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MOBILITY & TRAFFIC EXPERTS

2016

Advancements in Surge Protection

Outline:

- Basics
  - Transient Overvoltages
  - How an SPD works
  - Industry Standards
- Applying/Installing AC Voltage SPDs
- Emerson/APT Products

February 2, 2016

Advancements in Surge Protection 2015

Dave Snelling

Sales and Support

EMERSON
Network Power

Edco - APT - Emerson

- Edco – Purchased by Emerson in 1997
- APT - Purchased by Emerson in 2013
- Surge HQ in Clearwater
- Most comprehensive line of surge protection in the world
- ISO 9001-2008 Quality Management System
- ISO 17025 evaluation by UL
- ITS Florida Outstanding Achievement – 2013
- Members of IMSA, ITSA, ITS FL, GRITS, SDITE, etc.
- Members of UL, IEEE, NEMA standards committees

Agenda - Surge Suppression

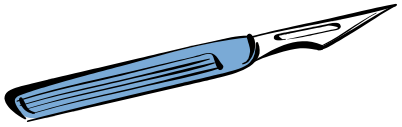
Outline:

1. **Basics**
   - **Transient Overvoltages**
   - **How an SPD works**
   - **Industry Standards**
2. **Applying/Installing AC Voltage SPDs**
3. **Emerson/APT Products**

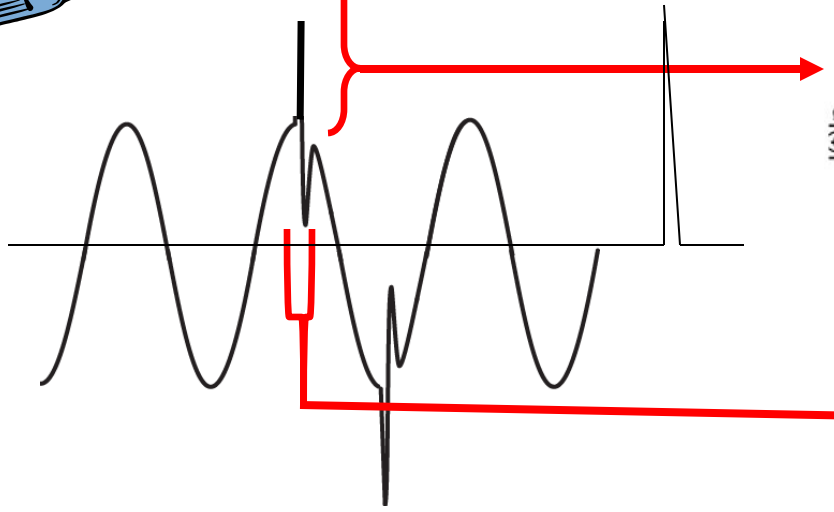
What Is a Surge/Transient?

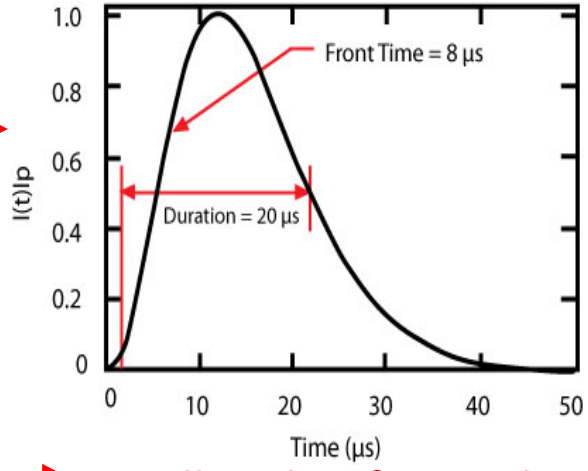
- **High amplitude, short duration overvoltage**
- **Can be positive or negative polarity**
- **Can be from energized or grounded conductor**

Surge Protectors
'Chop Off' surges



Transient Overvoltage –
Can be thousands of volts





Millionths of second

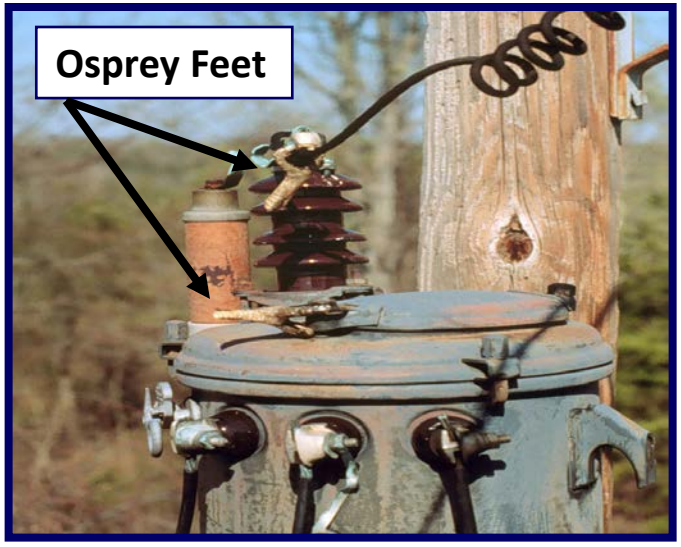
What Causes Surges/Transients?

Practical:

- **Lightning**
- **Switching:**
  - **Load Switching – utility & customer**
    - **Motors, Large Loads, Faults, Fuse Operation**
  - **Source Switching**
    - **Smart Grid, Gensets, PV, Wind Turbine**
- **Internally generated surges: ≈70%**
- **Externally generated surges: ≈30%**

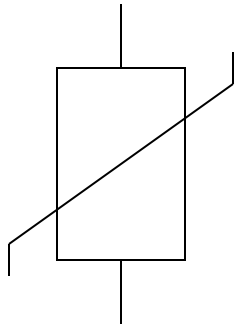
In outdoor environment, this ratio probably reverses

