White Paper

Surge Protection: New Life Safety Requirements

ASCO®

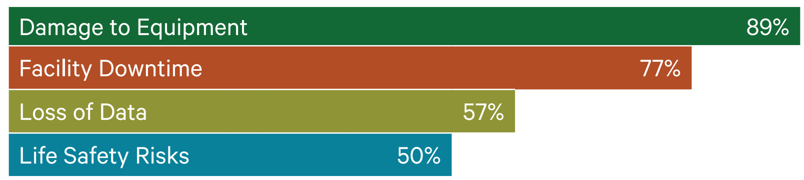
SURGE PROTECTION: NEW LIFE SAFETY REQUIREMENTS

When facility executives think of surge protective devices (SPDs), the first thing that probably comes to mind is protecting sensitive electrical equipment from surges. Most facility executives are familiar with the importance of SPDs in protecting computers, servers, and other IT equipment, as well as the plethora of wired hubs for Building Internet of Things devices.

However, the 2014 and 2017 editions of the National Electrical Code (NEC®) recognize that many disparate building systems are necessary to protect life and safety, including emergency lighting, access control, fire alarms, communications, and even elevators and escalators. Emergency electrical power to these essential systems must also be protected from surges caused by fire, weather events, accidents, utility switching, and even the on-off switching of high-powered equipment inside a facility. Despite new code requirements, many facility executives have not fully recognized potential impacts of surges to their life safety systems. A recent ASCO Surge Protection (ASCO)/Building Operating Management (BOM) survey showed that only 50 percent of respondents identified life safety risks as a potential impact of surges.

What impacts do you think a power surge from a nearby lightning strike or other sources could have on your facility?

R=415



Surge Defined

People sometimes inadvertently misuse the term "power surge," applying it to all sorts of power disturbances, not just to transient overvoltages. For example, when lights went out during the 2013 Super Bowl, announcers called it a "power surge." But it was not a surge and could not have been prevented by an SPD.

A surge or transient is an overvoltage that lasts less than a half-cycle of the normal voltage waveform, notes the National Electrical Manufacturers Association's (NEMA) Surge Protection Institute website. The surge can have positive or negative polarity, will add to or subtract from the normal voltage waveform, and generally is oscillatory and decaying over time.

Electrical equipment is designed to handle nominal variations in normal operating voltage. When electrical engineers design a facility's surge suppression system, they often use a layered or tiered protection strategy. The first line of defense often is a large high-current SPD that is connected at the utility service input. This SPD will divert the largest surges and is generally the best equipped to handle very high overvoltage situations. Medium-sized protectors are connected at electric panels to limit overvoltages within a building's branch circuits. Smaller SPDs protect critical equipment and plug-in receptacles from voltage transients, including transients generated within a facility.

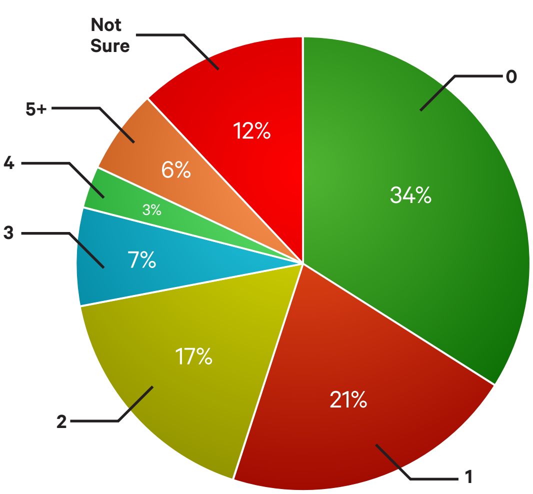
Damage, Downtime Understood as Big Risks

Facility executives know that surges from internal and external sources may damage equipment, resulting in downtime, expensive repairs, and business interruption — all important factors to consider when assessing the value of SPDs. In the ASCO/BOM survey, 89 percent of respondents identified damage to equipment as an impact of power surges.

Facility executives are rightfully concerned when it comes to the risks posed by surges. While surges are not the only power quality problem that facilities experience, surges "cause data corruption and catastrophic equipment damage as well as incremental damage that degrades equipment performance and shortens its useful lifespan," points out Ron Mojica, Senior Associate at CallisonRTKL.

