

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"> 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 I	Electronic	<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 61010 applies to *low-voltage* (< 1000 V) test equipment.

PPE Recommendations based on NFPA 70E for live electrical measurements

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

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).

Who sets the rules for electrical testing and safety?

Application Note

Alphabet soup

There's no question that electrical safety is a key concern for electricians and engineers, their employers, unions and the government.

Every day, an average of 4,700 workers in the U.S. suffer disabling injuries on the job. Insurance industry estimates put the direct cost of workplace injuries in 2005 at more than \$8 billion.* With costs that high, no wonder so many government agencies and private groups hold pieces of the safety puzzle.

To maximize safety for yourself and your team, you need a solid understanding of the rules and standards that govern safe electrical work. This article will help you cut through the alphabet soup of safety organization names to see how each plays a role in safety.

We'll check them out in two groups. First, we'll look at the government agencies that oversee workplace safety, such as the U.S. Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH).

Then we'll examine the independent safety and standards organizations, including the National Fire Protection Association (NFPA), the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE) and the International Electro-Technical Commission (IEC). Though they're not part of government, they too help set the rules of the safety game.

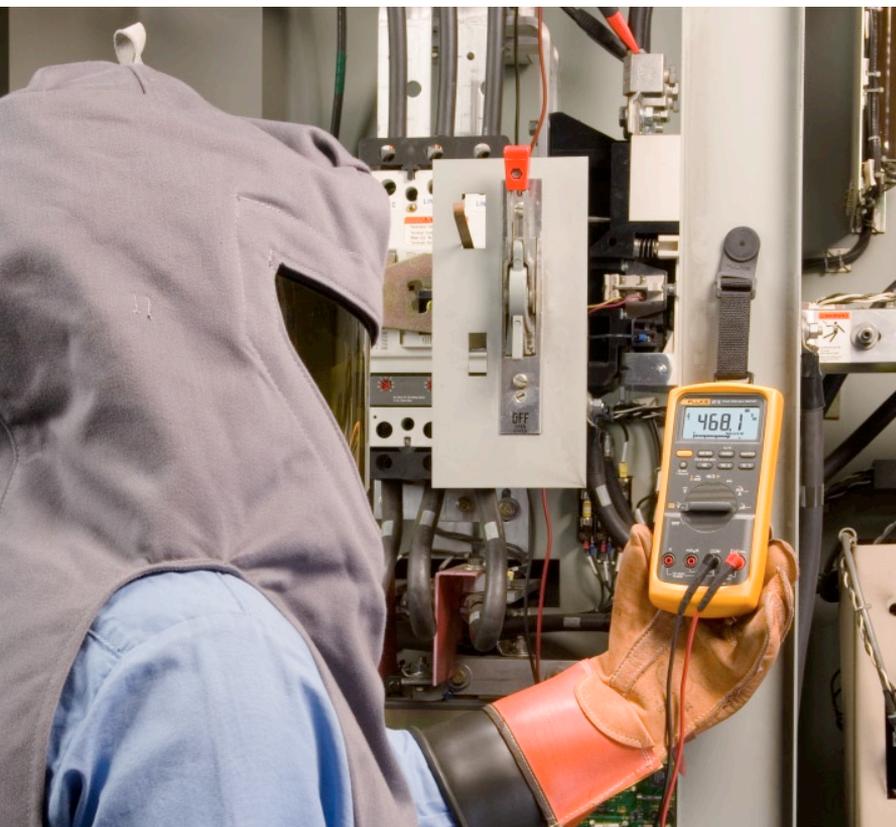
The government agencies

First, where did OSHA and NIOSH come from, and what do they do?

Both agencies were created by the federal Occupational Safety and Health Act of 1970. OSHA is in the U.S. Department of Labor and is responsible for developing and enforcing workplace safety and health regulations. In addition, many states have their own occupational safety agencies that work with OSHA and govern workplace safety on the state level.

NIOSH is an agency of the U.S. Department of Health and Human Services, established to help assure safe and healthful working conditions by providing research, information, education, and training in the field of occupational safety and health.

