

FLUKE®

Insulation Testing



Fluke Academy of Certified Training

Distributor Training Program



Product Knowledge

Insulation Testing

Leaking current can cause a range of problems. Find out if poor insulation is the cause. Insulation resistance testers can be used to determine the integrity of windings or cables in motors, transformers, switchgear, and electrical installations.



The *most* important reason for testing insulation is to insure public and personal safety. By performing a high dc voltage/low current test between de-energized current-carrying (hot), grounded, and grounding conductors, you can eliminate the possibility of having a life-threatening short circuit or short to ground. Usually performed after the initial installation of equipment, this process will protect the system against miswired and defective equipment, and will insure a high quality installation, customer satisfaction, and protect against fire or shock.

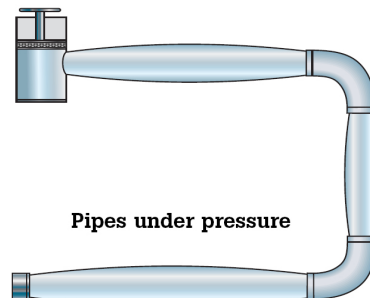
The *second most* important reason for insulation testing is to protect and prolong the life of electrical systems and motors. Over the years, electrical systems are exposed to environmental factors such as dirt, grease, temperature, stress, and vibration. These conditions can lead to insulation failure, resulting in loss of production or even fires. Periodic maintenance tests can provide valu-

able information about the state of deterioration and will help in predicting possible failure of the system. Correcting problems will result not only in a trouble-free system, but will also extend the operating life for a variety of equipment.

Electrical insulation isn't just the plastic polymer material that covers electrical wire. It's an entire system of cable insulation, bushings and spacers within conduit, motors and general equipment. It's important to test insulation because mechanical stress contamination and thermal stress can all degrade these components over time, allowing current to leak.

If current leakage occurs, it can cause many problems:

- Current generates heat as it leaks through insulation, degrading the insulation until it eventually fails and potentially causes a fire.
- Leaking current must get back to the source and will flow through any available conduit, raceway, pipes, water or earth to get there. This undesirable current flow can cause dangerous voltage levels.
- Leaking current is inefficient. Current that leaks out of insulation doesn't turn the motor, or produce light or heat, but still costs money to produce and supply.
- Leakage current can cause overcurrent protection devices to trip and motors and transformers to overheat.



An electrical system is like a plumbing system, where voltage is like fluid pressure, current is like fluid flow rate, resistance is like a shut-off valve and electrical insulation is like the walls of the pipe. If there is corrosion in the wall of the pipe water will leak

Product Knowledge

Insulation Testing

What you will learn in this module:

- Reasons for testing insulation
- Steps to take prior to measurement
- Types of tests
- Common Questions

out. Similarly, insulation keeps electrons from leaking out of conductors; how well it does this is expressed as insulation resistance.

To look for leaks in a plumbing system, you need to pressurize it. You wouldn't turn off the water supply to check for leaks, because the leak is easiest to see when water pressure is at its highest. However, you would limit the available water supply, so if you found a big leak you wouldn't have too much water spraying around. Your ideal test would supply a limited amount of water at high (but not too high) pressure. This is exactly what an electrical insulation tester does.

Insulation testers apply dc voltage across an insulation system at a known current ($V = I \times R$). This allows them to calculate and display the resistance of the insulation (how well the insulation is keeping the current inside the wire, or letting it leak out).

An effective insulation resistance system has high resistance, usually (at an absolute minimum) greater than a few megohms ($M\Omega$)¹. A poor insulation system has lower insulation resistance. The optimal insulation resistance for a system is often determined by the manufacturer's specifications, the criticality of the system, and the environment where it is located.

Portable insulation testers typically output test voltages at 50V, 100V, 250V, 500V or 5000V. The goal is to apply a voltage (pressure) that is high but not too high. We want to find existing leaks, but not overstress the system and cause new leaks. The lower voltages are used for lower-voltage systems like telecommunications or some control wiring, while the higher voltages are used for testing power system insulation, motor windings or transformer windings.