Causes of Surges

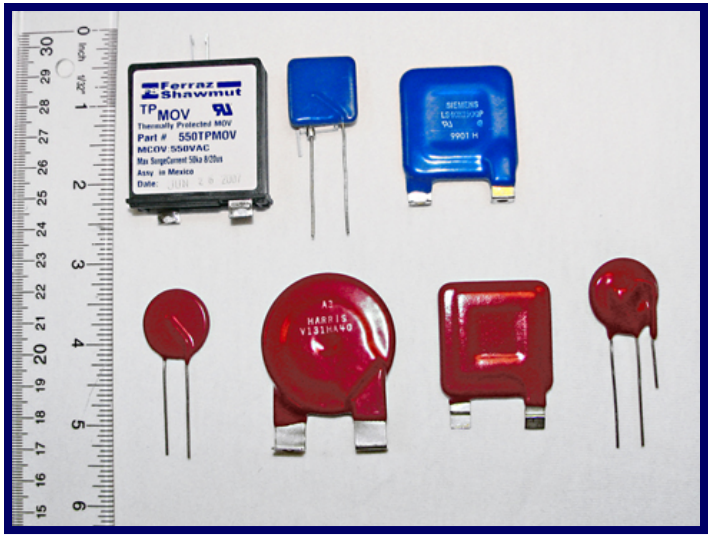


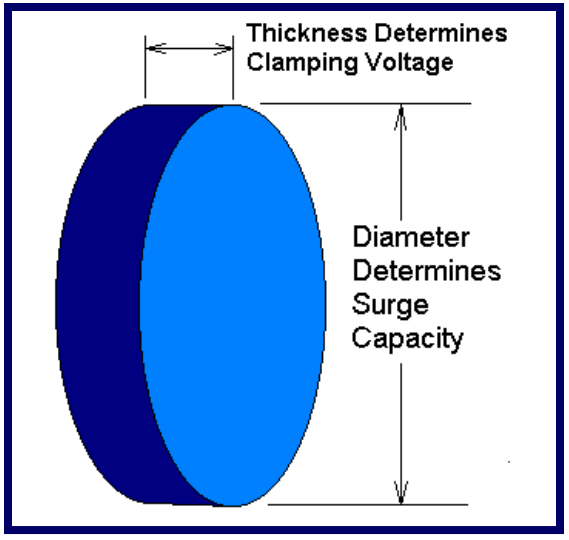
MOV - Metal Oxide Varistor

- Varistor - variable resistor
- Semiconductor; generally zinc oxide
- Connects parallel to load (not series)
- Thickness determines clamping voltage
- Diameter determines current capacity



MOV symbol





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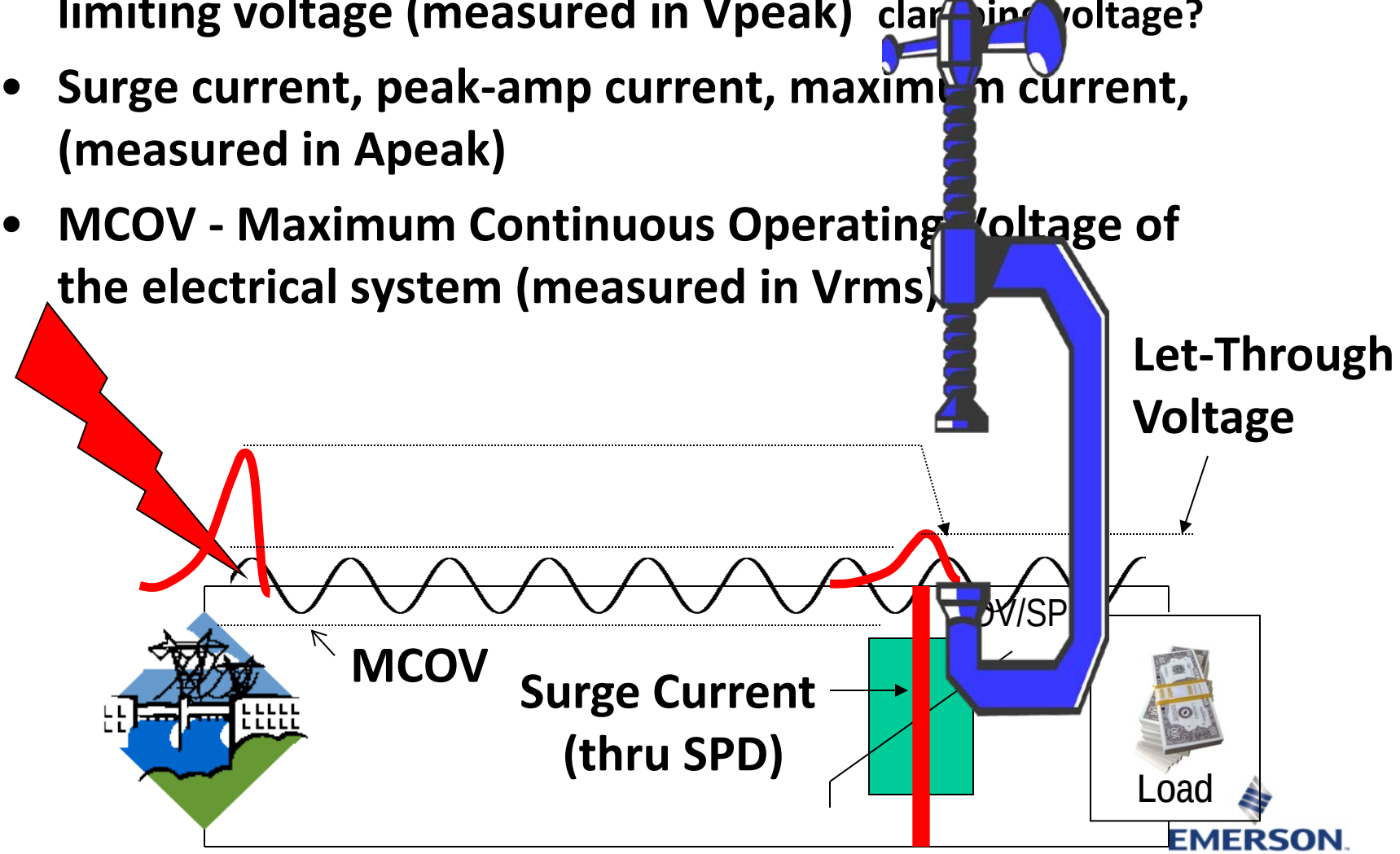
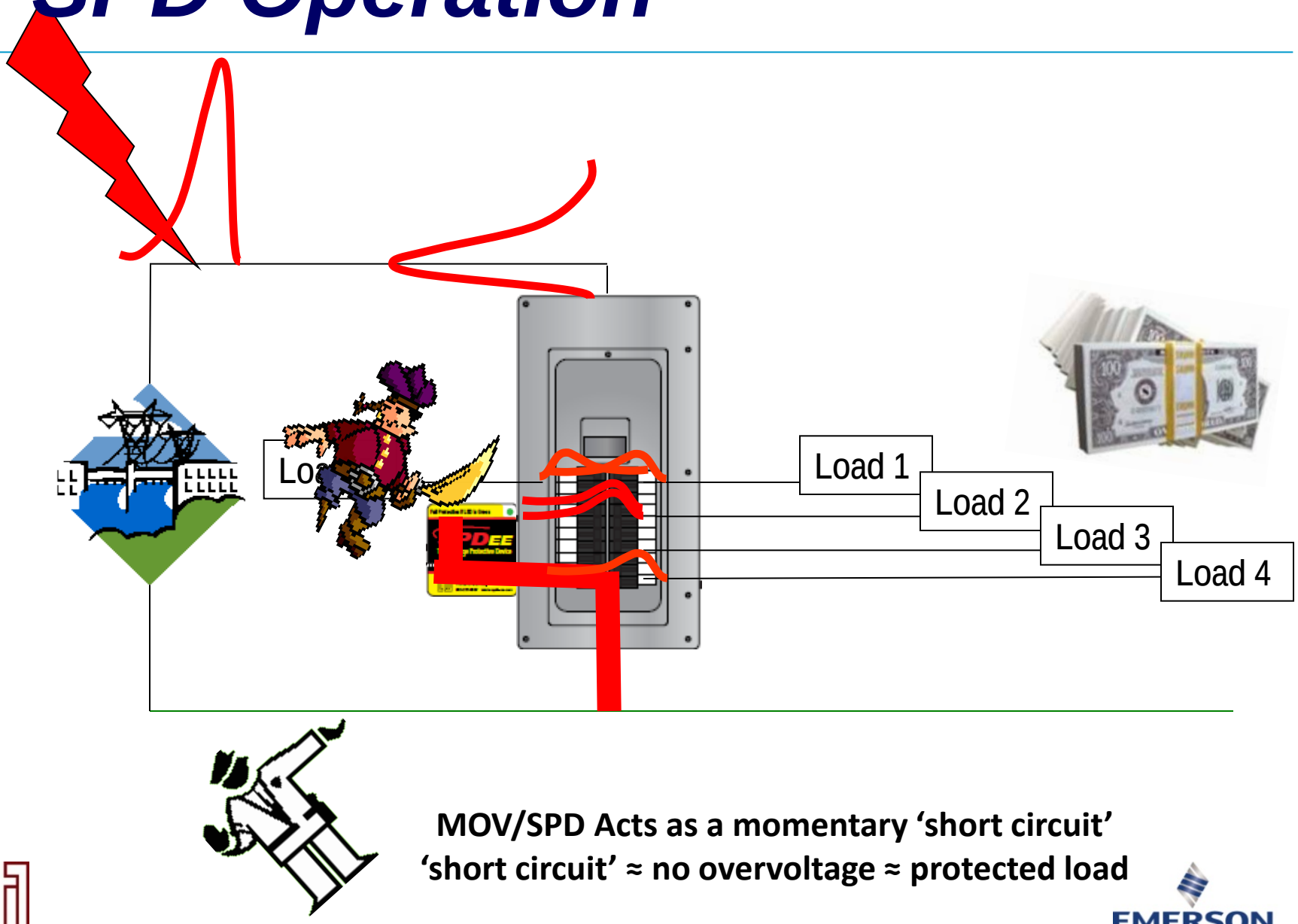
SPD/TVSS Terminology

