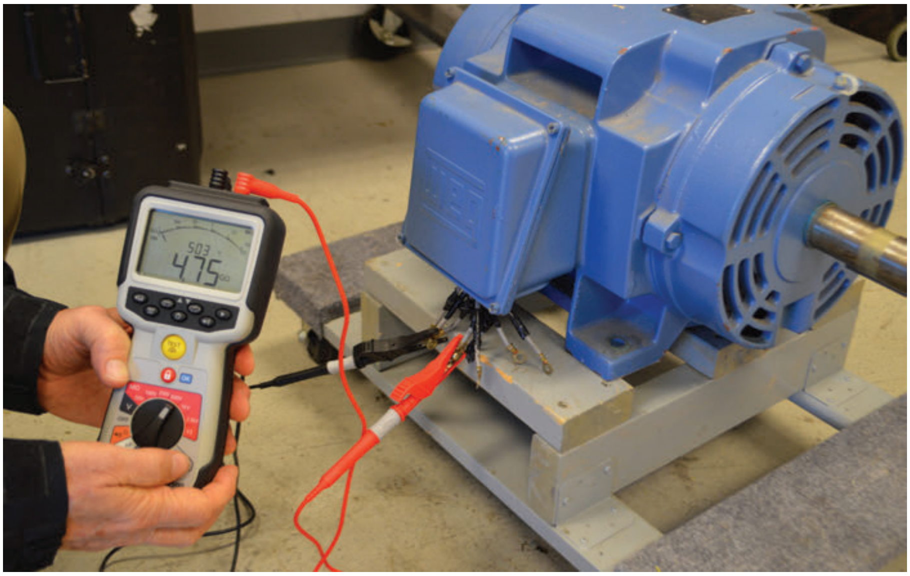
# Medium-Voltage Insulation Testing to New Levels!

By Jeff Jowett, Megger

**For building-wiring and associated equipment**, operating at common 120, 240, 480 & 600 volts, the old, familiar hand-cranked analog insulation testers at 1 kV were the recognized industry standard from the Turn of the Century…the 20th Century, that is. Most maintenance testing could be performed at or around rated operating voltage, and for stress testing and troubleshooting, the top of the selector switch at 1 kV was sufficient. But when necessary to move to medium-voltage applications in industry and utilities, a quantum leap in test capability and attendant instrumentation, to 5 kV and higher, became a challenge.



They weighed up to 40 pounds, came in elegant teakwood boxes, and often only a supervisor or Master electrician would be the authorized operator. These old testers were fine in their ability to make a quality measurement, and probably a few are still in use today. But they took some judicious handling. The original measurement circuit in these old medium-voltage insulation testers was by an ingenious cross-coil mechanism, whereby two circuits operated independently while within a coaxial C-shaped magnetic core. These were called the current (deflecting) and potential (control) coils. The current coil was in series with the load (Item Under Test, or IUT), while the control coil was in series with an on-board standard resistor. A coaxial shaft, supported on either end by spring-supported jewel bearings to which was affixed the pointer that traveled over the scale plate, completed the mechanism.

When energized by cranking the on-board generator, the two coils were connected in opposition, so that the pointer would come to rest when the opposing torques balanced. When no load was connected, only the control coil carried current and, unopposed, would rest on "infinity" [∞]. Some sophisticated models would have an Index Adjustor so that the operator could adjust the rest position directly on infinity. How to complete the measurement system? Simple! Simple? Every scale plate was hand-drawn against standard resistors. Each instrument was unique in its own way.

An elegant system, indeed. But it did have limitations. Number one, don't drop it! The jewel bearings were very sensitive and the whole mechanism could easily pop out. Static, even from so much as the operator's hand, could move pointers. Quality units came with leveling feet and an oil bubble in the middle of the scale plate so that the tester could be perfectly leveled in order to minimize pointer drift. Calibration was done in units of pointer widths. In order to cover the enormous range of measurement required by an insulation test, from less than a MΩ to (as in quality models) tera-Ohms, there were multiple scales and the operator had to stay mentally sharp to be always on the right one. On-board generators were typically around 1/20 hp. Line-operated models were available too, but battery power, with its many saving graces, has only been around for less than forty years. The on-board generators could be a source of erratic pointer travel if not of good quality. And of course the same can be said of line power. It wasn't until fairly late in their genealogy that testers offered enough voltage selection to facilitate Step Voltage testing, an invaluable asset for determining intermittent faults. Records were kept on hand-written cards typically hung on equipment in water-proof plastic jackets. Yes, you cold record test results…on something like a 65 foot roll of chart paper!

Instrumentation proceeded pretty much along these lines into the late '70s. But with ever-increasing speed and quickness, modern instrumentation has become a dream by comparison. No, not even by comparison. It's just that good. Over the last 40 years, not only has every aspect of insulation testing been improved, but also capabilities have been added that weren't even imagined a few decades ago.

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The most readily visible is size. We said that old units could weigh 40 pounds. Over recent decades, 12 to 15 pound testers have become pretty common, and “good” models came in around 7. That’s still pretty much the rule, but fading fast. Testers are now available with voltages extended up to 2.5 kV in a **handheld** design, weighing less than 2 pounds! With all the familiar low-voltage tests incorporated into the same tester, all the standard building-wiring equipment plus much that’s on the lower end of medium voltage can now be reliably and rigorously tested with a single tester. And one that requires only minimal operator involvement in terms of set-up and test time…a far cry from the old labor-intensive operation.

