

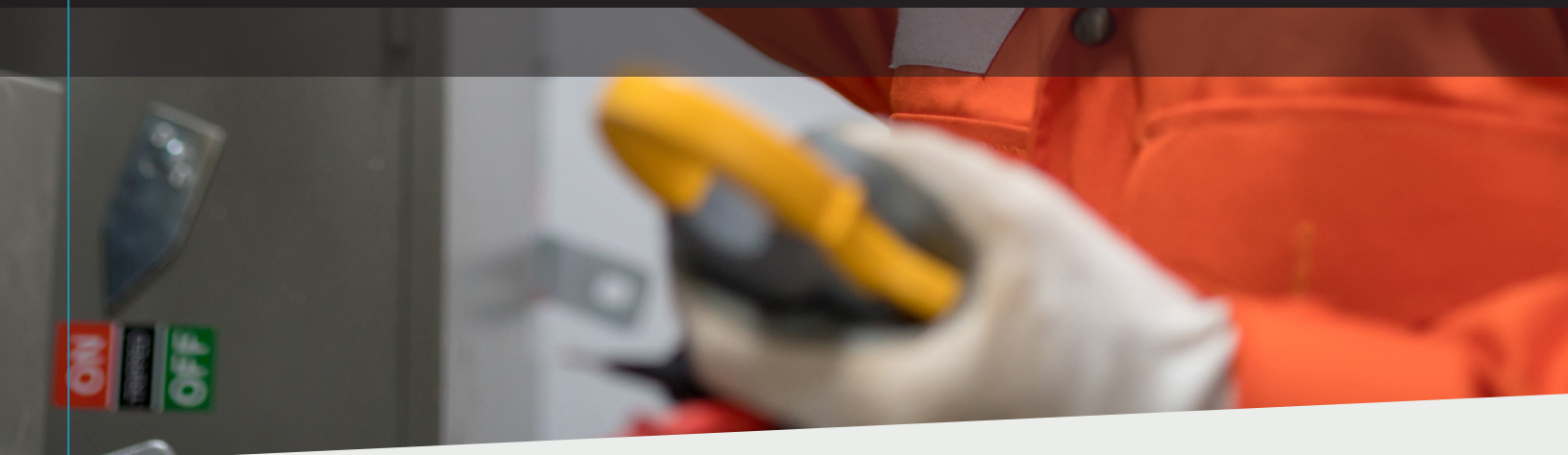
Exploring Permanently Mounted Voltage Testing Products

Take a closer look at the benefits and differences.





There are a variety of different electrical safety products that are permanently mounted, each with different functionality and limitations. They all have different purposes and should not be discussed interchangeably. Three common types of permanently mounted products are voltage indicators, test portals, and absence of voltage testers.





Voltage Indicators – Detect Presence of Voltage

Voltage indicators are permanently mounted and use LED-style indicators that illuminate when presence of voltage is detected. They typically illuminate at approximately 40V to 1000V, depending on the device and manufacturer. These devices are an excellent way to provide a visual warning when voltage is present.

Voltage indicators should never be used to verify the absence of voltage. Equipment may be energized, even if the voltage indicator is not illuminated. Lack of illumination can be caused by a failed LED, a bad installation, or a failed device. Installation codes often require voltage indicators to be fused. If the fuse is open, the voltage indicator will not illuminate when voltage is present.

Additionally, voltage indicators bring line voltage (for example, 480V) directly to the door or external surface where the indicator is installed. This could present a shock hazard, especially when troubleshooting with the door open as door mounted devices typically operate at control voltages and workers may not be expecting the wires to the indicator to carry hazardous voltages. Wires that carry three-phase voltage across a hinge need to be protected to ensure that repeated opening and closing of doors does not pinch or damage the wire or insulation.

These are some of the reasons why OSHA stated in an Interpretation Letter¹ that voltage indicators are not allowed to be used to verify the isolation and deenergization of a machine or equipment. Regardless of whether electrical or mechanical work will be performed, voltage indicators are not a test instrument and should not be used when verifying the absence of voltage.



Examples of Voltage Indicators

¹Galassi, T. (2012, December 12). Whether an LED type device can be used for the isolation and deenergization verification requirements of 1910.147 and 1910.333. Retrieved from <https://www.osha.gov/laws-regs/standardinterpretations/2012-12-12www.osha.gov/laws-regs/standardinterpretations/2012-12-12>.



