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ADVANCEMENTS IN THE INDUSTRY

CHOOSING THE RIGHT GROUND RESISTANCE TESTER

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A heightened focus on safety, combined with the increased application of highly sensitive, low-powered electronics susceptible to electrical noise issues, has made the need for an effective low-resistance grounding system more critical today. Additionally, grounding systems do degrade over time.

As a result, awareness of the importance of periodically testing installed grounding systems to ensure their integrity has also increased. Many organizations require annual testing with written reports filed. Today, the test engineer or technician has access to a wide variety of ground resistance test equipment to complete this task.

Test equipment varies in design, features, and complexity, including small, handheld models as well as larger field instruments with a full complement of user-selectable functions packaged as part of a complete kit. These products range in price from a few hundred dollars to several thousand dollars. Several critical questions are key when selecting a ground resistance tester. This article is a guide to choosing the instrument best suited to your specific application and requirements.

REGULAR TESTING FOR SOIL RESISTIVITY

The first question is whether your current or future needs require soil resistivity testing, because this will determine the type of ground resistance tester needed. For example, if the work involves the calculation and/or expanding/upgrading existing systems, soil resistivity testing is necessary to determine design characteristics the system must have to achieve the desired resistance. The number and depth of ground rods and the interconnection of the ground grid are some of the parameters. An instrument designed for four-pole testing (also referred to as four-point testing) is required for this application. In addition to the instrument, four test electrodes and cables are needed. A basic four-pole tester provides measurement results in ohms. You can then use this reading to manually calculate soil resistivity known as Rho (ρ) by applying the result in a formula that also requires knowledge of the test rod spacing and depth. The result is usually expressed in ohm-centimeters (Ohm-cm) or ohm-meters (Ohm-m).

More sophisticated instruments include built-in formulas for calculating soil resistivity using one of two methods: Wenner (Figure 1) or Schlumberger. If you regularly perform soil resistivity testing, consider purchasing an instrument that automatically calculates soil resistivity. This will save time and eliminate potential math errors.

Figure 1: *Soil Resistivity Test Using the Wenner Method*

TYPES OF GROUND SYSTEMS FOR TESTING

The obvious follow-up question involves which types of grounding systems will be tested. Will this include small systems such as residential, or larger and more complex systems such as commercial, industrial, telecommunication, or electric utility installations?

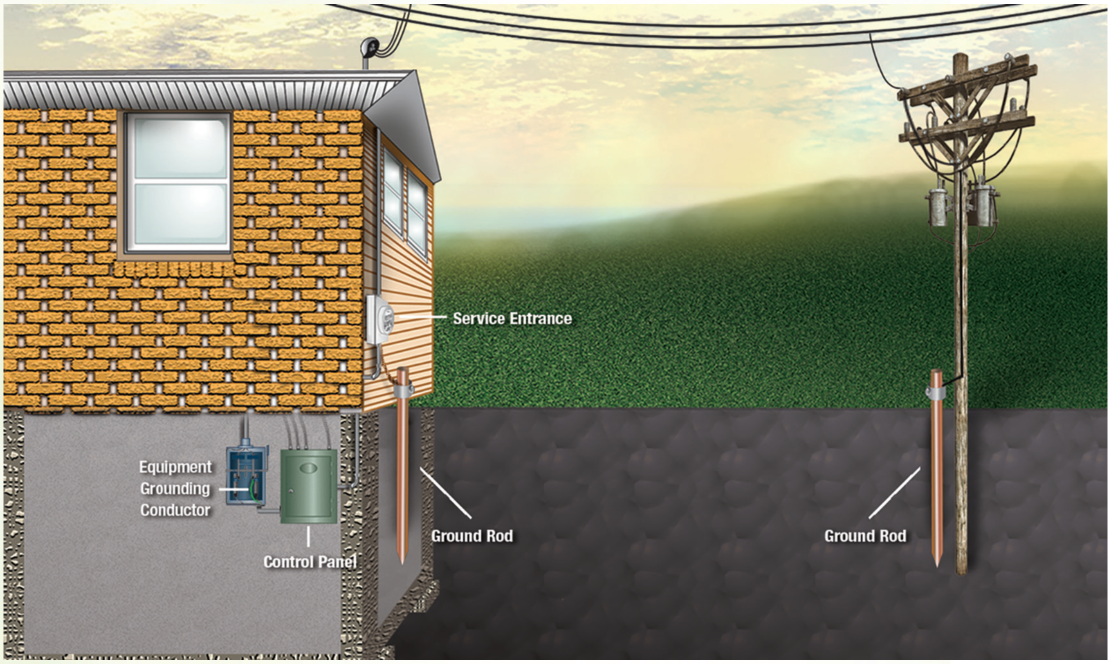

Figure 2: *Small Grounding System*

To illustrate the importance of this question, consider a typical small site with a grounding system consisting of a ground rod or two, driven into the earth and connected to the service entrance.

