Absence of Voltage Testing Compliance & Misconceptions

Analyzing Risks & Safety Solutions

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Introduction

Absence of voltage testing is the most vital step in the process of verifying and establishing a deenergized state of any electrical system. According to the Article 120.5, NFPA 70E, it is a process-oriented approach that takes various steps to establish a deenergized state and is not accomplished with any single device. Verifying a deenergized state is a risky task which requires strict adherence to policies and procedures to establish a safe environment to work.

> **Because it is a high risk task, verifying a deenergized state requires strict adherence to policies and procedures.**

Lockout/Tagout (LOTO) is a regulatory requirement per OSHA's 29 CFR 1910.333 (b)(2)(iv)(B) and NFPA 70E, Article 120.5. Historical data suggests high incident rates of both shock and electrocution because of performing the task of "absence of voltage testing" inside the electrical cabinets. The data further points out that the incidents are primarily caused due to workers' inadvertent contact with electrical circuit parts inside the panel, wrong application of test instruments, human error, production pressures, and complacency. Many safety centric organizations and product innovators have devised a variety of methods to minimize the risk of exposure to workers from the hazards of presence and absence of voltage testing over the past several decades. The 2018 Edition of NFPA 70E created an exception to allow an alternative method for the same task. This document delineates the differences between presence and absence of voltage testing from the application standpoint of LOTO and compares the pros and cons of these devices, and their limitations of use. Products discussed include voltage indicators, test portals, portable test instruments, and absence of voltage testers.

Given the process centric approach, additional clarification is placed on worker qualification, installation conditions, training requirements, procedures, and failure modes of these risk control methods and their effect on both the task and the worker.

Permanent Electrical Safety Devices (PESDs®) are installed on electrical equipment to provide voltage presence indication and/or test for absence of voltage using an adequately rated portable test instrument. They reduce exposure to electrical hazards, meet NFPA 70E 120.5(7), and are listed to UL 61010.

Permanently Mounted Absence of Voltage Testers (AVTs) are installed on electrical equipment to detect and indicate voltage status. When installed properly, they provide an alternative method of verifying deenergization, meet NFPA 70E 120.5(7), Exception No. 1, and are listed to UL 1436.

Conductive vs. Non-Conductive

PESDs® are classified into two categories based on the application of use.

1. PESDs® with LED voltage presence indication and portals that are that are non-conductive and use non-contact voltage detector pen (NCVD pen) for voltage detection
2. PESDs® with conductive test points that use portable test instrument and test probes for absence voltage testing & troubleshooting

PESDs® are UL 61010 listed devices that are meant for voltage testing using an adequately rated portable test instrument. The UL classification further terms this product as “Panel Mounted Test Point Meter”. These devices can be used for both troubleshooting the equipment and to verify the absence of voltage to the source they are connected to.

The major difference is the application of use. If the portals are used with an NCVD pen for voltage detection, they are meant for unqualified workers (AKA task qualified workers who are not qualified electrical workers). The main purpose of both the voltage indicators and portals with NCVD pens are to assist task qualified workers performing mechanical LOTO to quickly verify the deenergized state in addition to bump test once the energy isolating device or disconnect is thrown to the “off” position. While the indicators and the portals that use NCVD pens are meant for voltage presence indication only, the test points are used for absence of voltage testing.

Mechanical Lockout/Tagout

✓Voltage Presence

Voltage Indicator

Voltage Portal

Voltage Indicator and Portal Combination

Electrical Lockout/Tagout

✓Voltage Absence

Safe-Test Point™

5-Wire Safe-Test Point™

✓Voltage Presence and Absence

ChekVolt®

Voltage Test Station

Devices that are listed to UL CCN. PICQ are investigated with respect to fire, shock or injury to persons.

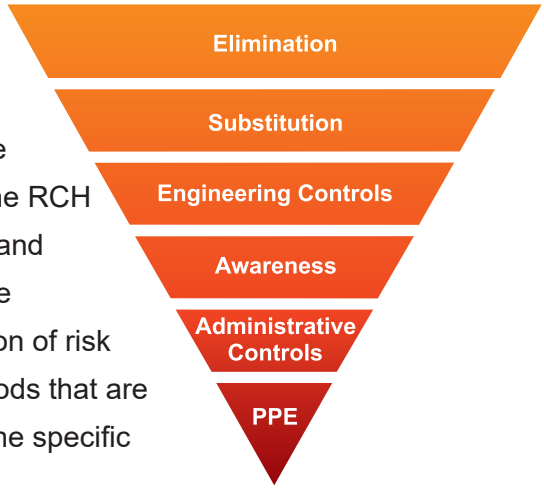
Why use a Safe-Test Point™ or ChekVolt® to Verify the Absence of Voltage?