- Let-through voltage, suppressed voltage, measured limiting voltage (measured in Vpeak) clamping voltage?
- Surge current, peak-amp current, maximum current, (measured in Apeak)
- MCOV - Maximum Continuous Operating Voltage of the electrical system (measured in Vrms)

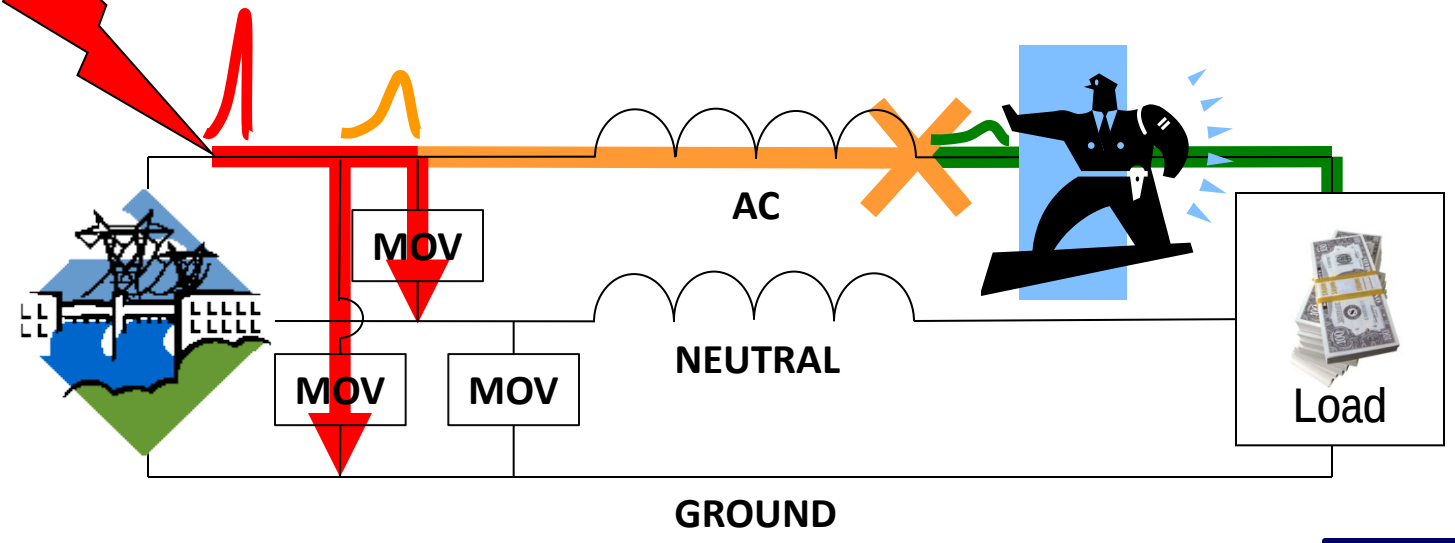


SPD Operation



MOV/SPD Acts as a momentary 'short circuit'
'short circuit' ≈ no overvoltage ≈ protected load