In Figure 2, if the building has not yet been connected to the utility ground, a basic three-pole ground resistance tester (or a four-pole instrument configured for three-pole testing) will suffice for measuring the resistance of the ground rod. In addition to the instrument, two auxiliary electrodes and spools of test cable are required.

If the building's grounding system has been connected to the incoming power system through connection at the service entrance, a clamp-on ground resistance tester is a better choice, because it can measure the grounding resistance without the need to disconnect from the Utility neutral or to drive auxiliary test electrodes. If you choose a three- or four-pole instrument for this, bear in mind the distances required for auxiliary rod placement. For example, performing a fall-of-potential test (Figure 3) on a single grounding electrode driven eight feet deep requires at least an 80- to 100-foot test lead to connect to the injecting test electrode and a 50- to 70-foot test lead to connect to the potential measuring electrode. If more ground rods are used, the distance requirement increases.

Ground resistance test kits are available that include the measurement instrument, the auxiliary electrodes (two are needed for fall-of-potential testing, four are needed for soil resistance testing), and test leads to complete all the connections. Typical lead lengths provided in these kits range from 100 to 500 feet. It will be well worth your investment to select a ground resistance test kit with leads at least one size longer than your immediate need. So if 150 feet is required, a kit that includes 300-foot leads will provide for your current need and potential future needs. For larger sites with multiple rods or ground grids, consider kits that provide 500-foot leads.

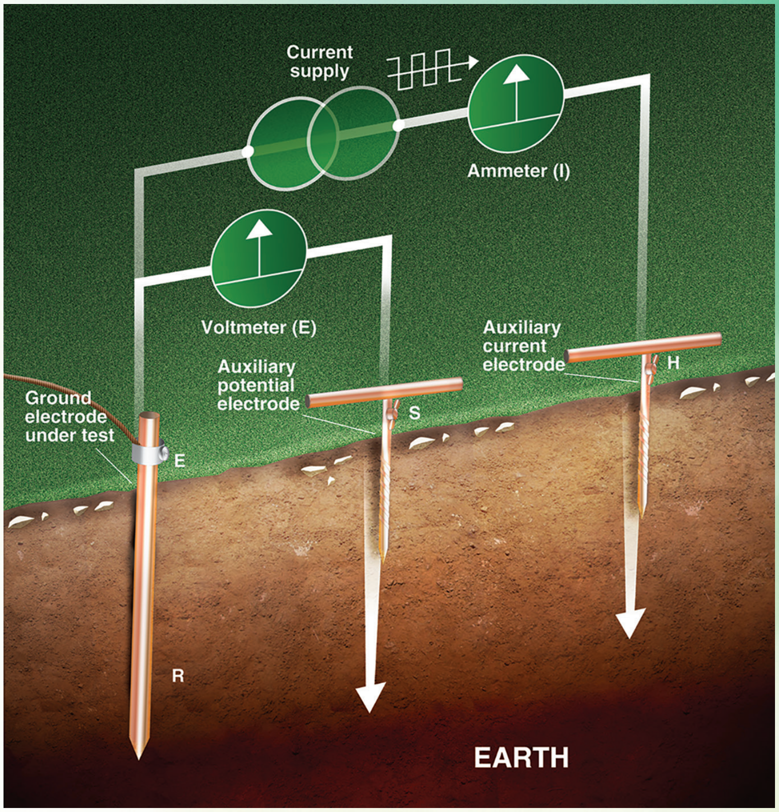

Figure 3: *Typical Fall-of-Potential Test Setup*

DETERMINING HIGH SOIL RESISTIVITY AND TEST LEAD LENGTH

Another question is whether the soil resistivity in the testing area is high or whether the distance required for the auxiliary rods to perform fall-of-potential testing is unusually long. If the answer to either of these questions is yes, and you intend to perform fall-of-potential and/or soil resistivity tests, you must consider the instrument's injection current and test voltage. Typical injection currents range from a few milliamps up to several hundred mA. High soil resistivity usually produces high contact resistance for the auxiliary electrodes. This can be of concern when using lower-cost instruments that typically provide 10mA or less of test current. In this circumstance, an instrument capable of delivering higher test current is recommended. Note that clamp-on instruments do not require any auxiliary rods or leads. Another advantage is that you do not need to take the grounding system out of service to perform the test.

PRESENCE OF ELECTROMAGNETIC INTERFERENCE

Another factor is whether electromagnetic interference is present at the test site. EMI can result in unstable or inaccurate readings, particularly at lower test frequencies.

