

## Testing your test leads For electrical measurement safety

### Application Note

Test leads are more than a means to connect your digital multimeter (DMM) to the unit under test—they're an integral part of the complete measurement system. Poorly made, worn, or under-rated test leads can cause inaccurate readings and may pose a serious shock or electrocution hazard if you touch live wires that the meter has read as being de-energized.

Using the correct test probe for the application is important. If your work is limited to circuits below 30 V, performance and quality remain important but issues such as shock hazard concerns are reduced. However, if you use the leads for measuring medium to high voltage, or high energy circuits such as distribution systems (240 V to 600 V), using leads that are in good condition with the proper markings and ratings is critical. Always take precautionary steps to verify the condition and rating of your leads before testing.

#### Materials make a difference

Leads made from poor quality materials can affect the readings recorded on the DMM. For example, if dissimilar metals were used in the manufacture of the test leads, they can produce errors that are very difficult to trace if you are trying to measure very low voltage (e.g. in the mV range) or very low resistance, such as when working on low voltage electronic circuits. The contact between dissimilar metals can act like a thermocouple and generate its own voltage.

There are test leads designed to meet the requirements of virtually every application. Some may be a little more expensive, but safety and accuracy are not areas where cheaper is better.

#### Category ratings, safety standards

Before starting any job, confirm that the DMM and test leads are rated for the category and voltage level appropriate for the electrical environment they will be used in. Electrical measurement category ratings are defined by the safety standard, IEC 61010, and are separated into four distinct category ratings, CAT I, CAT II, CAT III or CAT IV (See Table 1).

Other requirements of IEC61010 to be familiar with include those relating to transient test, dielectric withstand voltage, clearance spacing, exposed metal probe tips, impact and markings. For more information go to the Fluke Electrical Measurement Safety web page at [www.fluke.com/safety](http://www.fluke.com/safety).

The NFPA 70E standard also requires that the test tools used on the job be rated for the environment they will be used in. This applies to both the meter and the test leads/probes, and any PPE (Personal Protective Equipment) necessary for safe measurements. PPE ratings are somewhat different than CAT ratings, as illustrated in Table 2.



1000V CAT III, 600V CAT IV, 10A

## IEC 61010 Electrical measurement category ratings for test tools

**Important note:** CAT ratings on test tools are different than hazard/risk category ratings on PPE gear. CAT ratings are determined by the potential transient impulse in the workplace that a connected test tool might experience. PPE requirements are determined by the surface energy level a user might experience.

Measurement category	In brief	Examples
CAT IV	Three-phase at utility connection, any outdoor conductors	<ul style="list-style-type: none"> <li>Refers to the "origin of installation"; i.e., where low-voltage connection is made to utility power.</li> <li>Electricity meters, primary overcurrent protection equipment.</li> <li>Outside and service entrance, service drop from pole to building, run between meter and panel.</li> <li>Overhead line to detached building, underground line to well pump.</li> </ul>
CAT III	Three-phase distribution, including single-phase commercial lighting	<ul style="list-style-type: none"> <li>Equipment in fixed installations, such as switchgear and polyphase motors.</li> <li>Bus and feeder in industrial plants.</li> <li>Feeders and short branch circuits, distribution panel devices.</li> <li>Lighting systems in larger buildings.</li> <li>Appliance outlets with short connections to service entrance.</li> </ul>
CAT II	Single-phase receptacle connected loads	<ul style="list-style-type: none"> <li>Appliance, portable tools, and other household and similar loads.</li> <li>Outlet and long branch circuits.                             <ul style="list-style-type: none"> <li>Outlets at more than 10 meters (30 feet) from CAT III source.</li> <li>Outlets at more than 20 meters (60 feet) from CAT IV source.</li> </ul> </li> </ul>
CAT I	Electronic	<ul style="list-style-type: none"> <li>Protected electronic equipment.</li> <li>Equipment connected to (source) circuits in which measures are taken to limit transient overvoltages to an appropriately low level.</li> <li>Any high-voltage, low-energy source derived from a high-winding resistance transformer, such as the high-voltage section of a copier.</li> </ul>

Table 1. Measurement categories. IEC 61010 applies to *low-voltage* (< 1000 V) test equipment.

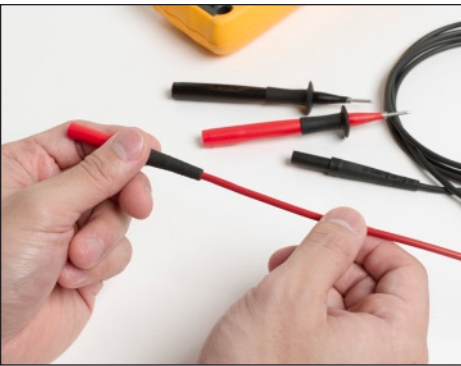
## PPE Recommendations based on NFPA 70E for live electrical measurements

