

# What You Need to Know about Surge Protection

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# Course Objectives

Upon completion of this course you will be able to:

- Define the basic principles of a transient surge
- Identify the causes of surge events
- Describe how transient surge affects you today
- Explain how an SPD works
- Describe how to use surge protection correctly
- Identify important surge protection codes and standards and their requirements

# Surge Protection Overview

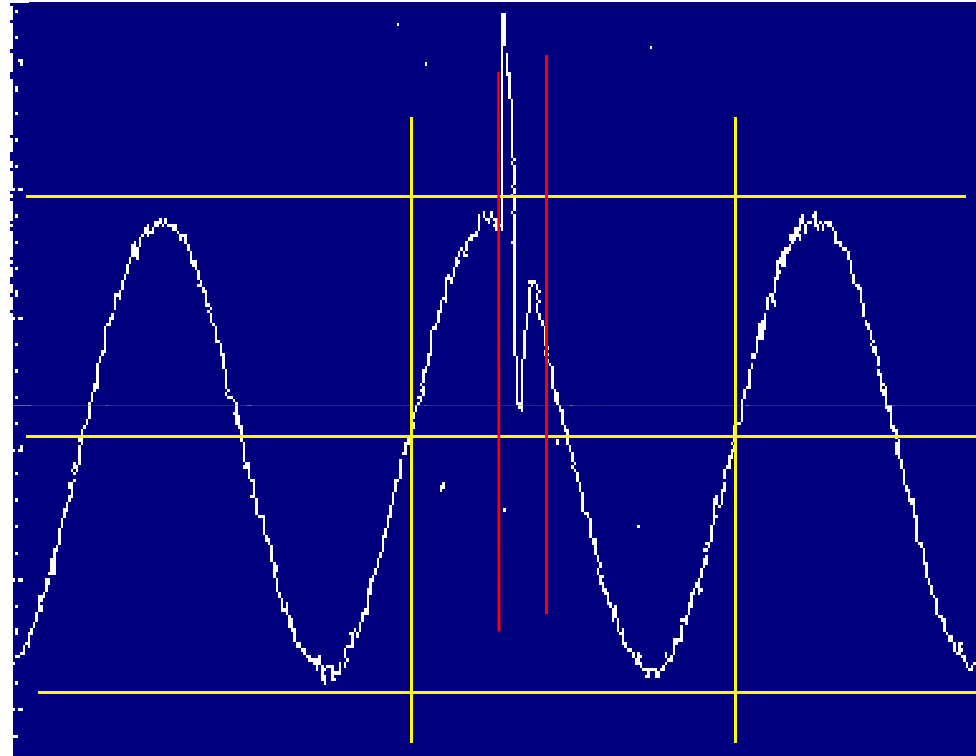
# What is the purpose of a Surge Arresters and Surge Protective Devices (SPDs) ?

- > To protect your distribution equipment
- > To protect your critical and sensitive equipment

This is done by diverting and limiting damaging *transient* voltages and currents.

# What is a Transient Surge?

- > A surge or transient is a voltage spike that only lasts a few millionths of a second (the “blink of an eye” is thousands of times longer than the typical surge).
- > A surge can contain thousands of volts and thousands of amps.

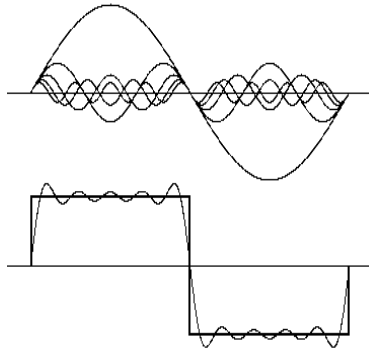


1 cycle at 60 Hz = 16.6 milliseconds

Transient event (between red lines) approximately 500 microseconds

# What is NOT a Transient Surge?

*Harmonics*



*Powerfactor Imbalance*

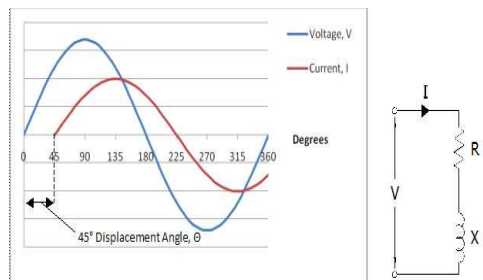
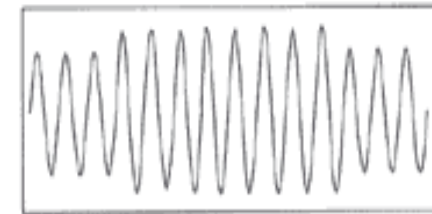
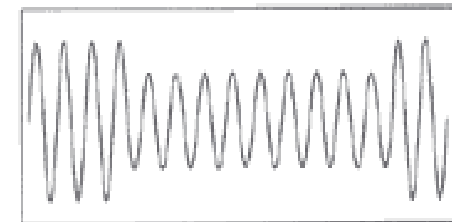