"[Surges] tend to be temporary in nature and of sufficient magnitude to severely damage electronic equipment," says Erika Bolger, Senior Electrical Engineer at McGuire Engineers.

The ASCO/BOM survey shows that most facility executives have first hand experience with the damaging impact of power surges, with 52 percent reporting such equipment damage at least once in the past three years.



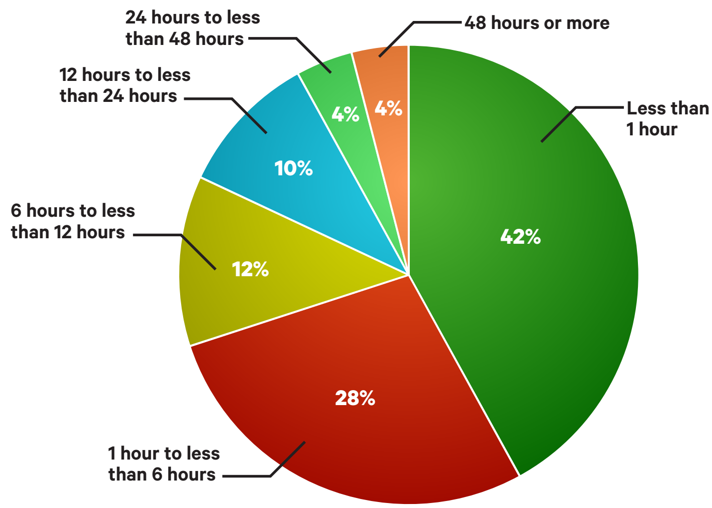
How many times has your organization experienced equipment damage from power surges in the past 3 years?

R=419

Jim Ballengee, Director of Facilities and Engineering for City of Hope Medical Center, considers the main primary risk to be "damaging equipment," which can result in downtime and inaccurate medical information. He says that even when equipment isn't destroyed, the wear and tear from surges can shorten its useful life. Steven Tobias, Director of Buildings/Grounds and Safety at the Tippecanoe School Corporation, has seen damage to equipment and feeder conductors.

What Was the Total Amount of Downtime that Resulted from Power Surges?

R=367



Facility downtime is another major concern — 77 percent of the respondents to the ASCO/BOM survey mentioned that risk. Asked about the amount of downtime they attributed to power surges, 30 percent reported downtime of six hours or more, including 4 percent who put downtime at 48 hours or more.

System downtime presents both primary and secondary concerns. Phil Koth, Chief Engineer at Transwestern, says that he is concerned with "equipment downtime, primarily." "Sometimes we have to go around the building resetting equipment from surges," says Chuck Klinger, Lead Engineer at Foulger-Pratt Management.

Digital Devices at Risk

Thanks to the Internet of Things penetration into facilities today, microprocessors are everywhere. Static electricity at levels well below human perception can cause sensitive electronic equipment to malfunction, leading to data corruption and even equipment lock-ups. Nicholas Stolatis, Vice President at EPN Real Estate Services, is concerned with surges "frying electronics that are connected. A secondary risk is the electronic device is knocked off-line and not doing its job," he says.

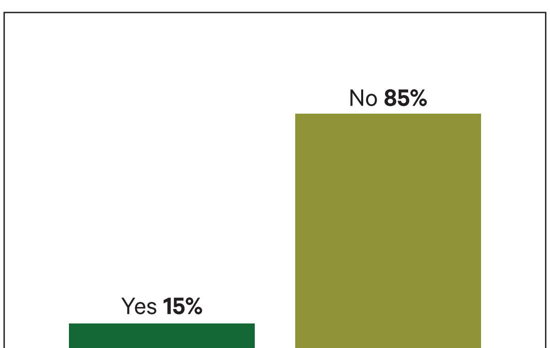
Bill Cronin, Facility Superintendent of Missouri City, Texas, explains that protecting important data was one reason SPDs were installed when the city's large data center was updated about eight years ago. "We also have SPDs at outlying facilities to protect radio and data operations," Cronin says.

"With the influx of digital devices, which rely heavily on sophisticated modern electronic components, SPDs are more important than ever in the electrical distribution system," says Mojica. Modern digital devices often are more delicate than older equipment, which makes them more sensitive to power surges.

