



# Changes to Surge Protection Device Standards

IEEE / Music City Power Quality Group Meeting  
May 2011

# Agenda

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- Changes and Updates to Surge Protection Device standards
- Review of major changes to UL 1449
- Terminology and how to specify
- Affect on UL96A Lightning Protection System Certification

# Tic, toc....Time's up!!

- As of September 29<sup>th</sup>, 2009 **NO** manufacturer can produce **ANY** listed TVSS or Secondary Surge Arrester or Lightning Arrester rated 1000 V and below per ANSI/UL 1449 3<sup>rd</sup> Edition



# Surge Protective Device Standards Changes

- Numerous changes to a number of surge protection documents have been made:
  - **UL 1449 3rd Edition** – compliance 9/29/09
    - Surge Protective Devices  $\leq$  1kV
  - **NEMA LS-1** – obsolete standard no longer contains relevant tests or parameters, rescinded by NEMA
  - **IEEE C62.41** – 2002
    - Surge Arrestors  $>$  1kV
  - **NEC 2008 / 2011**
    - Article 280 – Surge Arrestors  $>$  1kV
    - Article 285 – Surge Protective Devices  $\leq$  1kV
  - **UL96A 12<sup>th</sup> Edition** – 2007/2010
    - Lightning Protection Systems
- Many terms used in the past are now obsolete

# Obsolete terminology

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- UL category code XUHT – **expired 9/28/09**
  - UL 1449 2<sup>nd</sup> Edition
  - **Transient Voltage Surge Suppressors**
  - NEC Article 285
- UL category code OWHX – **expired 9/28/09**
  - ANSI/IEEE C62.11
  - **Secondary surge arrestor**
  - There is no longer a UL standard for secondary surge arrestors above 1kV
  - NEC Article 280

# New terminology

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- Category code VZCA (sidemounted SPD's) and VZCA2 (integrated)
  - UL 1449 3<sup>rd</sup> Edition
  - **Surge Protective Devices**
  - NEC Article 285
  - First manufacturers' products listed January 2008
  - Published 9/29/06 – **mandatory 9/29/09**

# UL1449 3<sup>rd</sup> Edition Safety Enhancements

- Safety standard
  - UL 1449 – “UL Standard for Safety for Surge Protective Devices”
- UL 1449 3<sup>rd</sup> Edition is now an ANSI standard
  - Reviewed, voted on, and approved by a balanced group of technical advisors including individuals from manufacturers, end-users and other interested parties
  - Changes must be voted on by this technical advisory group
- Duty Cycle Testing
  - 15 impulses of the manufacturer selected nominal discharge current
  - To pass:
    - SPD can not create a shock or fire hazard
    - Nothing in the surge path can open at any time during or after the test
  - This test includes all internal or external supplementary protective devices or overcurrent devices such as fuses or circuit breakers
- Intermediate Current Test (“Slow Cook Test”)
  - L-L voltage place on the L-N mode
  - Current is limited to 1000A, 500A, 100A, and published SCCR
  - Test run for 7 hours on each or until the until safely disconnects
  - Added in addition to the Low Current Test from 2<sup>nd</sup> Edition
    - 10 amps, 5 amps, 2.5 amps, 0.5 amps
    - Test run for 7 hours on each or until the until safely disconnects

# UL 1449 3<sup>rd</sup> Edition Safety Enhancements

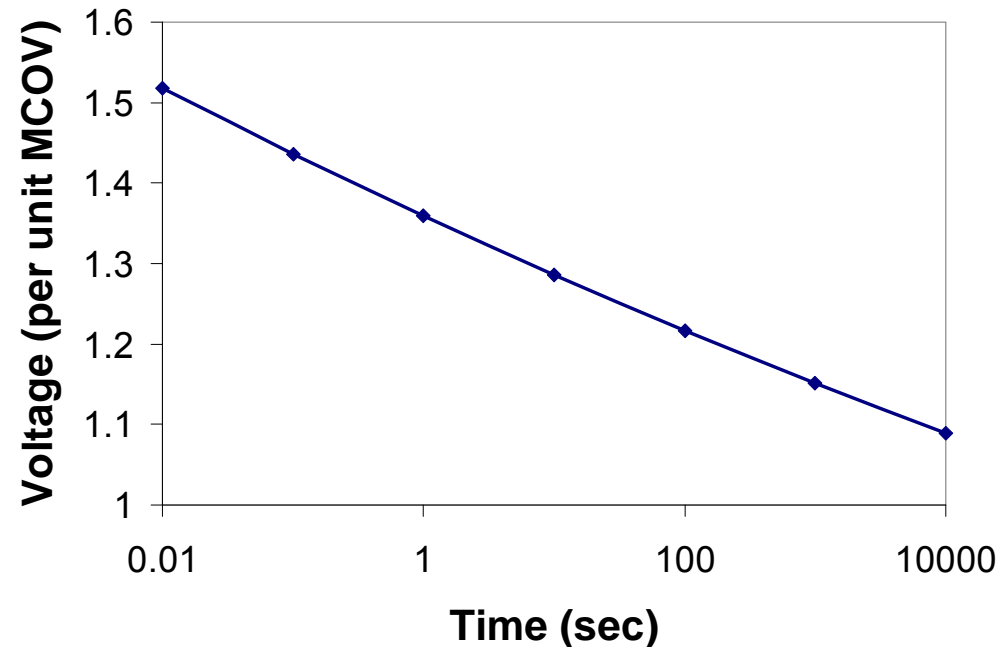
- “Slow Cook Tests” are meant to ensure SPD’s don’t catch on fire
- Voltage surges and transients rarely, if ever, cause a surge protector to fail
- Most common failure by far is sustained overvoltages due to misapplication or system voltage problems that cause the suppressor components to go into “**thermal runaway**”





# Thermal runaway of MOV

- Thermal runaway of an MOV occurs when a sustained overvoltage is applied to an MOV
- As the MOV conducts, heat is generated
- As more heat is generated, the impedance of MOV becomes less...which creates more current flow, which creates more heat, etc.
- MOVs can withstand many thousands of short duration surges (8x20 $\mu$ s) but will experience damage when an extended overvoltage is applied



- Time to failure depends on magnitude and duration of overvoltage

# Terminology and how to specify – required marks

- **SPD Type**
- NRTL listing mark
- Peak surge current per phase (not a UL requirement, but all SPD manufacturers use this)
- Short circuit current rating
- Nominal Discharge Current Rating
- Maximum Continuous Operating Voltage
- System voltages
- System frequency
- Voltage Protection Rating

**EAT•N** | **Cutler-Hammer**

TYPE 1 & 2 SPD



Surge Protective Device.  
Contains no servicable parts.

Model #: CVX100-208Y

SCCR: 100kA

Nominal Discharge Current Rating (In): 20kA

MCOV Rating: 150V L-N, NG, L-G; 300V L-L

Sys.V: 100V/174V; 120/208V; 127V/220V

Sys. Frequency: 50/60Hz

VPR: 700V L-N; 700V L-G; 700V N-G

Date of Manufacture: 11/21/2007

Suitable For Use on a Circuit Capable of Delivering  
Not More Than 100,000 rms Symmetrical Amperes.

Tel: 1-800-809-2772 • Web: [www.Eaton.com](http://www.Eaton.com)

# SPD Types

- Type 1 – Permanently connected SPDs intended for installation between the secondary of the transformer and the line side of the service overcurrent device and intended to be in an external overcurrent protective device.  
**Secondary Surge Arrestor**
- Type 2 – Permanently connected SPDs intended for installation on the load side of the service overcurrent device; including SPDs located in branch panels.  
**Transient Voltage Surge Suppressor**
- Type 3 – Point of utilization SPDs, installed at a minimum conductor length of 10 meters (33 feet) from the electrical service panel to the point of utilization for example cord connected, direct plug-in type.  
**Surge Strip**

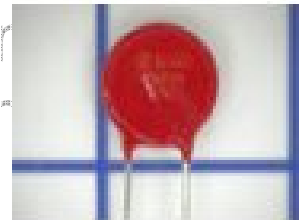


# SPD Types

- Type 4 – component assembly consisting of one or more Type 1 SPD components.
- Component Type 2-2 is a Type 4 with overcurrent protection suitable for application in Type 1, 2, or 3 locations
- Type 5 – Discrete component surge suppressors such as MOVs that may be mounted on a PWB, connected by its leads or provided within an enclosure with mounting means and wiring terminations.