Test Portals – Measure the Presence of Voltage

Test portals are permanently mounted devices that can be used with a portable tester, such as a digital multimeter, to measure voltage. These devices are an excellent tool for troubleshooting and determining the magnitude or value of any voltage that is present. Test portals will test at the point in the circuit at which the test leads are installed.

If there are multiple test points, more than one test portal may be required. Test portals may have features such as IP20 “finger safe” ingress protection as well as a high impedance circuit located at the door to limit current at the test points to less than 5mA. The impedance reduces the likelihood of shock or arc flash when measuring voltage presence via the portals, but the added impedance requires a conversion to determine the actual voltage value.



Examples of Test Portals

Should Test Portals be used to Verify Absence of Voltage?

The process for verifying the absence of voltage, often referred to as the “live-dead-live test,” is described in NPFA 70E 120.5 (7) and OSHA 1910.333 (b)(2)(iv)(B). Using test portals with a portable test instrument can lead to unreliable results when testing for absence of voltage and is not recommended. Here are some of the reasons why voltage test portals are not adequate for absence of voltage testing:

- a) **Installation test** – verifying absence of voltage through a permanently mounted device requires assurance that you are in contact with the test point when the measurement is taken. If the leads from a permanently mounted device are not properly terminated or disconnected, voltage will not be detected, regardless of whether or not the conductor is energized. This is why permanently mounted absence of voltage testers are required to have an installation test to confirm that the device is in contact with the conductor at the time the voltage measurement is taken.

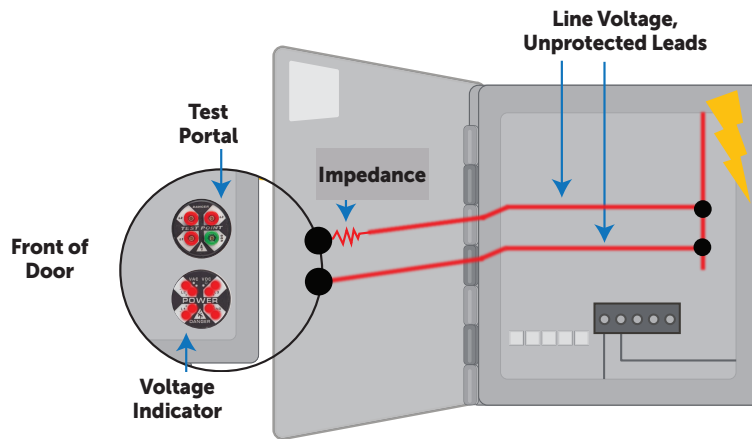
Test portals do not have a feature to verify leads are connected to the source conductor when a measurement with a portable test instrument is taken. This condition could result in reading zero voltage when voltage is present. Even if it is possible to use a portable tester to measure voltage presence through test portals before opening the disconnect, it does not guarantee that the test portal installation is valid after the disconnect is opened. A known voltage source is also required to verify the portable tester is functional after measuring through the portals, which may require PPE.

- b) **Installation code requirements** – the local authority having jurisdiction (AHJ) will often require overcurrent protection for test portals with leads longer than 12 inches in order to meet NEC or UL 508A requirements. If fusing is required, testing through the portals will only test the load side of the fuse, not the actual circuit part. The circuit part could be energized if the fuse is open and a portable tester would not detect voltage through the test portal. Use of fuses or terminal blocks to extend test portal leads to comply with installation codes introduces additional installation failure points.
- c) **Bringing hazardous voltage to the door** – installing test portals requires routing wires that carry hazardous line voltage across the hinge and/or to the external enclosure. Bringing source voltage (ex. 480V) directly to an accessible surface is not a best practice, particularly when that surface moves, like a door. The wire will be subject to wear and tear and could eventually present shock hazards if not properly installed and maintained (another reason why the installation test described earlier is so critical). Test portals are designed with the impedance at the portal; therefore, the wire is not protected.