Figure 1 Displacement Angle



*Sustained Overvoltage*



*Undervoltage*

Surge Protective Devices are designed to protect against

one thing **Transient Surge**



# Where do Transient Surges Come From?

Elevators

Lightning

Pump  
Motors

Electrical Accidents

Air conditioners

**80% inside**

**20% outside**

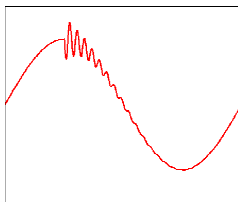
Air compressors

Blower Motors

Switching Cap Banks

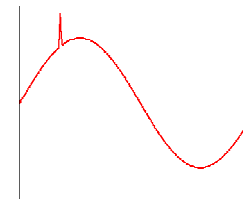
Office Copiers

Utility Grid Switching



Oscillatory transients  
Typical of Internal events  
**(Smaller, lower energy)**

Impulse transients  
Typical of External events  
**(Larger, higher energy)**

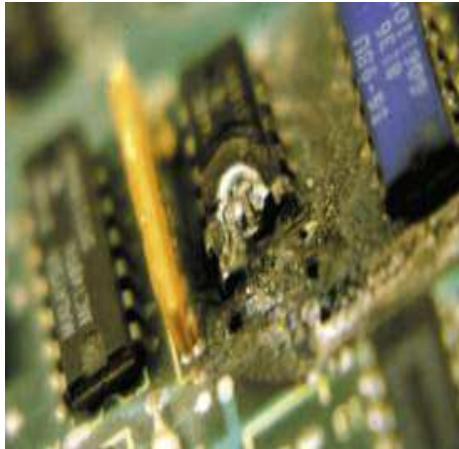


# The Effects of Transients on Business

## \$80B

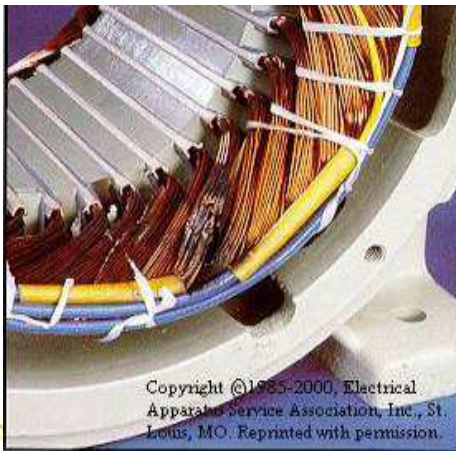
*“Power related problems cost companies over \$80 billion a year”*

(Source: Lawrence Berkeley National Laboratory)



*“Industry experts estimate that power surges cost businesses \$26 billion annually in lost time and equipment repairs and replacements”*

(Source: Insurance Institute for Business & Home Safety)



- High Facility Maintenance Costs
- Equipment Failure
- Long-term System Degradation
- Process disruptions
- Data Loss or Corruption
- Costly Downtime
- Safety to drinking water



# Transients – A Problem of “The Electronic Age”



## Expanded Use of Electronics

- Sensitive Instrumentation
- Computerized Work Stations
- Industrial Machine Tools
- Automated Irrigation Controls
- Programmable Logic Controllers
- Security Systems
- Motor Control Systems
- Communications
- Data Centers

