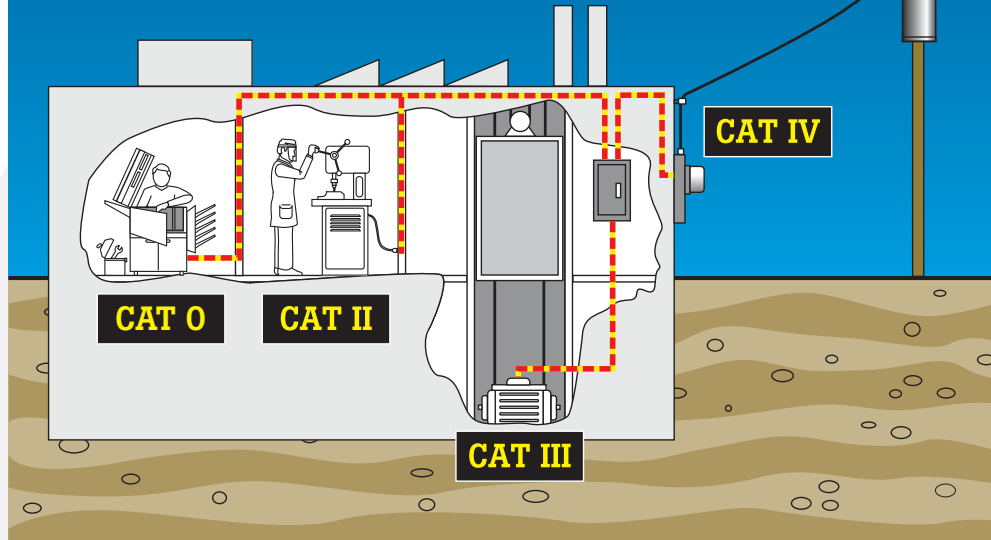


Multimeter safety by the numbers

A common misconception in choosing a multimeter is that as long as you choose one with a high enough voltage rating, you're covered. However, the voltage rating is only part of the story. Engineers who analyze multimeter safety often discover that failed units were subjected to a much higher voltage than the user thought was being measured. This can occur when a meter, rated for low voltage (1000 V or less), is inadvertently used to measure medium voltage. Or, it can result from a momentary high-voltage spike or transient that hits the multimeter input without warning.

These transients are “invisible” and largely unavoidable but they occur regularly on low-voltage power circuits, and can reach peak values in the many thousands of volts. Your safety depends on the safety margin built into your meter. And that safety margin is based on several specifications beyond just the voltage rating alone.

The higher the IEC CAT number, the higher the power available and the higher the voltage transients



IEC measurement categories are based on the fact that a dangerous high-energy transient, such as a lightning strike, will be dampened as it travels through the impedance (ac resistance) of the system.

Understanding measurement categories

The International Electrotechnical Commission (IEC) publishes international standards for all electrical, electronic and related technologies. Multimeters designed to the IEC ANSI 61010-1 standard offer a significantly higher level of safety.

The most important thing to understand about the IEC safety standards is “Measurement Category”. The IEC 61010-1 standard divides the power distribution system into four categories:

Measurement category	In brief	Examples
CAT IV	Three-phase at utility connection, any outdoor mains conductors	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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-phase receptacle connected loads	<ul style="list-style-type: none"> Appliance, portable tools, and other household and similar loads Outlet and long branch circuits <ul style="list-style-type: none"> Outlets at more than 10 meters (30 feet) from CAT III source Outlets at more than 20 meters (60 feet) from CAT IV source
CAT 0	Electronic equipment not directly connected to mains	<ul style="list-style-type: none"> Protected electronic equipment Equipment connected to (source) circuits in which measures are taken to limit transient overvoltages to an appropriately low level Any high-voltage, low-energy source derived from a high-winding resistance transformer, such as the high-voltage section of a copier

Table 1. Measurement categories. IEC 1010 applies to low-voltage (< 1000 V) test equipment.