* Source: Liberty Mutual Workplace Safety Index, Winter 2008





NFPA 70E flash-hazard requirements as a way of meeting the OSHA standard.

The key distinction is this: OSHA 1910 Subpart S and other OSHA safety and health standards are law. Failure to follow these standards could result in a citation, a work shutdown, fines or other sanctions. The NFPA, ANSI and other standards OSHA refers to, on the other hand, are intended as guidelines to safety.

“We’re pointing employers and employees to these documents as sources for additional information,” said David Wallis, director of the OSHA office of engineering safety. “For safe work practices there are some general-type requirements in OSHA 1910 related to protection from electric shock and electric arc hazard. Employers can look toward NFPA 70E for more specific information about the kind of equipment they need to protect their employees.”

“There is another caveat I might explain,” Wallis continued. “Sometimes OSHA will have a specific requirement not contained in NFPA 70E, or where the 70E provision might not be quite as stringent. In that case, OSHA would expect employers to comply with the OSHA standard. Compliance with NFPA 70E would not automatically be considered adequate.”

In other words, OSHA sets and enforces the rules, while NIOSH provides helpful information on workplace safety. Here are some examples:

Several OSHA regulations have an impact on electrical workplace safety. For instance:

- **29 CFR (Code of Federal Regulations) 1910 Subpart I** sets standards for Personal Protective Equipment (PPE), including eye and face protection, footwear and protection for electrical workers, such as insulating blankets, gloves and sleeves.
- The key electrical safety rules are part of **29 CFR 1910 Subpart S**, including design safety standards for electrical systems, safe work practices, maintenance requirements and safety requirements for special equipment. This regulation also covers training requirements, sets guidelines for work on energized parts, outlines lockout/tagout procedures and provides rules for use of PPE in electrical work. The OSHA web site provides other electrical safety resources at <http://www.osha.gov/SLTC/>.

While OSHA sets the broad safety agenda, it leaves some details to others. For example, the OSHA electrical safety rules in 1910 Subpart S specifically refer the reader to NFPA and ANSI codes and standards for help in complying with OSHA. These include NFPA 70E (Standard for Electrical Safety in the Workplace), ANSI/NFPA 70 (National Electrical Code) and others. Subpart S was updated in August 2007 and further amended in October 2008.

Here’s an example of how the standards work together. OSHA’s safety-related work practice standards in Subpart S do not currently address flame-resistant (FR) clothing. However, OSHA standard 29 CFR 1910.335 (a) (2)(ii) requires use of protective shields, protective barriers, or insulating materials to protect employees from shock, burns or other electrically related injuries while working near exposed energized parts or where dangerous electric heating or arcing might occur. Chapter 1 of NFPA 70E-2009 contains specific requirements and methodology for hazard assessment and selection of protective clothing and other personal protective equipment. Employers may follow

Key Points:

- Both employers and employees are responsible to know and follow OSHA standards.
- Citations and penalties may be imposed if standards are not observed.
- Other safety standards, including NFPA 70E, provide guidance on safety measures and procedures. They do not supplant OSHA. In case of conflict, follow OSHA standards.

NIOSH: Helpful information

While OSHA sets the rules, and sometimes levels penalties, NIOSH provides useful safety information. A good example is a new 88-page electrical safety handbook, **Electrical Safety – Safety and Health for Electrical Trades Student Manual**, available for downloading in portable document format (PDF) at <http://www.cdc.gov/niosh/docs/2002-123/2002-123a.html>. The NIOSH web site also provides a number of electrical safety alerts, reports and links to other electrical safety resources.

Key Point:

- NIOSH is a valuable source of electrical safety information, but is not a regulatory agency.

NFPA establishes standards through consensus

Outside government, a key player in establishing electrical safety practices is the nonprofit National Fire Protection Association. The NFPA sets and updates more than 300 safety codes and standards, covering everything from building construction to connectors for fire hose. NFPA standards are set through consensus, developed by more than 200 committees of volunteers from industry, unions and other interest groups.