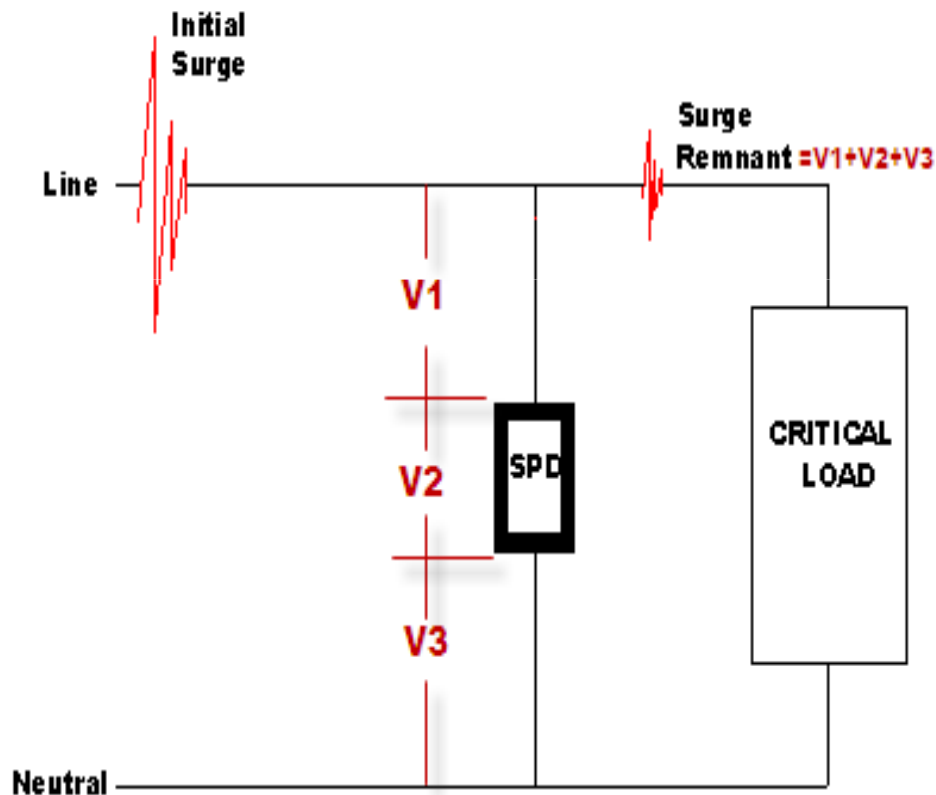


*What doesn't have some level of 'control' associated with it today ??*

# How a Surge Protective Device Works

# How does an SPD work?

The purpose behind installing any SPD is to divert damaging voltage and currents away from down stream equipment.



## SPD Method of Operation

1. The SPD is installed in a parallel path with respect to the load.
2. When a surge voltage does come down the line, the SPD will respond in nanoseconds creating a low impedance path through the components within the SPD.
