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The Need to Protect Outdoor Circuits from Transient Overvoltages

White Paper

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National Electrical Code® (NEC®) Article 708 – Critical Operations Powers Systems (COPS) requires certain surge protection measures in facilities that must operate continuously. This document explains the requirements and describes a best practice for compliance.

BACKGROUND INFORMATION

NEC Article 708 specifies measures for electrical power distribution systems serving facilities or portions of facilities that must operate continuously in accordance with industry codes and government regulations. Implementing these measures at hospitals, data centers, police and fire stations, 9-1-1 call centers and other facilities enables them to operate as designed following electrical power disturbances. A review of facility uptime records, case studies, and anecdotal reports reinforce that the general requirements for COPS systems improved the reliability of mission critical facility power systems.

A key requirement in Article 708 is a mandate to deploy surge protection at all facility distribution voltage levels.[1] The resulting deployment of Surge Protective Devices (SPDs) throughout regulated power distribution systems contributed to adoption of Article 700.8 for emergency system switchboards and panelboards as identified in both the 2014 and 2017 editions of the NEC. The 2017 Edition the NEC requires SPDs on disconnects serving elevators, dumbwaiters, escalators, moving walks, platform lifts or chairlifts as well.[2]

APPLICABLE CODES

The premise for deploying facility-wide surge protection is to mitigate the impact of surges that enter power distribution systems through a main service entrance or originate from switching loads within a facility. In regions with above-average thunderstorm activity, some of the limitations of this practice became evident. Electrical surges were found to be entering facilities through circuits that serve exterior loads. Circuits that serve security cameras and lighting in parking areas and along walkways are an example of exterior loads (Figure 1).

Figure 1: Security Cameras and Outdoor Lighting are Examples of Exterior Loads

[1] National Fire Protection Agency. NFPA 70 - National Electrical Code®. Quincy, Massachusetts, USA. 2016. 708.20(D). p. 70-602.
[2] Ibid. Article 620.51(E). p. 70-508.

Surges travelling from outdoor load circuits into facilities were first identified by fire alarm code groups. They responded by requiring surge suppression on all exterior load conductors. This resulted in terminating exterior fire alarm circuits onto the surge-protected input and output terminals of low voltage distribution blocks before these circuits exited a facility. This measure was first specified in the 2013 Edition of *NFPA 72 – National Fire Alarm and Signaling Code* and remains in the 2019 Edition.[3,4] As of 2019, the 2014, 2017 and 2020 NEC do not extend this practice to exterior power circuits; however, one state in the USA has modified their building code to require exterior circuit surge protection at healthcare facilities.

In Florida, health care construction is regulated by the Agency for Healthcare Administration (AHCA). This agency was influential in updating lightning protection provisions of the Florida Building Code. In the Sixth Edition, Article 449.3.15.6 states:

> *"All low voltage system main or branch circuits entering or exiting the structure shall have surge suppressors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible."*[5]

Applying surge protectors to 1 or 2-pole hardwired exterior power circuits was new to the surge protection community. Compliance required the installation of local SPDs on each exterior load circuit. In some instances, this led to clumsy or bulky installations that made it difficult to inspect SPD status indicators. For example, to surge-protect a rooftop receptacle, an installer would mount a receptacle within a double gang box. Then an SPD would be mounted on a DIN Rail placed within the empty section of the box and wired to the terminals of the receptacle. This installation practice continued until centralized surge protection solutions appeared.

To ease SPD status verification, SPD suppliers began to offer centralized tap box-like assemblies through which exterior circuits passed. One configuration integrates DIN Rail-mounted suppressors equipped with double-barrel terminals to facilitate input and output circuit tap terminations. However, both types of solutions offered limited surge protection capacity, and their connection taps could deteriorate with age to become points of fault.