## Integrated Transient Voltage Surge Suppressor

## Board Level MOV Components



**All these terms have been replaced with  
“Surge Protective Device (SPD)”**

# New Component Assembly SPDs for integrated surge created in UL 1449

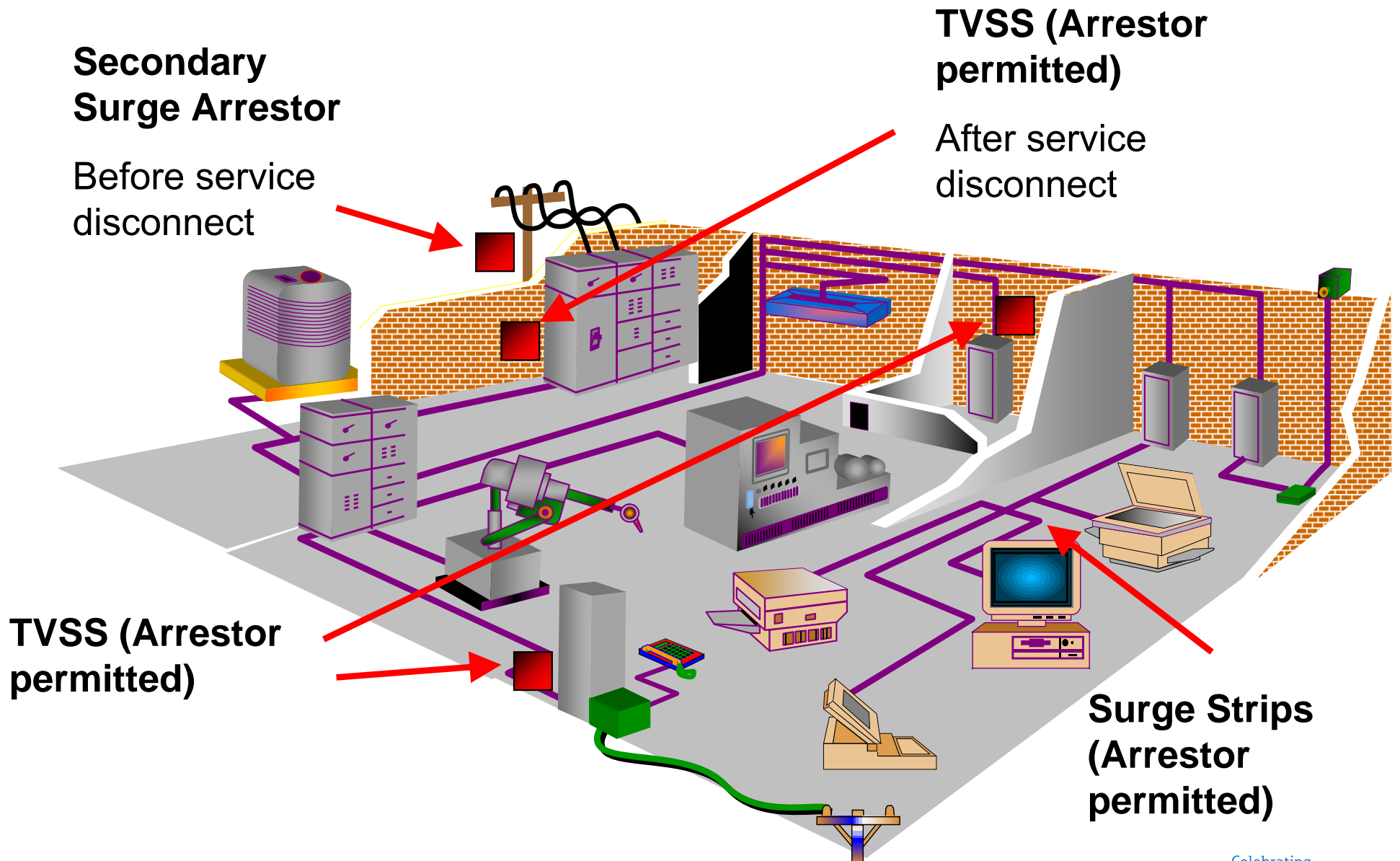
- Introduced in April 2010
- Type 1, 2, 3 Component Assemblies
  - An SPD intended solely for factory installation in another component, device or product
- Very significant safety improvement in ANSI/UL 1449 3<sup>rd</sup> Edition
- This new designation requires the integrated SPD to pass **ALL** electrical safety tests without the benefit of a complete, heavy enclosure
  - Tougher to pass a component assembly SPD test regimen than it is to pass as a stand alone unit
- Previous to UL 1449 3<sup>rd</sup> Edition, loopholes in the standard did not require complete testing of an integral SPD. This was corrected with UL 1449 3<sup>rd</sup> Edition ensuring that integral SPDs are always just as safe, if not safer than externally mounted SPDs

# Listed vs. recognized

- Type 4 and Component Type 1, 2, 3 devices carry a UL Recognized component label



# Current acceptable locations for TVSS and Secondary Surge Arrestors (Prior to UL1449 3<sup>rd</sup> Edition)



# Locations for SPD Types

## Type 1 (or Component Type 1)

Before service disconnect

## Type 2 (Type 1 permitted, or Component Type 1 or 2)

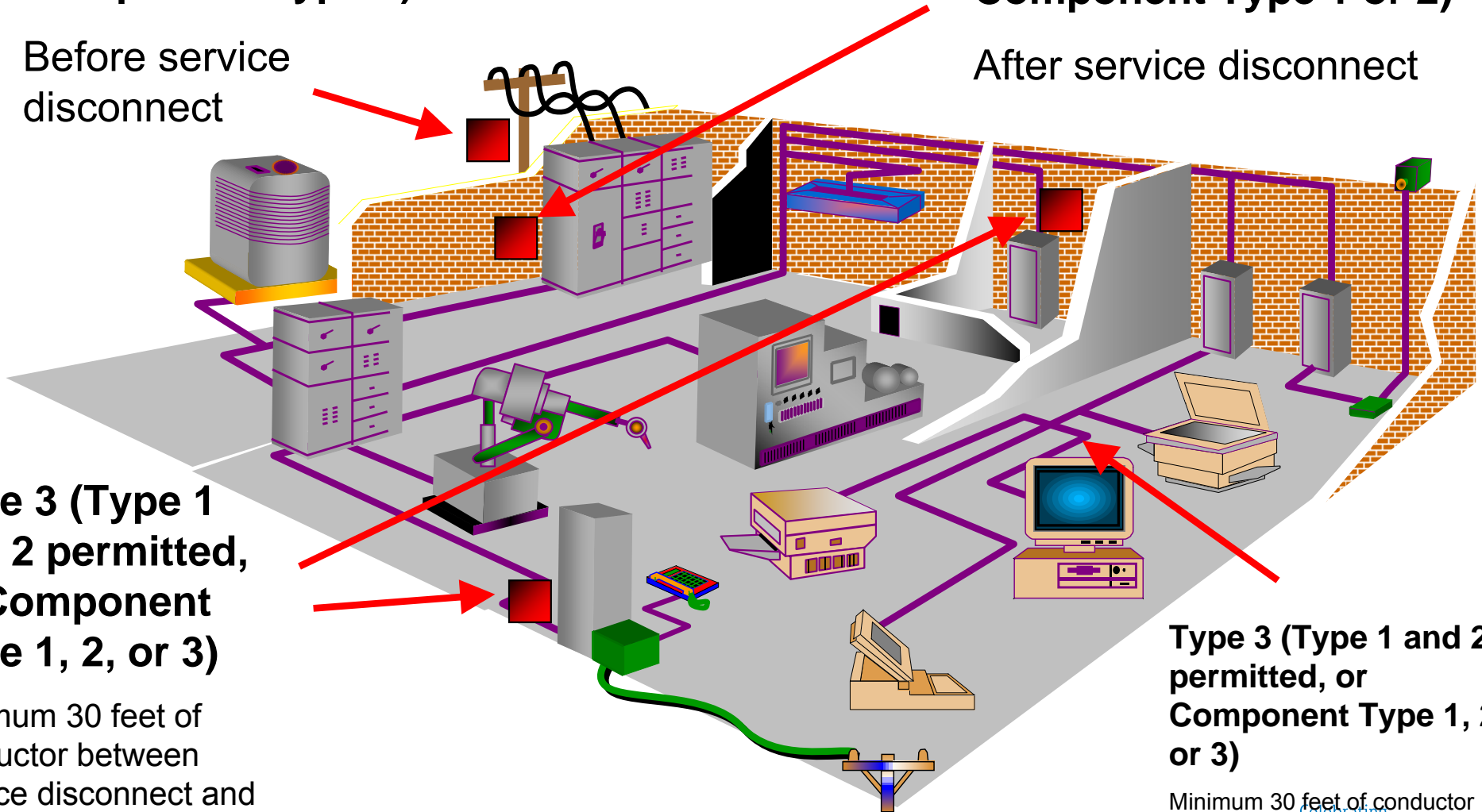
After service disconnect

## Type 3 (Type 1 and 2 permitted, or Component Type 1, 2, or 3)

Minimum 30 feet of conductor between service disconnect and SPD

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Minimum 30 feet of conductor between service disconnect and SPD