Before measuring

In order to obtain meaningful insulation resistance measurements, the electrician should carefully examine the system under test. The best results are achieved when:

1. The system or equipment is taken out of service and disconnected from all other circuits, switches, capacitors, brushes, lightning arrestors, and circuit breakers. This ensures that the measurements are not affected by leakage current through switches and overcurrent protective devices.
2. The temperature of the conductor is above the dew point of the ambient air. When this is not the case, a moisture coating will form on the insulation surface, and, in some cases will be absorbed by the material.
3. The surface of the conductor is free of carbon and other foreign matter that can become conductive in humid conditions.

4. Applied voltage is not too high. When testing low voltage systems; too much voltage can overstress or damage insulation.

5. The system under test has been completely discharged to the ground. The grounding discharge time should be about five times the testing charge time.

6. The effect of temperature is considered. Since insulation resistance is inversely proportional to insulation temperature (resistance goes down as temperature goes up), the recorded readings are altered by changes in the temperature of the insulating material. It is recommended that tests be performed at a standard conductor temperature of 20°C (68°F). Otherwise a mathematical correction must be performed in order to get viable results.

During the testing procedure, the high dc voltage generated by pressing the test button will cause a small (micro-amps) current flow through the conductor and the insulation. The amount of current depends on several factors:

- amount of voltage applied
- system capacitance
- total resistance
- temperature of the material

Conductive current is a small (micro-amp) amount of current that normally flows through insulation, between conductors or from a conductor to ground. This current increases as insulation deteriorates. Because it is fairly steady and time independent, this is the most important current for measuring insulation resistance.

When two or more conductors are run together in a raceway or through conduit, they act as a capacitor, storing an electrical charge. Due to this capacitive effect, a leakage current flows through conductor insulation. This current lasts only for a few seconds as the dc voltage is applied and drops out after the insulation has been charged to its full test voltage.

Installation test - Proof testing

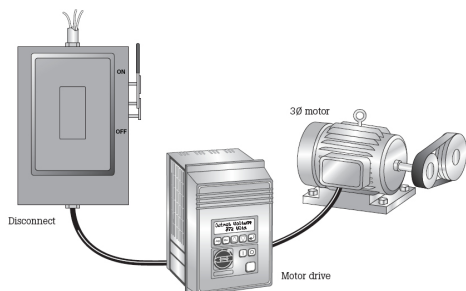
Electricians and engineers perform proof tests to insure proper installation and integrity of conductors. Sometimes called **GO/NO GO TEST** because it tests cable systems for maintenance errors, incorrect installation, serious degradation, or contamination, the proof test is a simple, quick test used to indicate the instantaneous condition of insulation. The installation is declared acceptable if no breakdown occurs during testing.

Product Knowledge

Insulation Testing



Preventative maintenance test



Maintenance tests can provide important information about the present and future state of conductors, generators, transformers, and motors. The key to effective maintenance testing is good data collection. Examining the collected data will aid in scheduling diagnostic and repair work, which will reduce unplanned downtime from unexpected failures.

Spot-reading/short-time resistance test

During the short-time or spot test, the insulation tester is connected directly across the equipment being tested and a test voltage is applied for about 60 seconds or less.

Longer-time resistance tests

Polarization index (PI) and dielectric absorption ratio are two longer-time tests that often give the user more information about the insulation system than a simple spot reading.

Step voltage test

The step voltage test involves resistance testing at various voltage settings. In this test, you apply each test voltage for the same period of time (usually 60 seconds), graphing the recorded insulation resistance. By applying increasing voltages in steps, the insulation is exposed to increased electrical stress that can reveal information about flaws in the insulation such as pinholes, physical damage, or brittleness. Good insulation should withstand an increase in over-voltage stress and its resistance should remain approximately the same during testing with different voltage levels. On the other hand, especially at higher voltage levels, deteriorated, cracked or contaminated insulation will experience an increased current flow, resulting in a decrease in insulation resistance.

