

EXECUTIVE SUMMARY

Purpose

The Fire Protection Research Foundation sponsored this project to address electrical surge protection for residential dwelling units. The goal of the project is to develop a data collection plan to assess loss related to electrical surges in homes, and address the potential impact electrical surge protection devices (SPDs) would have in mitigating these losses. The deliverables from this project represent a Phase I study (this report) in support of a potential second phase (not included in the scope of this effort).

Report Content

This report provides information regarding:

- Surge phenomena and their sources.
- Surge protection methods.
- Surge protection strategies recommended by various sources.
- Industry standards and their recommendations.
- Available data associated with electrical surges and their impact.
- Recommended data collection in support of code-making efforts.

Surge Protection

Sources of Surges

A surge is a transient wave of voltage or current. The duration is not tightly specified but is usually less than a few milliseconds. The following are typical sources of surges:

- Lightning.
- Utility switching, including capacitor switching.
- Equipment switching and switching inductive loads within a facility.
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Protection against surges is referred to as *surge protection*, and includes protection against both surge voltages and currents. The devices used to protect against surges are referred to as *surge protective devices*, or SPDs. A surge of duration longer than a few milliseconds is referred to as a swell or temporary overvoltage (TOV) and requires a different type of protection design; SPDs can fail if exposed to long duration TOVs.

Surge Effects

Surges can cause equipment damage. Large surges damage equipment and other components in the electrical distribution system. Smaller surges can cumulatively damage equipment and can cause nuisance equipment tripping. Both surge voltage and current can be damaging. In the case of lightning strokes, the surge can be carried into a facility via all of the connected conductive paths.

There is a limit on how high of a voltage can be transmitted into a facility or residence. Above a certain level, a high voltage will result in flashover in the insulation system of electrical equipment and conductors. A flashover can cause insulation damage, electric shock, and fire. NEMA surveys of facility managers confirmed catastrophic failure or damage of electrical or electronic equipment due to a lightning event or voltage surge and premature failure of electrical or electronic equipment, including failure of life safety equipment.

The Insurance Information Institute report for 2013 identified 114,740 insurer-paid lightning claims for residential locations. The average lightning paid-claim amount was \$5,869.

Residential Surge Protection

Residential surge protection has long been viewed as an important safety consideration and guidance has been issued by IEEE and NIST to help homeowners protect their house and its contents. This protection has often been described as being similar to an insurance policy, partly because there is not an NFPA code requirement for SPD installation in residences. Today's residences often contain electronic equipment throughout, including appliances, computers, security systems, life safety equipment, automation systems for internet-enabled applications, and home entertainment systems.

Industry Standards

SPDs are routinely used in facilities that are potentially exposed to voltage or current surges from nearby lightning, utility switching, or other sources; and there are many manufacturers of SPDs and these manufacturers often offer guidance regarding SPD installation ratings and recommended applications. However, industry codes and standards provide limited guidance regarding selection, rating, and application.

One limitation with surge protection design is that there is no industry standard that describes what is an acceptable level of surge protection for standard facilities or residential locations. Although industry codes and standards are available that establish standardized surge criteria and assist with the application of specific surge protector types, these standards do not provide adequate design guidance that ensures a facility is properly protected against surges. There is no existing industry guidance for surge protection of residential facilities. Refer to Section 3 for an overview of the available industry standards.

Data Acquisition Plan

Surge Data and Its Effects

Lightning strokes, either direct, nearby, or some distance away can cause voltage and current surges into a facility. Information is available regarding lightning strokes and their intensity. But, less information is available regarding the extent to which these surges are transmitted into commercial facilities, industrial facilities, or residences. Section 4.2 describes the difficulty associated with obtaining this data.

Available Data

Vaisala owns and operates the National Lightning Detection Network (NLDN) that provides accurate lightning data information across the USA. And, Vaisala can provide lightning location reports that provide individual cloud-to-ground lightning strikes and the intensity of strike at a specific location on the date of loss. This capability represents the largest and most complete source of lightning surge location and intensity.

Data for lightning surges that extend to the inside of facilities is not readily available. Published papers and IEEE C62.41.1 provide information regarding the expected surge levels within a facility or residence, but extensive data is not available.

Switching-related surge data, either internally or externally generated, is sparse. The added difficulty with this data is that these surges often do not cause immediate failure of electrical and electronic equipment; the damage occurs as a cumulative effect. The largest documented source of surge effects is contained within the insurance claim documents for damage caused by surges. The Insurance Information Institute in collaboration with State Farm® produces annual reports of insurance claims associated with lightning-induced damage.

Data Acquisition Plan

There are challenges in obtaining usable data applicable to residential applications, such as:

- Confirming that equipment failures were a direct result of a surge event.
- Establishing any median and upper bounds to actual surge levels since this is not recorded inside facilities.
- Defining the protection improvement realized by applying SPDs.

Given the scarcity of real data relating to surges and the effects of surges, the approach described below is recommended. The purpose of the recommended data acquisition approach is to produce real data regarding damage and injuries caused by surges. This information is intended to assist the NFPA 70 codemaking committees with additional technical data to support a decision to require or not require SPDs for the variety of electrical applications proposed in past NFPA 70 update cycles (refer to Section 1.2).

The starting point for this project is to acquire the nationwide lightning stroke data for the continental USA for 2013 (or 2014 if the project starts in 2015). This information can tie back to insurance claim data and possibly provide surge current values for the locations of interest. The Insurance Information Institute is proposed to manage the insurance industry claim data. Their involvement assures that the insurance industry claim reports can remain confidential while allowing access to additional data that might be contained in the claim reports. The Insurance Information Institute already publishes annual summaries of the number of lightning-related insurance claims and the claim amount. Additional information of interest that might be available in the claim data includes:

- Date and location of surge event (to establish geographical correlations).
- Electronic equipment and appliances damaged.
- Life safety equipment damaged – smoke detectors, CO or CO₂ detectors, or other equipment.
- Fires caused by surge effects.
- Personal injuries associated with the surge event.
- Presence of or lack of installed SPDs.

Life safety equipment damage, fires caused by surge events, and personal injuries are of particular interest for code-making efforts. Although the annual Insurance Information Institute survey has historically focused on residential claims, the survey for this project should include commercial and industrial claims also. NEMA assistance and direction with this effort will be helpful. NEMA Low Voltage Surge Protective Devices Section (5-VS) participation is recommended for the following:

- Assisting with project scope, including commercial and industrial users.
- Reviewing the project checklist for the type of information to be obtained from the insurance industry.
- Reviewing failure data report summaries.
- Considering recommended SPD design principles, including the specification of surge protection in low-lightning flash density areas versus high-lightning flash density areas. Should NFPA elect to require SPDs in dwelling units or other applications, then minimum surge protection current limits should also be addressed, similar to the method provided in NFPA 780. As SPD surge current rating increases (and the degree of protection), the SPD cost also increases.