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- SPD Type
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# Nationally Recognized Testing Laboratory Mark - NRTL

- Other laboratories besides Underwriters Laboratories can test and list devices to be compliant with any standard, including UL 1449
- Only an SPD that is tested by UL is “UL Listed”
- An SPD tested by another NRTL can be “Compliant to UL 1449” but will be “Listed” by the NRTL – e.g. “ETL Listed”, “CSA Listed”
- Testing Labs such as Intertek (ETL) are approved and nationally recognized testing facilities per OSHA requirements



# UL listing vs. other NRTLs listing

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However...

- UL 96A – Lightning Protection Systems
  - UL96A Field Inspectors will **NOT** accept SPDs listed by NRTLs other than UL
  - If a specifier specifies and accepts an SPD listed by another NRTL and the customer desires a UL 96A Certificate at any time in the future, the customer **MUST** purchase a UL listed SPD
- Other UL listings – e.g. UL508A Industrial Control Panels, UL67 Panelboards, UL891 Switchboards, etc.
  - If a specifier specifies and accepts an SPD listed by another NRTL to be placed in control panel or other assembly, that assembly can **NOT** be UL listed.

# Terminology and how to specify – required marks

- SPD Type
- NRTL listing mark
- **Peak surge current per phase (not a UL requirement, but all SPD manufacturers use this)**
- **Short circuit current rating**
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# Peak surge current rating

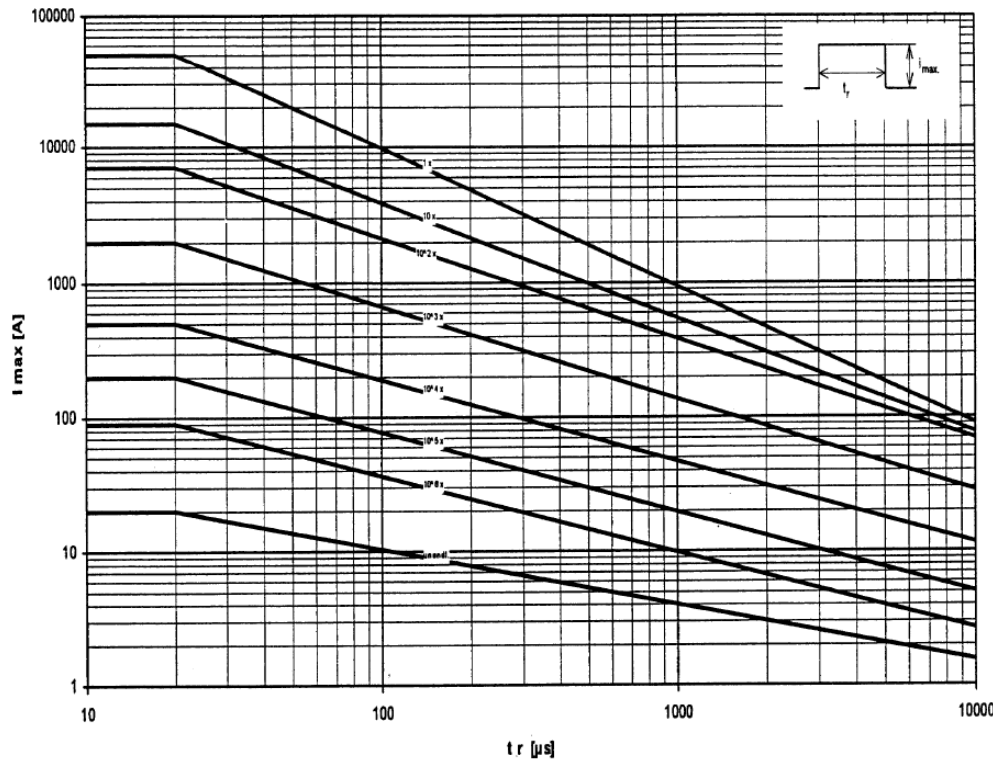
- This is how virtually all manufacturers rate or size their SPDs (Very poor method for sizing / selecting SPD's, but not other method currently exists)
- Also called:
  - Surge current capacity
  - Single pulse surge current
  - Maximum surge current
  - Peak surge current
- **Important note: it is never intended that an SPD is ever subjected to the peak surge current in actual installed conditions!!!**
  - **Flashover would occur before that magnitude of current could travel through the electrical distribution system**
  - **Test labs are not capable of generating surges over ~200kA**
  - **Manufacturer's kA ratings are based on calculations**

# Peak surge current rating

- The peak surge current is a predictor of how long an SPD will last in a given environment
  - The higher the kA, the longer the life of the MOVs
- Similar to the tread on a tire
  - The thicker the tread, the longer the tire will last



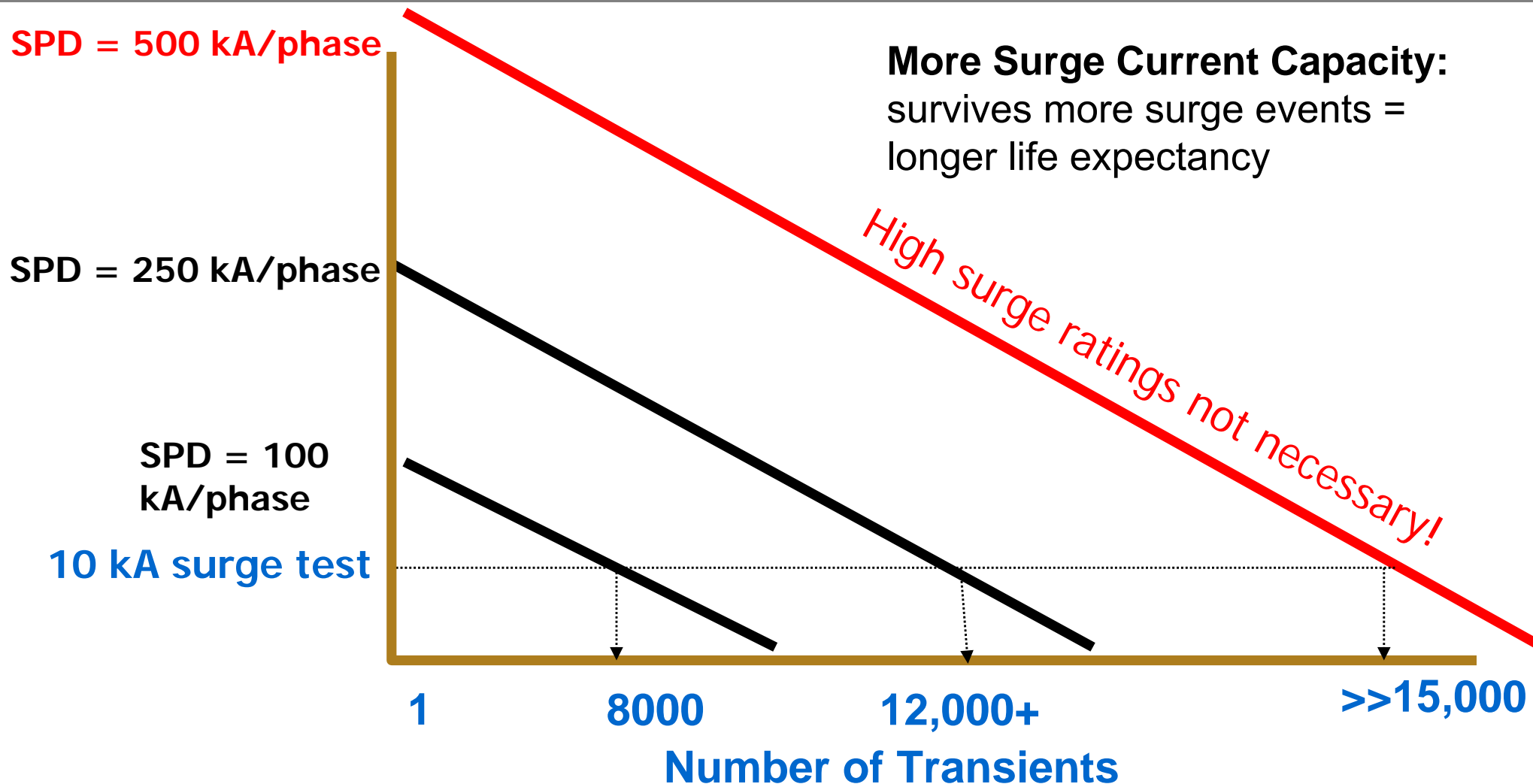
# Life curve for 50kA MOV



current level (amps)	# of strikes (useful life)
50,000	1
13,000	10
7,000	100
2,000	1,000
500	10,000
200	100,000
90	1,000,000
20	unlimited