Basic Suppressor Layouts: Series



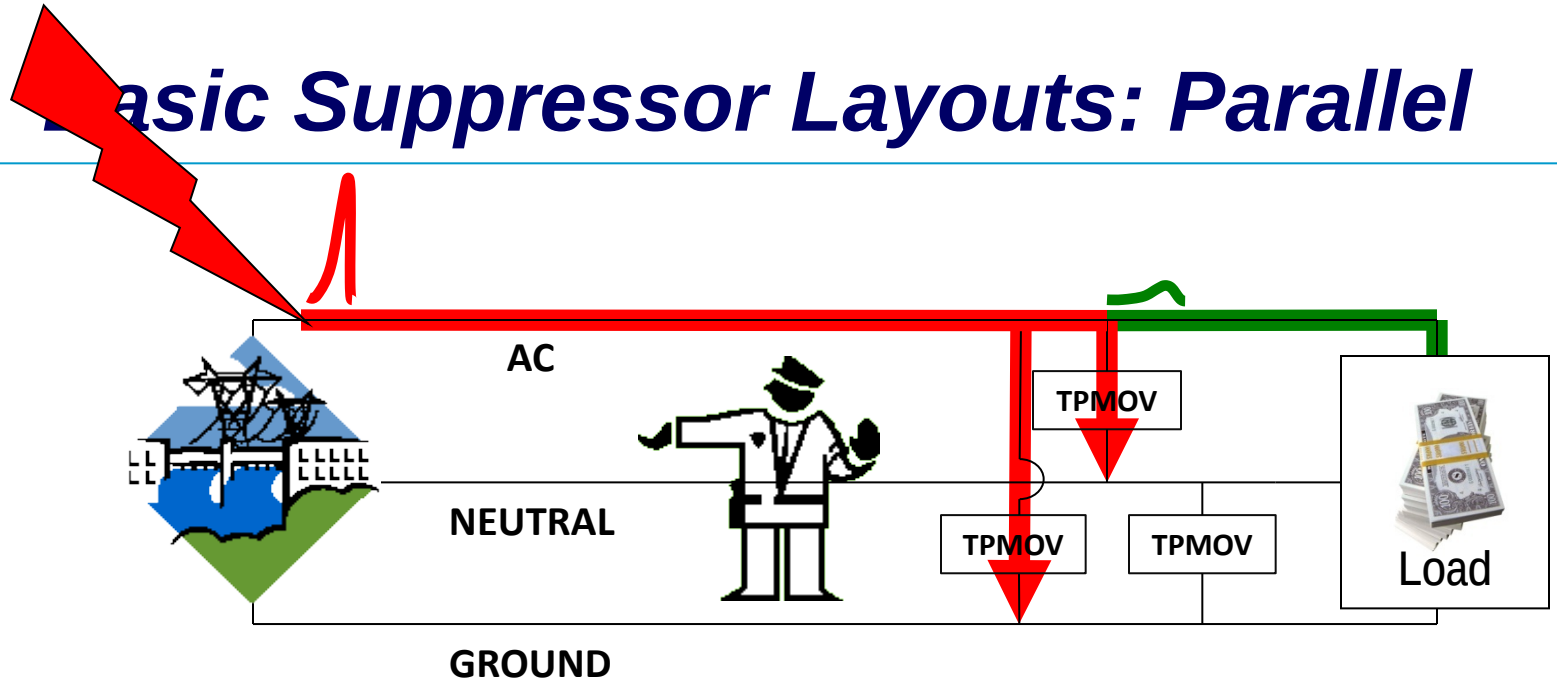
Advantages

- Inductive Filter - denies the instantaneous change in current, prohibiting the propagation of transients
- MOV + Filter = Improves SPD Let Through Voltage

Concerns

- Current limitations
- Not Bi-directional
- Potential loss of Power/Signal upon failure
- Servicing requires de-energizing system

Basic Suppressor Layouts: Parallel



Advantages

- Advanced Suppression Componentry - TPMOV
- Bi-directional Operation
- Can be serviced without de-energizing entire system

Concerns

- Lead Lengths effect performance
- Higher Let Through Voltages compared to Series Filters

Can Anything Go Wrong?

(Good thing that will never happen to me…)

SPD/MOV Failures

- **Industry Issues – Lot of UL & NEC action**
- **MOV is an expendable element - will protect or die trying**
- **Failures caused by *Sustained* Overvoltage - TOV**
  - **Can be as few as 2-3 cycles**

Sequence: MOV protects, fails, fails short, follow-on fault current causes MOV to catastrophically overheat

Typical causes:

- **Loss of neutral (X0 not bonded to ground)**
- **Incorrect installation**
  - **120V SPD on 277V system**
  - **Cross Phase with N or G**
- **Improper application**
  - **Ungrounded or impedance ground**
- **Genset or transfer switch related**

Typical Sequence of MOV Failure

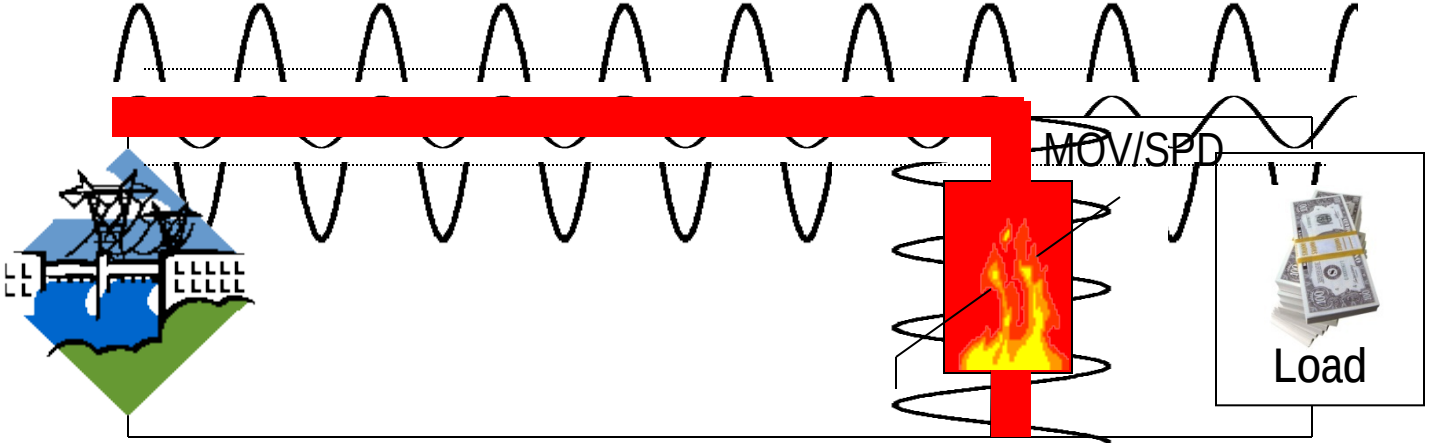
System level *Sustained Overvoltage* – TOV

Voltage exceeds MCOV – as little as 2-3 cycles

MOV attempts to protect

MOV fails towards short circuit

Follow-on/fault current causes MOV to catastrophically overheat



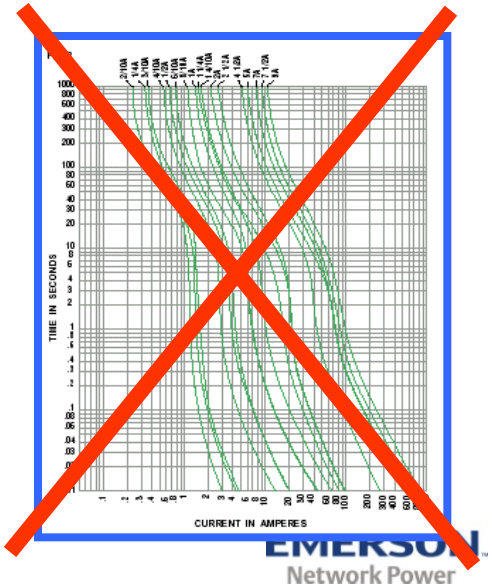
MOV Failure

- MOVs are *Variable* Resistors
- MOVs fail *toward* short, but not necessarily *hard* short
- Failed MOV impedance can vary from ≈200Ω - 0Ω
  - Depends on how & how hard MOV failed
  - 120V / 100Ω = 1.2A
  - 277V / 100Ω = 2.8A
  - 120V / 10Ω = 12A
  - 277V / 10Ω = 28A
  - 120V / 1Ω = 120A
  - 277V / 1Ω = 277A