How to evaluate a multimeter's safety rating

Within each measurement category, a higher voltage rating denotes a higher transient-withstand rating. So a CAT III 1000 V meter offers superior protection compared to a CAT III 600 V rated meter. However, a problem can occur if someone selects a CAT II 1000 V rated meter thinking that it is superior to a CAT III 600 V meter.

To understand the difference you need to understand the voltage-withstand ratings. IEC 61010-1 test procedures take into account three main criteria: steady-state voltage, peak impulse transient voltage, and source impedance. These three criteria tell you a multimeter's true voltage-withstand value.

When is 600 V more than 1000 V?

To understand an instrument's true voltage-withstand you need to consider that:

- Within a category, a higher "working voltage" (steady-state voltage) is associated with a higher transient. 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.
- The 6000 V transient for CAT III 600 V and the 6000 V transient for CAT II 1000 V are not the same. This is where 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. Therefore, 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. It is the combination of the steady-state voltage (called the working voltage), and the measurement category that determines the total voltage-withstand rating of the test instrument, including the transient voltage withstand rating. Refer to Table 2 for more specifics.

Bottom line

If you are looking to replace your multimeter, a good place to start is to analyze the worst case scenario of your job and determine what Measurement Category that scenario fits into. Then choose a meter rated for the highest category you could be working in, and with the highest voltage rating you will need within that category. And don't forget the test leads. IEC 61010-1 applies to test leads too so they should be certified for a category and voltage as high or higher than the meter.

Measurement Category	Working Voltage (dc or ac-rms to ground)	Peak Impulse Transient (20 repetitions)	Test Source ($\Omega = V/A$)
CAT II	600 V	4000 V	12 Ohm source
CAT II	1000 V	6000 V	12 Ohm source
CAT III	600 V	6000 V	2 Ohm source
CAT III	1000 V	8000 V	2 Ohm source
CAT IV	600 V	8000 V	2 Ohm source

Table 2: Transient test values for measurement categories. (50 V/150 V/300 V values not included.)

The key to safety compliance

How can you tell if you're getting a genuine CAT IV, CAT III, or CAT II meter? It's not always easy. A manufacturer can self-certify that its meter is at a certain CAT level without any independent verification. The IEC develops and proposes standards, but it is not responsible for enforcing those standards.

So the best way to determine that a meter's CAT certification is genuine is to look for the symbol and listing number of an independent testing lab such as UL, CSA, TÜV or other recognized approval agency. That symbol can only be used if the product successfully completed testing to the agency's standard, which is based on national/international standards. UL 61010-1, for example, is based on IEC 61010-1. Beware of wording such as "Designed to meet specification ..." Designer's plans are never a substitute for an actual independent test.

Helpful tips for applying categories to your work

- The general rule-of-thumb is that the closer you are to the power source, the higher the CAT number, and the greater the potential danger from transients.
- The greater the short-circuit current available at a particular point, the higher the CAT number.
- The greater the source impedance, the lower the CAT number. Source impedance (or total impedance) includes the impedance of the wiring between the point where you are measuring and the power source. Source impedance is what dampens transients.
- A transient voltage surge suppression (TVSS) device installed at a panel must have higher energy-handling capacity than one installed right at the computer. In CAT terminology, the panel board TVSS is a CAT III application, and the computer is a receptacle-connected load and therefore, a CAT II installation.
- A single piece of equipment may have more than one category. For example, in office equipment, from the 120 V/240 V side of the power supply back to the receptacle is CAT II. The electronic circuitry, is CAT 0. In building control systems, such as lighting control panels, or industrial control equipment such as programmable controllers, it is common to find electronic circuits (CAT 0) and power circuits (CAT III) existing in close proximity. Always select a multimeter rated to the highest category in which it could possibly be used.

Look for these test lab marks on your meter. Don't trust meters that haven't been independently tested!