[3] National Fire Protection Agency. NFPA 72® - National Fire Alarm and Signaling Code®. 2019 Edition. Quincy, Massachusetts, USA. Article 24.6.7.3.
[4] Ibid. Article 27.7.3.7.
[5] International Code Council, Inc. Florida Building Code. 2017 Edition. Country Club Hills, IL, USA. Article 449. 3.15.6. Viewed September 11, 2019. https://codes.iccsafe.org/content/FBC2017/chapter-4-special-detailed-requirements-based-on-use-and-occupancy

CONNECTOR SECURITY

The AHCA's intent in enforcing exterior circuit surge protection requirements was to protect electrical power systems from surges that couple onto exterior circuits and back-feed into electrical systems. Some SPD suppliers are now promoting local protection for 1, 2 and 3-pole circuits. Installing local surge protection in a 3-pole system can maintain security while complying with NEC and/or other applicable codes. However, 1 and 2-pole surge protection becomes increasingly complex. For example, if two or more SPD cables are connected to a terminal that is UL-listed for only a single conductor, the installation violates NEC 110.14(A), which states, *"Terminals for more than one conductor and terminals used to connect aluminum shall be so identified."*[6]

Terminal identification is derived from the terminal's listing. If the terminal listing does not provide for multiple conductors, combining an SPD's leads could compromise the integrity of the connection. If uncorrected, connections could loosen and impact load equipment operation while creating potential safety or shock hazards. As specifiers move away from this design to SPDs with claimed ability for secure tap connections, a second look at this decision is warranted.

One solution for 1, 2, and 3-pole exterior circuits is to specify SPDs equipped with double-barrel terminals for connecting input and output phase taps. SPD terminals should not be repurposed for continuous current applications without knowledge about the long-term security of the resulting tap connections.

PROTECTION CAPACITY

SPD connection security was not the only deficiency in either type of installation. Both offer limited surge protection as well. Protecting a large quantity of exterior circuits with SPDs can require considerable amounts of space, complicating wire connections. To keep costs low, both wire practices deploy singlemode line-to-neutral SPDs, primally for 1 and 2-pole applications. The problem with this approach is that exterior circuits are prone to surges originating from nearby or direct lightning strikes. Lightning-induced surges will cause an exterior circuit to experience a Ground Potential Rise, resulting in surge current flow through the load equipment ground conductor and into the facility. Circuits protected only with line-to-neutral to SPDs will not be protected when surges travel along ground conductors, a condition that could result in equipment impacts. ASCO Power Technologies recognized these deficiencies and developed a solution that provides comprehensive surge protection using proven, long-lasting tap connections.

Figure 2: Exterior Circuit Surge Protection Hub

ASCO's exterior circuit surge-protected hub meets the NEC 314.28 requirement by placing UL 1953-listed power distribution blocks in a NEMA 4X enclosure with UL-listed SPDs. This unit can protect either three or six 1 or 2-pole exterior circuits. ASCO's solution is shown in Figure 2. Its distribution block is shown in Figure 3. Figure 4 provides a one-line diagram of its circuitry.

Figure 3: Exterior Circuit Surge Protection Hub Distribution Block

Protecting exterior circuits exceeding 30A is typically accomplished locally by connecting SPD conductors at terminals listed for accommodating more than one conductor. For 1 and 2-pole circuits less than 30A, the phase, neutral and ground conductors must run through dedicated UL 1953-listed power distribution blocks to secure connections for the life of the circuit. Because the available fault current for these circuits remains below 10kA, the ASCO exterior circuit protector hub does not require upstream fault current protection.

[6] National Fire Protection Agency. NFPA 70 - National Electrical Code®. Quincy, Massachusetts, USA. 2016. Article 110.14. p. 70-45.