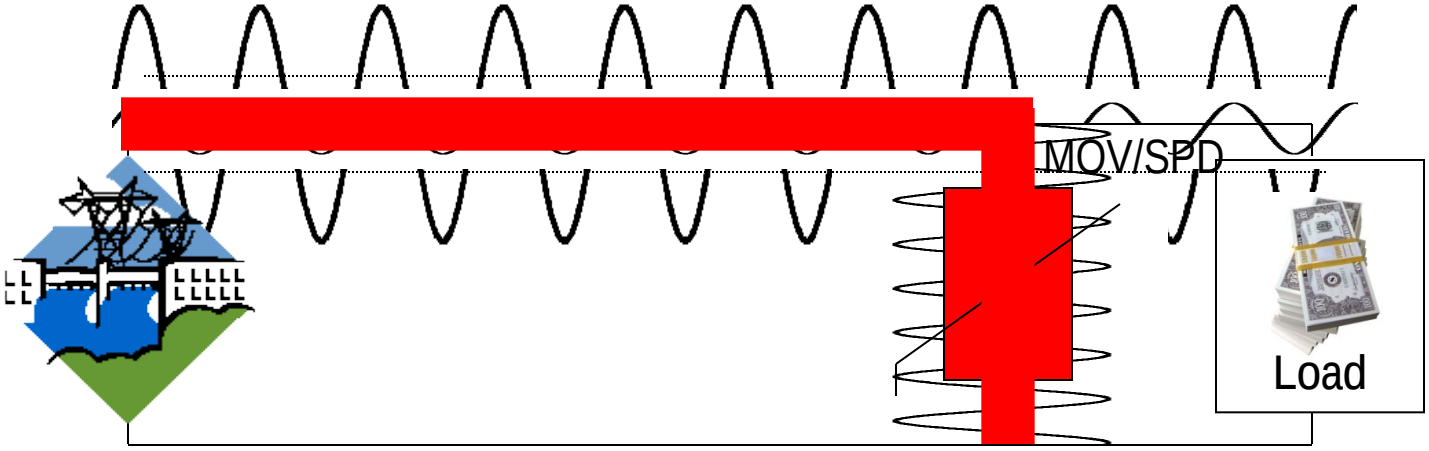
When would 30A overcurrent protection open?

277V x 28A = 7756W

- No MOV clearing curves
- Safety determined by factory testing, not calculations – many variables
- Not realistic to field-determine SPD overcurrent or thermal protection



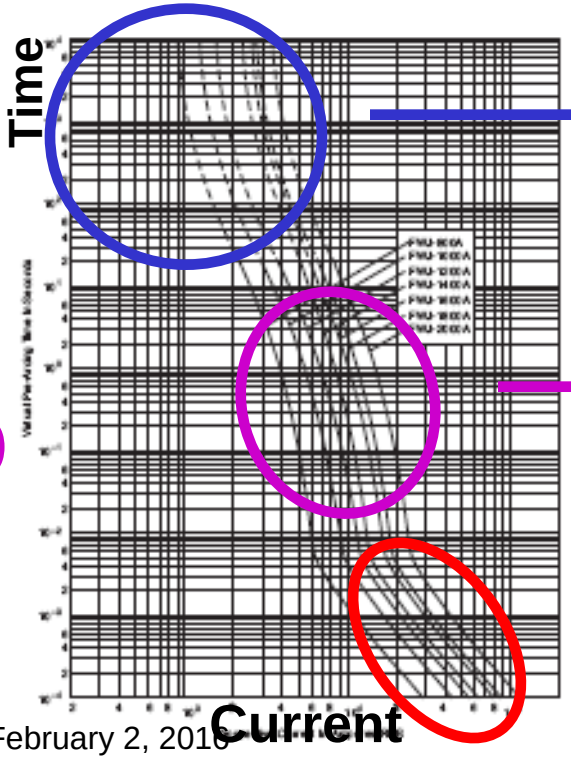
MOV Failure Intensity Increases With The Amount of Fault Current Drawn by the MOV



'Lower' Fault Currents (0-20A)

'Intermediate' Fault Currents (20-1000A)

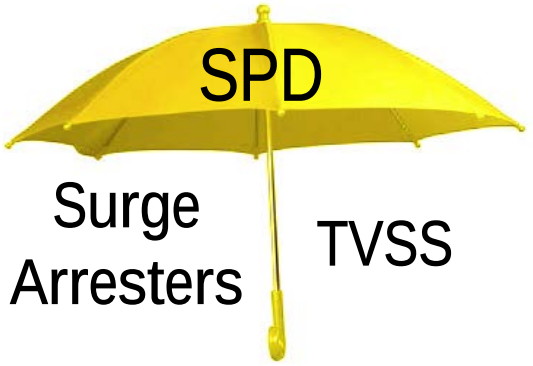
'Higher' Fault Currents (>1000A)



Safety, UL 1449-4 & NEC

SPDs/TVSS arguably the most regulated electrical product category in the 2000's

- UL 1449-2 (Aug 1998)
- 2002 NEC Article 285
- 2005 NEC Article 285
- UL 1449-2.5 (Feb 2007)
- 2008 NEC Article 285
- UL 1449-3 (Sept 2009)
- 2011 NEC Article 285
- UL 1449-4 (March 2015)



Safety evolved quickly as the body of knowledge grew

- **UL 1449 Plays Huge Role in Surge Industry**
- **Much More Than a Safety Standard**
- **Perform Multiple Performance Tests**
- **UL uses for internal UL 96A Lightning Protection Master Label Eval**