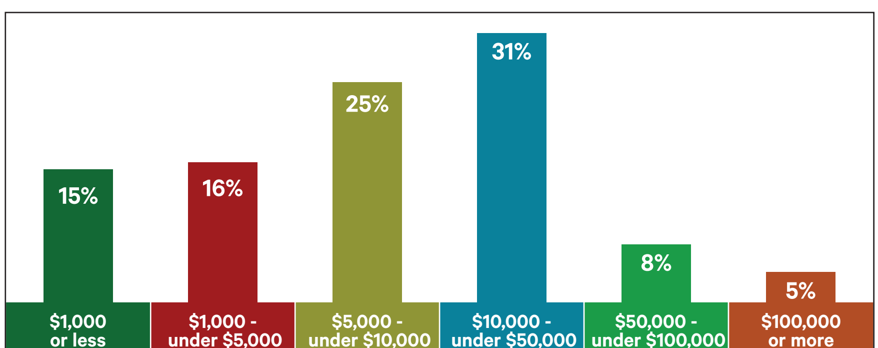
Preventing Costly Damage

Surge protection devices prevent costly equipment from being damaged by surges. Not only do SPDs protect the initial investment in the equipment, but they also prevent the loss of revenue that would have occurred in the event of equipment outage or downtime of a facility, explains Bolger. That's why sensitive medical equipment such as CT scanners or MRIs in hospitals are protected by SPDs, as are servers for banks, trading companies, and data centers.

Some facility executives have attempted to quantify the costs of power surges to their organizations. In the ASCO/BOM survey, 56 percent put the cost of repairing or replacing damaged equipment at between $5,000 and $50,000.



Have you ever attempted to quantify the cost of power surges on your organization? *R=419*



What was the total cost to repair or replace the equipment damaged because of voltage surges? *R=61*

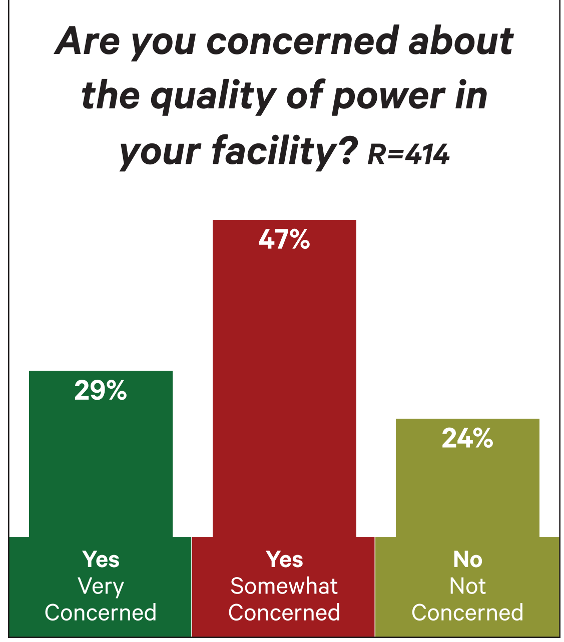
Many school buildings in the Tippecanoe district have installed SPDs on distribution panels. Tobias reports that schools have experienced "damage to motor control circuits and electrical distribution equipment" because of voltage transients. He recalls that one surge "caused three days of downtime" for affected systems.

To avoid medical equipment failures, Ballengee says his hospital has installed SPDs "throughout the operating rooms and on all IV poles."

Life safety equipment also needs SPD protection from voltage transients. A fire increases the possibility of power loss, as does a lightning storm. If life safety equipment is unprotected, voltage transients could damage a fire alarm system protecting the building and its occupants. Community safety and protection can also be compromised should a loss of communication systems prevent proper dispatch of fire and police resources.

Power Quality is a General Concern

Most facility executives are concerned about power quality issues in their buildings. In the ASCO/BOM survey, 76 percent said that they are very concerned or somewhat concerned about the quality of power in their facilities.



Electrical Code Safety Requirements

Although facility executives are well aware of the risks that surges pose to equipment, fewer seem aware of the importance of SPDs for life safety systems, the ASCO/BOM survey shows. As noted earlier, only 50 percent of respondents recognized the life safety risks of power surges. But those risks are so significant that they have led to code changes requiring expanded SPD use. The National Electrical Code (NEC) sets minimum life safety requirements for electrical systems in facilities. Article 700.8, which requires SPDs on all emergency power system switchboards and panel boards, was added to NEC 2014, says Mark Earley, Chief Electrical Engineer for the National Fire Protection Association (NFPA®).