Tips for Testing

By testing insulation resistance on different elements of the system (transformers, switchgear, conductors, motors), a technician can isolate and repair the faulty component. Whenever the testing is conducted, here are some tips for effective insulation resistance testing:

- Disconnect power from the system to be tested, using proper lockout/tagout procedures where appropriate.
- Disconnect any electronic devices such as motor drives, programmable logic controllers (PLCs) or transmitters before performing insulation testing. Electronics can be damaged by applying higher-than-normal voltage.
- Select a test voltage appropriate for the insulation being tested. The objective is to stress the insulation but not to over-stress it. When in doubt, use a lower test voltage. It's usually appropriate to test insulation at twice the voltage. For example, 460V to 600V rated equipment often is test at 1000V.
- When using a modern insulation tester, leave the leads connected when the test is stopped. The insulation multimeter can discharge any residual test voltage.

Conductors that are close to each other have a normal capacitance. This will cause an insulation resistance reading to start low and increase steadily until it stabilizes. This type of increase is normal, but if the reading jumps violently down and up again, this indicates arcing.

Exercise Caution

Although the current is closely controlled and limited, an insulation tester can generate sparks and minor but painful burns. The unexpected surprise can cause an operator to jerk away. As always, work away from live systems and use safe work practices when working overhead.

The most common questions in insulation testing are:

- What values should you expect for an insulation spot check?
- What indicates "bad" insulation?

Because insulation, equipment and environments vary so widely, no simple answer exists. Most practitioners work in orders of magnitude rather than hard-and-fast limits.

Product Knowledge

Insulation Testing

Test your knowledge

1. If current leakage occurs, it can _____.
A. generate heat
B. flow through any available conduit
C. cause transformers to overheat
D. All of the above
2. Insulation testers apply _____ across an insulation system.
A. dc voltage C. resistance
B. ac voltage D. current
3. Insulation testers can be used for _____.
A. installation testing/proof testing
B. predictive maintenance testing
C. spot reading/short time resistance
D. All of the above
4. When two or more conductors are run together in a raceway or through conduit, they act as a _____.
A. resistor B. diode
C. capacitor D. None of the above

1. D 2. A 3. D 4. C

Product Knowledge

Insulation Testing



Chapter Summary

Reasons for Testing Insulation

- To insure public and personal safety
- To protect and prolong the life of electrical systems and motors

If Current Leakage Occurs, it can

- Generate heat as it leaks through insulation, degrading the insulation until it eventually fails and potentially causes a fire
- Get back to the source and will flow through any available conduit, raceway, pipes, water or earth to get there
- Cost a lot of money. Leaking current is inefficient as it does not turn the motor, or produce light or heat
- Cause overcurrent protection devices to trip and motors and transformers to overheat

Types of Tests

- Installation test (Proof testing)
Used to insure proper installation and integrity of conductors
- Preventative maintenance test
Provides information about the present and future state of conductors, generators, transformers, and motors
- Spot reading/short-time resistance test
Connected directly across the equipment being tested for about 60 seconds or less
- Longer-time resistance test
PI and DAR can often give more information than a spot reading
- Step voltage test
Resistance testing at various voltage settings, for the same period of time, while graphing the results

Fluke. *Keeping your world up and running.*

Fluke Corporation
PO Box 9090, Everett, WA USA 98206

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
Web access: <http://www.fluke.com>

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Product Knowledge

Insulation Testers and MegOhmMeters

Electrical insulation includes the entire complex system of cable insulation, bushings, and spacers within conduit, motors and general equipment.



Why test insulation?

Low insulation resistance indicates that current is leaking through the insulation, which can cause heat build up, in turn causing the insulation to degrade even faster and eventually fail. Leaking current can cause over-current protection devices to trip, motors and transformers to overheat, and is just plain unsafe and inefficient.

Insulation problems are usually caused by improper installation, environmental contamination, mechanical stress or age. Insulation testing is easily combined with regular maintenance to identify degradation before failure and during installation procedures to verify system safety and performance. When troubleshooting, insulation resistance testing can be the missing link that enables your customer to get a system back into operation the easy way, by simply replacing a cable.

Insulation testers apply dc voltage across

an insulation system and measure the resulting current. This allows them to calculate and display the resistance of the insulation. Typically, the test verifies high insulation resistance between a conductor and ground or high insulation resistance between adjacent conductors.