3. Current will flow through the path of least resistance.
4. The SPD becomes the path of least resistance and shunts the damaging energy before it is forced through the down stream protected equipment.
5. NO SPD will shunt 100% of the initial surge energy away from the load.
6. There is always some voltage/current that will be pushed through the load.
7. But if the SPDs are installed correctly and in the proper location, this Surge Remnant is well below the damaging level of the protected equipment.

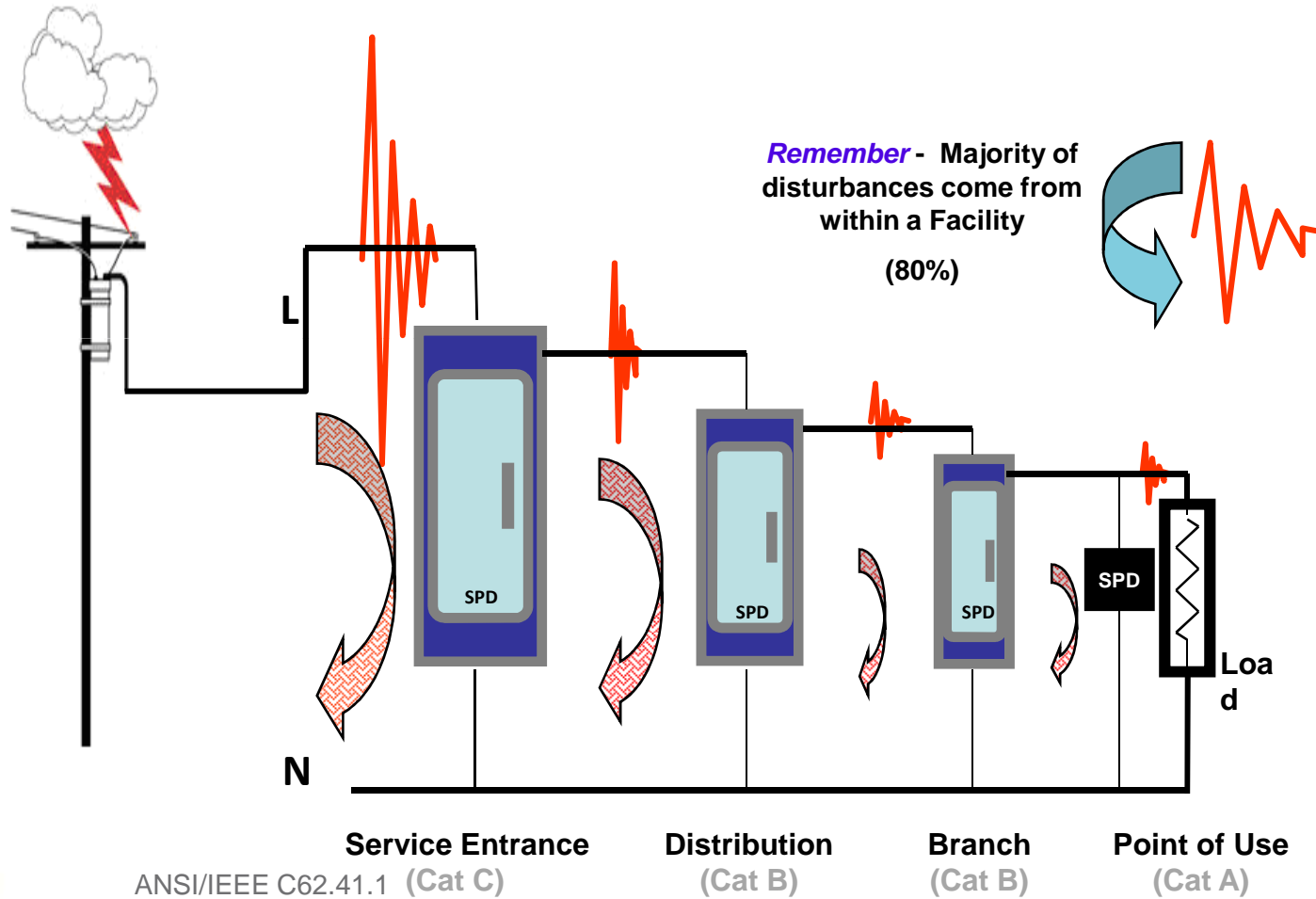
# Practical Application of Surge Protection

