



GROUNDING TEST REQUIREMENTS AND EQUIPMENT: KNOW BEFORE YOU GO

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The gold standard for grounding testing is IEEE Std. 81–2025, *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System*. Its purpose is to assist engineers and technicians in obtaining accurate, reliable grounding system measurements and interpreting data for design validation. This standard covers:

- Safety considerations
- Measuring earth resistivity, power system frequency resistance or impedance of the ground system, touch and step voltages, and transient/surge impedance
- Verifying the integrity of the grounding system
- Common test methods, instrumentation characteristics and limitations, and factors that can distort test measurements

In addition to being familiar with this standard, successful testers must also be aware of grounding test equipment options, their pros and cons, and the correct application of each device.

SAFETY FIRST

Many years ago, grounding testing relied on low-current, low-power test equipment, and

sites could often be tested successfully using the fall-of-potential (FOP) method. Today's equipment is much more powerful, and therefore more dangerous. One critical hazard includes induced voltages and current on the test leads due to capacitive and inductive coupling from overhead lines or underground power cables. Voltage can be sourced at a site other than the site under test or from other energized sources in the area, even if the site under test is de-energized.

A written job safety analysis (JSA) with a briefing must be conducted prior to testing. All team members should understand the testing process and potential safety hazards and have the authority to stop work to resolve issues. Test personnel should maintain clearance from the test probes when energized by test sets producing more than 50 V.

DEFINITIONS PER IEEE STD. 81

The new IEEE Std. 81, released in November 2025, covers four new and redefined ground testing terms:

1. The **integrity** test is a measure of electrical continuity between two or more conductive items that, when energized, will become an acceptable path for current conduction with a negligible voltage drop across the elements and their points of interconnection. The test equipment is specified as requiring either a large enough signal to make errors due to power system noise (and other sources) negligible by comparison, or using other means, such as filtering, signal type, and polarity, to adequately reject errors due to site noise.
2. An **impedance** (or resistance) test is a measured value between a ground system and remote earth that can validate the performance of a new or existing grounding system. Some test equipment methods require the site to be isolated to measure impedance/resistance accurately.
3. A **current distribution** measurement is used to validate and determine current splits. The intent is to determine the contribution that each current path makes and calculate its apparent impedance. The test can identify paths that require further investigation and identify potential transfer hazards. This test is limited to evaluating only accessible grounding paths.
4. The existing **current injection test** (CIT) term has a new definition. Per the new standard, this test is an injection of an AC test signal at a frequency different from the nominal power frequency to minimize interference into the grounding system over the following:

Overhead. A transmission feeder line, the preferred method, requires a transmission line outage, which is rarely feasible and adds considerable expense and complexity.

Overland. This test does not utilize an existing conductor and will require deployment of a test lead conductor.

The CIT measures ground potential rise (GPR), touch voltage, step voltage, mesh voltage, and transfer voltage for a response at key locations. It can measure the zone of influence for telecommunication equipment and provide an evaluation of the expected grounding system performance by scaling the measured response to the value expected during a ground fault.

TEST EQUIPMENT SPECIFICATIONS

All of the test equipment presented has the ability to meet the new IEEE Std. 81-2025 test definitions described above. However, each type of test equipment has its advantages and disadvantages, specific requirements, and/or limitations. It must be noted that the site under test may have conditions that render a particular model or brand of equipment inadequate or inapplicable.

VIEW TESTING EQUIPMENT >



**AEMC
Test Equipment**

Image courtesy of AEMC® Instruments

AEMC 6472 + 6474 + ACCESSORIES *

Although AEMC and Megger have been around for a long time and offer newer versions of their test equipment, many pitfalls still exist in today's grounding testing, specifically, limited current output that can't overcome test lead interference (low signal-to-noise ratio). This equipment is:

- Less expensive (\$16K)
- DC power, portable
- 250 mA output—very limiting in field testing, even on small sites
- Output frequency 0–440 Hz
- No user interface data—requires the user to interpret data points in the field to determine validity
- Available for rental

MEGGER DET 2/3 *

- Inexpensive (\$6K)
- DC power, very portable
- 50 mA output—extremely limiting in field testing, even on small sites
- Output frequency 10–200 Hz
- No user interface data—requires the user to interpret data points in the field to determine validity
- Available for rental



**Megger
Test Equipment**

Image courtesy of Megger



**OMICRON
Test Equipment**

Image courtesy of OMICRON

OMICRON CPC 100 (OR COMPANO 100) *

- Expensive (\$70K+)
- Training recommended
- Requires AC power for CPC 100 and DC power for COMPANO 100
- Provides real-time data feedback during testing
- Data recorded on tablet/computer
 - CPC 100 = 3 A output
 - COMPANO 100 = 200 mA output
 - CP CU1 = 100 A/50 V or 10 A/500 V output (overhead injection)
- Output frequency 15–400 Hz
- Available for rental



**Safeearth
Test Equipment**

Image courtesy of Safeearth

SAFEARTH AX1 & CS3 *

- Expensive (\$80K+)
- Requires training
- Requires AC or DC battery power
- Data must be recorded by hand—no associated software for field testing (some software for post-test analysis)
- No user interface data—requires the user to interpret data points in the field to determine validity
- 32 A output (overhead)
- Output frequency 40–70 Hz
- Due to training requirements and complexity, not available for rental