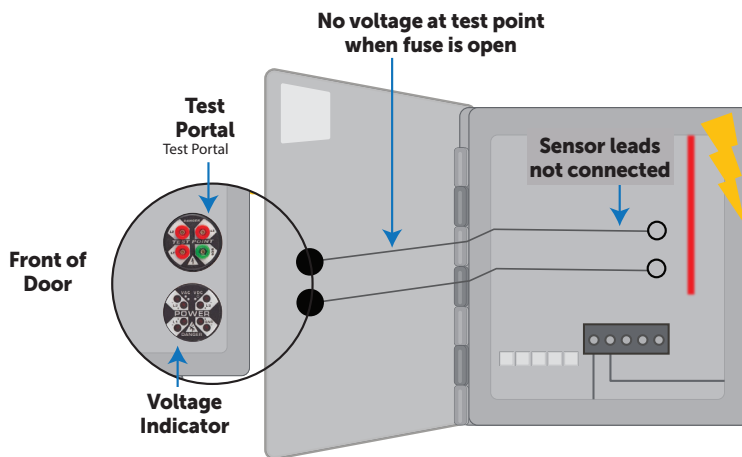
Test portals are a great tool to reduce risk when troubleshooting and measuring voltage **presence**. However, proving **absence** of voltage through a permanently mounted device has additional requirements that test portals do not meet.

The test portal can be thought of as an extension of the circuit part or source conductor – not the actual circuit part. Portals are okay to do a preliminary verification check at the portal. However, before removing PPE or performing any work, best practice is to perform **an additional test with the portable test instrument directly at the source conductor or actual circuit part to conclusively prove a de-energized condition exists.**

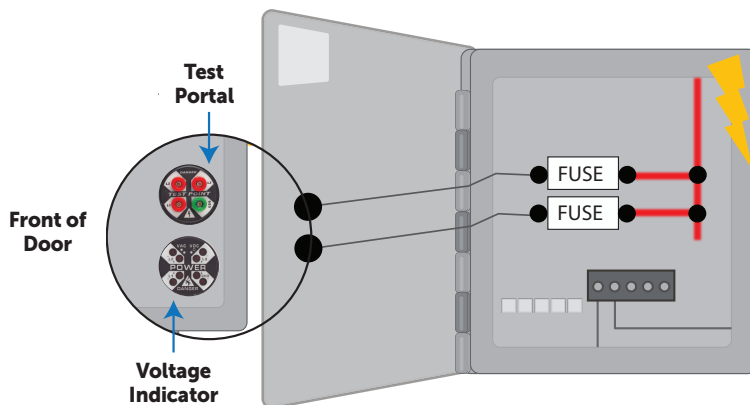
Limitations of Voltage Indicators and Test Portals



Both Test Portal and Voltage Indicator leads bring hazardous voltage to the door.



Poor workmanship or installation failures can lead to a zero voltage indication when the conductor is energized.



If the fuse is open, zero voltage will be indicated when the conductor is energized.



Absence of Voltage Testers – Verify Circuit is Deenergized

Absence of Voltage Testers (AVT) are permanently mounted test devices designed specifically to prove the absence of voltage exists. With AVTs, the absence of voltage is verified prior to opening an electrical enclosure. Requirements for AVTs are described in UL1436 as specified in NFPA 70E 120.5 (7) Exception 1. Informational Note No. 2. To operate an AVT, a user pushes a button to initiate the test sequence. The test sequence is performed automatically and includes verifying the tester is functioning with a known voltage source, ensuring the tester is properly installed and in direct contact with the circuit at the time of testing, and testing for absence of AC and DC voltage phase-to-phase and phase-to-ground. If all requirements in the test sequence are satisfied, a green indicator will illuminate to visually convey that the absence of voltage has been confirmed.

Requirements in UL 1436 for AVTs are very extensive and include a variety of features to ensure the absence of voltage test function is fail-safe and reliable. Active indicators, built-in overcurrent protection, and SIL 3 reliability for all safety functions are some of the important features. Built-in overcurrent protection ensures that the AVT can be installed directly in contact with the circuit being tested (without the need for in-line fusing) eliminating the failure modes that voltage indicators and test portals are subject to. In addition, AVTs are designed to keep hazardous voltage away from the door and user interface.