Test points greatly reduce the risk of exposure to qualified electrical workers as they use high impedance protected circuitry that is built-in these devices.

> **Maximum fault current is limited to less than 3.5mA at the door with a Safe-Test Point™ installed.**

Hence there is no shock or arc flash hazard for the worker performing the task. Compared to the conventional method of absence of voltage testing inside an electrical cabinet, assuming the system is still energized, these devices provide a much safer alternative to verify the absence of voltage as outlined in Article 120.5 (7), of NFPA 70E, 2021 and OSHA 29 CFR 1910.333(b)(2)(iv)(B).

Per NFPA 70E, there are six risk control methods that are required to be implemented per Article 110.1(H)(3). Risk Control Hierarchy (RCH) classifies risk controls in six categories such as elimination, substitution, engineering controls, awareness, administrative controls, and PPE and the controls must be applied in the order of priority with elimination as highly effective to PPE as least effective. The purpose of the RCH is to identify and apply a single or combination of risk control methods that are suitable for the specific application and the task performed. PESDs® fall under the engineering controls category within the RCH. NFPA 70E realizes that there is no one-size-fits-all solution as it relates to applying risk controls across a wide variety of tasks performed.



Further, when it comes to electrical safety there is no such thing as absolute zero risk and the same is outlined in the NFPA 70E handbook as failure modes associated with every type of risk control method with examples.

> **When it comes to electrical safety, there is no such thing as absolute zero risk.**

UL 508A connections require a device with NO cords or plugs. Meaning the leads of the device are permanently connected to the circuit part or source of voltage.

UL 61010 Listed PESDs® are NOT allowed to have plug ends. These devices are not meant to be connected using a corded supply and they are only intended for permanent connection.

Importance of Worker Qualification & Training

Using any PESDs® or AVTs for absence of voltage testing at the door still begs the question of failure modes in terms of device functionality, wiring, workmanship, worker qualification, training, and physical damage to the device itself.

Key point: Poor workmanship, installation failures, and device malfunctions are all potential failure modes that can lead to a zero-voltage indication/no indication when the conductor is still energized.

As we know, there are several failure modes that exist with every product from design through installation and operation, it is equally important to know the effect of those failure modes on both the worker and the task performed.

AVT Potential Failure Modes

1. Missing battery or wrong battery in the indicator module (AA Type, 3.6 Volt Lithium Battery).
2. Accidental disconnection of leads and contacting low impedance ground path – ***leads to false indication of absence indication "GREEN" when the circuit is still energized.***
3. Loose/disconnection of AVT system cable connecting from the isolation module to the door module.
4. Miswiring of leads by connecting one set to the line side and second set to the load side on the connections.
5. Wrong application of device in CAT IV, 600V environments when the device is only rated for CAT IV, 300V.
6. Misinterpretation of the fault codes by the operator.

Limitations: Before installation, please ensure the phase to ground voltage is less than 1.3 volts of circuit to be monitored when the power is removed. If the voltage of the monitored circuit is above 3 Volts, absence of voltage cannot be verified at the door.

Test Point PESD® Potential Failure Modes

1. Accidental disconnection of the leads from the source inside the panel.
2. Insulation damage to the conductors coming to the door.

Limitations: Voltage measured value is affected by -3.3% (10 Meg Ohm meter) due to impedance protection in the device.

If a qualified person cannot verify absence of voltage from outside of a panel, they must verify a deenergized state inside the panel using an adequately rated portable test instrument.

The Responsibility of a Qualified Person:
Per NFPA 70E, Article 110.4 (A), only qualified persons shall perform the absence of voltage testing. The qualified person is the one who knows what steps must be taken if the absence of voltage cannot be verified from outside an electrical cabinet.

> **In simplistic terms, "Push of a Button" to verify the deenergized state does not necessarily constitute qualified electrical work.**

Given the failure modes with every product, it is more important to address what steps must be adhered to verify the deenergized state inside the panel (example: donning the right amount of PPE and following safety policies and procedures to establish a deenergized state). When using Safe-Test Point™ or ChekVolt® with an adequately rated portable test instrument, a qualified person is responsible for

performing the task of voltage testing and taking adequate safety measures before accessing a panel.