UL 1449 Third Edition

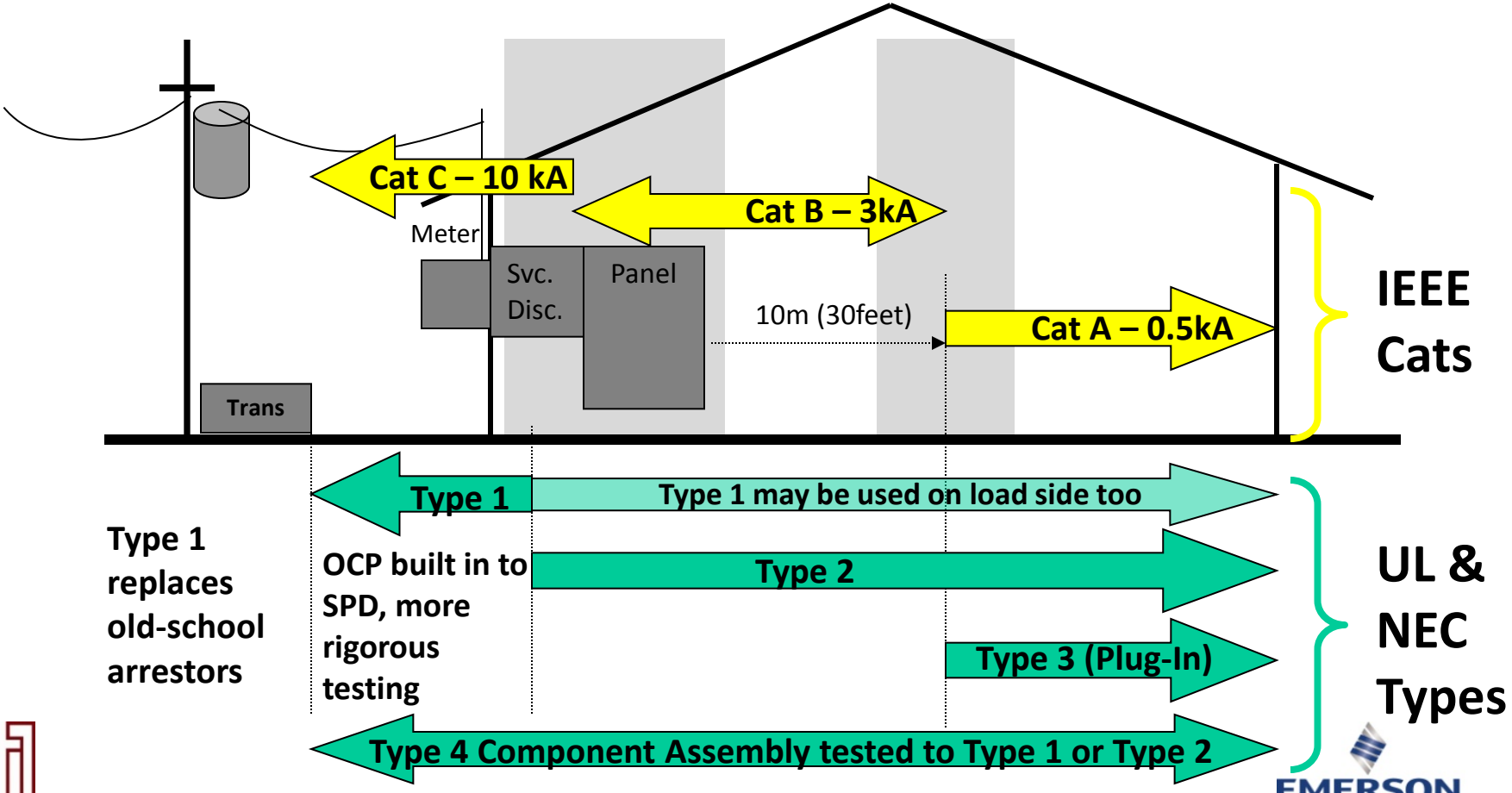
Combined TVSS & Surge Arrestors into *Surge Protective Devices (SPDs)*
Sept, 2009

- **New SPD Types: Types 1, 2, 3, 4 (& 5)**
- **New Voltage Protection Ratings (VPRs) replace old-style Suppressed Voltage Ratings (SVRs)**
- **New I nominal ratings**
- **Bid Specifications become Obsolete as product evaluation & ratings change**
  (Expensive big deal to manufacturers)

SPD Types

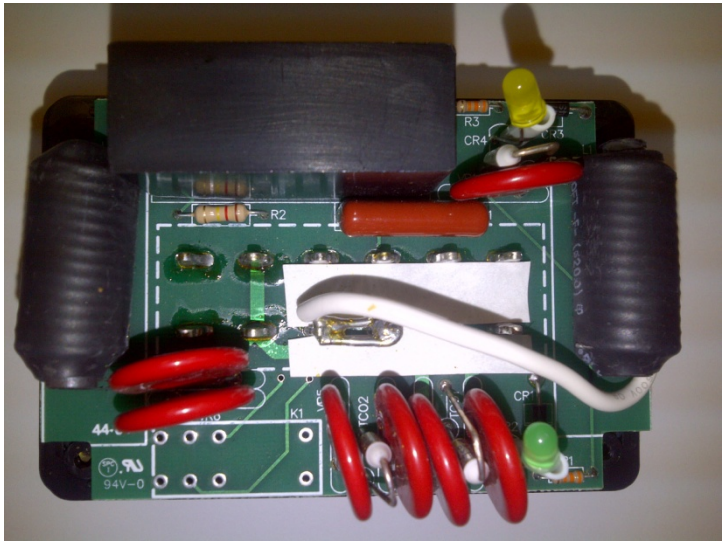
SPD Types: Types 1, 2, 3, 4 & 5

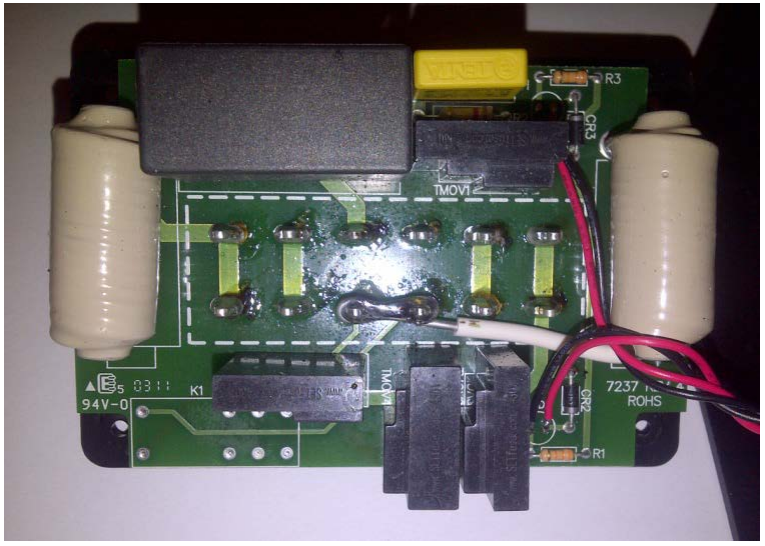
Based on SPD Location within electrical distribution system
(also coincides with ANSI/IEEE C62.41.2-2002 Categories C, B & A