The Best Surge Protective Device  
is Only as Good as its

*Location* and *Installation*

# Cascading - Location

*Cascading (layering)* your protection throughout your facility insures proper protection for your equipment.



# Where to install Surge Protection

At the service entrance – to protect from externally generated surges

- Externally generated surges can be the highest energy surges

At any panels that have conductors that exit the building – to protect from alternate paths for lightning induced surges to enter

- Outdoor lighting
- Rooftop HVAC
- Outdoor equipment (Points often identified as ‘back door’)

Panels feeding critical loads – IEEE Emerald Book

- *“For large surge currents, this diversion is best accomplished in several stages. The first diversion should be performed at the entrance to the building, then, any residual voltage resulting from the action of the first protective device can be dealt with by a second protective device at the power panel of the computer room, or at the terminals of a connected load, or both.”*

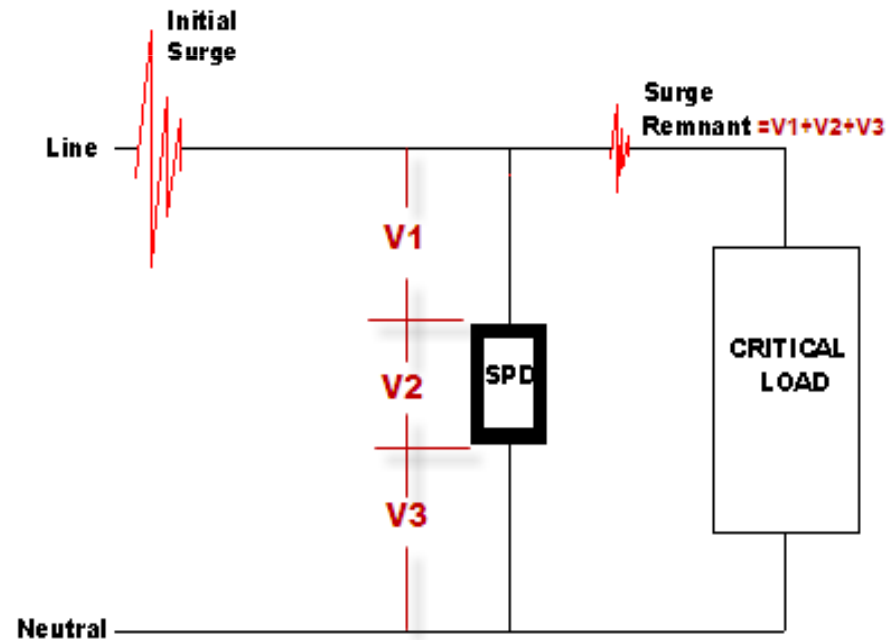
Critical loads

- Point of Use



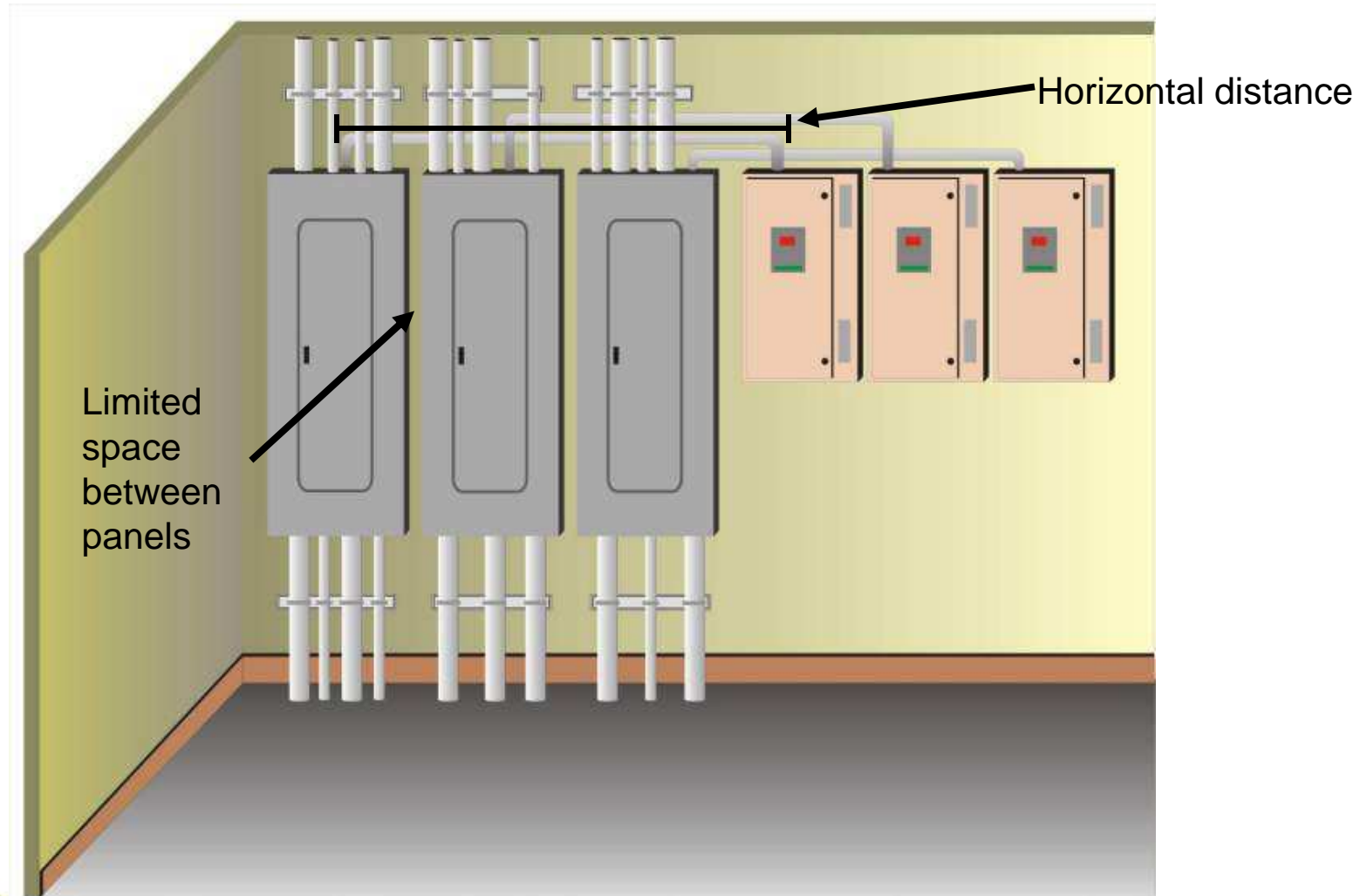
# Lead Length - *Installation*

## Impact on Clamping Voltage





# Lead Length Challenges



# Integral versus External

## Integral

- can be provided in all new equipment such as switchgear, switchboards, panelboards, motor control centers, and bus duct.
- can be provided as retrofit for switchboards (I-Line mount), motor control centers, and bus duct.

## External

- is required for retrofit for panelboards or in cases where space inside the equipment is not available.