Two common examples include testing motor windings for insulation from the motor frame and checking phase conductors for resistance from bonded conduit and enclosures. The cause of a specific motor failure isn't always obvious and insulation resistance testing is crucial in this situation.

After talking to the client about the problem, the technician will begin taking DMM measurements including voltage, fuse checks and ground connections to establish a baseline. The next step is insulation testing, but first the technician will verify lock out and tag-out of the disconnect to the starter. Next, the technician will engage the starter manually and measure the resistance across each contact and the resistance of line and load circuits to ground. If the load side resistance values are reasonable, he proceeds to the next test until the problem is isolated.

The product family



Fluke has a range of solutions to meet your customer's requirements.

Product Knowledge

Insulation Testers and MegOhmMeters

What you will learn in this module:

- Why test insulation?
- The product family
- Key functions
- The Fluke advantage

1587/1577 — Two powerful tools in one, an insulation tester and a DMM. Best solution for all around insulation testing.

1507/1503 — Dedicated insulation testers where a more powerful solution is required.

1550 — Designed as a portable solution, not handheld, for heavy industry and the utilities where 5KV tests are required.

Fluke 1587/1577 Insulation Multimeters

Two powerful tools in one

The Fluke 1587 and 1577 Insulation Multimeters combine a digital insulation tester with a full-featured, true RMS digital multimeter in a single, compact, handheld unit, which provides maximum versatility for both troubleshooting and preventative maintenance.

Whether you work on motors, generators, cables, or switch gear, the Fluke 1587/1577 Insulation Multimeters are ideally suited to help you with your tasks and at a cost that is far less than buying the two products.

Fluke engineers have become adept at making complex tools easy to use and easy to carry in the palm of your hand. The 1587 and 1577 Insulation Multimeters combine all the functions of an advanced multimeter with the most frequently used features of an insulation tester—for less cost than some insulation testers alone and half the size and weight. Their small size is made possible by higher circuit densities and advances in safety design.

For example, both meters are 600 V CAT IV and 1000 V CAT III overvoltage rated. They're designed for use on service entrances up to 600 V, and on PWM inverter dc buses up to 1000 V. They automatically disable insulation testing if connected to a live circuit with more than 30 volts, and following insulation resistance testing the meters discharge all capacitive voltage from the equipment under test to help prevent accidental shocks.

Other advances include a remote activation probe that enables one-handed insulation testing via a voltage trigger on the probe handle. This new category of test tool is ideal for electricians who work on motors, switchgear and cabling and for HVAC/R technicians who work with compressors. To make the advanced model even more flexible, Fluke engineers added a low-pass filter for accurately measuring variable frequency drives,



Min/Max, temperature, diode test, frequency, and capacitance.

1507/1503 Insulation Resistance Testers

The Fluke 1507 and 1503 Insulation Testers are compact, rugged, reliable, and easy to use. With their multiple test voltages, they are ideal for many troubleshooting, commissioning, and preventative maintenance applications. Additional features, like the remote probe on these tools save both time and money when performing tests.

Insulation test range:

- 1507: 0.01 MΩ to 10 GΩ
- 1503: 0.1 MΩ to 2000 MΩ

Insulation test voltages:

- 1507: 50 V, 100 V, 250 V, 500 V, 1000 V
- 1503: 500 V, 1000 V

Saves both time and money with automatic calculation of **Polarization Index** (a test that is particularly useful because it can be performed on even the largest equipment and yields a self-contained evaluation based on relative readings rather than absolute values) and **Dielectric Absorption Ratio** (obtained by taking MegOhmMeter readings at a one minute and ten minute interval automatically) – **only available on the 1507**