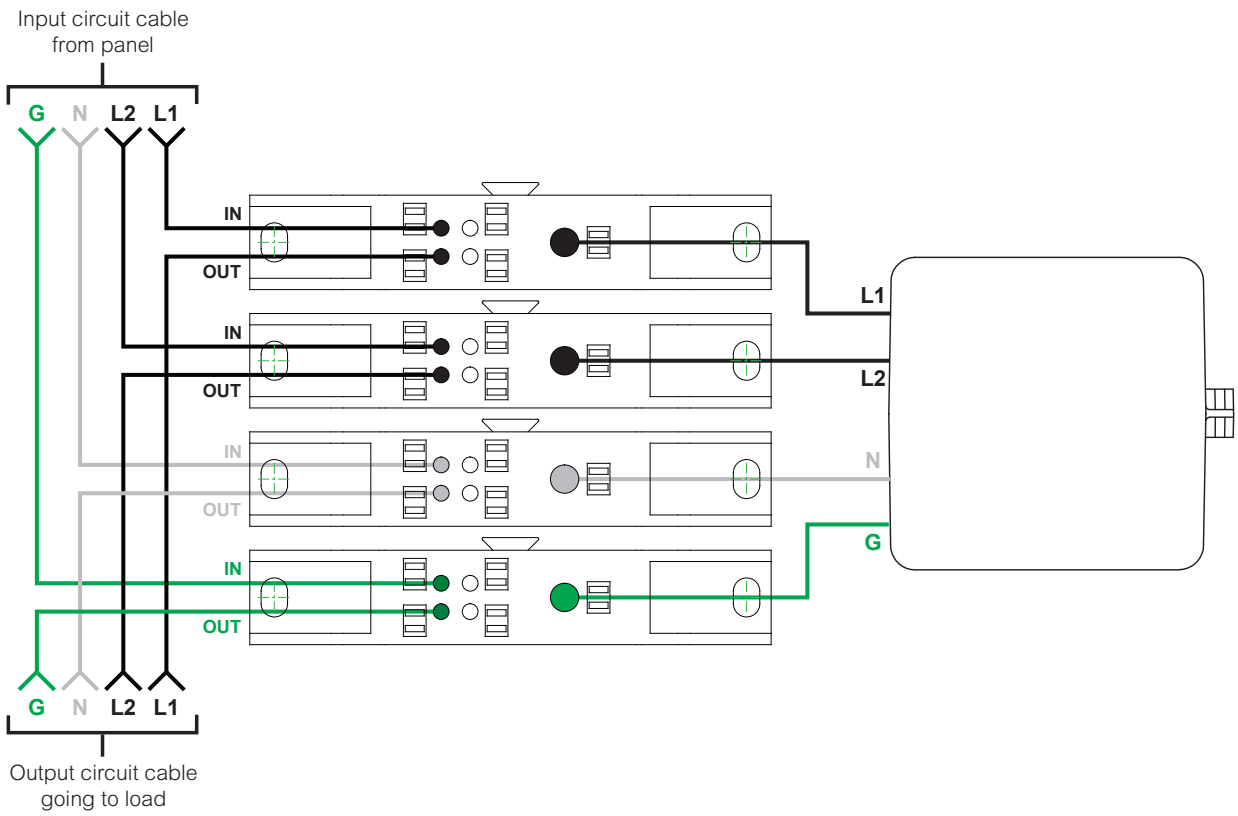

Figure 4: One-Line Diagram - Exterior Circuit Surge Protection Hub

EXTERIOR CIRCUIT SURGE PROTECTION

Because one cannot predict whether a surge will propagate on a particular conductor, exterior circuits should be equipped with line-to-ground (L-G) and line-to-neutral (L-N) protection. Thus, each three or six-circuit exterior protector hub uses UL-listed SPDs with L-G and L-N protection for 1 pole circuits or L-G and L-L protection for 2 pole circuits. In addition, this unit provides some of the industry's lowest Voltage Protection Ratings together with a 100kA Short Circuit Current Rating. ASCO's exterior circuit protection hub provides 100kA per phase surge current capacity for 2-pole circuits and 200kA for 1-pole circuits.

VISUAL DIAGNOSTICS

ASCO's exterior circuit hub protects 1 and 2-pole circuits with UL 1449 4th Edition-listed SPDs equipped with bright protection status LEDs. The exterior circuit protector features a clear door cover for quick visual inspection. When an SPD element fails, the corresponding diagnostic LED will extinguish. Protection is restored by replacing the SPD with a warranted unit.

SUMMARY

The best practice is to deploy hardwired SPDs to protect normal and emergency power systems from transient overvoltages. Code authorities are enforcing a higher degree of exterior circuit protection. Compliance is best accomplished by using exterior circuit protection that follows the intent of NEC 314.28 by deploying UL 1953-listed power distribution blocks. These provide secure surge-protected tap points for phase, neutral and ground conductors.

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