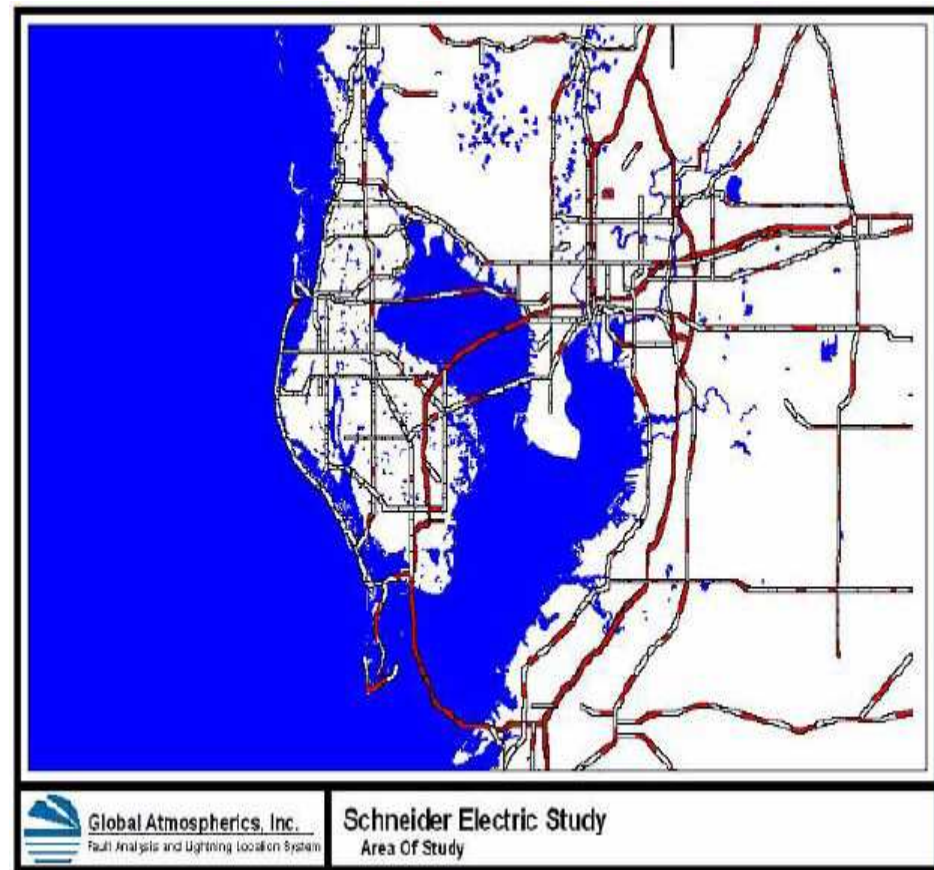
## Benefits of Integral versus External

- Minimized lead lengths – improves overall performance and protection
- Reduces footprint required by external products
- Coordinated design between SPD and distribution equipment

# How Big of SPD is Needed?

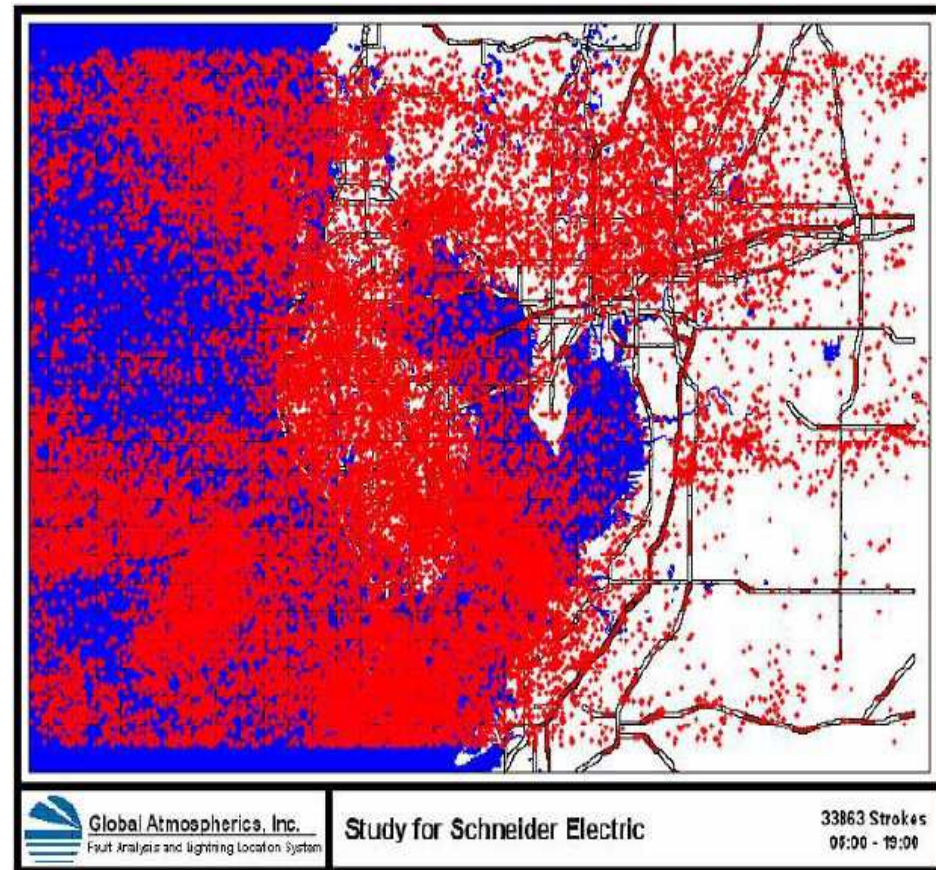
SE Lightning Study

- > July 15, 2000 Tampa Bay Area
- > National Lightning Detection Network



# SE Lightning Study (cont)

- > 14 Hour Storm
- > 33,863 Recorded Lightning Strikes
- > Cloud to Ground Strikes