Thermally Protected MOV's

TMOV





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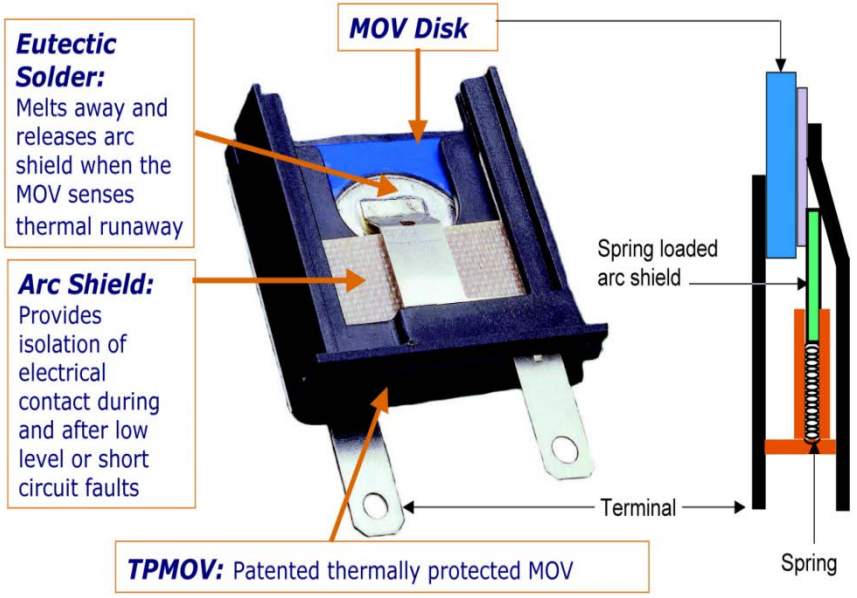
TPMOV

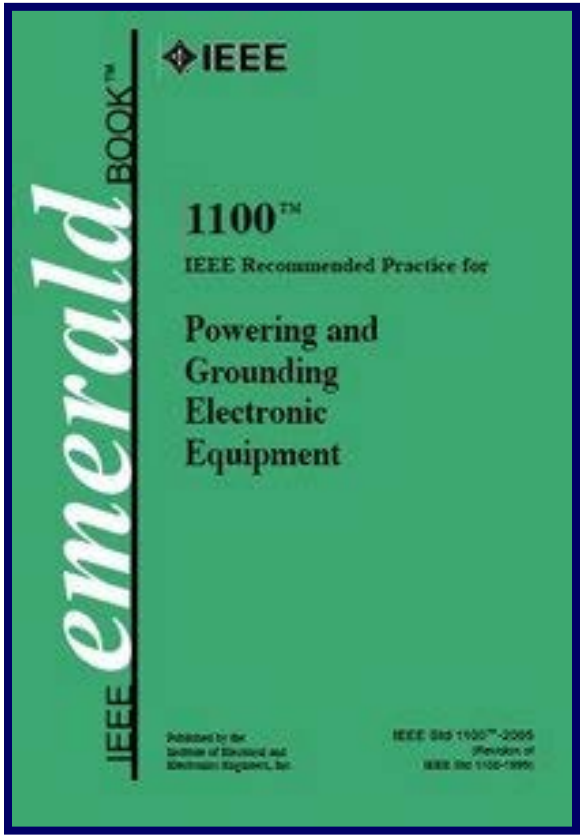
- Popular in SPD industry
- Large 34mm sq. MOV
- TPMOV Optimizes Thermal Protection to double-function as Overcurrent Protection
- Each MOV is individually fused
- Robotized assembly minimizes tolerances between fuses, MOVs, and thermal disconnectors (more consistent)
- TAC switch allows for individual monitoring of each MOV



II) Applying/Installing AC SPDs

- ITS/DOT Surge Environment
- Modes of Protection
- Inductance and Surges
- Installing AC SPDs

IEEE Emerald Book – Standard 1100 Cascade Protection



Section 7.2.4

"…Effective surge protection requires the coordinated use of large-capacity current diverting devices at the service entrance followed by progressively lower voltage-clamping devices applied strategically throughout the power system"

Section 8.6.3

"Facilities housing electronic load equipment of ANY type should have service entrances equipped with effective lightning protection in the form of listed Category C SPD's…"

Section 8.6.4

"...it is recommended that additional surge protective devices….be applied to downstream electrical switchboards and panelboards…"

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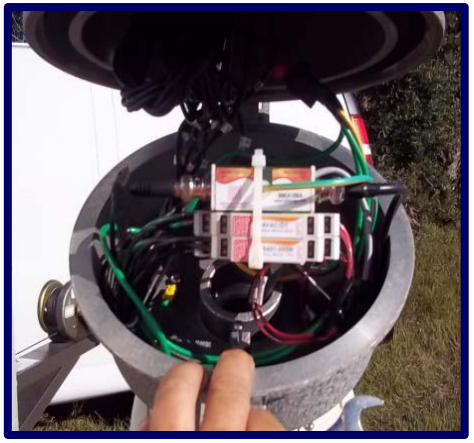
IEEE Emerald Book – Standard 1100
Data, Exterior Loads & Cascade Protection