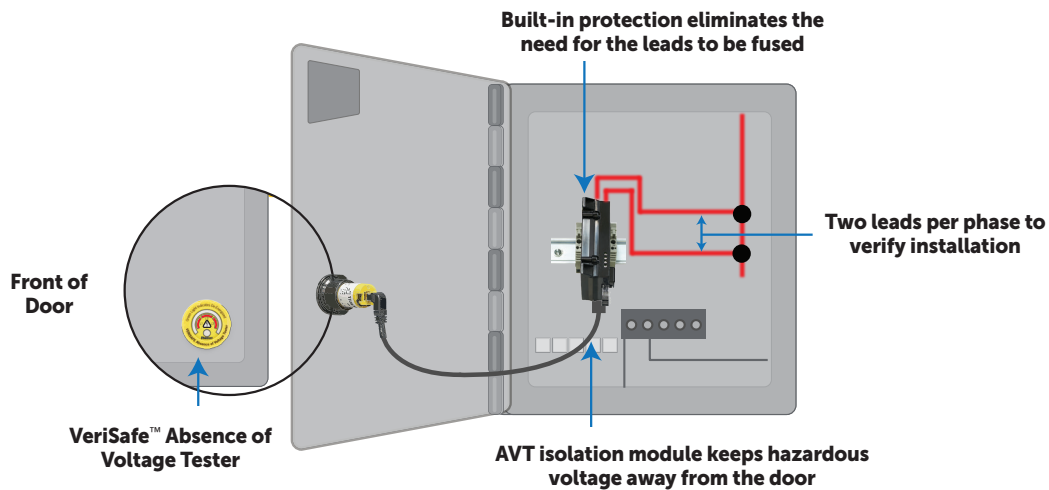
Like voltage indicators and test portals, AVTs will only test the point in the circuit at which the test leads are installed. If there are multiple test points or multiple sources of electrical energy (including stored energy sources) additional testers may be required.

AVT manufacturers often include voltage presence indicators as an additional feature, but this functionality is separate from the absence of voltage safety function and is not required by UL 1436.



Example of
Absence of Voltage Tester
(AVT)