For electrical workplace safety, the key NFPA standard is NFPA 70E, *Standard for Electrical Safety in the Workplace*. The 2009 edition was issued by the NFPA Standards Council and approved as an American National Standard in September 2008. NFPA 70E is written to correlate with the National Electrical Code (NEC), which many jurisdictions adopt as part of local building codes and regulations. But NFPA 70E focuses on such issues as safety-related work practices, maintenance of safety equipment, safety requirements for special equipment and safety-related installation requirements.

It is intended for use by employers, employees, and OSHA.

NFPA 70E uses six categories of hazard and risk for electrical work, from minus one up to four. As the work environment and the type of job become more hazardous, the need for protection increases. The standard makes it clear that test equipment is an integral part of the PPE electrical workers must use on the job and must be inspected before each shift. In addition, test equipment must be rated and designed for the circuits and environments where it will be used. To clarify what this means, the 2009 Edition of NFPA 70E now refers users to ANSI/ISA-61010-1 (82.02.01)/UL 61010-1, the standard first established as IEC 61010.

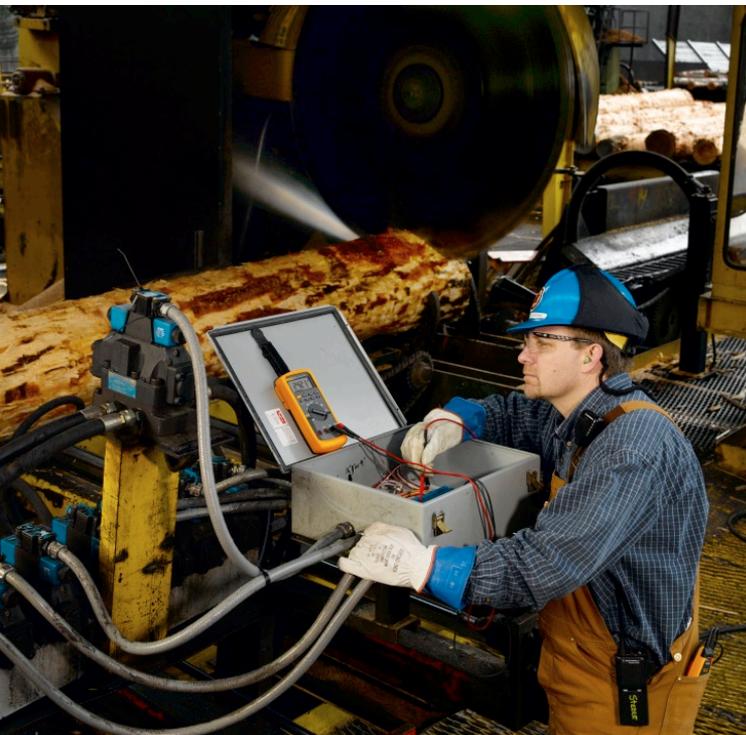
The NFPA 70E standard provides extensive information on what it takes to work safely, and to run an effective electrical safety program. It provides guidance on employee training, work planning and procedures (including lockout/tagout) and use of PPE. Whether you're a professional electrician, an apprentice or a supervisor, NFPA 70E is must reading. And don't forget, OSHA also refers to NFPA 70E.

Key Points:

- NFPA 70E is a key resource for both employers and employees. It contains detailed instructions on PPE and safe work procedures required for specific tasks.
- This standard specifically defines test equipment as part of PPE.

ANSI sets standards for equipment

The American National Standards Institute (ANSI) also plays a role in electrical safety. This private, nonprofit organization administers and coordinates the U.S. voluntary standardization and conformity assessment system. And it represents the U.S. in international standards organizations, such as the International Organization for Standardization (ISO) and the IEC.



OSHA electrical safety regulation 1910 Subpart S refers to several ANSI standards. The key ANSI standards involving electrical safety are ANSI C33.27-74 (Safety Standard for Outlet Boxes and Fittings for Use in Hazardous Locations) and ANSI S82.02 (see below), which provides important safety rules for electrical test instruments. ANSI C2-81 (National Electrical Safety Code) deals with electric installations of more than 1000 volts, an area beyond the scope of this article.

