Permanent Electrical Safety Devices Will Verify Zero Electrical Energy

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Abstract -– Article 120.1 of the NFPA 70E establishes the procedure for creating an electrically safe work condition. Since this was written, the day-to-day practice of electrical safety has changed going beyond the precise language of Article 120.1(1-6). This is due to the increased usage of permanent electrical safety devices (PESDs) in Lock-out/Tagout procedures. The relatively new concept of permanent electrical safety devices actually improves the workers' ability to safely isolate electrical energy beyond that which was originally conceived when Article 120 was written. PESDs go beyond the high standard, yet they still adhere to the core principles found in Article 120.1. With PESDs incorporated into safety procedures and installed correctly into electrical enclosures, workers can transition the once-risky endeavors of verifying voltage into a less precarious undertaking that never exposes them to voltage. Since, every electrical incident has one required ingredient – voltage, electrical safety is radically improved by eliminating exposure to voltage while still validating zero energy from outside the panel.

Index Terms -– Voltage detectors, voltage portals, non-contact voltage detector, NCVD, power warning alerts, permanent electrical safety devices, voltage detector validation procedures, verification, voltmeters

Introduction

To employees all safety – especially electrical safety – is personal. Little else matters to them unless electrically safe work conditions can be created and maintained through their work environment. Article 120.1 of the NFPA 70E was, as its title suggests, penned with the important purpose of establishing the "gold standard" for creating an electrically safe work condition. Since then, however, innovation in the realm of electrical safety has surpassed the precise language of Article 120.1(1-6) because it does not speak directly to the value permanent electrical safety devices have in achieving an electrically safe work environment. The relatively new concept of permanent electrical safety devices (PESDs) actually improves the workers' ability to safely isolate electrical energy beyond that which was originally conceived when Article 120 was written.

The forward-thinking concept of PESDs goes beyond the high standard of safety for which competent companies strive, yet they still adhere to the core principles found in Article 120.1. With PESDs incorporated into safety procedures and installed correctly into electrical enclosures, workers can transition the once-risky endeavor of verifying voltage into a less precarious undertaking that never exposed them to voltage. Let's face it; every electrical incident has one required ingredient – voltage. Electrical safety is radically improved by eliminating exposure to voltage while still validating zero energy from outside the panel.

The standard shoulder belt you (hopefully) use each time you are in a vehicle is an improvement on a simple lap belt found in many vehicles of the past. American car manufacturers offered seat belts only as options until Saab introduced them in 1958 as a standard safety element – an act that changed the landscape of passenger safety in vehicles. Later, driver- and passenger-side airbags offered breakthrough safety advances beyond the then-simplistic seatbelt only to later be enhanced by side-impact airbags. Each of these safety innovations relies upon each other for peak functionality and surpassed conventional safety protocols of 1958. Airbags provide little protection if drivers are not wearing seatbelts; shoulder belts without lap belts are ineffective, and side airbags alone are insufficient. These safety reformations, when used in conjunction with each other, raised the expectations of safety for all users and ultimately manufacturers began offering them as standard equipment. Similarly, PESDs are revolutionizing electrical safety and should be used in conjunction with existing safety practices.

Definitions and Resources:[1]

Non-Contact Voltage Detector (NCVD): A battery–operated voltage detector that senses voltage without actually touching an energized conductor.

Voltage Portal: Extends a voltage source to the outside of an electrical enclosure in an encapsulated non-conductive housing designed for a NCVD to sense voltage if placed into the voltage portal (Fig. 1).

The Voltage Portal:

Extends voltage to the outside of an enclosure into an encapsulated non-conductive housing.