- All MOV's degrade slightly over time depending on the magnitude and duration of the impulses it is subjected to (8x20  $\mu s$  is most common test waveform)

# Surge Current Ratings: Higher Capacity = Increased SPD Life



- 250 kA/phase is enough for any facility (>> 25 year life in Florida)
- Manufacturer's promote high ratings (500 kA) to sell for higher \$\$ . The life expectancy for these units is over **200 years** !!!!





# Lightning strikes the earth 6,000 times a minute

Each year, there are over \$1 billion worth of lightning-related insurance industry losses

**Nashville Area  
averages 6 strikes/km<sup>2</sup>  
per year**

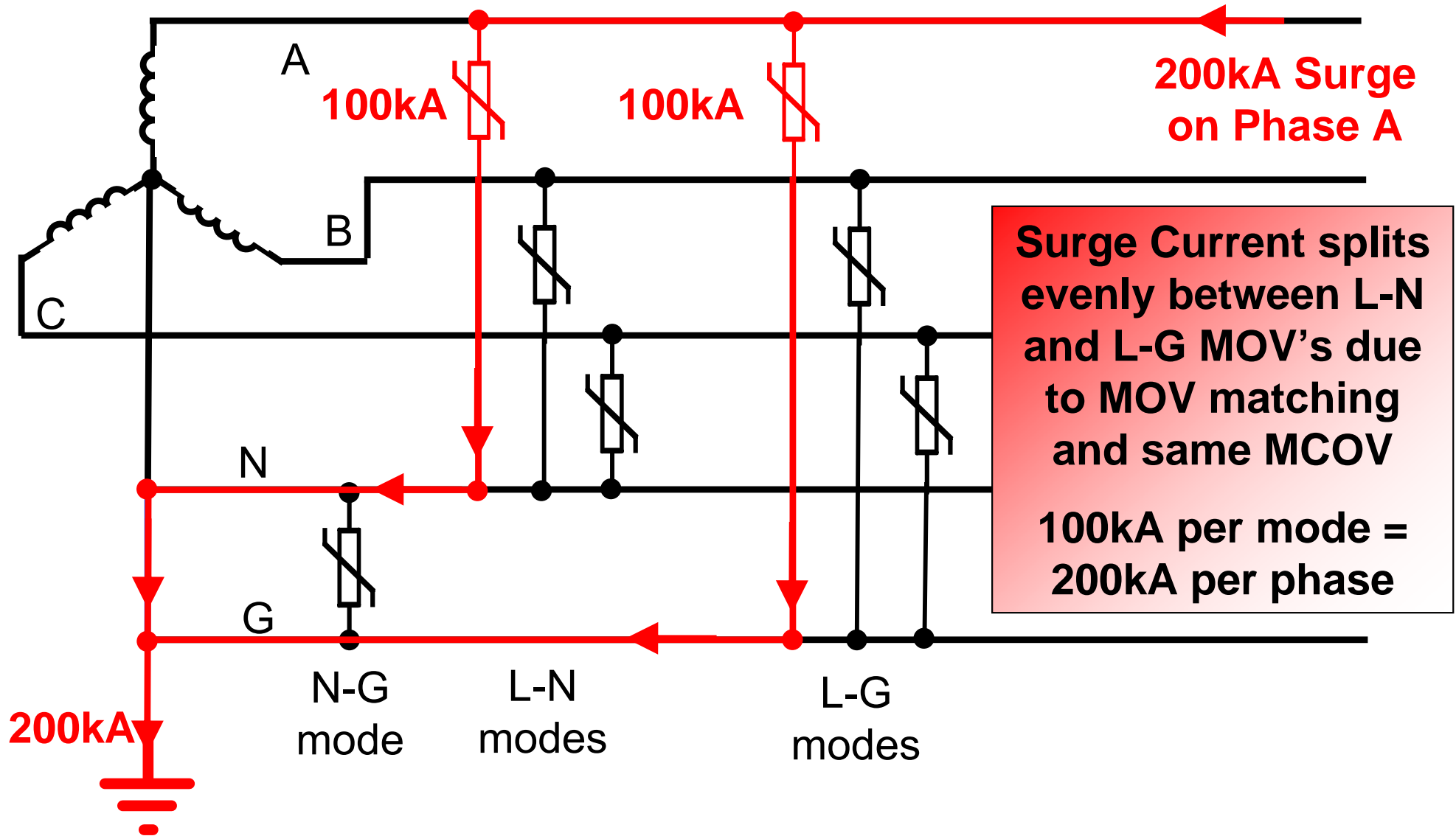
# How much life do you need?

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- On average electrical equipment has a design life of 30 years
- Experience and calculations have shown:
  - Service entrance 250kA – 300kA / phase (125kA – 150kA / Mode)
  - Sub panel 120kA – 160kA / phase (60kA – 80kA / Mode)
  - Point of use SPDs rated at 80kA – 100kA / phase (40kA – 50kA / phase)
- Typically, Let Through Voltage (VPR) performance is the same regardless of kA rating
- Warranty periods are the same regardless of kA rating
  - Standard Eaton warranties are 10 year full replacement warranties
    - Not pro-rated
    - Not individual component replacement

# Modes of Protection

## 3 Phase – 4 Wire System



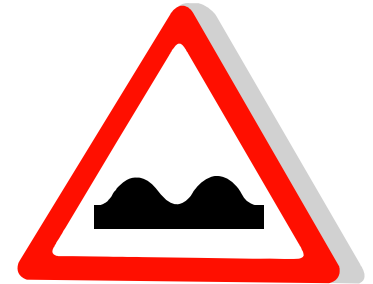
# Nominal Discharge Current - $I_n$

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- New rating introduced with UL 1449 3<sup>rd</sup> Edition
- Measure of the “ruggedness” or “robustness” of an SPD
  - “Stress Test”
- Measure of how the SPD performs when installed and subjected to operating scenarios closer to real life situations

# Nominal Discharge Current - $I_n$

- Nominal discharge current tests the complete SPD under strenuous “real life” scenarios
  - MOV’s, circuit protection, leads, resistors, circuit boards, etc.
- Similar to a test track or road test for an auto



# Nominal Discharge Current test

- Manufacturer chooses a current:
  - Type 1 – 10kA or 20kA
  - Type 2 – 3kA, 5kA, 10kA or 20kA
- Complete SPD is tested along with any required overcurrent devices (fuse or breaker)
- Let through voltage for a 6000V 3000A surge recorded
- SPD is subjected to 15 surges at chosen current one minute apart with rated voltage applied between surges
- Let through voltage for a 6000V 3000A surge recorded
  - must not deviate more than 10% from original voltage

# Nominal Discharge Current - $I_n$

- UL 96A and NFPA 780 (Lightning Protection Systems) requires 20kA nominal discharge current
- All things being equal, customers and specifiers should choose  $I_n$  of 20kA
- Energy =  $I^2 \cdot t$ 
  - 10kA SPD can only take 25% of the energy of 20kA
  - 5kA SPD can only take 6.25% of the energy of 20kA
  - 3kA SPD can only take 2.25% of the energy of 20kA
- Unless there is a **significant** difference in cost between a 20kA  $I_n$  SPD and a lower  $I_n$  SPD recommendation is to choose the 20kA SPD