In an emergency such as a fire, a lightning strike, or even a power outage, electrical surges will occur. Nevertheless, emergency exit lighting must illuminate exits. Fire pumps must be ready to supply automatic sprinkler systems. Elevators must return to a building's main floor, where they can be operated by fire personnel. Fire doors must close, and alarms and emergency communications must all operate. When emergency equipment is compromised, the lives of building occupants are endangered. Protecting emergency equipment from damage or even destruction by transients during critical events is the role of surge protective devices.

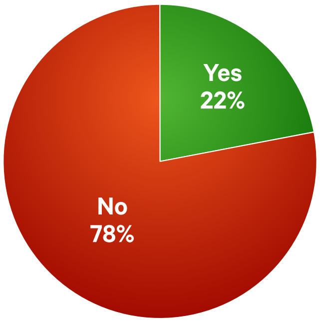
"Emergency power systems are legally required to supply power automatically to designated emergency loads for illumination, power, or both when normal power is interrupted," explains Earley. "Emergency systems receive that classification by municipal, state, federal, or other codes, or by a governmental agency with jurisdiction." Such systems include emergency lighting, communication, fire control systems, and essential medical equipment.

While the NEC is a national code, each state can choose whether to implement it or use other requirements for life safety. According to the Electrical Code Coalition, the status of NEC adoption on January 1, 2017, was as follows:

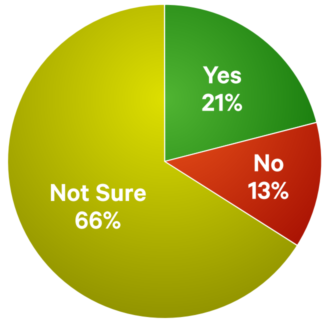
- Massachusetts had adopted NEC 2017
- Thirty-five states had adopted the 2014 code
- Five states observed NEC 2011
- Six states still used NEC 2008
- Arizona, Missouri and Mississippi relied on local jurisdictions to adopt the NEC

Many states are in the process of adopting newer versions of the NEC. According to the Electrical Code Coalition, as of January 1, 2017, 23 states were updating their statutes or administrative rules to reference the 2017 edition, four states were in the process of adopting NEC 2014, and one state was in the process of adopting NEC 2011.

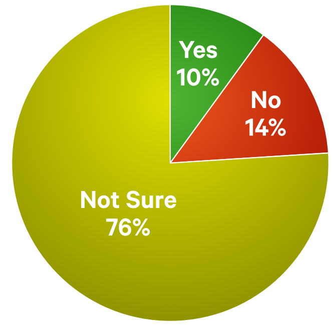
What's more, NEC's 2017 edition, issued in September of 2016, added requirements for SPDs on disconnects supplying emergency systems in Article 620.51(E). This section addresses SPD requirements for elevators, escalators, moving walks, platform lifts, and stairway chair lifts. "Where any of the disconnecting means has been designated as supplying an emergency system load, surge protection shall be provided," says Earley. Although the NEC has been widely adopted, many facility executives are unaware of its requirements, according to the ASCO/BOM survey. More than three quarters of the respondents were unaware of the recent NEC surge protection requirements. Two thirds were unsure if any of their facilities are located in states that have adopted NEC 2014. And more than three quarters didn't know whether NEC 2017 is poised to be adopted in any of those states within the next six months. Facility executives interested in the status of NEC adoption in their locations can contact their NFPA regional electrical code specialist.



Are you aware of the recent 2014 and 2017 NEC requirement for surge protection on emergency circuits? *R=366*



Have any states in which you have facilities adopted the 2014 NEC? *R=370*



Is the 2017 NEC standard poised to be adopted within the next six months in any area where you have a facility? *R=370*

There are special requirements for SPDs with patient care equipment. The National Electrical Code for Health Care Facilities (NEC Article 517) requires SPDs to protect medical equipment used in general or critical patient care areas. SPDs in these areas also must comply with the requirements of UL-60601 - Medical Electrical Equipment, Part 1: General Requirements for Safety and IEC 60601-1-1 - Medical Electrical Equipment - Part 1: General Requirements for Basic Safety and Essential Performance.

Ballengee is well aware that SPDs must meet specific hospital code requirements. "We have an audit every year to pull off any illegal surge protectors," he says.