Testing capability has expanded exponentially in two other ways as well. Test voltage selection has now become almost infinite. Yes, there have been medium-voltage megohmmeters on the market for decades that could be set at any voltage up to the limit. They operated by Variacs, and the operator would turn a dial and watch the voltage meter until the desired value was reached. The tradeoff was that they would only read direct at one voltage per range selection. At all other test voltages, the operator had to adjust the megohm reading by a multiplier from the bottom of the scale plate, depending on pointer position. A lot of extra work, not to mention confusion and possible error. Not any more! Fully modern testers read direct everywhere, and never require adjustment of the reading. Even more! They show you the unit of measurement, so you know if you’re reading in KΩ, MΩ, GΩ, or TΩ. And by going to a setup position, any almost any voltage across the whole range can be selected by very small increments, usually one volt, and then put into memory against an open selector switch position. No need to set up each time the voltage is required; just turn to the selector position and it’s restored. Such a capability is of enormous advantage in the modern market, as more standards agencies and manufacturers are designating specific test voltage for compliance, and these may be above 1 kV.

Going hand-in-hand with greater voltage selection is greater voltage stabilization. As standards and manufacturers become more rigorous in test voltage application, so do they in voltage accuracy. It has always been a major hallmark of quality instruments to deliver full voltage under load. Only poor, sub-standard testers failed to reach selected voltage until well into the megohm range. Quality testers have always delivered selected voltage right to the edge of what could be considered acceptable insulation. But they would load up a few volts. A 1 kV test might, for instance, be conducted at, say, 1032 Volts…but **never** at 998. Now, manufacturers of equipment are more and more wanting to see tests performed under more rigorous standardization, including a narrow window for applied test voltage. And modern testers can deliver. A typical test voltage accuracy would now be -0, +2%. This represents a ten-fold improvement over standard specifications less than a year ago.

Numerous functions have been streamlined in modern testers with the goal of substantially reducing operator **time**. Discrete selector switch positions help the operator move through a job quickly but with no loss of effectiveness that often accompanies “speeding up” a job. Microprocessor efficiency in instrumentation has made it possible to better integrate many functions so that the operator expends less set up time. An example would be the integration of continuity function with what was often called a “resistance” measurement, meaning a measurement at only a few volts taken below a MΩ. Advanced testers can now measure continuously from below an ohm up to a MΩ, where the higher voltages take over, and accomplish this with a single selector position…no more switching back and forth, with the attendant possibility for error. Measuring kilohms has many invaluable uses, including identifying and restoring deteriorated equipment that may nonetheless be cleaned, dried, and returned to service.

Another critical time saver is the inception and implementation of pass/fail values in the test instrument. Such a capability was unheard of until recent years. Operators would have to observe the display and make a determination. But many tests…installation tests and agency compliances, for example…require only the achievement of a specified resistance at a specified voltage. Set that value on the setup menu and the tester will now both visibly and audibly indicate when the value is reached. Hear the beep, end the test, and move on. Speaking of convenience, remember when road jobs were routinely interrupted, delayed,

and even aborted by failed/discharged batteries? No more. Top quality testers can fully recharge in as little as 3 hrs. Go to lunch or work on some mechanical aspect of the job and then pick up the electrical testing well before quitting time.

All these conveniences are not achieved without a price, but manufacturers of shoddy equipment try. Be especially aware of **missing** data on a spec sheet. It is a common ploy for poorly-integrated equipment to trumpet a few state-of-the art features while cutting costs on functions that may be taken for granted. No better example exists than that of the guard terminal. Sometimes mistaken for a “ground”, the guard terminal is indispensable on medium-voltage testers, but often not necessary on 1 kV models. It is now available on handheld medium-voltage testers. The guard provides an added dimension of analytical capability by enabling the operator, through judicious connection of three test leads, to eliminate a parallel leakage path and concentrate on just one aspect of the IUT. A prime example (and one of great relevance in medium-voltage testing) is that of bushings, where surface leakage down the bushing can be eliminated and only leakage through defects in the ceramic is measured.

Artful use of the guard facilitates salvaging of equipment that might otherwise have been thought to have failed. But watch out! The guard circuit is a prime target for shoddy manufacturers cutting production costs. A deceptively attractive specification can then be proffered for the two-terminal aspects Continued on page 20

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of testing while conveniently leaving the guard spec out. But the guard circuit competes for limited output current with the test circuit and can introduce an error approaching 100%! Furthermore, other features, such as IEC 61010 conformance for arc flash safety, are often compromised by poor guard design. Examine the guard terminal spec, and if it's not there, don't buy!

An easy, convenient, and high-quality handheld tester can now be utilized in medium-voltage applications like the testing of manufacturing production line goods, commercial avionics, military land, marine and air communications, solar panels, battery powered traction equipment, component testing, electrostatic measurement, cable commissioning, motor and generator testing, panel construction, HVAC, wind turbines, and a gathering field of additional uses. But never lose sight that a quality tester is an invaluable aid to quality work. It is **not** a substitute for a well-trained, knowledgeable and experienced operator. ❏