# Short Circuit Current Rating

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- Every electrical system has an available short circuit current. This is the amount of current that can be delivered by the system at a particular point in a short circuit situation
- SPD must be able to safely withstand (for 7 hours) or interrupt this amount of current
- Typical available short circuit currents are:
  - Residential – 5-10kA
  - Small commercial – 14-42kA
  - Large commercial/industrial – 42-65kA
  - Large industrial/utility/downtown in large cities – 100-200kA



# Terminology – required marks

- SPD Type
- NRTL listing mark
- Peak surge current per phase (not required)
- Short circuit current rating
- Nominal Discharge Current Rating
- **Maximum Continuous Operating Voltage**
- System voltages
- System frequency
- Voltage Protection Rating

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# Maximum Continuous Operating Voltage

- The maximum rms voltage that can be applied to each mode of the SPD
- This is a manufacturer selected value
- Users and specifiers should make sure there is enough “head-room” so that normal voltage fluctuations do not exceed the MCOV

## Typical MCOVs

120V system – 150V MCOV

240V system – 320V MCOV

480V system – 550V MCOV

# Terminology – required marks

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- Peak surge current per phase (not required)
- Short circuit current rating
- Nominal Discharge Current Rating Maximum Continuous Operating Voltage
- **System voltages**
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# Voltage System Configuration

- It is extremely important that the configuration of the SPD is compatible with the system voltage configuration
- Delta SPD's can be connected on a Wye system
  - Not recommended because it provides less protection
  - Voltage Protection Rating (Let Through Voltage) would be higher
  - MOV's are connected L – L and L – G but have MCOV above the nominal L – L voltage
    - Example: 480v Delta = 550v MCOV
- Wye SPD's can NOT be connected on a Delta system
  - L – G connected MOV's have an MCOV rating based on L – N voltage
    - During a Ground Fault, full line voltage is put across the L-G connected MOV's

# Terminology and how to specify – required marks

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# UL 1449 Voltage Protection Rating

- VPR is a rating published and marked on all UL 1449 listed SPDs
- Residual voltage from a 6000 V, 3000 A 8/20  $\mu$ s surge waveform impulse
- This is the real “performance” indicator for a surge protective device

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# Voltage Protection Rating

- Voltage Protection Rating is assigned to an SPD model by UL from a table based on the average of the measured limiting voltage from 3 impulses of a 6000V/3000A surge
- VPR is the highest value in the measured limiting voltage range
  - Example: Measured Limiting Voltage of 701 volts = VPR of 800.

Measured Limiting Voltage	Voltage Protection Rating
330 or less	330
331 - 400	400
401 - 500	500
501 - 600	600
601 - 700	700
701 - 800	800
801 - 900	900
901 - 1000	1000
1001 - 1200	1200
1201 - 1500	1500
1501 - 1800	1800
1801 - 2000	2000
2001 - 2500	2500
2501 - 3000	3000
3001 - 4000	4000
4001 - 5000	5000
5001 - 6000	6000

# VPR vs. SVR

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- Under old UL 1449 2<sup>nd</sup> Edition there was a lower magnitude surge test used to measure the Suppressed Voltage Rating – SVR
  - 2<sup>nd</sup> Edition - SVR – 6000V **500Amp**
  - 3<sup>rd</sup> Edition - VPR – 6000V **3000Amp**
- VPR will be higher with UL 1449 3<sup>rd</sup> Edition than SVR using UL 1449 2<sup>nd</sup> Edition
  - Does NOT mean 3<sup>rd</sup> Edition products don't protect as well as 2<sup>nd</sup> Edition
  - Simply means a different test was used

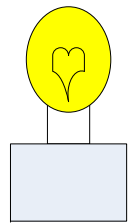


# UL 1449 test for VPR uses 6" of external lead length

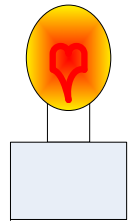
- In order to have consistency in VPR voltage levels, UL specifies that six inches of lead length is protruding from SPD
- Actual, as installed Measured Limiting Voltage could be significantly higher or lower than published VPR depending on the installation method



