**Electrical testing safety**  
**Part 1: Preparing for absence of voltage testing**

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OSHA and the NFPA 70E Standard for Electrical Safety in the Workplace both direct workers to **deenergize all live parts to which an employee may be exposed**, unless live conditions are required for troubleshooting.

Placing electrical equipment or systems in an electrically-safe work condition might seem simple, but there are several factors to consider.

- Proper planning and preparation will make any type of testing simpler and safer.
- Having to stop work to fetch other tools or testers interrupts focus and can contribute to an accident.

Before you take a single measurement, first determine:

- Will you be troubleshooting or testing for the absence of voltage?
- What tools will you use to verify the energized or de-energized state?
- What Personal Protective Equipment (PPE) will be required?
  - What is the voltage of the circuit?
  - What is the Flash Protection Boundary?
  - How much incident energy is possible at your working distance?
- Is your lockout/tagout complete?
- Is your test tool functioning properly?

If you’re testing for the **absence** of voltage, that is, to verify there is no voltage present before beginning work, you might consider using a non-contact proximity tester (Figure 1), an electrical tester (Figure 2), or a multimeter (Figure 3).

**Tools to use**

**A) Low-voltage proximity or non-contact voltage testers**

These little tools are good for a first test, but should always be followed up with a direct-contact meter. At Shermco Industries, we issue each of our technicians a proximity tester like the one shown in Figure 1 to keep in their top pocket or somewhere it can be easily seen, if it lights up in the presence of voltage.

Keep in mind that proximity tester readings can be thrown off if:

- the insulated test point touches grounded metal.
- the cable being tested is partially buried.
- the user is isolated from ground.
- it is used inside a metal enclosure.

Proximity testers also won’t detect shielded cable. To better understand why proximity testers have these limitations, read the Fluke application note on the subject, “Understanding capacitive voltage sensors.” The key word is “proximity.” Proximity varies not just by distance, but also by the strength of the voltage field. And “distance” has to account for everything between the tester and the electrical source, including the air, insulation, breaker material, twist locks, and so forth.

The real issue is that proximity testers may indicate voltage, or they may not, depending on specific circumstances. For absence of voltage testing, a different, completely reliable test method is required.

**Figure 1. Use a non-contact voltage tester for your first test.**
B) Electrical testers (previously solenoid)
Back in the day, solenoid testers were the weapon of choice, mostly because everything else was so expensive. There are a couple of big issues with these:

- If the voltage drops below about 70 to 90 volts, depending on the specific tester used, the tool doesn’t indicate voltage is present. I’ve been nailed more than once because of this. Once I was testing a motor controller that had a blown fuse. That phase was being back-fed through a control power transformer (CPT) and should have shown voltage. Due to the impedance of the CPT and the tester, I received no indication. I screamed like a chicken when I made contact.
- Even solenoid units with indicator lights stop lighting up at about 30 volts or so. This won’t send a person into fibrillation, but it could cause them to back into something that could.
- Solenoid testers wear out and the voltage scale becomes scarred up. If you can’t read the voltage indicator and the solenoid is so weak that it barely vibrates, it’s not reliable to use.
- Solenoid testers aren’t fused and don’t comply with CAT safety rating requirements. If a transient hits the system while you’re connected, there’s nothing to protect you from serious injury.

Fluke strongly recommends using the newer generation of fused, electronic testers. They still vibrate and light up, but they’re much more accurate, they measure to 10 volts and they’re fused for transient protection.

C) Digital multimeter
Multimeters are the best standard tool for making accurate contact measurements to determine if a circuit is live. However: Turning the multimeter dial to the wrong function (amps instead of volts, for example) is one of the most common mistakes people make when using a multimeter. Older models that are not auto-ranging could be put into a range that is too high, making the voltage appear much smaller than it really is. Someone in a hurry, stressed or not careful could get in trouble. Using newer meters resolves the issue, as well as bringing new features in.

The Fluke model 117 for example, has a low impedance function for voltage testing that can be a great safety feature. The Fluke 117 also has a built-in non-contact voltage test function, for people who want to start with a proximity test and then move to a contact test, with the same instrument.