Emergency Circuits, Luminaires, Data Systems

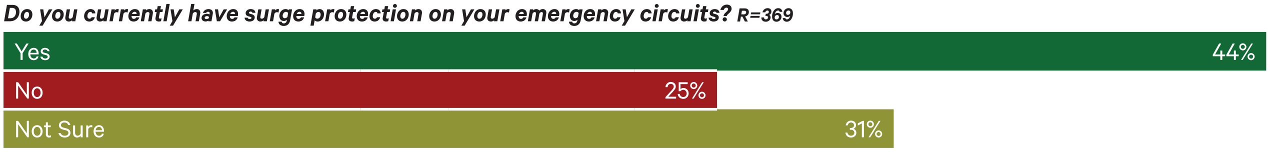
Emergency systems under NEC 700.8 include branch circuit emergency lighting transfer switches, when they are connected on the load side of a branch circuit overcurrent protective device. Their purpose is to transfer emergency lighting loads from the normal electrical supply to an emergency supply.

Also included are emergency luminaires with a control input for an integral dimming or switching function that turns the lighting to full illumination when normal power is lost. Automatic load control relays are also used to reset dimmed or turned-off emergency lighting equipment to full illumination when normal power is lost, and to return the emergency lighting equipment to its normal status when normal power is restored.
NEC Article 645.18 broadens the application of SPDs by specifying protection of critical data system equipment. The NEC states that Article 645.18 applies to "information technology equipment systems that require continuous operation for reasons of public safety, emergency management, national security or business continuity."

In addition to common office equipment, other sensitive electronic equipment is covered by the NEC, according to Bolger. She points out that expensive hospital radiology equipment and life safety equipment, such as fire alarm systems, security systems, and fire pump controllers, require the surge protection specified for controllers in Article 695.15. Article 708.20 requires surge protection for public service notification equipment "at all levels of distribution."

Many facility executives recognize the role of surge protection in the emergency management infrastructure. For example, Stolatis has installed SPDs to protect equipment used in organization's emergency management system. He also uses SPDs to protect his facilities' access control systems. But, according to the ASCO/BOM survey, more than half of respondents either do not have surge protection on emergency circuits or aren't sure whether SPDs are present.

Do you currently have surge protection on your emergency circuits? *R=369*



Causes of Surges

NEMA estimates that between 60 and 80 percent of power surges originate within a facility. Common sources for surges are devices that switch power on and off. That could occur in a thermostat turning a heating or cooling element on or off, or a switch-mode power supply on the device itself.

Surges can be caused from both external and internal sources. "Common external sources include utility switching and lighting strikes," says Bolger. "Common internal sources include faults, loose connections, power factor correction equipment (switching of capacitor banks), static electricity, operation of contactors, switching, etc." Surges caused by switching power on and off may not immediately disrupt or damage equipment as quickly as lightning can. But their occurrence as part of everyday operations can take its toll over time.

When starting, high-powered electrical equipment uses large amounts of electrical power, explains Mojica. When they switch on, "they create sudden, brief demand for power that impacts the steady flow of voltage in the electrical system. These sudden surges can be severe enough to damage components immediately or gradually, since they occur regularly in most buildings' electrical systems."

Internal switching and oscillatory surges are caused by contactor, relay, and breaker operations; load factor correction by switching capacitor banks and loads; discharge inductive devices such as motors and transformers; starting and stopping loads; fault or arc initiation; ground fault arcing; fault clearing or interruption; power system recovery after an outage; and loose connections. Another source for internal facility surges is inductive coupling from building systems such as elevators, HVAC systems with variable drives, fluorescent light bulbs, copy machines, and computers.

In addition to internal power surges, facility executives must protect their facilities from transients that originate outside of buildings. Surges can result from direct contact between the facility's electrical system and an energy source. More commonly, indirect or nearby lightning may induce surges into conductors in power or communication systems, as noted on the NEMA website.

"Overvoltages are the most severe types of surges caused by weather events such as direct lighting strikes," explains Bolger. "In addition to high level overvoltages, indirect lightning strikes can also induce lower level overvoltages onto electrical cables, in both power and communication systems."

"Overvoltages are the most severe types of surges caused by weather events such as direct lighting strikes..."

