Recognizing the value in continuous monitoring of critical motors

03/21/2019

By Jeff Elliott

For decades, utility plant personnel have performed insulation resistance tests with handheld megohmmeters to prevent motor failures that lead to costly unplanned shutdowns, penalties and re-winding repairs.

However, these tests only provide a "snapshot" of motor health. In a matter of only a few days, motor windings and cables that are exposed to moisture, chemicals, contaminants or vibration can become compromised and fail at startup.

Portable megohmmeters also require electrical technicians to manually disconnect the equipment cables and connect the test leads on potentially energized or damaged equipment to perform the manual testing.

These tests expose technicians to potential arc flashes when they access the cabinet. In the United States non-fatal arc flash incidents occur approximately 5 to 10 times per day, with fatalities at the rate of approximately one per day.

With so much at risk, plant managers are recognizing the value of continuous megohm monitoring of insulation resistance that initiates the moment the motor is off until it is re-started again.

Armed with this real-time information, maintenance personnel are able to take corrective actions ahead of time to avoid a failure that would interrupt production. By doing so, they can save utilities hundreds of thousands of dollars in repair fees for expensive rewinding, failure-to-produce penalties and lost production time.

Furthermore, permanently installed automatic testing devices allow for "hands-off" monitoring without having to access cabinets – keeping technicians out of harm's way.

Motor Protection at Utilities

Power generation utilities rely heavily on motors, though the number and type vary depending on the size of the plant and type of fuel burned. Coal-fired power plants can have as many as 20-30 critical motors, with less for other types of fossil fuels. A combined-cycle plant may have less motors.

Critical motors are essentially those that could significantly impair the ability to safely meet business objectives or affect production levels if unexpectedly offline. This could include small 480-volt motors up to 13.8 kV. Some examples include circulating water motors, boiler feed pumps, gas compressors, forced draft and induced draft fans.

Most utilities maintain these motors through time-based preventative maintenance (PM) programs. Insulation resistance tests are typically scheduled on a semi-annual basis; however, given the reduction in personnel at most plants, it may even be less frequent. Based on these tests, motors may be scheduled to be sent out to repair shops for reconditioning.

Typically, insulation resistance tests are also conducted at the start of annual overhauls or planned outages, to identify any motors that might also need repairs.

Still, despite PM programs, motors that are offline or are frequently cycled can be quickly compromised.

"We had our fair share of motor failures, and it became quite costly," said Richard Hohlman, who retired after 37 years working in power generation.

In the 1990s, Hohlman was plant manager at a four-unit 1,500-MW plant located on Long Island Sound.

"Sometimes the failures can be really expensive," Hohlman said. "At that particular plant, we had a couple of Westinghouse two-speed PAM AC induction motors and rewinding one of them would have been a six-figure expense.

"From an O&M perspective, if we can identify a weak motor and avoid the risk of trying to start it up and having it fail, that is a big savings."

To avoid this scenario, Hohlman says he required all critical motors that were shut down for 24 hours or more to be manually tested with a megohmmeter before being restarted.

"That became an expense in itself, because the tests are often conducted at different hours of the day, at overtime rates," says Hohlman. "But, by doing it we avoided a number of motor failures."

Hohlman says a member of his team discovered a continuous testing and monitoring device, the Meg-Alert, and installed it initially on four circulating pumps and several induced draft fans. Later, the devices were also added to several forced draft fans and other critical motors throughout the plant.

The Meg-Alert unit is permanently installed inside the high voltage compartment of the MCC or switchgear and directly connects to the motor or generator windings. The unit senses when the motor or generator is offline and then performs a continuous dielectric test on the winding insulation until the equipment is re-started.

The unit functions by applying a non-destructive, current limited, DC test voltage to the phase windings and then safely measures any leakage current through the insulation back to ground. The system uses DC voltage levels of 500, 1000, 2,500 or 5,000 volts that meet the IEEE, ABS, ANSI/NETA and ASTM International standards for proper testing voltage based on the operating voltage of the equipment.

The test does not cause any deterioration of the insulation and includes current limiting technology that protects personnel.

"With continuous monitoring, the O&M team is aware at all times of the motor's fitness for duty," said Hohlman.

"Every single time the motor shuts off, if it is for seconds, a day, or for the 10 days of an outage, the motor is being tested," he added. "And, if it goes below a safe level, it alarms immediately and can lock the motor from even starting."

This stands in stark contrast to the snapshot taken by a megohmmeter at the start of a shutdown. In a matter of days, the motor can pick up considerable moisture due to humidity and contamination.

"After a planned maintenance period, you can have megohmmeter readings that look good, but perhaps something happens to cause a delay to the start up," Hohlman said. "Now, the motor is sitting in moist or damp conditions and insulation resistance to ground is degrading. Perhaps two days later, you start the motor and lose it because the conditions have changed."

"Hands-Off" Monitoring

The continuous monitoring system also allows for a "hands-off" approach that does not require service technicians to access control cabinets to perform a manual insulation resistance test.

Instead, an analog meter outside on the control cabinet door shows the insulation resistance megohm readings in real time. The meter also indicates good, fair and poor insulation levels through a simple "green, yellow, red" color scheme. When predetermined insulation resistance set point levels are reached, indicator lights will turn on to signal an alarm condition and automatic notifications can be sent out to the monitoring network.

"If you lose a critical motor, especially during peak production time, you have just lost 350 megawatts of production at the site," he said. "You could be down for weeks if you have to remove the motor and send it out for repairs. That can have a huge financial impact."

Even if a spare motor is available on-site, the downtime and labor costs can escalate quickly. Continuous monitoring can also show if the heaters used to maintain thermal temperatures or prevent condensation are working properly.

Most motors utilize heaters to maintain the temperature inside the motor so it doesn't vary drastically from operating temperature or ambient temperatures outside the unit. If it goes below the dew point, the motor will start picking up condensation while offline.

However, if these heaters fail to operate properly or the circuit breaker is tripped, plant personnel may not be aware of it until the motor fails on startup. Although these motor heaters are checked regularly, this can leave critical motors unprotected for weeks or even months.

"Given that a large 4160V pump motor costs about $150,000 to rewind, I can buy an awful lot of continuous insulation testing and monitoring devices for that price and it prevents the issue," Hohlman said.

"I'm just trying to automate the process to prevent problems," he added.

Preventing Arc Flashes

Arc flashes are an undesired electric discharge that travels through the air between conductors or from a conductor to a ground. The flash is immediate and can product temperatures four times that of the surface of the sun. The intense heat also causes a sudden expansion of air, which results in a blast wave that can throw workers across rooms and knocked them off ladders.

Arc flash injuries include third degree burns, blindness, hearing loss, nerve damage, and cardiac arrest and even death.

Among the potential causes of an arc flash listed by NFPA 70E includes "improper use of test equipment."

Although de-energizing equipment before testing and wearing appropriate personal protective equipment (PPE) is recommended, the best solution is to eliminate the need to access the control cabinets at all to perform insulation resistance tests.

Constant Vigilance

According to Hohlman, the bottom line with automated, continuous insulation resistance testing is that it can help utilities ensure critical motor reliability, decrease the probability of failure on startup, reduce unscheduled downtime and save on repair costs.

He added that plants can also avoid penalties associated with failure to meet contractual power generation commitments. If a surprise motor failure occurs, it can cause production delays or cause the utility to be temporarily de-rated.

"If you have continuous monitoring, it reduces exposure to those kinds of penalties as well," Hohlman said.

About the author: Jeff Elliott is a Torrance, Calif.-based technical writer. He has researched and written about industrial technologies and issues for the past 20 years.