SAFESIDE
Permanent Electrical Safety Devices

Voltage Indicator* Overcurrent Protection Application Note

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 2008 NEC:

> "90.1 (A) Practical Safeguarding. The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity.
>
> "(B) Adequacy. This Code contains provisions that are considered necessary for safety. Compliance therewith and proper maintenance results in an installation that is essentially free from hazard."

Compared to the purpose of the NFPA 70E:

> "90.1 Purpose. The purpose of this standard is to provide a practical safe working area for employees relative to the hazards arising from the use of electricity.
>
> "90.2 Scope. (A) Covered. This standard addresses electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees during activities such as the installation, operation, maintenance."

These are two very different goals. While the NEC protects people using electricity and property, the NFPA 70E only protects employees who work with or around electricity. In very few instances these two objectives do not conflict, and 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. Over-current protection (fusing) of a Voltage Indicator (VI) provides us with an excellent test case.

Blown Fuse is 'False Negative':
Getting 'bit' by live voltage is almost always a surprise!
Far worse is an electrician starting to work on a conductor that he just tested 'dead', but actually is 'live'. This is referred to as a 'false negative' indication, which means the voltage detector falsely indicated no voltage. Since the VI's only full time job is indicating voltage, a blown fuse on its input creates a false negative indication of voltage, which is a hazard. A fuse also adds four connection points 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. Therefore, it is critical to avoid any chance of false-negatives.

Hazard Risk Analysis
Users need to determine the greater risk: The chance of a false negative voltage indication or a damaged or shorted 18AWG wire inside an enclosure?

The 'Increased Hazard' Exception
The NFPA 70E recognizes that 'perfect safety' does not exist and there is always a trade-off between 'safe' and safer'. For example, energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional or increased hazards (NFPA 70E 130.1(A)(1)).

The NEC states that a wire without overcurrent protection is a lesser hazard that a non-functioning fire pump motor due to a blown fuse. A greater hazard exists when a building burns down because the fire pump motor doesn't start due to a blown fuse in the control circuit! *"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(C)

The informational note in NEC 725.1 provides another example relating to proper installation of 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 shall be classified as Class 1 if the failure of the equipment to operate introduces a direct fire or life hazard [emphasis added]"* NEC 725.31(A)

In electrical safety, determining zero electrical energy is critical. Installing overcurrent protection for a VI installation increases the opportunity for a false negative reading thereby *potentially creating a greater hazard*.
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.

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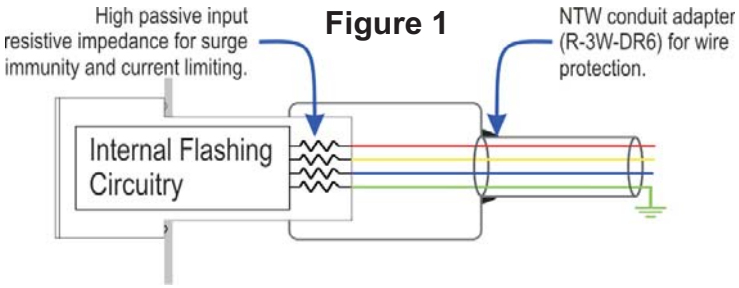
Over-current Protection Design Considerations
Fusing protects both the wires and the devices from permanent damage due to excessive current flow during a short circuit. Since VI's install between all 3-phases and ground, it is



imperative that the failure of the VI does not create a bolted fault condition. Consider these design facts relating to fusing the :

High Impedance: SafeSide™ VIs are UL Listed as Auxiliary Devices for use in a UL 508A industrial control panels or UL 845 motor control centers. UL performed a single component evaluation test that insures the device would not experience a catastrophic failure due to a component failure, thereby causing a direct short circuit between phases. UL determined that VIs are a self-protected device whereby a single component failure draws no more than 3.7mA current at 750VAC applied to the device. The large passive input resistors on each phase of the VI provides this current limiting function with a nominal current draw of 300µA between phase at 480VAC.

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

Surge Rated: The VI known as part number R-3W2 carries a CAT III (1000V) and CAT IV(600V) surge rating for reliability.

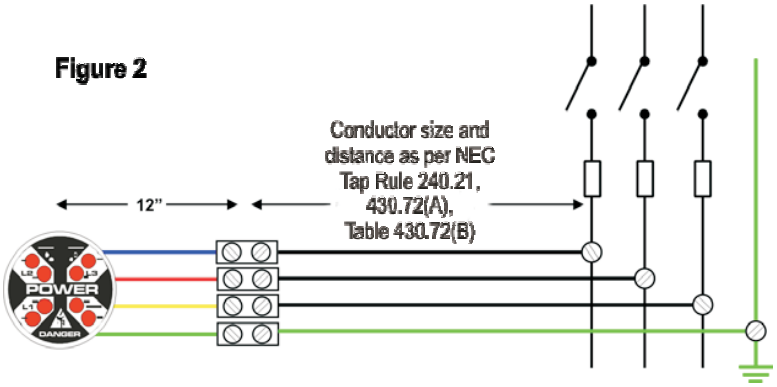
Integral Lead Wires: The integral potted 18AWG UL listed 1000V rated lead wires will not 'vibrate loose' causing a short circuit to ground. Since the failure mode of the VI is 3.7mA, these wires should not fail due to a device failure.

Wire Protection: An optional NTW conduit adapter (R-3W-DR6) provides physical protection to the wires.
In conclusion, over-current protection will only protect VI'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.

Other Installation Options: NEC Tap Rule and the UL 508A 12" Rule Approach
NEC 430.72(A), Table 430.72(B) allows smaller conductors to be tapped off larger branch circuits. In addition, the UL 508A 40.3.2 Exception 2 allows for unprotected leads less than 12" from the device. This gives you two installation options to consider:

- Mount the VI within 12" of the main disconnect. The best location is on the flange or the side of the enclosure. An NPT conduit adaptor (R-3W-NPT125) for the VI may facilitate some other creative mounting options.
- From the main disconnect, wire to terminal blocks as per the NEC tap rule. Locate the terminal blocks within 12" of the VI as per figure 2.

The NEC has been around a lot longer than the NFPA 70E. The writers of the NEC never envisioned that a safe electrical installation and electrical worker safety would conflict with each other. 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, 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, 2010 National Electrical Code (NEC) NFPA 70 - 2008 Edition, NFPA 70E - 2009 Edition, and CSA Z 462.

Warning: Before working on an electrical conductor, verify zero electrical energy with proper voltage testing instrument and the proper procedure as per NFPA 70E 120.1(5), 120.2 (F)(2)(f)(1-6), OSHA 1910.333(b)(2)(iv)(B).