Fig. 1
Cut-away view of a typical voltage portal

Voltage Indicator: A hardwired LED indicator permanently wired to the phase(s) and ground that illuminates when a 40VAC/30VDC or greater voltage deferential exists between two lone inputs. Typical 3-phase/4-wire voltage indicator requirements include (Fig 2):

- Powered from the line voltage (no batteries)
- Applies to any power system by operating on a wide voltage range (40-750VAC/30-1000VDC)
- Cat IV rated for high surge immunity
- UL Certified to UL 61010-1 as per NFPA 70E 120.1(5) FPN

The Voltage Indicator:

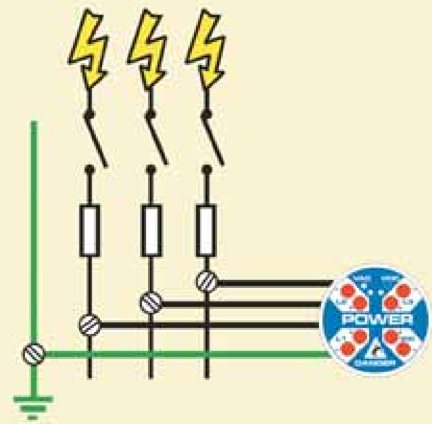

Fig. 2
Voltage indicator wiring diagram

Written Procedures and Training: Using PESDs in an electrical safety program requires written Lock-out/Tag-out (LOTO) procedures. Employees need to be trained and have access to these procedures.[2]

What does it really mean and what happens when it's validated?

An electrically safe work condition requires 100% accuracy from voltage detectors. To ensure this, the NFPA 70E says, "Before and after each test, determine that the voltage detector is operating satisfactorily," (NFPA 70E 120.1(5). In order to comply, electricians first check their voltage detector to an independent voltage source (i.e. a nearby 120VAC outlet). Next, they check for zero voltage on the primary source. Work begins only after the voltage detector is rechecked to the independent live voltage source. This straight-forward validation procedure works for a portable voltage detector because it can be physically moved between two voltage sources. The authors of NFPA 70E only considered the portable voltage detector (i.e. voltmeters) when writing Article 120.1, and by doing so limited the level of achievable safety to that which was available at the time it was written. The same principles apply to PESDs, however, because a PESD cannot be moved between two voltage sources, the technique for validation needs a slightly different approach.

So what really happens when a voltage detector is validated? Indicating voltage on a voltage detector requires a small amount of current to flow between the two voltage potentials. The voltage detector circuit determines if a safe voltage potential exists by measuring this current flow and providing the worker an indication (audible, visual or digital display).