Outdoor cables and cameras are another source of potential surge problems. "Low voltage cabling can also transmit power surges into a building's electrical system," explains Bolger. "In addition to direct lightning strikes, exterior cameras, antenna towers, etc., which have buried low voltage components, can carry an induced surge from an exterior lightning strike inside a structure. It is important to protect all incoming electrical components, not just the power side, with surge protection."

Surges also may come from utility grid and capacitor bank switching. For example, a fallen tree limb or a small animal can cause a fault on a line. Surges occur when the power is disconnected and then reconnected to the facility's load.

Even when electricity is provided without interruption, transients can result from normal operation of the electrical grid. Rather than make constant adjustments to generation equipment to respond to customer electrical needs, utilities switch power from one element of the grid to another to keep generation equipment running at optimal constant speeds. But switching from one grid element to another also can cause power disturbances, including transients, spikes, overvoltage, and undervoltage conditions. Without adequate surge protection, a facility's electrical system could transmit these transients, causing damage or operational difficulties.

Of course, unforeseen events, such as vehicle crashes into power poles, also can result in two utility power lines contacting each other causing a surge, notes Mojica.

ANSI®/UL® Requirements for SPDs

Many commercial SPDs are hardwired to a facility's electrical system. An SPD's primary function is to eliminate short duration voltage spikes by diverting excess voltage to ground.

The American National Standards Institute/ Underwriters Laboratories (ANSI/UL) Standard for Surge Protective Devices specifies a host of safety tests for SPDs. These include evaluations of Maximum Continuous Operating Voltage (MCOV), Short Circuit Current Rating (SCCR), and other tests. In addition, ANSI/UL 1449 specifies performance tests for Voltage Protection Rating (VPR) and Nominal Discharge Current Rating (In or I-nominal). VPRs result from UL's evaluation of peak let-through voltage, plus the I-nominal duty-cycle test based on passing 15 consecutive impulses at an SPD's specified current rating. A major revision to ANSI/UL 1449 took effect in 2009 (aka, Third Edition), while a minor Fourth Edition update in 2014 addressed direct current (DC) and photovoltaic DC SPDs.

According to NEMA, facility executives need to understand the difference between a "listed" SPD and a "recognized component." A listed SPD meets all requirements of ANSI/UL 1449. A recognized component SPD may not have been subjected to all ANSI/UL 1449 testing, and is assigned "conditions of acceptability" relating to its use. Those conditions must be observed to avoid creating a hazardous condition.

Types of SPDs

SPDs are widely used today, but the places where they are used vary among facilities. By far, the most common use is to protect servers. Other common uses include service entrance switchboard/switchgear, distribution panels, and surveillance cameras.

Do you currently have Surge Protective Devices (SPDs) protecting the following?

Location	Yes, on half or more	Yes, on less than half	No	N/A	Res.
Service Entrance Switchboard/Switchgear	43%	14%	31%	12%	357
Distribution Panels	35%	21%	37%	7%	355
Branch/Lighting Panels	28%	15%	50%	7%	344
Rooftop Air Conditioning Units	28%	15%	47%	10%	349
Servers	79%	10%	6%	5%	367
External Lighting	18%	14%	62%	6%	344
Interior LED Lighting	19%	12%	59%	10%	343
Surveillance Cameras	40%	15%	35%	10%	352
Motors	24%	25%	40%	11%	352
Industrial Control Panels	23%	15%	37%	25%	351

Based on their installation locations, five SPD types are covered by codes and standards. "Surge-protective devices that facilities engineers and consulting engineers are primarily concerned with consist mainly of three types ...," explains Bolger.

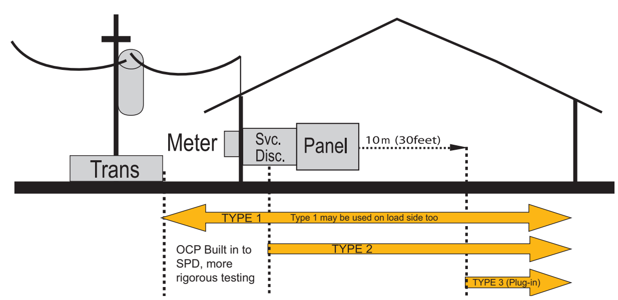
Type 1 SPDs are permanently connected between the secondary side of the service transformer and the line side of the building service overcurrent protective device or main breaker, explains Mojica.

"Type 1 protects the electrical system from externally generated surge events," Bolger says.