The most common test frequency employed in ground test instruments is 128Hz. Newer instruments available today feature manual and/or automatic test frequency selection and can scan through a range of frequencies to find the cleanest available frequency. This provides an advantage in high-EMI environments, thus eliminating, or greatly reducing, the ill effects of the noise. Clamp-on ground resistance testers can also be effective in such locations, since they typically test at higher frequencies that are not multiples of the normal power frequency. Newer clamp-on ground resistance testers also offer test frequency selection. Note that in some high-inductive environments, lower test frequencies can produce more reliable results.

USE OF MEASUREMENT DATA

The choice of instrument depends on how you intend to use the data. For example, if you plan to save, analyze, and distribute the test results, data storage and report generation are important considerations. Newer and more advanced instruments — three- and four-pole testers as well as clamp-on ground resistance testers — can store test results in internal memory. This data can then be downloaded and analyzed using software supplied with the tester or via mobile apps for smartphones and tablets (Figure 4).

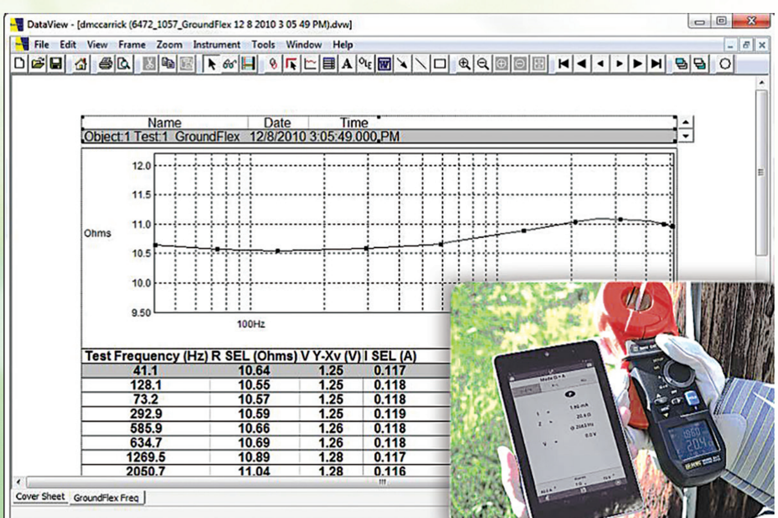

Figure 4: *Application Software Fall-of-Potential Test Report (left) and Clamp-On Ground Tester Communicating with an Android™ App (right)*

This can be a very powerful tool for contractors conducting tests for clients. The ability to easily compare the new measurement data with past data is a valuable tool in determining system degradation. An added advantage with a mobile app is the ability to immediately send test results as an email or text message right from the job site.

TESTING THE BONDING OF GROUNDING SYSTEM COMPONENTS

Finally, if you plan to test a complex grounding system consisting of many components including a ground mat or grid, the continuity of bonding between the various elements must be tested. This test is most often conducted using dc voltage and current. Several ground resistance testers provide this capability, with test currents up to a few hundred milliamps. In addition, a more complete test can be performed with a micro-ohmmeter. The advantage in using this instrument is its ability to test at high test currents, typically up to 10A or more. This can expose problem areas not always revealed when testing with milliamp-range currents.

SUMMARY

Basic grounding electrode resistance testing requires a three-pole tester to conduct the common fall-of-potential test. To conduct this test adequately, the system under test must be isolated from other grounding systems. If it is not possible to disconnect or isolate the system under test, then a clamp-on ground resistance tester is a better option.

If you are conducting tests in electrically noisy environments, such as near transmission towers or power lines, a three- or four-pole tester with selectable frequencies may provide more accurate results.

If soil resistivity testing is needed, a four-pole tester is required. Consider one that will calculate the final result in ohm-centimeters (Ohm-cm) or ohm-meters (Ohm-m) and has minimal test current of 10 milliamps or more.

Bond resistance testing is best conducted with dc current. Consider a four-pole tester with higher test current capability typically in hundreds of milliamps. You could also move up to a more capable micro-ohmmeter capable of testing up to 10 Amps.

Finally, if you are conducting ground-resistance testing on a regular basis and are required to provide reports of the test results, consider an instrument that can store and output the measurements and includes application software to generate the fall-of-potential plots and provides a professional report. It will pay for itself in a very short time.

There are specialty tests using fall-of-potential methods to effectively measure tower leg resistance and the effects of adjacent grounding systems on each other, which is a topic for a future article.

***John Olobri**, Director of Sales and Marketing at AEMC® Instruments, holds degrees in electrical and industrial engineering and has worked in the design and marketing of instrumentation for over 35 years. He began his career designing oscillographic chart recorders and subsequently held positions of Service Manager, Product Marketing Manager, and Sales Manager for several instrument manufacturers. For the past 20 years, John has been Director of Sales and Marketing for AEMC® Instruments, where he has been actively involved in insulation resistance, ground resistance testing, power quality testing, and data logging. He also conducts accredited seminars on ground resistance testing in various cities around the country.*