Key Point:

- Employers and technicians should be familiar with ANSI electrical safety standards C33.27-74 and S82.02 and, if applicable, C2-81.

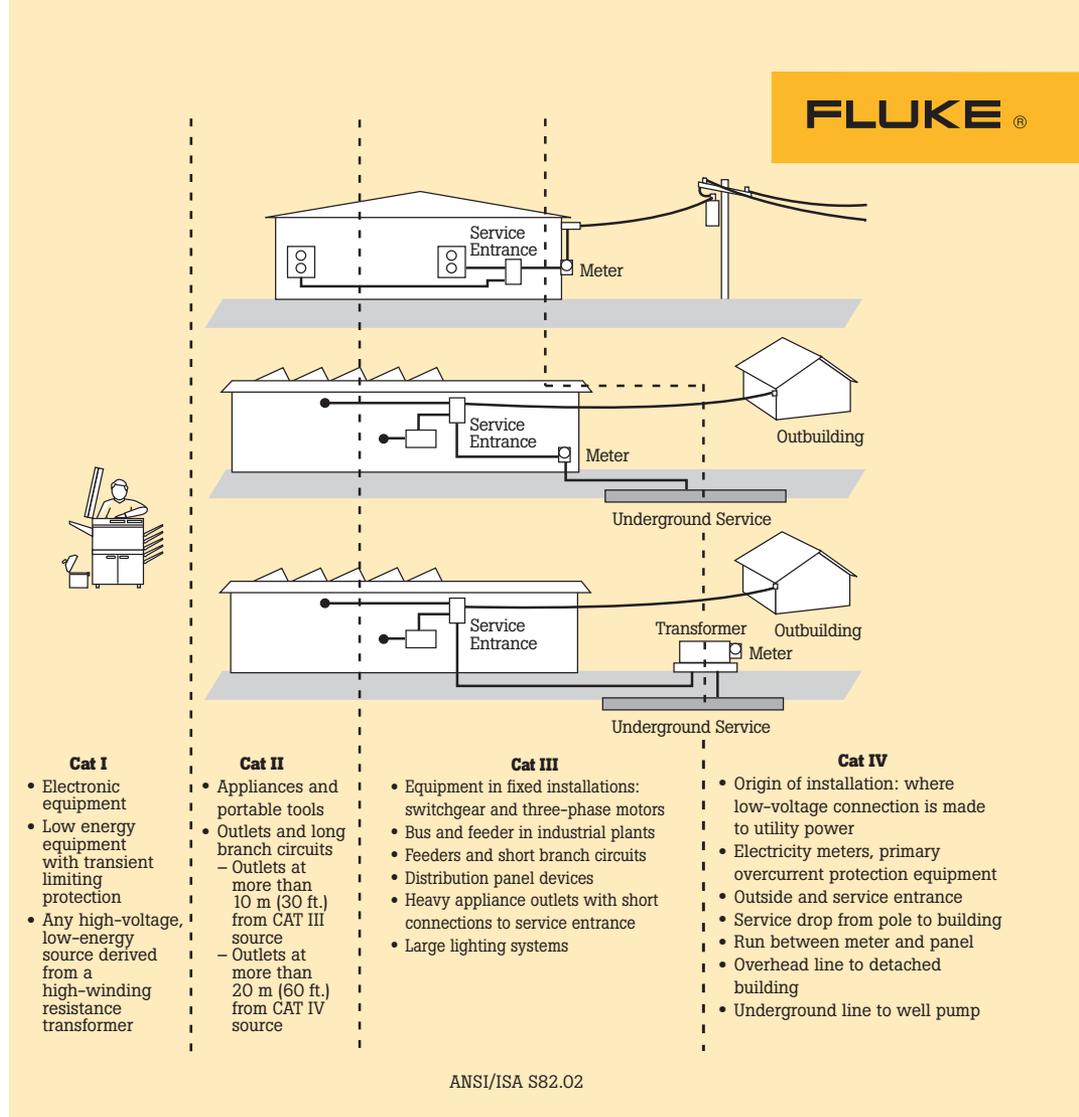
IEEE helps calculate arc flash hazard

Another authority in safety is the Institute of Electrical and Electronics Engineers. IEEE 1584-2002, *Guide for Performing Arc-Flash Hazard Calculations*, (amended as IEEE 1584a in September 2004) does just what its title suggests, providing technical information employers can use to determine the arc flash hazards present in the workplace. IEEE publishes a number of other useful safety standards and practice guides, including the twelve-volume IEEE Color Books series.