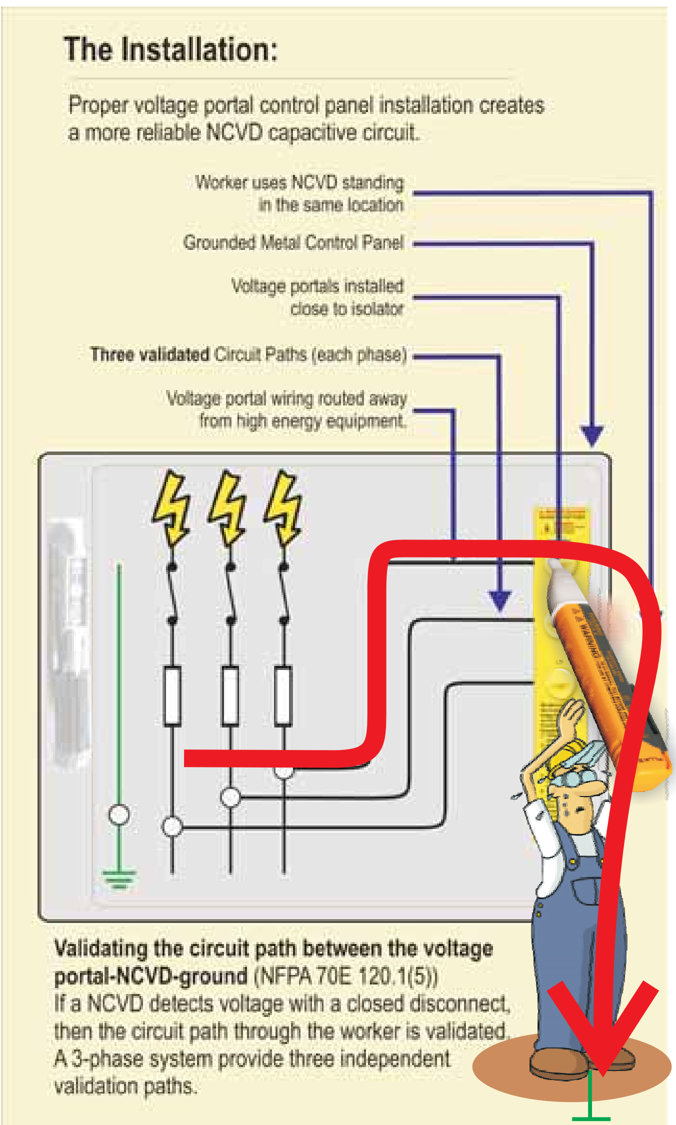

Fig. 3 Proper voltage portal installation improves reliability of NCVD operation

Validating a Voltage Portal & NCVD Combination

A NCVD determines if voltage exists by creating a low current capacitive circuit between the conductor, the NCVD, and ground.[3] When the NCVD is positioned close to a voltage source, the NCVD circuitry allows current to flow through this capacitive circuit (Fig. 3). Since NCVDs use a small amount of current in checking for voltage, other electrical variables will negatively influence its operation. However, a voltage portal correctly installed into an electrical panel increases the reliability of the NCVD voltage reading by reducing these variables. For example, the permanent location for a voltage portal forces workers checking voltage to stand in the same location every time. As a result, the ground path through the worker has less variability. By routing the voltage wire leads the shortest distance from the main disconnect also reduces variation. In addition, because NCVDs are portable, they can also be checked to an independent voltage source as per NFPA 70E 120.1(5).

Validating a Voltage Indicator

Voltage indicators installed by qualified electricians are hardwired to the main power disconnect and earth ground. Installation is simple because a phase-nuetral high impedance voltage detection circuit on each phase senses and illuminates AC/DC voltage.[4] The illumination of the LEDs occurs only when current passes through two of these voltage detection circuits. Envision four voltage detection circuits (L1, L2, L3, GND) "meeting" each other in the center of the voltage indicator circuitry. The amount of current flow through the voltage detection circuit depends upon the phase and ground voltages that results in six current paths (for validation) through the circuitry. In order for a single LED to illuminate, the current must pass through at least four LED flashing circuits. A voltage detection phase circuit has two LEDs; one LED illuminates when the AC sine wave is positive and the other LED illuminates when the AC sine wave is negative (Fig. 4). "Voltage when illuminated" means if only one of the four LEDs illuminates, it still provides voltage indication to the worker.

A hardwired voltage indicator brings up two interesting issues. First, it is impractical to verify

