SAFESIDE®
Permanent Electrical Safety Devices

Updated Aug 2014

Voltage Indicator*
Overcurrent Protection Application Note

SafeSide® Permanent Electrical Safety Devices (PESDs) are a family of electrical components hardwired to a source of voltages and permanently installed into electrical systems. They enable workers to reduce risks by having the ability to verify the voltage status of equipment without exposure to the hazard. PESDs reduce the likelihood of arc flash and shock hazard because they diminish voltage exposure, provide voltage labeling on all sources and allow for 24/7/365 visual and/or audible indication of voltage. Product information: http://graceport.com/safeside

Background:
The purpose of the NEC, as well as the UL 508A Industrial Control Panel Standard, is best summed up in Article 90 of the 2014 NEC:

> “90.1 (A) Practical Safeguarding. ....practical safeguarding of persons and property from hazards arising from the use of electricity.
>
> “(B) Adequacy. .. .results in an installation that is essentially free from hazard.”

Compared to the purpose of the NFPA 70E:

> “90.1 Purpose. ... practical safe working area for employees relative to the hazards arising from the use of electricity.
>
> “90.2 Scope. (A) Covered. ...electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees during activties such as the installation, operation, maintenance."

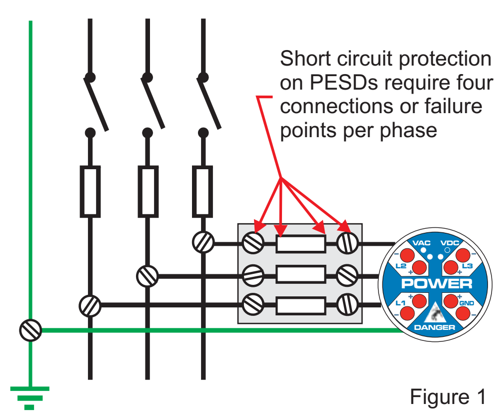

Figure 1

The NEC protects people and property from the hazards of electricity by insuring that installations are reliable and safe. likewise, the NFPA 70E focusing on protecting employees who work with or around electricity. The safest work practices cannot overcome a poor installations. Likewise, a high quality installation does little to create workers safety when sloppy work practices abound. However, in some instances these two objectives may overlap and conflict. When that occurs a hazard risk analysis needs to be performed to determine which solution poses the highest risk. Once this has been determined, we can decide how to resolve this conflict by focusing on reducing the greater risk first. Overcurrent protection (fusing) of a Voltage Indicator provides us with an excellent test case.

Blown Fuse is 'False Negative':
A false-negative occurs when a conductor tests as de-energized, but actually is energized, which means the voltage test instrument falsely indicated no voltage. Since the voltage indicator’s only full time job is indicating voltage, a blown fuse on its input creates an opportunity for a false-negative indication of voltage, which is a hazard. A fuse also adds four connection points (Figure 1) of failure for each phase (line-load for fuse and fuse block). In electrical safety, once you touch a live conductor there is ALWAYS an electric incident because electrical energy is instantaneous.

Hazard Risk Analysis
Users need to determine the greater risk: The chance of a false negative voltage indication or the possible results of a damaged or shorted 18AWG wire inside an enclosure? Installing overcurrent protection for a voltage indicator installation increases the opportunity for a false negative reading, which in most cases, *potentially creates a greater hazard*.

The Increased-Hazard Exception
The process of reducing risks to acceptable levels defines safety. Therefore, safety inevitably means that the risks must be clearly understood and decisions made between safe-choices and safer-choices. In this case, will a voltage indicator provide a worker with more or less reliable voltage indication with or without overcurrent protection? The tension between the safe-and-safer principle is clearly delineated NFPA 70E 130.1(A) where a worker must work on de-energized systems unless an employer demonstrates that de-energizing an electrical system introduces new hazards or increases other hazard. Obviously removing power from life support systems, critical ventilation or emergency systems creates a whole new set of hazards beyond electrical risk.

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<u>Examples of Conductors without Overcurrent Protection</u>
The NEC 2014 states that overcurrent protection is the lesser hazard and *shall be omitted if* a blown fuse results in an inoperable fire pump when there is a fire. "*Exception: Overcurrent protection shall be omitted where the opening of the control circuit would create a hazard as, for example, the control circuit of a fire pump motor and the like"*. NEC 430.72

The tap rule dictates conductor sizing for connections specifically between two overcurrent devices; typically the main and associated branch circuits. The 2014 NEC 240.21(B)(1)(1)b. added an exception to this rule that allows other listed equipment or non-overcurrent devices to use the tap rule. The wire sizing under this new exception is solely determined by the manufacturer: *"listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions."* Not only is a voltage indicator UL Listed, but there is enough similarities between an SPD circuit and a voltage indicator circuit to allow this exception to be applied to the installation of voltage indicators installed within10 feet of a main disconnect.