> **Verifying absence of voltage using a portable test instrument fundamentally assumes a qualified electrical worker is performing the task.**

Qualified Person: One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Article 250.4 Test Instruments: Test instruments and associated test leads used to verify the absence or presence of voltage shall be maintained to assure functional integrity. The maintenance program shall include functional verification as described in 110.4(A)(5).

Article 110.4 Test Instruments and Equipment

A) Clearly defines only qualified persons shall perform the tasks such as testing, troubleshooting, and voltage measurements on electrical equipment operating at voltages greater than or equivalent to 50 Volts.

B) Defines the rating of the instruments, equipment, and their accessories shall be:
   1) Rated for circuits and equipment where they are utilized.
   2) Approved for the purpose.
   3) Used in accordance with the instructions provided by manufacturer.

The informational note further clarifies the use of UL 61010-1 listed products for the equipment used in systems 1000 Volts and below.

Non-Hazardous Voltage to the Door

As the Safe-Test Point™, ChekVolt®, and voltage indicator PESDs® have built-in impedance protected circuits, these devices limit the current at the device, and they are validated to ensure the hazardous voltage and current are not brought to the outside of the door. (UL CCN PICQ) UL 61010 limits values for accessible parts both in normal and single fault conditions and determines the accessible parts are not hazardous before listing the devices to UL 61010 standard. Protecting the wires from pinch against door hinges is usually addressed with the use of fray resistant sleeves when the wires are brought to the doors via hinges and sharp objects. Most end users and panel OEMs mount their PESDs® on the flange as close as possible to the isolators or on a subpanel to avoid insulation damage to the wires.

Overcurrent Protection & Installation Code Requirements

In this specific case, overcurrent protection is meant to protect wires that are connected to the device, but not the device itself. Use of overcurrent protection is not required for an AVT, nor is it recommended for the Safe-Test Point™, ChekVolt®, and voltage indicator PESDs®. Therefore, the fusing concerns are common

for AVTs and PESDs®. Fuses create an additional point of failure and result in a false negative condition when voltage is present. Additionally, the impedance protected circuit design in the device limits voltage and current to safe levels during normal and single-fault conditions and do not create a hazardous condition at the door. No short circuit current protection (SCCR) is required for AVTs and PESDs®.

These devices are further listed to the transient overvoltage category up to 8kV allowing safe use in feeders and branch circuits inside distribution (CAT III), three phase utility connections, and outside (CAT IV). Under certain circumstances, per NEC Article 240.21(B)(1)(b), the feeder tap rule exception allows these devices to be installed without overcurrent protection. Your local codes and AHJs may still require you to provide the overcurrent protection in which case the device will function normally even with the fusing.

NFPA 70E Technical Committee Statement on PESDs®

The NFPA 70E is considered the golden standard for electrical safety in the workplace and provides a solid foundation for facilities around the globe in developing their electrical safety programs. The 70E technical committee welcomes public inputs during every revision cycle and goes with a regimented process of review. Since the standard touches a wide variety of facilities and industries, public inputs from users who have found new ways to reduce risks can submit their practices to the NFPA 70E committee, which in turn decides if the 70E standard should be updated or if the user's submittal is already covered in the standard. Each facility and industry can present unique challenges and the NFPA 70E arms employers to reduce personnel risk as they perform their daily tasks without regulating activities for every type of work situation.

> **NFPA 70E provides a broader language that allows users to customize their safety programs to meet their precise needs.**

Many manufacturers have devised methods and new types of devices to reduce workers' risks that are not even mentioned in NFPA 70E. A dual interlocked disconnect switch is one good example of a new electrical safety practice not mentioned in the standard. High impedance test points are another good example where the portable test instruments are used in a much safer way for absence of voltage testing.

NFPA 70E has two options for absence of voltage testing outlined below:

a. Article 120.5 (7) using an adequately rated portable test instrument (Live-dead-live test) (OR)
b. Article 120.5 (7) Exception 1, Permanently Mounted Absence of Voltage Tester

The Unexplained and Acceptable Option for Article 120.5 (7) in NFPA 70E, 2021

Use of PESDs® that are listed and labeled to UL 61010 (such as high impedance test points) for absence of voltage testing with portable test instruments are undefined in 70E, but still are acceptable for use.