Key safety rules from international partners

To make electrical measurements safely, it pays to stretch your horizons. Some of the most important safety guidelines for electrical measurement have been developed in cooperation with the IEC, the leading global organization that prepares and publishes international standards for all electrical and related technologies.

ANSI, the Canadian Standards Association (CSA), and the IEC have created more stringent



standards for voltage test equipment used in environments of up to 1000 volts. The pertinent standards include ANSI S82.02, CSA 22.2-1010.1 and IEC 61010. These standards cover systems of 1000 volts or less, including 480-volt and 600-volt, three-phase circuits. For the first time, these standards differentiate the transient hazard by location and potential for harm, as well as the voltage level.

In addition, the 2000 edition of IEC 61010 requires that multimeters and similar equipment shall not cause a shock, fire, arcing or explosion hazard even if subjected to operator error (for instance, connecting the meter to an energized circuit when set to the ohms position). Fluke meters not only protect the user in such circumstances—they also protect themselves, and keep working. ANSI and CSA are now in the process of adopting these more stringent IEC standards.

These standards establish an important four-category system for rating the electrical hazards electricians face when taking measurements on so-called “low voltage” equipment—up to 1000 volts.

ANSI, CSA and IEC define four measurement categories of over-voltage transient impulses (voltage spikes). The rule of thumb is that the closer the technician is working to the power source, the greater the danger and the higher the measurement category number. Lower category installations usually have greater impedance, which dampens transients and helps limit the fault current that can feed an arc.

- CAT (Category) IV** is associated with the origin of installation. This refers to power lines at the utility connection, as well as the service entrance. It also includes outside overhead and underground cable runs, since both may be affected by lightning.

- **CAT III** covers distribution level wiring. This includes 480-volt and 600-volt circuits such as three-phase bus and feeder circuits, motor control centers, load centers and distribution panels. Permanently installed loads are also classified as CAT III. CAT III includes large loads that can generate their own transients. At this level, the trend to using higher voltage levels in modern buildings has changed the picture and increased the potential hazards.
- **CAT II** covers the receptacle circuit level and plug-in loads.
- **CAT I** refers to protected electronic circuits.

Some installed equipment may include multiple categories. A motor drive panel, for example, may be CAT III on the 480-volt power side, and CAT I on the control side.

A higher CAT number refers to an electrical environment with higher power available and higher-energy transients. This is a key principle to understand when it comes to choosing and using test instruments. A multimeter designed to a CAT III standard can resist much higher-energy transients than one designed to CAT II standards. *Within* a category, a higher voltage rating denotes a higher transient withstand rating, e.g., a CAT III-1000 V meter has superior protection compared to a CAT III-600 V rated meter.

Key Point:

- The hazard category system detailed by ANSI, CSA and IEC provides useful information for preparing against the hazards of transient voltage impulses (voltage spikes) in the environments where most industrial electricians work.

Transient protection

The real issue for meter circuit protection is not just the maximum steady state voltage range, but a combination of *both steady state and transient overvoltage withstand capability*. Transient protection is vital. When transients ride on high energy circuits, they tend to be more dangerous because these circuits can deliver large currents.

If a transient causes an arc-over, the high current can sustain the arc, producing a plasma breakdown or explosion, which occurs when the surrounding air becomes ionized and conductive. The result is an arc blast, a disastrous event which causes numerous injuries every year.

The concept of categories is not new and exotic. It is simply an extension of the same common-sense concepts that people who work with electricity professionally use every day. It's another tool you can use to better understand the hazards you face on the job, and work safely.

