Fluke: Where safety is built in

As distribution systems and loads become more complex, the possibilities of transient overvoltages increase. Motors, capacitors and power conversion equipment such as variable speed drives can be prime generators of voltage spikes. Lightning strikes on outdoor transmission lines also cause extremely hazardous high-energy transients. If you're taking measurements on electrical systems, these transients are "invisible" and largely unavoidable hazards. They occur regularly on low-voltage power circuits, and can reach peak values in the many thousands of volts. To protect you against transients, safety must be built into your test equipment.

Electrical Safety

Who develops safety standards?

The IEC (International Electrotechnical Commission) develops international general standards for safety of electrical equipment for measurement, control and laboratory use. IEC61010-1 is used as the basis for the following national standards:

- US ANSI/ISA-S82.01-94
- Canada CAN C22.2 No.1010.1-92
- Europe EN61010-1:2001

Overvoltage installation categories

IEC61010-1 specifies categories of overvoltage based on the distance the piece of equipment is from the power source (see Figure 1 and Table 1) and the natural damping of transient energy that occurs in an electrical distribution system. Higher categories are closer to the power source and require more protection.

Within each installation category there are voltage classifications. It is the combination of installation category and voltage classification which determines the maximum transient withstand capability of the instrument.

IEC 61010 test procedures take into account three main criteria: steady-state voltage, peak impulse transient voltage and source impedance. These three criteria together will tell you a multimeter's true voltage withstand value.

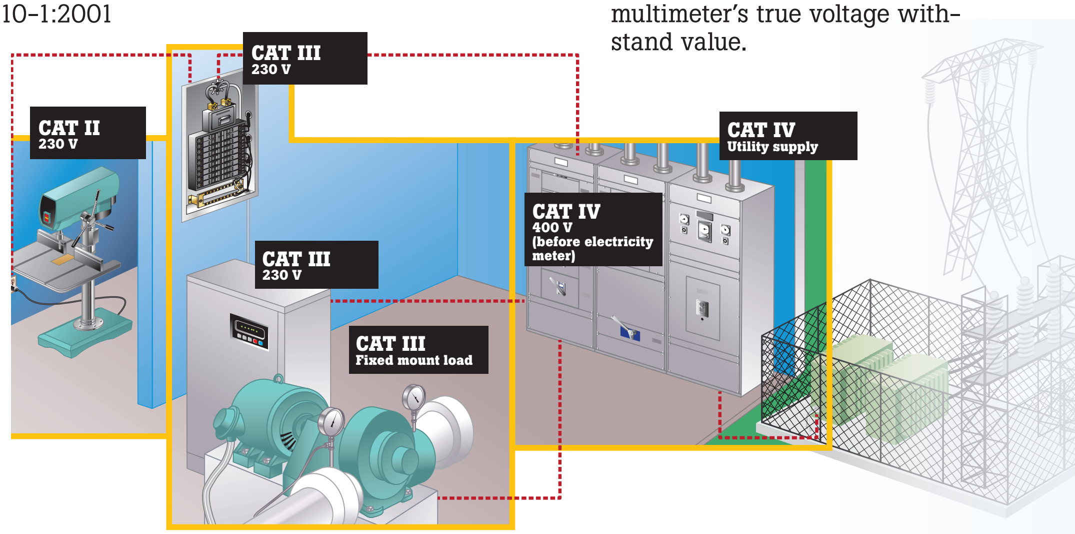

Figure 1. Understanding categories: location

Measurement category	In brief	Examples
CAT IV	Three-phase at utility connection, any outdoor mains conductors. Expected short circuit current above 50 kA.	• Refers to the "origin of installation," i.e., where low-voltage connection is made to utility power • Electricity meters, primary overcurrent protection equipment • Outside and service entrance, service drop from pole to building, run between meter and panel • Overhead line to detached building, underground line to well pump
CAT III	Three-phase distribution, including single-phase commercial lighting. Expected short circuit current above 10 kA up to 50 kA.	• Equipment in fixed installations, such as switchgear and polyphase motors • Bus and feeder in industrial plants • Feeders and short branch circuits, distribution panel devices • Lighting systems in larger buildings • Appliance outlets with short connections to service entrance
CAT II	Single and three-phase receptacle connected loads. Expected short circuit current up to 10 kA.	• Appliance, portable tools, and other household and similar loads • Outlet and long branch circuits

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

Within a category, a higher working voltage (steady-state voltage) is associated with a higher transient, as would be expected. For example, a CAT III 600 V meter is tested with 6000 V transients while a CAT III 1000 V meter is tested with 8000 V transients.

So far, so good. What is not as obvious is the difference between the 6000 V transient for CAT III 600 V and the 6000 V transient for CAT II 1000 V. They are not the same. This is where the source impedance comes in. Ohm's Law (Amps = Volts/Ohms) tells us that the 2 Ω test source for CAT III has six times the current of the 12 Ω test source for CAT II. The CAT III 600 V meter clearly offers superior transient protection compared to the CAT II 1000 V meter, even though its so-called "voltage rating" could be perceived as being lower. See Table 2.

