Motor Guarantee Corporation

Tech Talk

by L.Y. Wagner, Ph.D.

#2: Safety and Effectiveness in Resistance Testing

—Prioritizing Operating Characteristics

Brief: Automatic devices to test insulation resistance and safeguard rotating equipment all sound great...but performance varies widely. Particularly with regard to personal safety, and to utility (read: "is this worth doing?"*), stringent standards must be applied.*

About Conventional Megohmmeters

Effectiveness

Until a few years ago, megohmmeters provided the only means of testing insulation resistance.

Hand-held megohmmeters have been around for decades. They're simple, inexpensive, and generally reliable. They test with a suitable voltage—usually up to 500 and sometimes 1,000 volts. Diligent use as part of a rigorous preventive/predictive maintenance program can, in fact, "forecast" resistance degradation and allow conveniently scheduled repair or replacement before equipment is endangered.

Consistency of Use

As noted above, megohmmeters work only when people remember to use them. Further—above minimum safe levels*, the change in readings from one measurement to the next is more important than the level of the reading itself. Unless careful records are kept—for each piece of equipment—these vital variations will not be detected.

* Accepted industry practice is one megohm per rated kilovolt, plus one.

Common Mistakes

Because megohmmeters are so familiar, many people don't realize how often they're misused or misread. With the exception of a few expensive varieties, megohmmeters have analog scales. These are laid out in logarithmic fashion; near the top end of the scale, they're notoriously difficult to read accurately and consistently.

Compounding the problem, the same scale must often be "switched" to cover two or more ranges of readings. In order to gauge the actual resistance of the device being measured, the operator must first read the needle on the log scale, then apply the appropriate multiplier factor, obtained from a chart on the megohmmeter or from the instruction book. More than a few "emergency" repair calls have been made...only to find that resistance levels are fine and the wrong multiplier was used. Worse, of course, are instances where actual resistance is dangerously low, but the megohmmeter reading is misinterpreted to be safe.

Use Difficulty

The other fundamental problem inherent to all conventional megohmmeters is that it's sometimes difficult to access the electrical connections necessary to make a reading. It's *impossible* to make exactly the same connections each time. Though the focus is on variations between readings, repeatability is elusive and consistency unattainable.

Key Operating Characteristics

Numerous products and systems have recently been developed to eliminate the risk of low resistance failures. With any product or method, there are five critical factors to evaluate. These are listed in descending order of priority, reflecting the operating philosophy of this writer based on 20 years' field experience:

Factor #1—Safety

"Off" means Off

When an operating device is shut down, no current should flow through the circuit. A high voltage shock—even when current-limited to a few hundred micro-amps—is extremely unpleasant…and can be dangerous.

One manufacturer provides decals "…to warn people so they don't inadvertently go out, think a motor is off-line and get zapped by the tester. We can't hurt anyone other than shock them, but that aggravates people, and they may jump and fall. We don't want that to happen, so we try to warn them."

Decals are a poor excuse for safety. And — OSHA 29 CFR 1910.147 requires that all energy sources 55 volts or greater must be locked out or tagged out before they can be worked on!

No current should flow through idle equipment. Period.

A "trickle" is too much

Any rotating electrical device is a capacitor. Even a small current, applied continuously, can build up a charge *far greater* than the "safe" level of the current itself. Limiters may shut down the test current on sensing a large load (such as a person), but the stored charge in the machinery can still do considerable damage.

High-voltage isolation

Any test rig connected to circuits of 2,300 volts or more must include a Kilovac relay or other proven high-voltage isolation method. With higher voltages, redundant isolation relays are always desirable.

Factor #2—Usefulness

Resistance cannot, of course, be measured directly; only the current which "escapes" through the insulation can be gauged. Megohmmeters function by applying a test voltage across the windings to measure current leakage.

To determine what this leakage will be when equipment is in operation, it's necessary to test with a voltage—or electrical "stress"—that approximates the voltage the equipment will see while operating.

⇒*Testing a 6,600-volt, or even a 230-volt, piece of equipment with 12 volts is analogous to testing the strength of a railroad bridge by riding a tricycle across.*

The "information" gathered by such testing is not just irrelevant; it's *dangerous* if people make decisions based on the results. In this case, ***no*** test is preferable to one that does not accurately gauge operational resistance levels. —Better to be cautious than to proceed with false confidence.