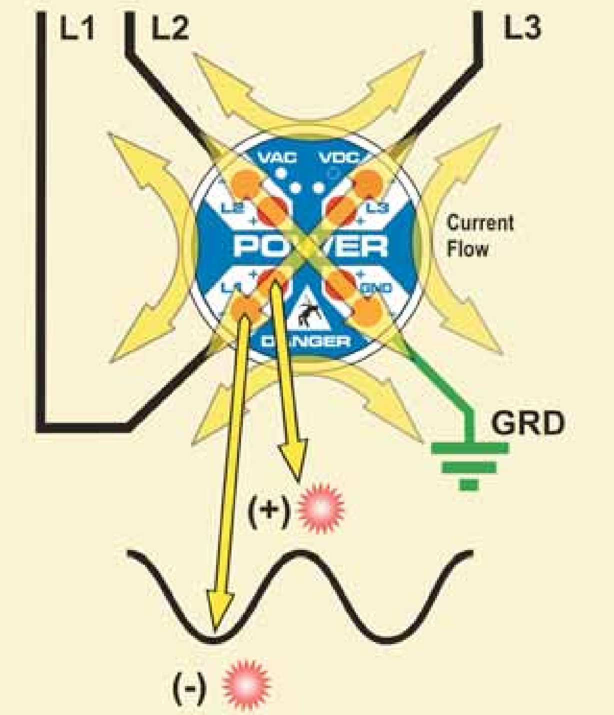

Fig. 4
The current flows through four voltage detector circuits 'meet each other' in the center of the circuit.

Six current 'validation' current paths exist through a voltage indicator circuitry.

Current must pass through two voltage detection that illuminates four LEDs.

LEDs illuminate on the (+) and (-) part of the sine wave.

the voltage indicator to another independent voltage source; trying to accomplish this by adding a switch to toggle between the line voltage and the test voltage adds more components and complexity; leading to unreliability.[5] Secondly, since the voltage indicator's sole purpose is to indicate voltage, anything between the source voltage and the voltage indicator increases the chance of a false negative voltage reading - switches, relays and fuses included.[6,7]

Until now, creating electrically safe work conditions relied solely upon portable voltmeters. Portable voltmeters and permanent voltage detectors are designed and built for different purposes. Understanding these differences will help determine an acceptable validation procedure for permanent voltage detectors.

Voltage indicators and voltage portals have unique strengths and complementary characteristics, and when used together they meet the requirements of NFPA 70E 120.1. The traditional method of validating the voltage detector to an independent voltage source is met with the NCVD/voltage portal combination. On the other hand, it can be argued that a voltage indicator by itself cannot be validated by the traditional method. However, because permanently-mounted voltage detectors are designed to only detect voltage, the built-in advantages over a simple voltmeter need to also be considered in validating this device (Fig. 5).

The Personal Protective Equipment (PPE) Question

When workers can determine a zero electrical energy state without any voltage exposure to themselves, it makes an electrical safety program safer. Verifying the proper operation of a meter and testing for absence of voltage before working on an electrical conductors ("Test before Touch") must remain a habitual practice for workers. The goal of PESDs is to ensure that when workers 'test before touch', that they test only dead conductors. Therefore, with PESDs written into this procedure, they can do this task without special PPE.

Conclusion

Safety is an evolution based on best work practices and innovation. High safety standards not only create safer workplaces, but also encourage safety innovations. Ultimately, safety standards must be rigid enough to garner the highest level of safety while still being flexible enough allowing for advances through innovation to be incorporated while still adhering to the principles of Article 120.1. Now, thinking outside the panel doesn't leave you boxed in.