# SE Lightning Study (cont)

> 2,597 Positive Strokes

98% less than 60kA

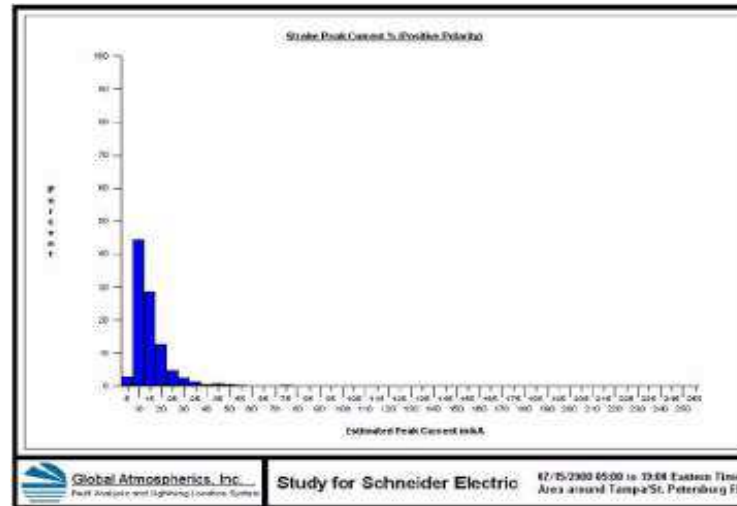
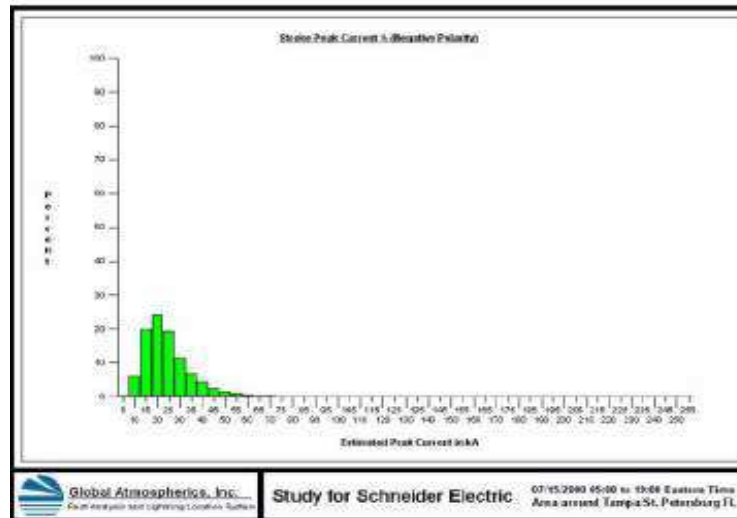


