



# Significance of Internal Surges

## Introduction

In our modern, complex electrical world, much attention is focused on the phenomena of electrical surges and spikes, also known as transients. This white paper will concentrate on those surges which are produced from within or “Internal” to the facility. Electrical engineering experts agree that from 60% to 80% of all damaging surges originate from within the facility. These surges range from a few hundred volts to many thousands of volts. A sound surge protection system will protect against external as well as internal surges by utilizing SPD protection at the Service Entrance in conjunction with cascaded protection down to Distribution / Branch Panels and through to Point of Use devices.

## What are Surges?

A Surge or transient overvoltage according to IEEE is defined as, “a short duration, highly damped, oscillatory or nonoscillatory overvoltage, having a duration of few milliseconds or less” classified in categories of lightning, switching, and very fast front, short duration events. Internal surges are caused by events such as: motors cycling on and off, load dynamic changes on large and small production machines, motor and control faults, panel lighting load switching, electronic lighting ballasts, switch mode power supplies, SCRs, HVAC systems, energy management systems, capacitor bank switching, variable frequency drives, portable electric tools, etc.

## Internal Surges (A closer look)

Momentary surges can originate from a number of events. The magnitude of the surge is dependent on many variables such as: energy associated with the system, impedance of the system, the bonding of the conductors, the number of restrikes, inductor and capacitor size, etc. The following is a breakdown of Internal Surges.

### **NORMAL OPERATIONS: Surges range from a few volts to over 6 times the “system peak voltage.”(IEEE 62.41.1-2002)**

- **Minor Switching** of loads near the point of interest such as random turn-off of an appliance in a household or turn-off of other loads in the individual system.
  - **Voltage notching** that occurs each cycle during the commutation in electronic power converters. The voltage notch is caused by a momentary phase-to-phase short circuit with a rapid change in voltage lasting in the 100 micro second range.
  - **Multiple reignitions or restrikes** during a switching operation. Air contactors or mercury switches can produce, through escalation, surge voltages of complex waveforms and of amplitudes several times greater than the normal system voltage.
  - **Major power system switching** of components such as capacitor banks, reactors, transformers, lines or cables can produce surges as high as four times the normal system voltage and involve high energy levels.
  - **Combination of Multiple reignitions and Major power system switching** has resulted in surges over 6.4 times the system peak voltage. (ex. 600 VAC system x 1.414 x 6.4 = >5400 volts)
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**ABNORMAL OPERATIONS: Surges range from 2 to 3 times the “Peak” line-to-ground voltage on average but much higher levels may occur depending on system variables.**

- **Arcing faults** result as insulation systems deteriorate and typically originate as a ground fault. The surges associated are on the order of 2 to 3 times the peak line-to-ground voltage of the system. Under resonant conditions, these surge magnitudes can be much greater.
- **Fault clearing** by current-limiting fuses or fast-acting breakers that are capable of current chopping leave inductive energy trapped in the circuit upstream. If no low-impedance path is offered for the current flowing in the inductance at the time of current interruption, high voltages are generated. Surges are dependant on the energy of the overall system and may be of catastrophic nature.
- **Power system recovery** following a fault sometimes occurs with phase-by-phase reclosing. Operation of a single fuse in a three-phase system also produces single-phasing in the remaining circuits. Surges of twice the normal voltage are common.

### **Frequency of Surges**

The frequency of the surges, (number of surges in a given time), is very dependent on the system set up, the number of machines / motors, the quality of incoming power, the amount of switching that occurs, etc. The frequency of the surges may range from a relative few to several thousand a day. The frequency of surges is a key indicator of the overall degradation potential to electrical / electronic equipment.

### **Electrical Damage Due to Surges**

Most surge damage does not occur in one single, smoking, arcing instant. Instead, the constant bombardments of these short-duration surges / impulses on electronic components cause them to wear prematurely and fail. Integrated circuits, transistors, diodes, solid-state voltage regulators, capacitors, miniature relays, miniature switches, and miniature transformers, etc. are quite susceptible to damage and operational upset caused by surges.

#### **Microprocessors**

As we dig into complicated electronics, Microprocessors are a big part of almost every electrical system. Microprocessors are getting smaller, faster and more sensitive, and need less power. Integrated circuits (chips) are the most delicate of all electronic components and the most sensitive to surges. When a server or a programmable logic controller fails, in most cases, only one component on the board stopped functioning. Look closely at a chip, and you will see a multilayered device with conductors, or pathways, as small as five microns in width by one micron in thickness. Normal current flow through a pathway is in the five-milliamp range. Because of these small ranges, surges of only a few amps can destroy the circuitry. Surges can open pathways or break through the thin dielectric material to ruin adjacent layers and leave devices inoperable.

#### **Motors**

Even though motors can be the source of many surges, they are not immune from their effects. Surges can cause motor insulation failure which may lead to a complete system failure. (Crawford, D. E., “A Mechanism of Motor Failures,” *General Electric Company*)

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## **Benefits of Surge Protective Devices (SPDs)**

Power related problems cost U.S. companies more than \$80 billion a year. Effects on business include: high maintenance costs, high production costs, production delays, lost sales, late deliveries, an idle workforce, and increased spoilage and scrap.(Source: Lawrence Berkeley National Laboratory) A sound SPD system is designed to divert harmful surges, generated externally and internally, and protect electrical equipment thereby reducing costs and improving business profitability!

## **Summary**

When asked, "Where do surges come from?" Most people would say that they are caused from external sources such as lightning or utility company capacitor bank or power bank switching when in fact, the majority of surges are caused from within a facility. These surges can originate from a number of events with the corresponding magnitude dependant on many variables. The magnitude of internal surges range from a few hundred to many thousands of volts. These voltages along with the frequency in which they may occur, will cause damage to electrical equipment. No longer is it acceptable to provide SPD protection only at the Service Entrance or in areas prone to lightning. A sound surge protection system will protect against external as well as internal surges by utilizing SPD protection at the Service Entrance along with cascading the protection down to Distribution / Branch Panels and Point of Use devices.