Another informational note in NEC 725.1 provides an example related to Class 1, 2, and 3 remote-control, signaling, and power limited circuits. These circuits have limited power outputs and characteristics that differentiate them from *'electric light and power circuits'*, so users may determine *'alternative requirements...with regard to… overcurrent protection, insulation requirements, and wiring methods and materials."* In addition, *"Remote-control circuits for safety-control equipment <u>shall be classified as Class 1 if the failure of the equipment to operate introduces a direct fire or life hazard</u> [emphasis added]"* NEC 725.31(A). SafeSide® voltage have power limited circuitry like Class 1,2 & 3 devices but operate a higher voltage, but the principle still applies.

If a control circuits and control circuit transformers can be excluded from overcurrent protection for reasons specified in NEC 430.72(B), (C)(1) to (5). The construction and design of the R-3W2 creates less points of failure points and a higher degree of electrical integrity than transformers.

<u>Over-current Protection Design Considerations</u>
Fusing protects both the wires and the devices from permanent damage due to excessive current flow during a short circuit. Since voltage indicator's install between all 3-phases and ground, it is imperative that the failure of the voltage indicator does not create a bolted fault condition. Consider these design facts relating to fusing the :

High Impedance: SafeSide® Voltage Initiators have UL Listings as Auxiliary Devices (NKCR, NOIV) in hazardous and non-hazardous locations and have been evaluated under UL 61010-1. UL performed a single component failure evaluation to insure these devices are power limited and would not fail catastrophically causing a short circuit between phases. UL determined a single component failure would draws no more than 3.7mA current at 750VAC applied to the device. The large passive input resistors on each phase of the voltage indicator provides this current limiting function with a nominal current draw of 200-300µA between phase at 480VAC.

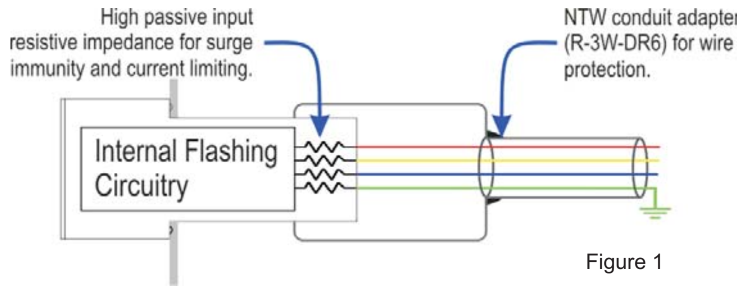

Figure 1

Electrical Integrity: The potted construction adds additional electrical strength to the voltage indicator. The physical presence of high voltage only extends ¾" from the rear (inside) where the leads enter the device (Figure 1).

Surge Rated: Part numbers R-3W2, R-3F2-Lxx carry a CAT III (1000V) and CAT IV(600V) surge rating as per UL 61010-1, which allows the devices to be used in power distribution systems.

Integral Lead Wires: The integral potted 18AWG UL listed 1000V rated lead wires will not 'vibrate loose' causing a short circuit to ground. Since the failure mode of the voltage indicator is 3.7mA, these wires should not fail due to a device failure.

Wire Protection: An optional NTW conduit adapter (R-3W-DR6) provides physical protection to the wires.

In conclusion, over-current protection will only protect votlage indicator's from a damaged lead wire that might short to ground or another bare conductor. If this happens, most likely the current will 'vaporize' the lead wire causing limited damage to the enclosure. Since the lead wire insulation is a flame-rated and UL-listed, it is designed to not sustain a flame. The UL installation sheets also state that overcurrent protection of the leads is not a requirement for every installation.