Since the addition of Exception 1 with the publication of NFPA 70E, 2018 Edition, there has been confusion and misinformation surrounding the use of high impedance protected test points for absence of voltage testing. In 2019, Grace Technologies

submitted a public inquiry to the technical committee during the 2021 revision cycle to propose a new Exception for UL 61010 test points. The technical committee provided a clarified response statement as to why a new Exception is not necessary. The context of the public comments and response is around "absence of voltage testing" and there is no such requirement for presence voltage testing under Article 120.5 as published by others.

Are the ChekVolt® and Safe-Test Point™ NFPA 70E Compliant? **YES.** Do they meet Exception 1? **NO.** Do they need to? **NO.**

Marketing literature published by other product manufacturers are misleading users with partial information by emphasizing the term committee action as "Rejected" and masking the "Response Message". "Rejected" in the context of the response is stating that these devices do not require any additional clarification or exception for use per Article 120.5 (7), NFPA 70E standards. This technical committee response clearly states the following regarding UL 61010 test point PESDs® (i.e.: permanently mounted accessories)

"The present text does not prohibit the use of permanently mounted accessories that are listed and labeled in accordance with UL 61010 in conjunction with portable test instruments."

During the review of public inputs on the topic of PESDs® for absence of voltage testing, the NFPA 70E technical committee established that the door mounted accessories and test leads must be listed and labeled to UL 61010 safety standards to comply.

Adding an additional statement about UL 1436 is purposeful to ensure readers do not confuse UL 1436 AVTs with UL 61010 PESDs®. There is no product category in UL standards or mention of "permanently mounted test instruments" in NFPA 70E standards as published by others.

NFPA 70E Article 120.5(7) 2021 Edition	Permanently Mounted Accessory GracePESDs® ChekVolt® and Safe-Test Point™	Permanently Mounted Testers: AVTs
Meets NFPA 70E 2021 Article 120.5 (4) and (7) Compliance	Yes	Only via Exception No. 1
Can Perform an Absence of Voltage Test	Yes (with an adequately rated portable test instrument)	Yes (with built in electronic circuitry)
Battery Required	No	Yes
Electrical Safety Program Training	Same as NFPA 70E Article 120.5(7) Live-Dead-Live Test	Requires NEW procedure and employee training

Conclusion

Safety is a condition of being protected from the risk of injury or hazard and is not something that can be attained by just installing a AVT or PESD® at the door. Personnel confidence plays a significant role when it comes to safety, as safety is a personal endeavor. A facility employer can enforce their employees to don a higher amount of PPE for a task at hand and make them comply. However, for the same task, one cannot enforce compliance of a lower amount of PPE when they realize it provides less protection or feels unsafe to do so. Installing AVTs for absence of voltage testing outside the door is similar in that way. A facility can install these devices on the door for absence of voltage testing and ask their qualified personnel to perform the task (through a push to test). However, employers cannot stop their electricians from reverifying the circuit part inside the cabinet with a portable test instrument after the AVT indicates the system is deenergized. It is that extra measure of reverification that adds confidence to the safety of the worker.

It will take time and trust for a qualified person to choose not to reverify the circuit part inside the cabinet after developing confidence. Portable test instruments and PESDs® have built that trust for over a decade and demonstrated confidence with absence of voltage testing through several iterations of use. Determining a right product fit for absence of voltage testing is a key step in your Electrical Safety Program.

A facility must perform a thorough risk analysis to determine the right product for any application. This detailed analysis must consider worker qualifications, installation conditions, training, and failure modes of the products and further evaluate the effects of those failure modes on your application.

> **The qualified worker community has built trust and confidence with portable test instruments and PESDs® for over a decade with absence of voltage testing, and that trust cannot be simply replaced overnight.**

About the Author

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Bhanu Srilla has over two decades of experience in power generation and distribution industry, and has led diverse programs in electrical power distribution and control system projects in various IEC and ANSI applications for low and medium voltage systems. Bhanu is an IEEE member, and a member of Standards Technical Panel (STP) for UL 1436, UL 61010, UL 508, and 508A Standards. Bhanu is a certified electrical safety compliance professional (CESCP) by NFPA, certified maintenance and reliability professional (CMRP) by SMRP, certified reliability leader (CRL) by reliability web, and holds advanced degrees in Electrical Engineering, Manufacturing Systems, and Technology Management.