Type 2 SPDs also are permanently connected and are positioned on the load side of the main service overcurrent protection device, according to Mojica. These SPDs protect the electrical distribution circuits within a structure from both external and internal surges.

"Type 2 can also include SPDs at the branch panel level," says Bolger.

Type 3 SPDs are portable devices that protect equipment, such as power strips.



SPD Types 1, 2, & 3

Based on SPD Location within electrical distribution system.

(also coincides with ANSI/IEEE C62.41.2-2002 Categories C, B & A.

According to the Fourth Edition of UL 1449, approved by ANSI on March 17, 2016, Type 3 SPDs are point-of-use units. These SPDs may be cord-connected, direct plug-in, receptacle type, or SPDs installed at the equipment being protected.

“Type 3 is intended to be the surge protection closest to the equipment it is protecting,” says Bolger.

Because SPDs are typed by their installation location within the facility’s electrical system, Mojica stresses the importance of selecting the correct type wherever these devices are used. “Specific applications must be customized to fit the unique needs of diverse operating environments and circumstances,” he says.

Beyond Type 1, Type 2, and Type 3, there are other types of SPDs, observes Bolger. “However, they are assembly and component protection-based and are addressed by equipment manufacturers.”

Lightning Protection

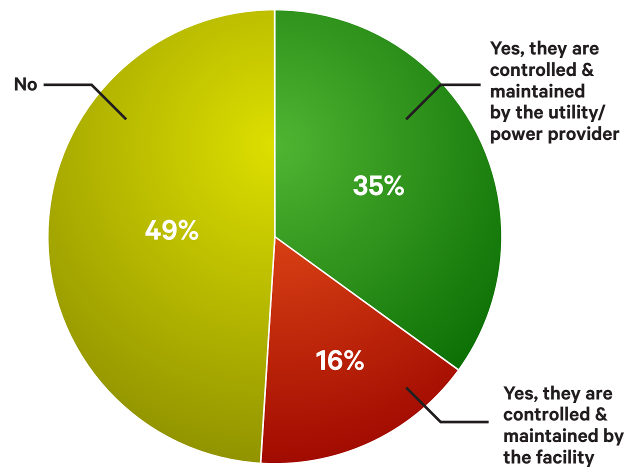
According to the National Oceanic and Atmospheric Administration’s National Severe Storms Laboratory (NSSL), about 20 million cloud-to-ground lightning strikes occur annually in the United States. Of these, approximately half involve more than one ground strike point.

“A lightning protection system provides a low resistance path for lightning to travel directly to ground in lieu of striking and entering a building or similar structure,” explains Bolger. Along with SPDs, the system prevents induced voltage from entering into the building’s electrical and communication systems.

SPDs in lightning protection systems must comply with UL 96A - Standard for Installation Requirements for Lightning Protection Systems and/or NFPA 780: Standard for the Installation of Lightning Protection Systems.

Among respondents to the ASCO/BOM survey, 51 percent reported that their facilities have lightning arrestors.

Mark DeVore, Chief of Engineering, in Delaware’s Division of Facilities Management, says he has “surge suppressive panels and lightning arresters on equipment in certain cases.”



Does your facility have Lightning Arrestors? *R=376*

Things to Consider

When considering installing an SPD, facility executives need to begin by assessing risk. Bolger suggests taking a critical look at the facility’s location and whether it is prone to frequent power disturbances from lightning or an aging power distribution infrastructure. Engineers should also assess whether the distribution infrastructure is under constant construction, which can cause frequent utility switching.

Engineers should also evaluate the cost of equipment and the time that would be required to repair it. If the cost or the repair timeframe is great, the equipment may warrant protection using a SPD. If even short periods of downtime would result in adverse impacts to an organization’s bottom line, the equipment probably should be protected with SPDs. Of course, if the equipment’s failure would affect public safety, such as at hospitals and police stations, SPDs are a wise option and could be required by code.

Bolger also recommends a thorough examination of the equipment’s limitations. “Can I install my SPD close to my main OCPD [Overcurrent Protection Device] in my distribution or does it need to be remote?” she asks.

Finally, SPDs themselves need to be evaluated. “Do I need to easily remove and replace my SPD without a lengthy equipment shutdown?” Bolger asks. “How often am I willing to replace my SPD? How do I protect my SPD? What is my available fault current where I am installing this equipment?”

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