Figure 2. For your second test, pick a digital, not solenoid, electrical tester.

Figure 3. A DMM with a low-impedance option is the smartest pick for a live-dead-live test.
Any direct-contact meter can be dangerous if connected to a circuit higher than it is rated for. In my travels around the country, several facilities have had fatalities due to an electrical worker troubleshooting a 2.3 kV or 4.16 kV motor starter control circuit. The CPT is often mounted on the side of the drawout unit and the terminals cannot be seen clearly. The technician is trying to test the 480 V circuit and comes into contact with the medium-voltage circuit instead. Bad things happen when this occurs.

OSHA states that test equipment, and their accessories, shall be rated for the circuits they’ll be connected to. The NFPA 70E contains similar statements.

**Personal Protective Equipment**

Does it sound strange to require PPE for a non-energized test? Until an electrical circuit or parts are tested and found absent of voltage, they must be presumed to be energized. Wear the appropriate PPE for the environment until it is proven de-energized.

Before working for Shermco, I was the Electrical Field Services Manager and Compliance Manager for SUNOHIO. Early one morning, I took a crew out to test a power transformer that was having problems at an industrial customer’s facility. Upon arrival, I asked for a one-line to write the LOTO procedure. The drawing I was given was so old it was yellowed. I was assured by both the plant manager and the electrical supervisor that the one-line was fine and no changes had ever been made to the 4.16 kV system.

My crew proceeded to lock and tag the system and, since it was a double-ended substation, it was fairly easy to isolate the problem transformer. The terminal chamber cover was removed and, being completely certain the circuit was de-energized, I was about to untape the connections in preparation for testing. At the last moment, I decided to follow good safety practice and test the circuit, even though I knew “it was dead”. The voltage detector lit up and I almost fainted. Another lesson learned. An alternate circuit had been installed at some time in the past and no one working there was aware (or remembered) it. Take my word for it, it’s not dead until it is proven dead. Don’t make my mistake. There was nothing funny about this incident.

The Fluke Safety Program offers a free poster http://shop.csepromo.com/Fluke/ describing both the test tool rating categories and the PPE categories. It helps clarify what to use and wear in particular electrical environments.

**Lockout/Tagout**

Electrical workers are required by OSHA to place equipment in an electrically-safe work condition (although they don’t use those words) in 1910.333(b) and the NFPA 70E in Article 120, which involves Lockout, Tagout, test operating, testing at the point of contact, and grounding, if necessary. Grounding may or may not be practical on low-voltage systems, but should be done whenever possible.

Capacitors, UPS systems and long cable runs can maintain a stored charge. The application of safety grounds eliminates this hazard by discharging the stored energy. There may also be induced voltages if the conductors are from a long cable tray containing other, unshielded conductors that are still energized. Grounding of low-voltage systems is not always simple and at times may not be possible. Be certain to have a positive connection on the grounds—otherwise they could blow off under short circuit conditions.

New

1000 V CAT III and 600 V CAT IV meters designed to withstand 8000 V transients

Use meters with these markings: 1000 V CAT III or 600 V CAT IV

Old

Fluke meters designed to older standards do not show category rating on front of instrument

Do not use meters without proper CAT markings on 480 V circuits

Figure 4.
Verifying the operation of the voltage tester

Before beginning the absence of voltage test, check the test instrument to ensure it is working properly.

1. Wearing proper PPE, measure a voltage similar to the voltage of the equipment about to be tested. This would include whether it is ac or dc and approximately the same magnitude.
2. Now test the circuit that is supposed to be de-energized.
3. Once testing is complete, re-verify the meter is still functioning properly by going to the same known voltage source and making another measurement.

This is known as “live-dead-live” testing and is mandated by OSHA when voltages are above 600 volts. It is also required by the NFPA 70E in Article 110.9(A)(4), “Operation Verification. When test instruments are used for the testing for the absence of voltage on conductors or circuit parts operating at 50 volts or more, the operation of the test instrument shall be verified before and after an absence of voltage test is performed.”

This live-dead-live requirement is new to the 70E, for the 2009 edition. Test instruments lead a tough life and when your life depends on them, live-dead-live is the only way to go, for voltages of any level.

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