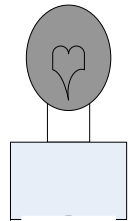
# Surge Protection Demonstration



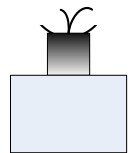
**Normal Transients**  
**< 700 V**



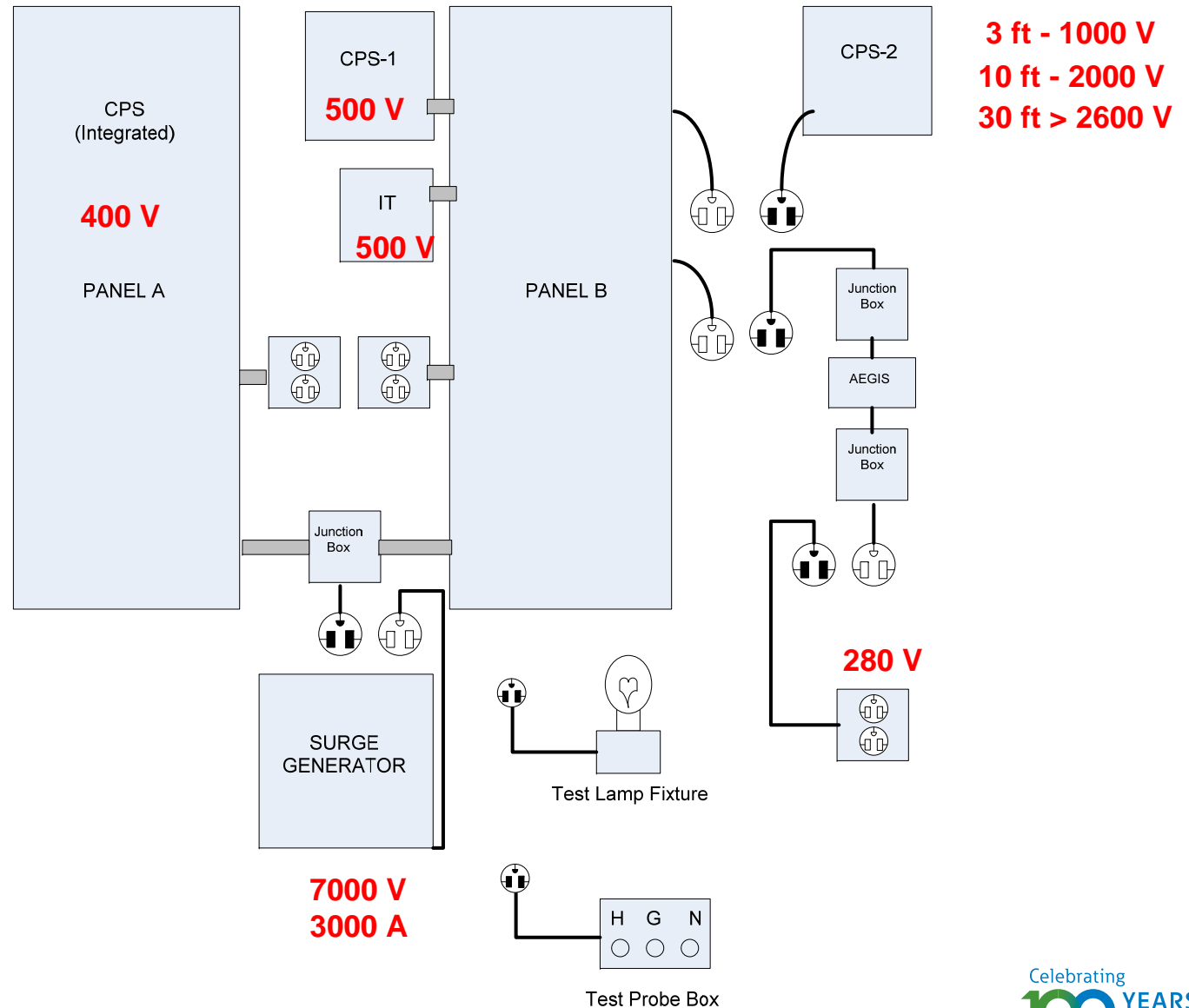
**Unrecoverable Transient**



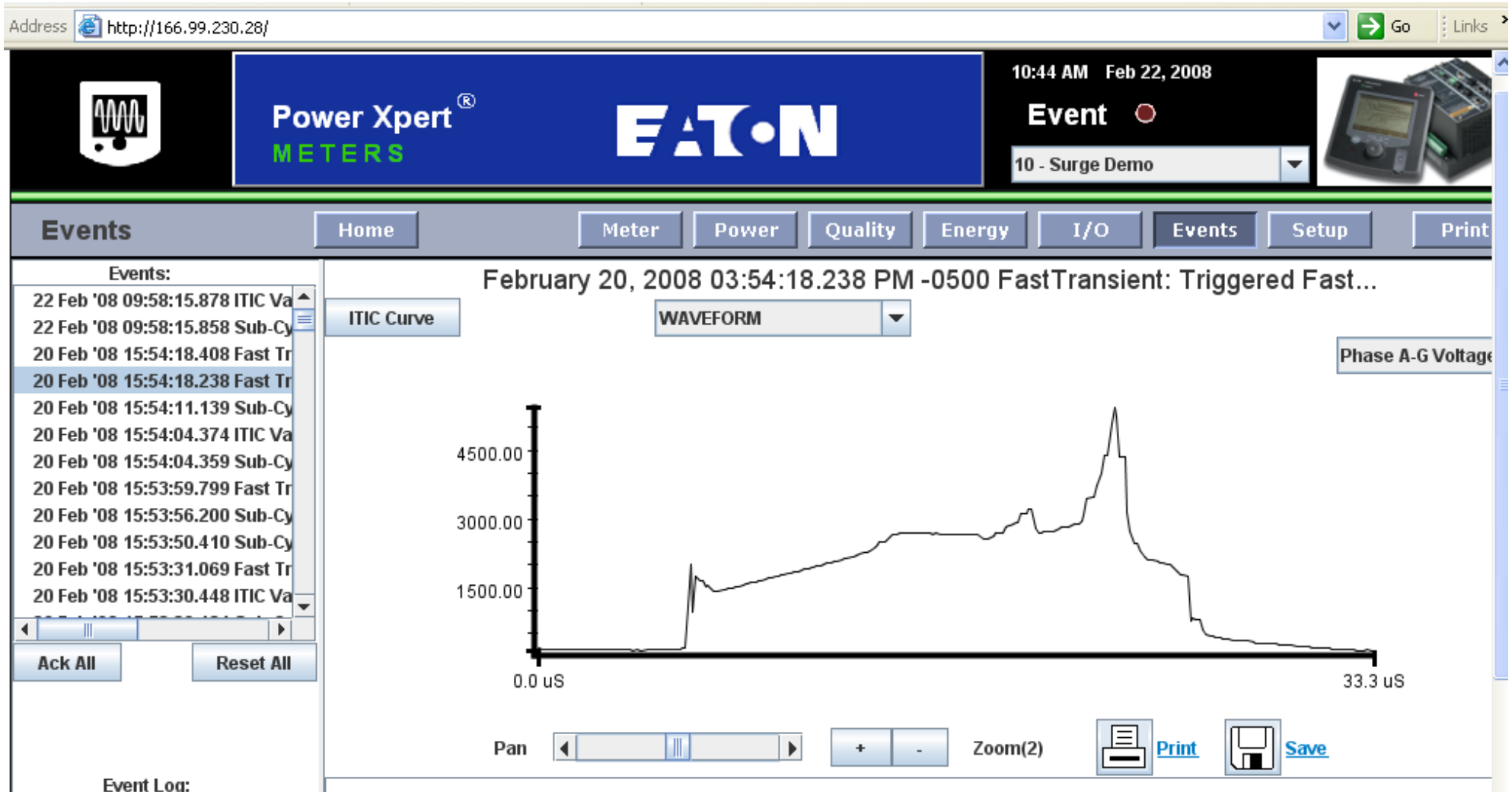
**Lights Out**  
**> 900 V**



**Light Disappears**  
**> 3000 V**

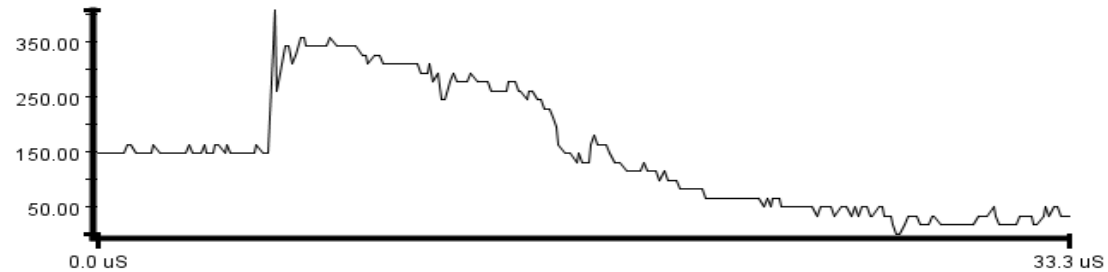


# Surge Protection Demo – No Protection

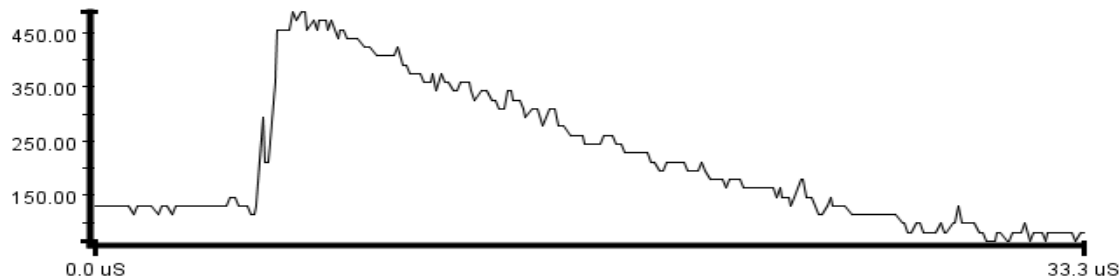


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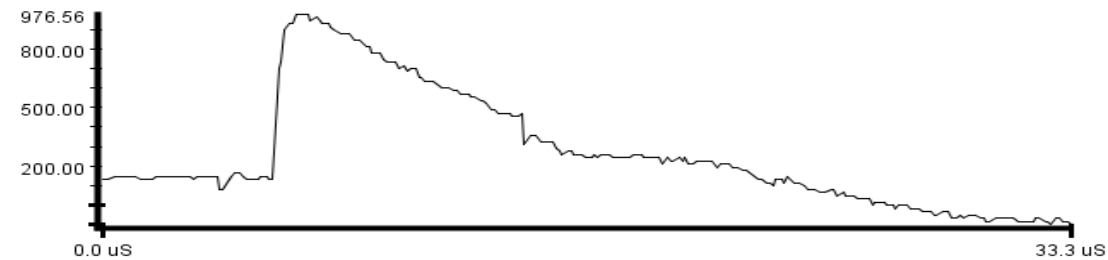
**Integrated SPD  
400 V Peak**