Reliable Results with AVTs

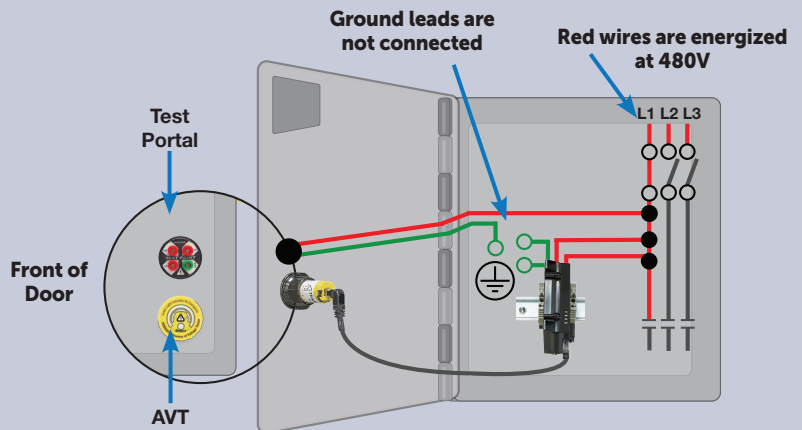





Case Study: Ground Lead Failure

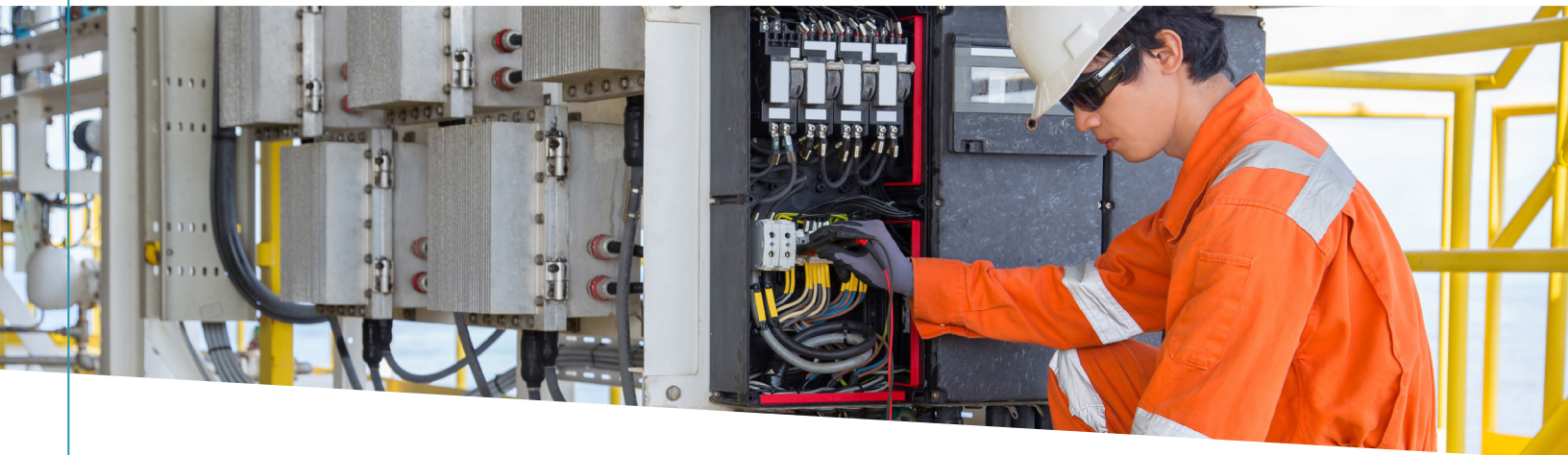
Situation

Worker approaches the enclosure and the disconnect switch for the 480V power source is in the OFF position. The disconnect switch has failed with one phase (L1) in the closed position (L2, L3 are open). The ground leads of the devices are NOT connected to ground because of an improper installation or termination failure.

The worker applies a lock. Following safety procedures, the worker performs an absence of voltage test with the electrical enclosure closed using a permanently mounted device.



Permanently Mounted Device	Failure Mode	Potential Cause	System State	Detection	Failure Effect	Incident Consequence
 <p>Absence of Voltage Tester (AVT)</p>	Ground lead(s) are NOT connected to ground	Improper installation or termination failure	Disconnect is in the OPEN/OFF position with L1 energized	<p>YES – the AVT will detect open ground (or phase) lead(s) and communicate the installation of sensor leads is not verified</p>	AVT will detect open ground lead(s) and communicate installation is the reason the absence of voltage test cannot be confirmed	None - Incident Avoided
 <p>Test Portal</p>				<p>NO – voltage measurement results in zero voltage when <u>voltage is present</u></p>	Worker erroneously considers electrical enclosure as deenergized	<p>Worker opens equipment while energized</p> <ul style="list-style-type: none"> • Probable shock or arc flash event • Equipment damage is likely
 <p>Voltage Test Station (VTS)</p>				<p>NO – the L1 LED for the voltage indicator will not be illuminated and measurement results in zero voltage when <u>voltage is present</u></p>		

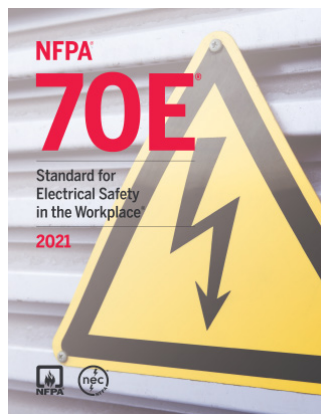


Permanently Mounted Test Devices in Standards & Regulations

NFPA 70E

Best practice for verifying the absence of voltage is described in NFPA 70E. NFPA 70E has requirements for verifying the absence of voltage with portable test instruments (120.5(7)) and permanently mounted absence of voltage testers (120.5(7) Exception 1).

120.5 Process for Establishing and Verifying an Electrically Safe Work Condition



“(7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to test for the absence of voltage. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

Exception No. 1 to (7): An adequately rated permanently mounted absence of voltage tester shall be permitted to be used to test for the absence of voltage of the conductors or circuit parts at the work location, provided it meets the all following requirements:

- (1) It is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the point of work;
- (2) It is listed and labeled for the purpose of testing for the absence of voltage;
- (3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground;
- (4) The test device is verified as operating satisfactorily on any known voltage source before and after testing for the absence of voltage.

Informational Note No. 2: For additional information on rating and design requirements for permanently mounted absence of voltage testers, refer to UL 1436, Outlet Circuit Testers and Other Similar Indicating Devices.”



In NFPA documents, an exception is defined as an “approved alternative.” This means that there is an option to use the primary process or follow the requirements of the exception. In the case of 120.5 Step (7) and Exception No. 1, this means that either a portable test instrument or permanently mounted absence of voltage tester can be used to verify the absence of voltage, but both are not necessary.

The 2021 edition of NFPA 70E clarifies that the permanently mounted “test devices” previously described in Exception 1 are in fact “absence of voltage testers.” The addition of Informational Note No. 2 was added to identify UL 1436 as the standard that describes the rating and design requirements to be listed and labeled for absence of voltage verification as noted in part (2) of Exception 1.