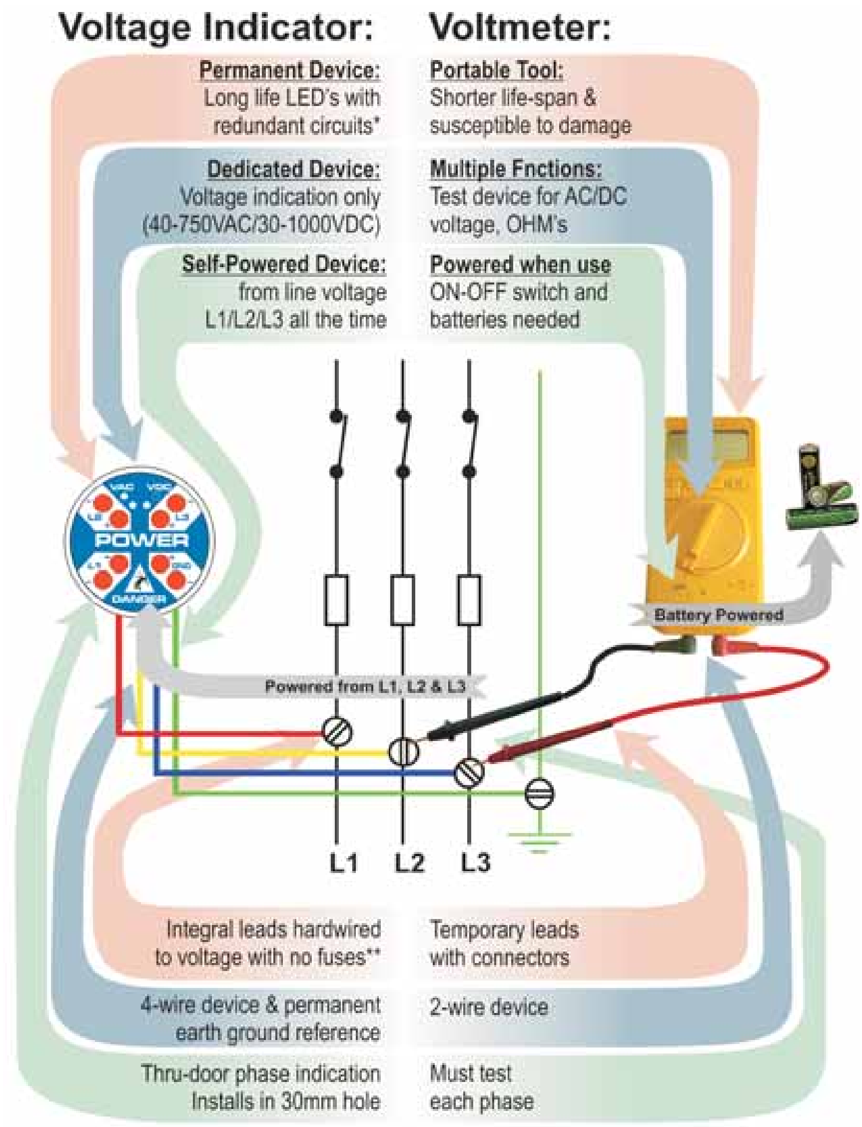

Fig. 5 Voltage indicator to voltmeter comparison.

Fig. 6 Installation of a voltages indicator and voltage portals on a typical 3-phase panel.

Footnotes & References

(1) For more reference information please see *http://graceport.com/thru_door.cfm*

(2) OSHA 29 CFR 1910.147, 1910,333(b) NFPA 70E 120.2(B)(2), 120.2(C)(1)

(3) NCVD rely on a path to ground to function correctly and do not work on an isolated ground system.

(4) For more detailed explanation on Voltage Indicator applications, go to *http://graceport.com/assets/files/Application%20Notes/VoltageVison%20How%20it%20works.pdf*

(5) This is impractical because it requires a 600V fused three -pole double throw relay. The fusing, the relay wiring, and switching introduces 18 connections between the voltage source and the voltage indicator.

(6) False negative: In electrical work, the most dangerous situation happens when voltage exists and the voltage detector does not detect it.

(7) For a detailed write-up on over-current protection for voltage detectors, see: *http://graceport.com/assets/files/Application%20Notes/VoltageVision_FusingDocument.pdf*

About the Author

Phil Allen is the President and owner of Grace Engineered Products, the leading innovator of thru-door electrical safety devices. He holds two US Patents, a power receptacle design and a voltage detector test circuit. His passion is finding new and more efficient ways of bringing electrical safety to the forefront. Phil did is undergraduate work at California State University, San Luis Obispo and is a 1984 graduate with a BSIE.

Grace Engineered Products is a member of the Rockwell Encompass Partner program, and is best known for its GracePort® line of custom-made data port interfaces. In addition to the GracePort® line, the company provides a well-established line of products – ChekVolt® and VoltageVision® - that make pre-verifying electrical isolation through enclosure doors safe and easy. Their focus is on NFPA 70E guidelines and making companies electrically safe while also increasing their employee productivity.