**SPD w/12 inch lead length  
500 V Peak**

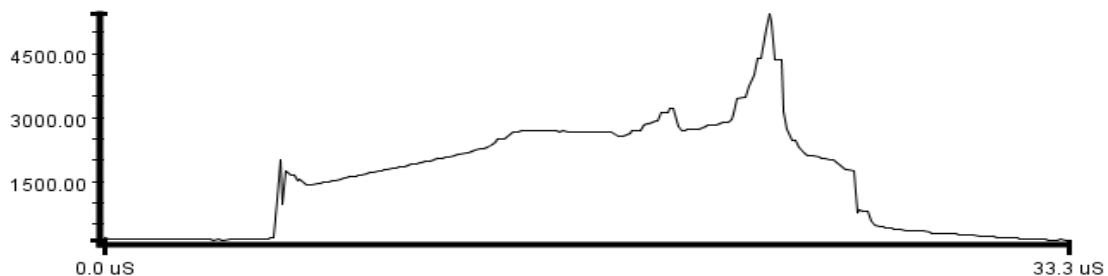


**SPD w/36 inch lead length  
1000 V Peak**

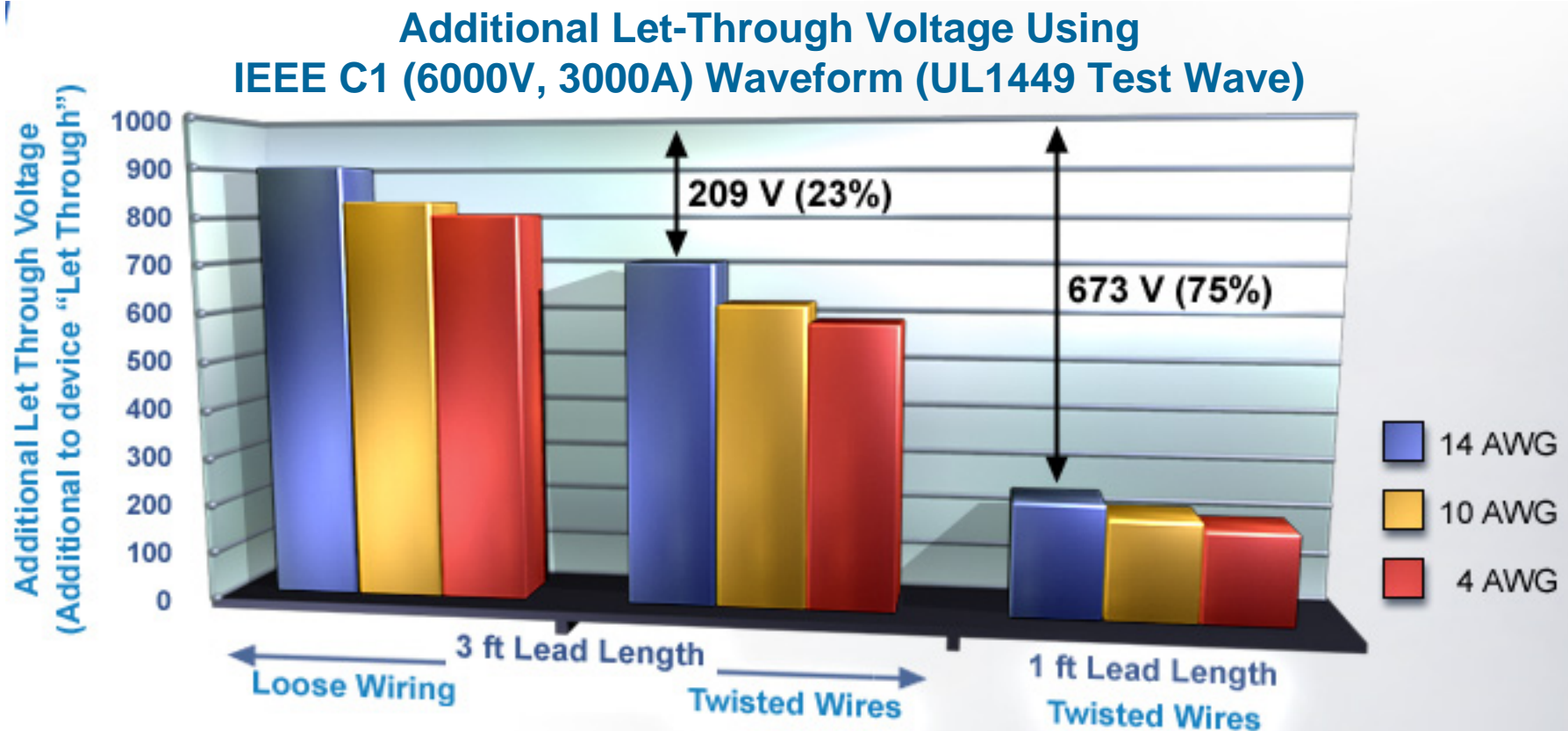


**No protection**

*(Sampled at 6MHz)*



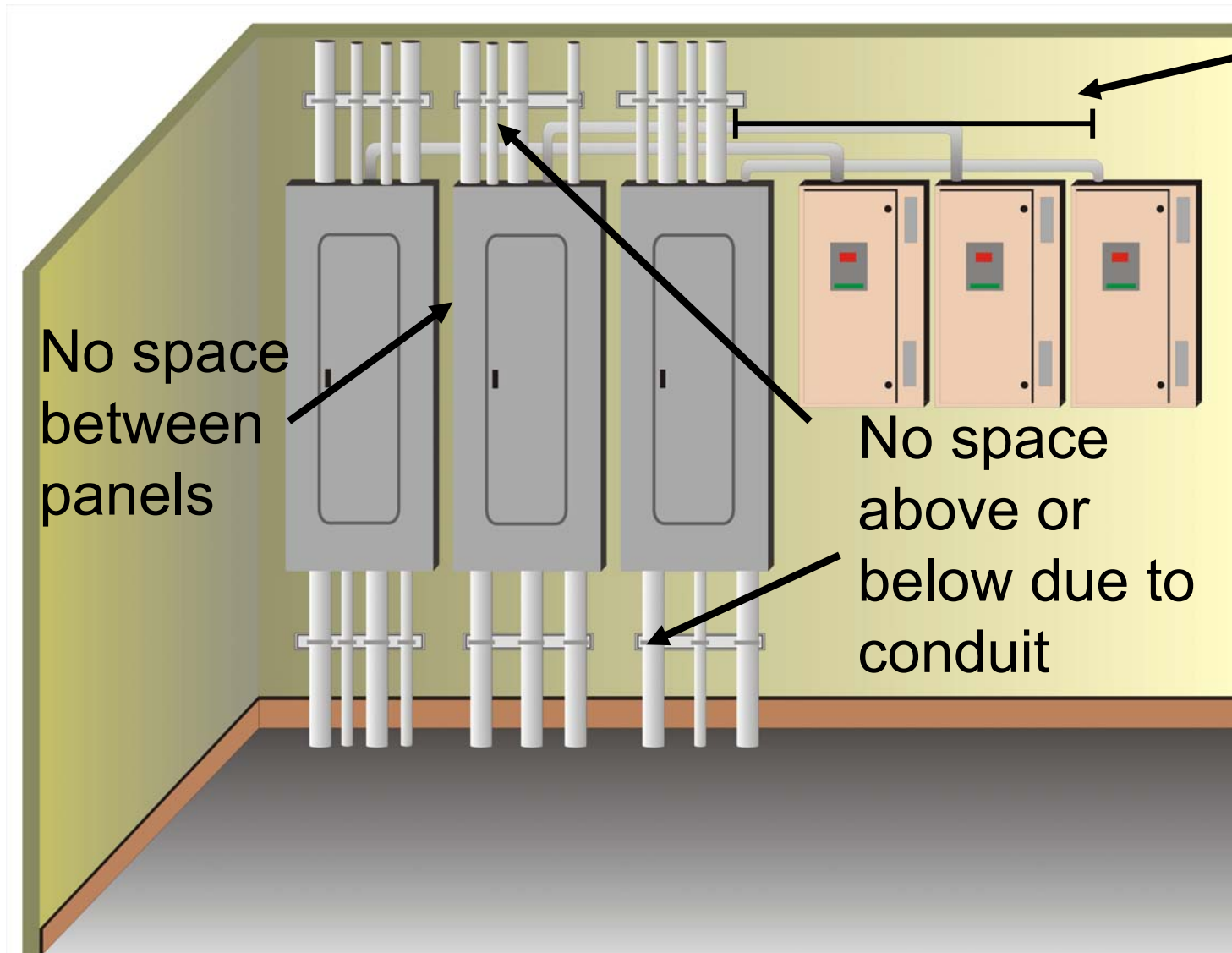
# Installation Lead Length Can Increase Let-Through Voltage by 15- 25v Per Inch



## Installation Criteria Order of Importance:

- 1) Lead Length - 75% reduction
- 2) Twisting Wires - 23% reduction
- 3) Larger Wire - minimal reduction

# Installation affect on SPD performance



Lead length = 6 - 10 feet

Increased let-through voltage can be 100's of volts!