Picture of an R-3F-Lxx & R-3F2-Lxx Optical Cable Indicator

Other Installation Options: UL 508A 12 Inch Rule

As with any consensus standard, various governing bodies decide which parts of the code the local inspectors will enforce. So in some cases a local inspector will require that SafeSide® indicators be installed with short circuit protection. The UL-508A has no other provisions for unfused conductors other than the 12 inch rule in 40.3.2 Exception 2. This provision allows for unprotected leads integral to the device shorter than

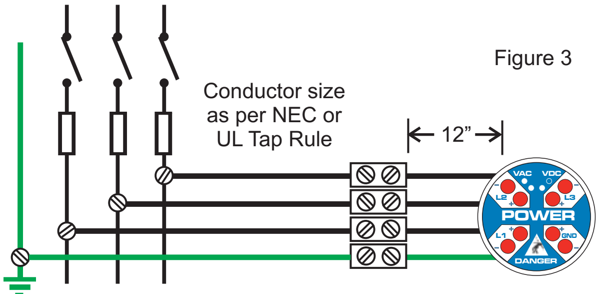

Figure 3

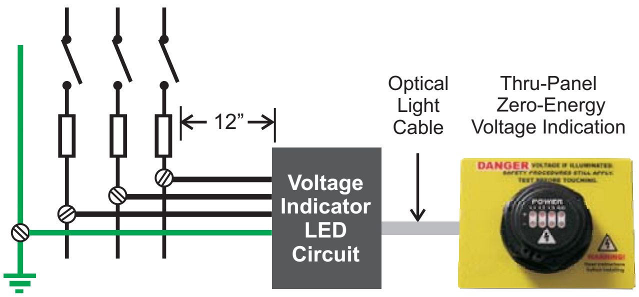

Figure 4 - R-3F-Lxx & R-3F2-Lxx Optical cable voltage indicator
Zero voltage on the outside of the enclosure.
Lead wires standard length 72”
Optical cable lengths: 12, 18, 24, 36, 48, 72”

12” to be unfused, which gives you two installation options to consider:

- Mount the voltage indicator within 12” of the disconnect. The best location is on the flange or the side of the enclosure.
- Use the R-3F-Lxx optical cable indicator (Figure 4) and mount the power unit within 12” of the disconnect.
- From the main disconnect, mount terminal blocks within 12 inches of the voltage indicator and size the conductor as per the NEC or UL 508A tap rule as per figure 3.

The NEC has been around a lot longer than the NFPA 70E. Perhaps the writers of the NEC never envisioned that a safe electrical installation and electrical worker safety would require choices between safe-and-safer. This whole issue boils down to discerning between the probability of an occurrence and the severity of that particular occurrence. As shown in this write-up, these inconsistencies are usually mitigated with a little common sense and good logic.

***Products:** VI includes part numbers R-3W, R-3W2, R-3W-SR, R-3W2-Lxx, and R-3F-Lxx. The same principles described herein apply to the voltage portal installations. Voltage Portals part number scheme included R-1A and R-T3.

UL Listing: R-3W2: UL File E334957, CCN:NOIV and E311256, CCN: PICQ (UL 61010-1). R-3W, R-3F-Lxx, and R-3W-SR: UL File E256847, CCN NKCR. NOTE:

Short Circuit Current Rating (SSCR) tells the user how much instantaneous short circuit current can pass through a device without permanent damage. Devices that supply current to other devices in normal operation, can have an SCCR rating. SafeSide® VIs do not have a SCCR rating because they are wired between all three phases and are effectively in a ‘shorted condition’ when energized. If a short circuit occurs in a system where an R-3W is installed, the high currents passing through the system will not find a path through the R-3W and the current flow would not cause any damage to the device. Therefore the SSCR rating is not applicable.

Application Standards: UL508A February, 2014 National Electrical Code (NEC) NFPA 70 - 2014 Edition, NFPA 70E - 2012 Edition, and CSA Z 462.

Warning: Verify an electrical conductor has been de-energized using an adequately rated voltage detector before working on it. Follow appropriate Energy Control (Lockout/Tagout) procedures as per OSHA Subpart; the current edition of NFPA 70E; and the current edition of CSA Z462.

Philip Allen is the President, owner and founder of Grace Engineered Products, Inc., in Davenport, Iowa. He is a leading innovator in thru-panel electrical safety with four US Patents related to thru-panel electrical safety. His passion for innovative permanent electrical safety products has made GracePort® a household name among the industrial electrical community.

A member of NFPA, IEEE, and NETA, Phil has spoken at the 2013 IEEE Pulp & Paper Conference, Charlotte, NETA PowerTest Conference 2011 & 2009, the IEEE Electrical Safety Workshop 2009, Wuhan University, Wuhan China 2008. He served on the IEEE PG-1683 TG3 Committee. He has also published several articles in various trade journals.

Phil received a BSIE degree at California State University, San Luis Obispo in 1984. Phil has two children, and has been married to his wife, Jane, for 26 years. From 1998 to 2001, Phil served as President of the Women's Choice Center in Bettendorf, Iowa. In 1998, he was a candidate for the Iowa State Senate. He is an active member of his church and an enthusiastic history buff.

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