All of the regulations we have covered are built in the same way. They grow from experience, and they are based on experience and sound, common sense principles. No tool, however, can do the job alone. It's up to you, the user, to learn these safety regulations and standards, and use them effectively on the job.

After all, it's your safety at stake. Read up, and work safely.

Independent testing labs help ensure safety compliance

You want your tools and equipment to help you work safely. But how do you know that a tool *designed* to meet a safety standard will actually *deliver* the performance you are paying for?

Unfortunately it's not enough to just look on the box. The IEC develops and proposes standards, but it is not responsible for *enforcing* the standards. wording like "Designed to meet specification ..." may not mean a test tool actually performs up to spec. Designers' plans are never a substitute for an actual independent test.

That's why independent testing is so important. To be confident, check the product for the symbol and listing number of Underwriters Laboratories (UL), the CSA, TÜV or another recognized testing organization. Those symbols can only be used if the product successfully completed testing to the agency's standard, which is based on national/international standards. That is the closest you can come to ensuring that the test tool you choose was actually *tested* for safety.

What does the CE symbol indicate?

A product is marked CE (Conformité Européenne) to show it conforms to health, safety, environment and consumer protection requirements established by the European Commission. Products from outside the European Union cannot be sold there unless they comply with applicable directives. But manufacturers are permitted to *self-certify* that they have met the standards, issue their own Declaration of Conformity, and mark the product "CE." *The CE mark is not, therefore, a guarantee of independent testing.*

LISTED



Underwriters Laboratories (UL)



TUV and VDE (German standards organizations) are approval/listing agencies



Canadian Standards Association (CSA)

Electrical safety rules and standards: Who does what

Authority	Standard	Title	Subject	Mandatory or Advisory?	Topics Covered	Also refers to
OSHA	29 CFR 1910 Subpart S	<i>Electrical</i>	Electrical Safety	Mandatory	Design safety standards for electrical systems, safety-related work practices, safety-related maintenance requirements and safety requirements for special equipment	NFPA 70E NFPA 70 ANSI C2-81 ANSI C33.27-74
OSHA	29 CFR 1910 Subpart I	<i>Personal Protective Equipment</i>	PPE	Mandatory	Personal Protective Equipment (PPE) including face and eye protection, footwear and insulating gear	
NIOSH	None	<i>Electrical Safety – Safety and Health for Electrical Trades Student Manual</i>	Electrical Safety	Advisory	Electrical Safety guidance for students and apprentices	
NFPA	70E**	<i>Standard for Electrical Safety in the Workplace</i>	Electrical Safety	Advisory	Safety training, work planning and procedures, PPE required for specific work situations, lockout/tagout and more. Specifies test tools as part of PPE; details test tool inspection schedules	
NFPA	70**	<i>National Electrical Code</i>	Electrical Safety	Mandatory*	Electrical installations in buildings, generally operating at 600 V or less	
ANSI/IEEE	C2-81**	<i>National Electrical Safety Code</i>	Electrical Safety	Mandatory*	Governs electric utility and heavy industrial installations, often operating in thousands of volts	
ANSI	S82.02	<i>Safety requirements for electrical equipment for measurement, control, and laboratory use</i>	Test tool safety	Advisory	Handheld probe assemblies and handheld current clamps for electrical measurement and test. Establishes four categories of overvoltage transient hazard	
CSA	22.2-1010.1					
IEC	61010					
IEEE	1584-2002	<i>Guide for Performing Arc-Flash Hazard Calculations</i>	Arc Flash	Advisory	Determination of arc flash hazard	
IEEE	Color Books	<i>12 titles in series</i>	Multiple	Advisory	Safety and other recommended practices for electrical work and electrical installations	

* Adopted both directly and indirectly in many U.S. and international jurisdictions. ANSI/IEEE C2 is typically adopted by state or local public utility commissions.

** Referenced in OSHA 1910 Subpart S: "The following references provide information which can be helpful in understanding and complying with the requirements contained in Subpart S:"

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