Chart 1: Positive Lightning Strokes

> 31,266 Negative Strokes

98% less than 60kA

2 strokes approached 180 kA

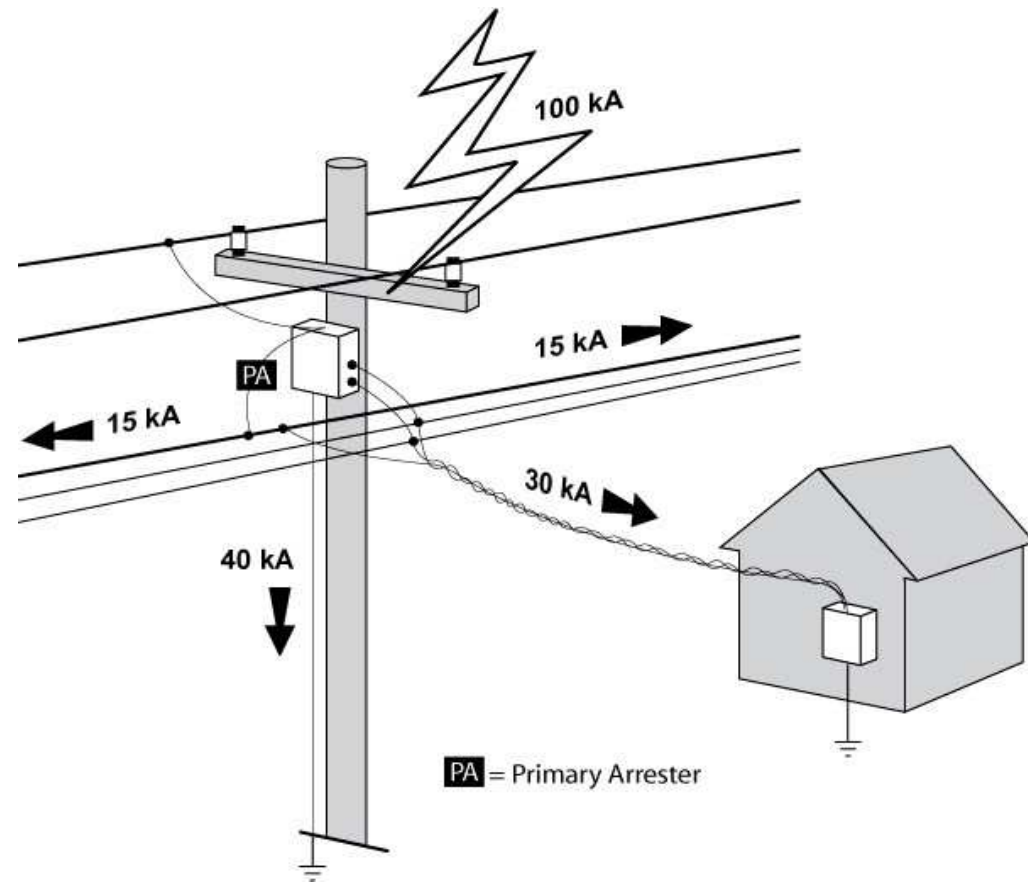


# SE Lightning Study (cont)

## IEEE C62.41.1-2002

It depends on where the stroke hits — but ANSI/IEEE indicates

**30% or less of the stroke current would enter a facility.**



Industry Codes, Standards and other reference documents.

# National Electrical Code



## Section 280

- Surge Arresters – Above 1,000 volts

## Section 285

- Surge Protective Devices (SPDs)  
1,000 volts and below



# National Electrical Code

708 – Critical Operation  
Power System



## C.O.P.S

"power systems for facilities or parts of facilities that require continuous operation for the reasons of public safety, emergency management, national security, or business continuity."

## Surge Protection Devices:

Surge protection devices shall be provided at all facility distribution voltage levels.

# National Electrical Code

700.8 - Emergency Systems



## Emergency Systems

- Safe egress
- Panic control
- Building safety systems (alarm, communications)
- Building mechanical systems (elevators, ventilation)
- Prevention of catastrophic industrial process failure

## Surge Protective Devices:

A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.

# Underwriters Laboratories

Industry Standard



## ANSI/UL 1449

### Surge Protective Devices

- Third Edition effective September 2009
  - TVSS to SPD
  - Introduction to Types of SPDs (Type 1,2,3,4)
  - Voltage Protection Rating
  - Nominal Discharge Current Rating
- Fourth Edition effective September 2014
  - Clarification
  - Additional testing not in effect till 2016 (PV)

## ANSI/UL 96A

### Lightning Protection Systems

## ANSI/UL 1283

### Electromagnetic Interference filters

# Institute of Electrical and Electronics Engineers

Industry Guidelines



## **ANSI/IEEE C62.41.1 – 2002**

IEEE Guide on the Surge Environment in Low Voltage (1000V and Less) AC Power Circuits:

## **ANSI/IEEE C62.41.2 – 2002**

IEEE Recommended Practice on characterization of Surge Voltages in Low Voltage AC Power Circuits:

## **ANSI/IEEE C62.45 – 2002**

IEEE Recommended Practice on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits:

## **ANSI/IEEE C62.62**

Test Specifications for Surge-Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low-Voltage (1000 V and Less) AC Power Circuits

## **ANSI/IEEE C62.72**

IEEE Recommended Practice on the Application of Surge Protective Devices in Low Voltage AC Power Circuits:

# Codes & Standards

## ANSI/IEEE C62.41.1-2002

IEEE Guide on the Surge Environment in Low Voltage (1000V and Less) AC Power Circuits:

## ANSI/IEEE C62.41.2-2002

IEEE Recommended Practice on Characterization of Surge Voltages in Low Voltage AC Power Circuits:

## ANSI/IEEE C62.45-2002

IEEE Recommended Practice on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits:

## ANSI/IEEE C62.72-2007

IEEE Recommended Practice on the Application of Surge Protective Devices in Low Voltage AC Power Circuits:



Guideline

# Questions ?

**THANK YOU !!**