Factor #3—Failsafe

No matter how well engineered and constructed, any electrical device can fail. Because the described devices are expressly designed to prevent damage at start-up, there *must* be positive assurance that faulty equipment cannot be energized:

- If the equipment fails, power must not flow through the circuit.

- If the testing device fails, power must not flow to the equipment being protected.
- If a test lead falls off, power must not flow to the equipment being protected.
- Insulation resistance must *positively* test within the “safe” range in order for protected equipment to be energized.

These conditions must be met each time the control switch is thrown. *Automatically.*

Factor #4—Accuracy

As noted above, conventional megohmmeters use analog meters—often with confusing multipliers—to indicate resistance levels. Many “automatic” systems do the same...with marginal results.

Since the information needed is the *rate of change* in insulation performance, it's necessary to record precise readings...consistently. The only way this is possible is to use a meter with a linear scale, preferably with a digital read-out. Logarithmic scales can't provide needed accuracy.

In case it's not obvious: systems with less instrumentation than even an analog meter seriously compromise utility. Some offer “stoplight” signals: a series of green, yellow and red LEDs (for “OK,” “caution,” and “danger”). Others offer only a warning buzzer, for a “go/ no-go” approach.

To catch equipment on the verge of failing, these are of marginal value. For predictive maintenance, they're useless.

Why is the “rate of change” more important than a single megohm reading? If a motor is tested first when hot and then when cold (or vice versa), resistance levels will change, and we know what shifts to look for. If a motor is tested under constant conditions and shows *declining* resistance, then we know the drop is due to insulation degradation. If conditions remain *constant,* the resistance drop is usually predictable, facilitating repair scheduling.

Also—one metering device may be used to test several pieces of equipment in parallel. In this circumstance, a radical change in the resistance of one component might show up as a very minor change on the entire circuit. Overall resistance may be high—or more likely low; in any case the total circuit resistance will not indicate “normal” levels we would encounter on individual components. The only reliable indicator available is the change—on that same circuit—from prior readings.

Accuracy is essential.

Factor #5—Reliability; Ease of Use

If we could afford the time for operators to accurately megger each piece of equipment, each time it was energized—and if we could count on them to remember, without fail, to do so—automatic systems would not be necessary.

Experience shows that such labor-intensive testing is not just expensive, but impractical; in the real world, the best shop supervisors say they try to megger critical equipment once a month...but can't always manage. Ask where records are stored on resistance levels—so they can make comparisons and analyze rates of change—and they'll likely tap their foreheads.

A system designed to prevent low resistance failure—both gradual and catastrophic types—must test *each* piece of equipment, *each* time it's energized, *without fail.* It must also generate accurate readings for a predictive performance log...and preferably generate reports based on those readings.

The level of “insurance” such a system can provide, and the resulting solid reduction in long-term equipment maintenance and replacement costs—not to mention reduced downtime—can make installation extremely cost-effective.

Safety and Effectiveness Checklist

Before implementing <u>any</u> system or method for testing insulation resistance, a user must answer “YES” to ALL these questions:

1. Is it *completely safe* to use? (Monitored

circuits must not be continually energized!)

2. Is the test close enough to actual operating voltage to be *useful*?
3. Is the system high voltage capable, with redundant isolation?
4. If the test device fails, will unsafe motors still be prevented from starting?
5. Is the display “goof-proof” and accurate across its entire range? [i.e. digital & linear]
6. Is the failsafe setpoint readily adjustable to meet the needs of the application?
7. Can the system be easily mounted, in a secure enclosure, and operated conveniently?
8. Will it allow & facilitate Polarization Index testing?

Remember—compromising user safety is unacceptable; compromising utility and performance is unnecessary.

Demand a system that satisfies your needs!

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L.Y. Wagner received his doctorate from Purdue University, and has been active in the electrical apparatus industry since 1976, focussing on field applications research. Dr. Wagner is Chairman of Motor Guarantee Corporation.

Motor Guarantee Corporation
1363 East 41st Street
Cleveland, OH 44103
(216) 881-MEGS