Integrate units where possible to maximize surge protection

# Limit Lead Length to Optimize Performance

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- Universally agreed by IEEE, NEMA, UL, SPD manufacturers and others that short lead lengths optimize SPD performance
  - *“...integrally mounted SPDs minimize the length of the SPD conductors, thus optimizing the effectiveness of the device...”*  
– IEEE Emerald Book
  - *“...Reducing the impedance of the connection between the electrical source and the TVSS unit will ensure that the clamping voltage is kept as low as possible. Ideally "zero" impedance is obtained by direct connecting the TVSS unit to the electrical system bus assembly...”* – T&B Current Technology

# Connection of SPD's

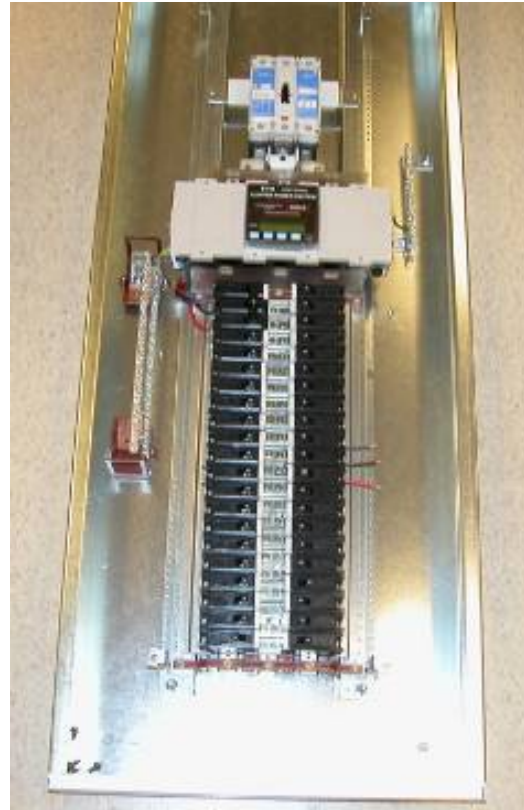
Good

Better

Best

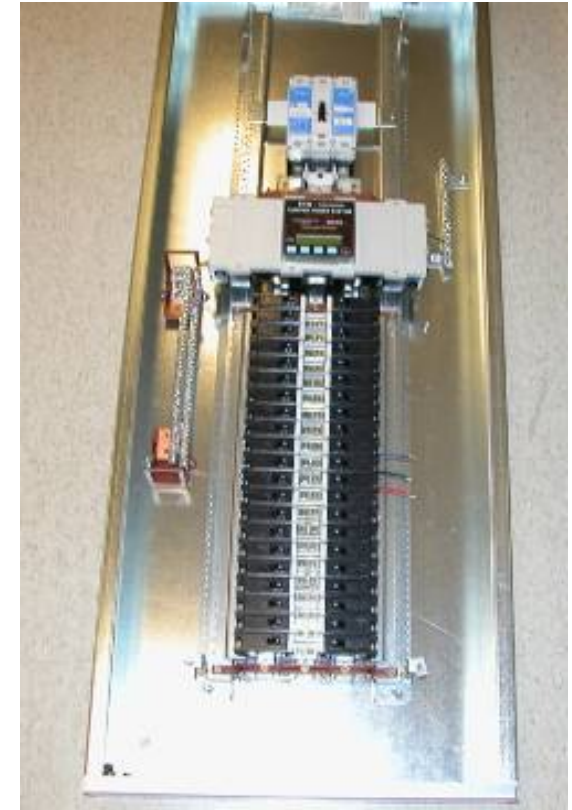


Sidemounted  
(~14" of twisted  
conductor)



Integrated with  
Disconnect  
(~6" of twisted conductor)

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Direct bus connected  
(No conductor length)



# SPD Features not addressed by UL1449

- Repetitive Surge (Life Testing)
  - No test standard exists in the industry
- Filter Performance for EMI / RFI attenuation
  - Must meet UL1283 requirements
  - Recommend a minimum filter rating of 45 – 50dB@100kHz
- Component Types
  - UL1449 is a performance based standard and does NOT prescribe the type of device(s) that are used for surge suppression
    - Silicon Avalanche Diodes, Selenium Cells, MOV's, special epoxy, “magic” sand, etc are all acceptable
    - Performance results (VPR) are the same for all types

# SPD Features not addressed by UL1449

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- Electrical Losses
  - SPD's are not loads and should consume little kWhr (only for indications / diagnostics / filter leakage to ground)
- Disconnect Size
  - Testing is done using manufacturer's recommended disconnect

# UL 96A (NFPA 780) Installation Requirements for Lightning Protection Systems

- Safety standard involving the *installation* of UL listed components to form a “Lightning Protection System”
- Previously did not recognize UL1449 2<sup>nd</sup> Edition TVSS. Required UL96A Secondary Arrestor even if a TVSS was present (or dual listed TVSS)
- New standards are better synchronized...but still have some issues
- NOTE: Not all UL1449 SPDs can be used in a Lightning Protection System



# UL 96A Lightning Protection Certificate SPD requirements

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1. SPD must be listed or recognized by Underwriters Laboratories
  - Other NRTL's are **NOT** acceptable!
  - (side note: UL has become extremely aggressive in policing UL listed and recognized components only in UL assemblies and products)
2. SPD must be Type 1 or Type 2
3. SPD must have a Nominal Discharge Current of at least 20kA

# UL96A Lightning Protection Certification



the standard in safety

Underwriters  
Laboratories

MARCH 11, 2010

## GUIDE TO DETERMINE SURGE PROTECTION DEVICES INSTALLED IN LIGHTNING PROTECTION SYSTEM INSTALLATIONS ARE COMPLIANT WITH UL 96A.

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- ❖ **HOW TO VERIFY SURGE PROTECTION DEVICES SUITABLE FOR USE ON  
ELECTRIC SERVICE ENTRANCES RATED 1000 VOLTS OR LESS IN  
COMPLIANCE WITH UL 96A**

**UL LISTED SURGE PROTECTIVE DEVICES (TYPE 1 & 2 ONLY SPD DEVICES ARE SUITABLE  
FOR LPS APPLICATION) - (CCN VZCA)**

- UL inspector has guidelines to follow to determine if the installation meets the requirements for Master Lightning Protection Certification

# How to determine if an SPD is listed



**BEGIN A BASIC SEARCH**

To begin a search, please enter one or more search criteria in the parameters below.

Company Name

City

US State

US Zip Code

Country

Region

Postal Code (non-US)

UL Category Code [\(options\)](#)


UL File Number [\(help\)](#)

Keyword

- Go to ul.com and click on the “certifications” link
- Type in the category code
- VZCA – Type 1 and 2 SPD
- VZCA2 – Type 4  
(Component Type 1, 2)  
Component Assembly  
SPDs (integrated)

# How to determine if an SPD is listed

- Retrieve the specific manufacturer's listing of product

 **ONLINE CERTIFICATIONS DIRECTORY**

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**VZCA2.E316410**  
**Surge-protective Devices - Component**

[Page Bottom](#)

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**Surge-protective Devices - Component**

[See General Information for Surge-protective Devices - Component](#)

**EATON** E316410  
1000 CHERRINGTON PKY  
MOON TOWNSHIP, PA 15108 USA

**Type 4 Surge Protective Devices, for use in Type 1 applications**, Cat. No. SPD, followed by 50, 80, 100, 120, 160, 200 followed by 208Y, 220Y, 230L, 240D, 240H, 240S, 400Y, 480D, 480Y, 600D, 600Y, followed by 1, followed by A, B, C or J, may be followed by -ND.

Cat. No. SPD, followed by 250, 300, 400, followed by 208Y, 220Y, 230L, 240D, 240H, 240S, 400Y, 480D, 480Y, 600D, 600Y, followed by 1, followed B, C or J, may be followed by -ND.

Cat. No. SPD, followed by 050, 080, 100, 120, 160, 200, 250, 300 or 400, followed by 208Y, 220Y, 240D, 240H, 240S, 400Y, 480D, 480Y, 600D or 600Y, followed by 1, followed by D, F, G or H.

# UL96A Lightning Protection Certification – Medium Voltage Surge Arrestors

## ❖ HOW TO VERIFY SURGE PROTECTION DEVICES SUITABLE FOR USE ON ELECTRIC SERVICE ENTRANCES RATED GREATER THAN 1000 VOLTS IN COMPLIANCE WITH UL 96A

### UL LISTED SURGE ARRESTERS GREATER THAN 1000 VOLTS – (VZOK)

**NOTE** – Currently, there are no listings established under this category. The Guide Card information is available to installers on the On-Line Certification Directory.

- Device Standard & Code References:
  - ANSI/IEEE C62.11 or ANSI/IEEE C62.1
  - NEC 2008 Reference: Article 280
  - UL 96A Paragraph Reference: 13.3

?????

To verify compliant devices to this category, the following guidelines should be used:

- The following is required to be marked on the device:
  - UL in a Circle
  - The Word “Listed”
  - Control Number (4 digit alpha numeric number)
  - Product Identity consisting of the following: "Surge Arrester," "Distribution Normal Duty Surge Arrester" or "Station Class Surge Arrester," or other appropriate product name as shown in the individual Listing.

- UL Inspector Guidelines contradict themselves
- UL is aware but won't have resolution until end of 2011
- New Eaton Datacenters were affected by this





# Questions?

THANK YOU!



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