Neither voltage indicators nor test portals meet UL 1436. Voltage indicators and test portals often have a UL listing, typically to UL 508 or UL 61010-1 as an “auxiliary device” suitable for use in an industrial control panels. However, this listing has no performance or safety requirements for proving absence of voltage. Test portals are permanently mounted but rely on a portable tester. As a hybrid, test portals would have to meet the requirements of both Step 7 and Exception No. 1 to ensure a reliable result. This involves having an installation test for the permanently mounted leads or ensuring the portable tester is in contact with the actual circuit part.

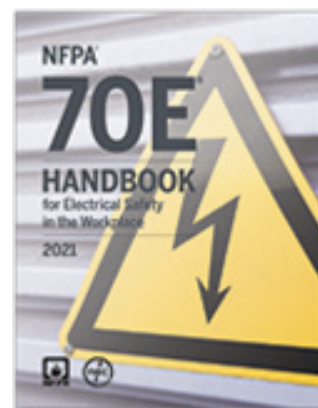
Test portals were proposed as additions into the standard for absence of voltage verification in the 2021 edition, but were rejected by the NFPA 70E Technical Committee. Use of test portals or voltage indicators for absence of voltage testing is not addressed in any edition NFPA 70E.

NFPA 70E Handbook

Exception No.1 was new to NFPA 70E in the 2018 edition. Because the 2018 language in NFPA 70E was voted on before the 6th Edition of UL 1436 was published with AVT requirements and absence of voltage testers were defined, additional information is included in the NFPA 70E 2018 and 2021 Handbooks.

NFPA 70E Handbook states:

“Typically measurement devices indicate when voltage is present, but lack of indicating a voltage does not guarantee the equipment has been de-energized. For this reason, these mounted devices are designed to run internal diagnostics, verify operation on a known voltage source, confirm contact with the circuit, and verify the lack of voltage. These measurement devices do not use equipment voltage to verify the operation of the device. A secondary test source is available to perform this function. See Exhibit 120.14 for an installed absence of voltage tester indicating that equipment is de-energized. Absence of voltage testing equipment for fixed installations is listed to UL 1436, Standard for Outlet Testers and Similar Indicating Devices.”





OSHA

Within OSHA 29 CFR 1910, test equipment used for the purpose of verifying the absence of voltage in either -.147 (control of hazardous energy) or Subpart S (electrical work) is not well-defined and has very few performance requirements. No distinction is made between portable or permanently-mounted voltage test instruments. OSHA regulations are rarely updated, so the latest in best practices and technology are often not specifically mentioned. However, OSHA has a history of relying on industry consensus standards, like NFPA 70E (updated every three years), to provide prescriptive requirements and best practices.

NFPA describes the relationship between OSHA and NFPA 70E requirements in their Fact Sheet on NFPA 70E.¹

¹NFPA. (2017, November). Fact Sheet – NFPA 70E®, 2018 Edition.

Retrieved from <https://www.nfpa.org/~media/3B937D481EAE4B8DA74C0C1CE5BFBE9E.pdf>

FAQs

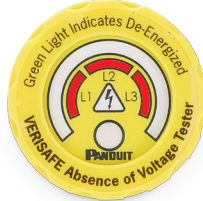
What is the relationship between OSHA's standards and the NFP 70E?

OSHA looks to the perspective-based requirements of NFPA 70E to fulfill the performance-based requirements included in it's standards. NFPA 70E fleshes out how the performance-based requirements in the OSHA standards should be met by providing the defining the minimum standard industry practice necessary for electrical safety. OSHA is the law, but NFPA 70E outlines how to comply with OSHA's electrical safety requirements.¹

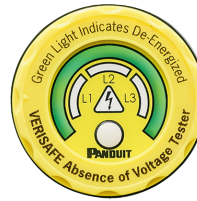
Comparison of Devices and Capabilities

The VeriSafe™ AVT is Unique

It combines voltage **presence** indicators with **absence** of voltage testing technology.



Red indicates
voltage presence



Green indicates
absence of voltage



VeriSafe™ AVT



Voltage Indicator



Test Portal



Indicates presence of voltage



Built-in known voltage source



Tests for absence of voltage



Verification tester is in contact with the test point



Keeps hazardous voltage off the door



Diagnostic codes provide intelligence



Built-in overcurrent protection



Automatically self-calibrates



UL listed and labeled for verifying the absence of voltage (UL 1436)



Meets the requirements to verify the absence of voltage described in NFPA 70E 120.5(7) Exception 1





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