive maintenance (PdM) tool; but, its benefits as part of a total motor management program can be a tremendous. A few items that a motor asset management program includes:

- Specifications for new and rebuilt motors
- Acceptance testing for new and rebuilt motors
- A method of tracking a motor from birth to burial
- A clean, dry location for proper storage
- A decision tree for replacement verses rebuild
- Motor reliability testing, both online and offline
- A system to address energy consumption and efficiency

EMT can be used to support many of these areas. Acceptance testing and utilizing offline tests can be used to validate the condition of new or rebuilt motors before accepting delivery. These tests can also be conducted before installing a motor pulled from storage. There is nothing more frustrating than installing a motor, especially one with difficult accessibility, only to find out that it won't start or it fails prematurely and you have to repeat the process. A quick offline check can provide confidence that you are installing a good motor. Properly identified motors and EMT software can allow for tracking of motors and their applications. Bad actors can be evaluated for appropriate application and design. Online and offline testing will facilitate proper planning and scheduling of repairs and replacement. This should allow for an economical clean, dip and bake as opposed to a less economical rebuild.

It is your ability to see a failure developing that is going to make your operation far more profitable and keep your customer satisfaction level at its peak.

As with any PdM technology, there is a decision to be made regarding implementation, an in-house program or outsourcing. Proper training and necessary experience are the primary concerns in making this decision. These days, motor testing equipment ranges in price from $30,000 to $50,000. Training and experience to become qualified and effective at gathering and analyzing data generally takes between one and two years. For most, starting a program by outsourcing makes good economical sense. While the program is being established, a sound business decision can be made as to the possibility of moving the program in-house. Regardless of your approach, Electric Motor Testing can save significant time and money by eliminating unexpected motor failures on critical systems.

In summary

Motors can be maintenance budget hogs. I think you will find that motor maintenance budgets can be reduced drastically by implementing a properly run motor maintenance program. Ultimately when your condition-monitoring (CM)/predictive maintenance (PdM) program incorporates Vibration Analysis, Oil Analysis, Infrared Thermography and EMT, you are well on your way to seeing most all of the failures coming at you long before they have a chance to become catastrophic. It is your ability to see a failure developing that is going to make your operation far more profitable and keep your customer satisfaction level at its peak.

For additional information about thermography, building inspections, and infrared training, visit www.thesnellgroup.com or contact The Snell Group at 1-800-636-9820.