<p><b>Hazard/Risk Category 1:</b>  <b>&lt; 240 V electrical environments</b>                      (110 V/120 V/208 V/220 V panels, 0 to 50 hsp motors and drives)</p> <p><b>Minimum arc rating for FR clothing:</b>                      16.74 J/cm(2) or 4 cal/cm(2)</p>	<ul style="list-style-type: none"> <li>Flame-resistant (FR) long-sleeved shirt and/or jacket with sleeves rolled down and front fully buttoned up (FR clothing must fully cover all skin and ignitable clothing)</li> <li>Natural fiber work pants, 12 oz denim pants, or FR pants</li> <li>Rubber insulating gloves with leather protectors worn over top</li> <li>Safety glasses</li> <li>Hard hat</li> <li>Leather work boots</li> <li>No jewelry, keys, or watch</li> <li>Insulated hand tools</li> </ul>
<p><b>Hazard/Risk Category 2*:</b>  <b>240 V to 600 V electrical environments</b>                      (270/480/600 V electrical panels, MCCs, switchgear, transformers, bus bars, UPS, and lighting; 100+ hsp motors and drives)</p> <p><b>Minimum arc rating for FR clothing:</b>                      33.47 J/cm(2) or 8 cal/cm(2)</p>	<ul style="list-style-type: none"> <li>FR long sleeved shirt and/or jacket with sleeves rolled down and front fully buttoned up</li> <li>FR work pants (not denims) or coveralls over natural fiber</li> <li>Rubber insulating gloves with leather protectors worn over top</li> <li>Leather work boots</li> <li>Switching hood with hearing protection</li> <li>No jewelry, keys, or watch</li> <li>Insulated hand tools</li> </ul>
<p><b>Hazard/Risk Category 3:</b>  <b>High voltage environments</b>                      (1600 A or higher) (Substations, utility transformers, big facility service entrances)</p> <p><b>Minimum arc rating for FR clothing:</b>                      104.6 J/cm(2) or 25 cal/cm(2)</p>	<ul style="list-style-type: none"> <li>Full flash suit (jacket, overalls, and hood)</li> <li>Rubber insulating gloves with leather protectors worn over top</li> <li>Leather work boots</li> <li>No jewelry, keys, or watch</li> <li>Insulated hand tools</li> </ul>

Table 2. PPE categories for live electrical measurement. For complete details, review NFPA 70E "Standard for Electrical Safety in the Workplace", 2004 Edition.

**Note:** If testing occurs in the proximity (within 4 feet) of an energized environment, then the PPE standards for the energized environment apply.

**Note:** Category 2\* is a higher energy environment than Category 2. These guidelines only list PPE for Category 2\*. For the specific distinction between 2 and 2\*, reference NFPA 70E "Standard for Electrical Safety in the Workplace", 2004 Edition, Tables 130.7 (c)(9)(a), (c)(10), (c)(11).



### Inspect the leads

Before using test leads, perform an inspection to ensure the leads are safe to use and able to conduct electrical signals accurately. In most common circumstances, the physical condition of the test leads is the most important factor affecting your measurements.

First, perform a visual inspection of the insulation, probe handles and connectors of the leads. Check to make sure the insulation is not nicked or cracked. With age the insulation material—whether PVC or silicone—can become dried out, brittle and susceptible to cracking. A visual inspection will often catch any parts of the leads that have this problem.



Also ensure that there are no signs of gaps or cracks at the junction between the insulated wire and the molded banana plugs or probes at each end. Though the visual inspection cannot absolutely guarantee the leads are safe, it can reveal obvious faults that can lead to injury.

### Test the leads

Once you're satisfied that the test probes are properly rated with no visual damage, conduct a simple ohms measurement to confirm they are electrically reliable and able to carry a signal within allowable loss parameters. To "ohm-out" your leads, place your DMM in the resistance (ohms) function, plug the leads into the DMM and touch the probe tips together—red to black. The meter should read about 0.5 ohms or less for good quality test leads.

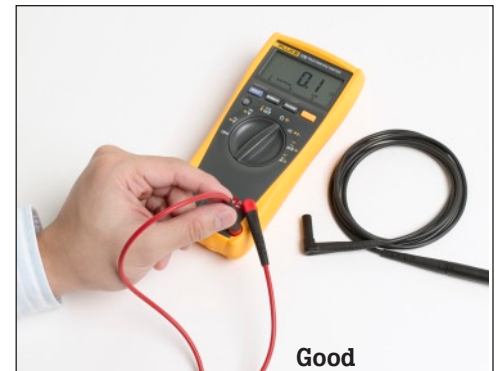
You may isolate a problem to one lead or the other by testing them separately. Simply connect one lead at a time between the ohms and common input.

Always make sure the leads are plugged into the correct DMM jacks and that the meter is set to the correct function before making any measurements.

While connected, wiggle or shake the lead wires to check for intermittents that may not be obvious with a static check. You may also use a continuity test to check your leads, however, the continuity functions of some DMMs are very forgiving. You may get a beep indicating continuity with up-to-15 ohms resistance in your test leads.

### Avoiding the weakest link

No matter how good your DMM is, it's only as good as the test leads you use with it. Taking a few minutes up front to confirm that the leads you're using match or exceed the IEC 61010 category of the DMM, that the two together are appropriately rated for the job, that all parts appear in good condition, and that they are electrically reliable are all essential steps for electrical measurement safety. If at any point in your inspection you notice a problem, you're probably due for a new set of leads. If your test leads are subjected to regular rough or heavy use, you may want to consider implementing an annual replacement program to ensure that they are always in good condition.



**Fluke.** Keeping your world up and running.®

**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>

©2007 Fluke Corporation. Specifications subject to change without notice. Printed in U.S.A.  
11/2007 3185695 A-EN-N Rev A