Independent testing is the key to safety compliance

How can you tell if you're getting a genuine CAT III or CAT II meter? Unfortunately it's not always that easy. It is possible for a manufacturer to self-certify that its meter is CAT II or CAT III without any independent verification. The IEC (International Electrotechnical Commission) develops and proposes standards, but it is not responsible for enforcing the standards. Look for the symbol and listing number of an independent testing lab such as UL, CSA, VDE, TÜV or other recognized approval agency.

These symbols can only be used if the product successfully completed testing to the agency's standard, which is based on national and international standards. UL 3111, for example, is based on EN61010-1. In an imperfect world, this is the closest you can come to ensuring that the meter you choose was actually tested for safety.

Safety is everyone's responsibility but ultimately it is in your hands.

No tool by itself can guarantee your safety when working with electricity. It's the combination of the right tools and safe work practices that gives you maximum protection. Here are a few tips to help you in your work:

☑ **Make sure you always comply with (local) regulations.**

☑ **Work on de-energized circuits whenever possible.**

Use proper lock-out/tag-out procedures. If these procedures are not in place or enforced, assume that the circuit is live.

☑ **Use protective gear when working on live circuits:**

- Use insulated tools
- Wear safety glasses and a face shield
- Wear insulated gloves, remove watches or jewelry
- Use hearing protection
- Stand on an insulated mat
- Wear flame resistant clothing, not ordinary work clothes

This is a minimum suggested list. More protective gear may be required, depending on the level of electrical hazard and regional regulations.

Select the right test tool:

- ☑ Choose a test tool rated to the highest category and voltage for which it could possibly be used (most often 600 or 1000 volt CAT III and/or 600 volt CAT IV).
- ☑ Look for the category and voltage marking near the recessed input connectors of your test tool and a "double insulated" symbol on the back.
- ☑ Verify your test tool has been tested and certified by two or more independent testing laboratories, such as UL in the United States and VDE or TüV in Europe by looking for the symbols of these agencies on (the back of) your test tool.
- ☑ Make sure that the test tool is made of a high-quality, durable non-conductive material.
- ☑ Check the manual to verify that the ohms, continuity and capacitance circuits are protected to the same level as the voltage test circuit, to reduce hazards when the test tool is used incorrectly in ohms, continuity or capacitance mode (if applicable).
- ☑ Verify that the test tool has internal protection to prevent instrument damage when voltage is incorrectly applied to an amperage measurement function (if applicable).
- ☑ Make sure that the amperage and voltage of your test tool's fuses meets specifications. Fuse voltage must be as high or higher than the test tool's voltage rating.
- ☑ Be sure to use test leads that have:
  - Shrouded connectors
  - Finger guards and a non-slip surface
  - Category ratings that equal or exceed those of the test tool
  - Double insulation (look for the symbol)
  - A minimum of exposed metal on the probe tips

Inspect and test your test tool:

- ☑ Check for a broken case, worn test leads or a faded display.
- ☑ Make sure the batteries still deliver sufficient power to get reliable readings. Many test tools have a low battery indicator on the display.

- ☑ Check the test leads resistance for internal breaks while moving the leads around (good leads measure 0.1 to 0.3 ohm).
- ☑ Use the meter's own test capability to ensure that the fuses are in place and working right (see manual for details).

Apply the appropriate working practices when measuring on live circuits:

- ✓ Hook on the ground clip first, then make contact with the hot lead. Remove the hot lead first, the ground lead last.
- ✓ Use the three-point test method, especially when checking to see if a circuit is dead. First test a known live circuit. If you work in environments where there isn't a reliable circuit, consider using a portable voltage source like a Proving Unit for this step. Second, test the target circuit. Third, test the live circuit again. This verifies that your test tool worked properly before and after the measurement.
- ✓ Hang or rest the test tool if possible. Try to avoid holding it in your hands, to minimize personal exposure to the effects of transients.
- ✓ Use the old electrician's trick of keeping one hand in your pocket. This lessens the change of a closed circuit across your chest and through your heart.

Measurement category	Working Voltage (dc or ac-rms to ground)	Peak Impulse Transient (20 repetitions)	Test Source (Ω = /A)
CAT II	300 V	2500 V	12 ohm source
CAT II	600 V	4000 V	12 ohm source
CAT II	1000 V	6000 V	12 ohm source
CAT III	300 V	4000 V	2 ohm source
CAT III	600 V	6000 V	2 ohm source
CAT III	1000 V	8000 V	2 ohm source
CAT IV	300 V	6000 V	2 ohm source
CAT IV	600 V	8000 V	2 ohm source
CAT IV	1000 V	12000 V	2 ohm source

Table 2. Transient test values for overvoltage installation categories. (50 V/150 V values not included)

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