- Make repetitive tests simple and easy with the 1507's **Compare** (Pass/Fail) **function** (only available on the 1507)
- Repetitive or hard-to-reach testing is easy with the remote test probe
- Live circuit detection prevents insulation test if voltage > 30 V is detected for added user protection
- Auto-discharge of capacitive voltage for added user protection
- AC/DC voltage: 0.1 V to 600 V
- Resistance: 0.01 Ω to 20.00 kΩ
- Save battery power with auto power off
- Read measurements easily with large, backlit display
- CAT IV 600 V overvoltage category rating for added user protection
- Remote probe, test leads, probes and alligator clips included with each tester
- Accepts optional Fluke TPAK magnetic hanging system to free your hands for other work
- Four AA alkaline batteries (NEDA 15 A or IEC LR6) for at least 1000 insulation tests
- One year warranty



Product Knowledge

Insulation Testers and MegOhmMeters



Fluke 1550B MegOhmMeter



Digital insulation testing up to 5000 volts
The Fluke 1550B is a digital insulation tester capable of testing switchgear, motors, generators and cables at up to 5000 V DC. It can be used for a wide range of tests: from simple spot checks to timed tests and breakdown tests. Measurement storage and PC interface software make it ideal for preventive maintenance. Heavy-duty leads, probes and alligator clips fit in the custom carrying case, for a rugged field testing kit.

Insulation test voltages:

- 250V, 500 V, 1000 V, 2500 V, and 5000 V
- Capable of testing in 50V increments between 250V and 1000V and 100V increments between 1000V and 5000V
- Measures 0 to 1 Tera-Ohm
- Warning voltage function alerts the user that line voltage is present and gives the voltage reading up to 600 V AC or DC

- Guard system eliminates the effect of surface leakage current on high-resistance measurements
- Large digital/analog LCD shows detailed measurement data
- Cable or insulation capacitance
- Leakage current
- Ramp function (0-5000 V DC) for breakdown testing
- Timer 1 to 99 minutes
- Polarization index and dielectric absorption calculated automatically
- 99 memory locations store all measurements parameters
- Includes Quicklink 1550B Software and Optical Interface cable
- Two year warranty



Product Knowledge

Insulation Testers and MegOhmMeters

Test your knowledge

1. Low insulation resistance indicates that _____.
 - A. there is an open circuit
 - B. current is leaking through the insulation
 - C. it needs to be refilled soon
 - D. none of the above

2. The Fluke _____ is two powerful tools in one, an insulation tester and a DMM.
 - A. 1507/1503
 - B. 1587/1577
 - C. 1550
 - D. none of the above

3. The Fluke _____ are ideal for many troubleshooting, commissioning, and preventative maintenance applications.
 - A. 1507/1503
 - B. 1587/1577
 - C. 1550
 - D. none of the above

4. The Fluke _____ is designed as a portable solution, not handheld, for heavy industry and the utilities where 5KV tests are required.
 - A. 1507/1503
 - B. 1587/1577
 - C. 1550
 - D. none of the above

1. B 2. B 3. A 4. C

Product Knowledge

Insulation Testers and MegOhmMeters



Chapter Summary

The product family

1587/1577 – Best solution for all around insulation testing

1507/1503 – Dedicated insulation testers where a more powerful solution is required

1550 – For heavy industry and the utilities where 5KV tests are required

- **1587/1577 Insulation Multimeters - Two powerful tools in one**

- Best solution for all around insulation testing
- Combines a digital insulation tester with a full-featured true RMS digital multimeter

- **1507/1503 Insulation Resistance Testers - Compact, rugged, reliable and easy to use**

- Ideal for troubleshooting, commissioning, and preventative maintenance applications
- Automatically calculate the Polarization Index and Dielectric Absorption Ratio (1507 ONLY)
- Repetitive tests made simple with the Compare (Pass/Fail) function (1507 ONLY)

- **1550B MegOhmMeter - Digital testing up to 5,000 volts**

- Includes a wide range of tests, from simple spot checks to timed tests and breakdown tests
- PC interface software included

Fluke. Keeping your world up and running.

Fluke Corporation

PO Box 9090, Everett, WA USA 98206

For more information call:

In the U.S.A. (800) 443-5853 or

Fax (425) 446-5116

In Canada (800)-36-FLUKE or

Fax (905) 890-6866

Web access: <http://www.fluke.com>

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Fluke Corporation
PO Box 9090, Everett, WA USA 98206

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: <http://www.fluke.com>

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