SMART GROUND MULTIMETER (SGM) *

- Expensive (\$75K+)
- Requires training
- Requires AC power
- Provides extensive real-time data feedback during testing
- Connected computer records all data
- 16 A output (overland)
- Output frequency 0–250 Hz default. User selectable to 2,000 Hz.
- Due to training requirements and complexity, not available for rental



**SGM
Test Equipment**

Image courtesy of Advanced Power Concepts

TEST EQUIPMENT COMPARISONS *

Based on IEEE Std. 81, the following are direct comparisons of the parameters of the different grounding test equipment:

TURN THE PAGE TO VIEW COMPARISONS THAT COVER THE FOLLOWING CATEGORIES

- Integrity
- Ground Impedance/Resistance
- Current Distribution/Split Factor
- CIT

COMPARE RESULTS OF EQUIPMENT TESTING >

TECH TIPS

INTEGRITY

Equipment	Can Perform	Can't Perform	Notes
AEMC 6472	✓		• DC – very portable • Low current output/signal to noise ratio = low confidence in data
Megger DET2/3	✓		• DC – very portable • Low current output/signal to noise ratio = low confidence in data
OMICRON CPC 100	✓		• Tests at very high current – good signal-to-noise ratio • No phase angle
Safearth CS3	✓		• Fastest but less data • DC – unspool leads as you go • User manually records test points • No phase angle
SGM	✓		• Includes phase angle – Provides additional qualitative data to determine the condition of the bonding conductor • AC – must fully unspool leads to avoid interference • Uses software to identify and reject noise • Software documents every test point with data

GROUND IMPEDANCE/RESISTANCE

Equipment	Can Perform	Can't Perform	Notes
AEMC 6472	✓		• DC – very portable • Low current output/signal to noise ratio = low confidence in data • Remote earth current probe = 5–10x diagonal distance
Megger DET2/3	✓		• DC – very portable • Low current output/signal to noise ratio = low confidence in data • Remote earth current probe = 5–10x diagonal distance
OMICRON CPC 100	✓		• Tests at very high current – good signal-to-noise ratio • No phase angle • Remote earth current probe = 5–10x diagonal distance
Safearth CS3	✓		• Fastest but less data • DC – unspool leads as you go • User manually records test points • No phase angle • Remote earth current probe = 5–10x diagonal distance
SGM	✓		• Includes phase angle • AC – must fully unspool leads to avoid interference • Software documents every test point with data • Remote earth current probe = 2x diagonal distance

CURRENT DISTRIBUTION/SPLIT FACTOR

Equipment	Can Perform	Can't Perform	Notes
AEMC 6472	✓		- Measures with Rogowski coil (1 line at a time, if reachable) and add up to determine split factor - Though not intended for this, per the procedure outlined in IEEE Std. 81–2025, it is capable of performing this test
Megger DET2/3		✗	Doesn't perform this test
OMICRON CPC 100		✗	Doesn't perform this test
Safearth CS3	✓		Measures with Rogowski coil (1 line at a time, if reachable) and add up to determine split factor
SGM	✓		Reports split factor based on measured values

CURRENT INJECTION

Equipment	Can Perform	Can't Perform	Notes
AEMC 6472 & Megger DET 2/3		✗	Doesn't produce enough current for this test
Safearth AX1 & OMICRON CPC 100	✓		Can perform multiple tests at the same time, such as impedance and touch, provided extra manpower and the additional equipment required (OMICRON HGT1 & Safearth MI3) is available
SGM	✓		- Tests at very high current – good signal-to-noise ratio - Includes phase angle

** Information Based on Manufacturers' Websites and Available Brochures*

KEY TAKEAWAYS

The FOP test is still commonly specified, but unbeknownst to most owners, engineers, and testers, it is rarely successful. There is no validation of data nor error reports—all you get is a number. Grounding testing has become much more complicated and expensive than most people realize due to the new standard, test equipment requirements, and time on site.

TECH TIPS

Test personnel must know the grounding test requirements (scope of work) and have extensive knowledge of IEEE Std. 81–2025, including test equipment applications and limitations. Manufacturer training is necessary, particularly with the higher-end test equipment (OMICRON, Sefearth, SGM). Custom equipment training, preferably a combination of classroom and hands-on field testing, is the most inclusive option and essential to successful testing.

The less expensive test equipment, while tempting due to the lower cost, portability, and ease of use, is extremely constrained due to limitations in current output. Only very small, rural, de-energized, isolated sites are likely to be successful. The higher-end test equipment requires a substantial upfront investment in both cost and training and is best considered when many ground testing projects are anticipated, as the learning curve is steep. **INW**



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He provides grounding articles, training, and presentations for conferences and clients nationwide. Rioux has a BS in mechanical engineering technology with a minor in electrical engineering technology from the University of Maine.



Lee Howard is a senior grounding specialist with Hood Patterson & Dewar, Inc. With more than 25 years of experience, Howard specializes in the design and analysis of grounding, lightning protection, and surge suppression systems. He speaks at various industry conferences and offers grounding testing and consulting services to a wide range of domestic and international clients, including

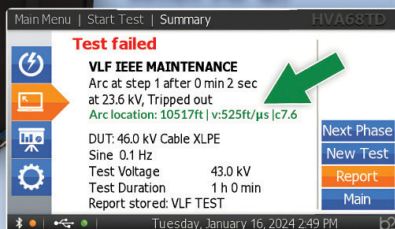
electrical utility, industrial, and commercial sites. Howard holds two patents in grounding and lightning protection products. He earned a BS in electronics engineering technology at DeVry University and a Power Systems Certificate from the Georgia Institute of Technology



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