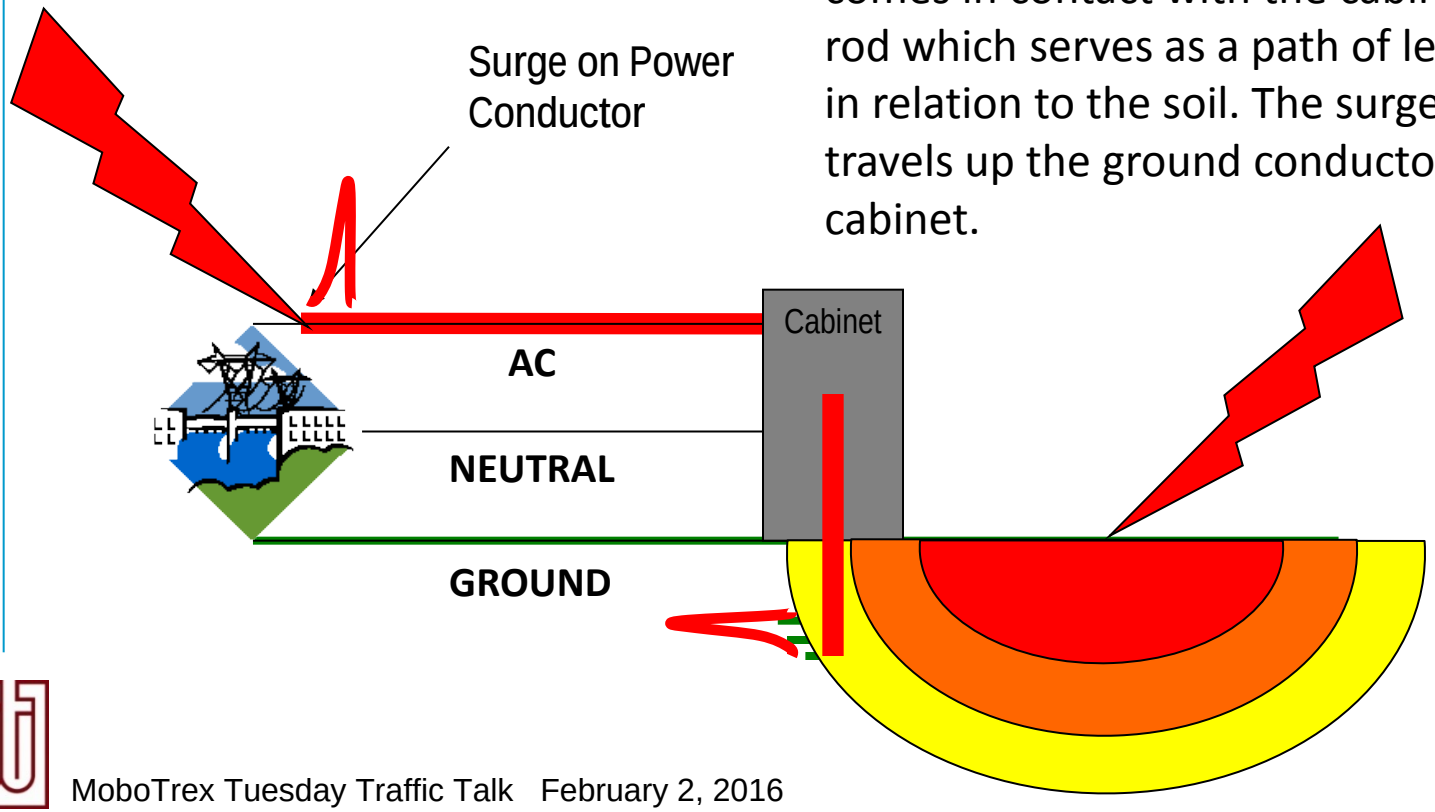


Surges in DOT Environments

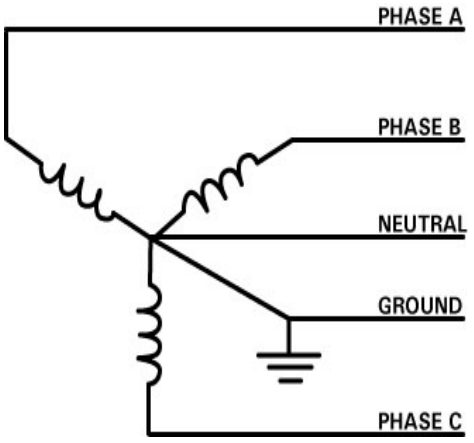
Transient overvoltages are not limited to power conductors

Surge on Ground Conductor

With a nearby lightning strike to earth, the surge current radiates out within the soil and comes in contact with the cabinet ground rod which serves as a path of least resistance in relation to the soil. The surge current travels up the ground conductor and into the cabinet.



Modes of Protection



Different ways to configure protection within SPDs

MOVs equalize voltage across MOV

Various ways to connect MOVs

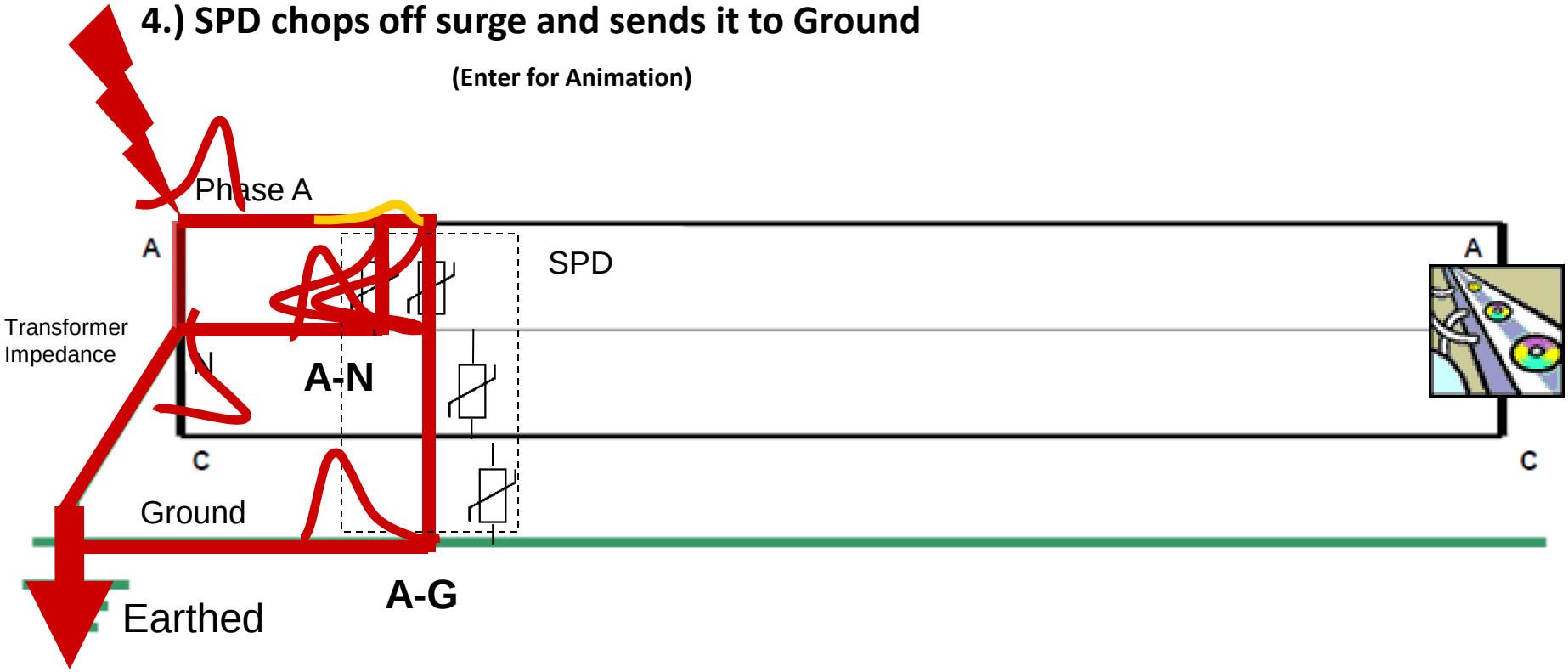
- **L-N**
- **L-G**
- **N-G**
- **L-L**

Modes of Protection: Service

Scenario Assumes:

1.) Surge is From Outside
2.) SPD near Service Entrance or Separately Derived System
3.) Propagation, Return Paths and Ground are Ideal
4.) SPD chops off surge and sends it to Ground

(Enter for Animation)



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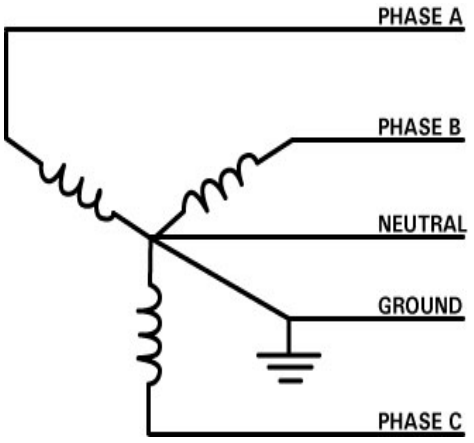
Modes of Protection: Different Modes Matter

At Service or Separately Derived System, SPDs equipped with only L-N protection are appropriate

- **Why: N-G are bonded, making N-G meaningless and L-G redundant to L-N**

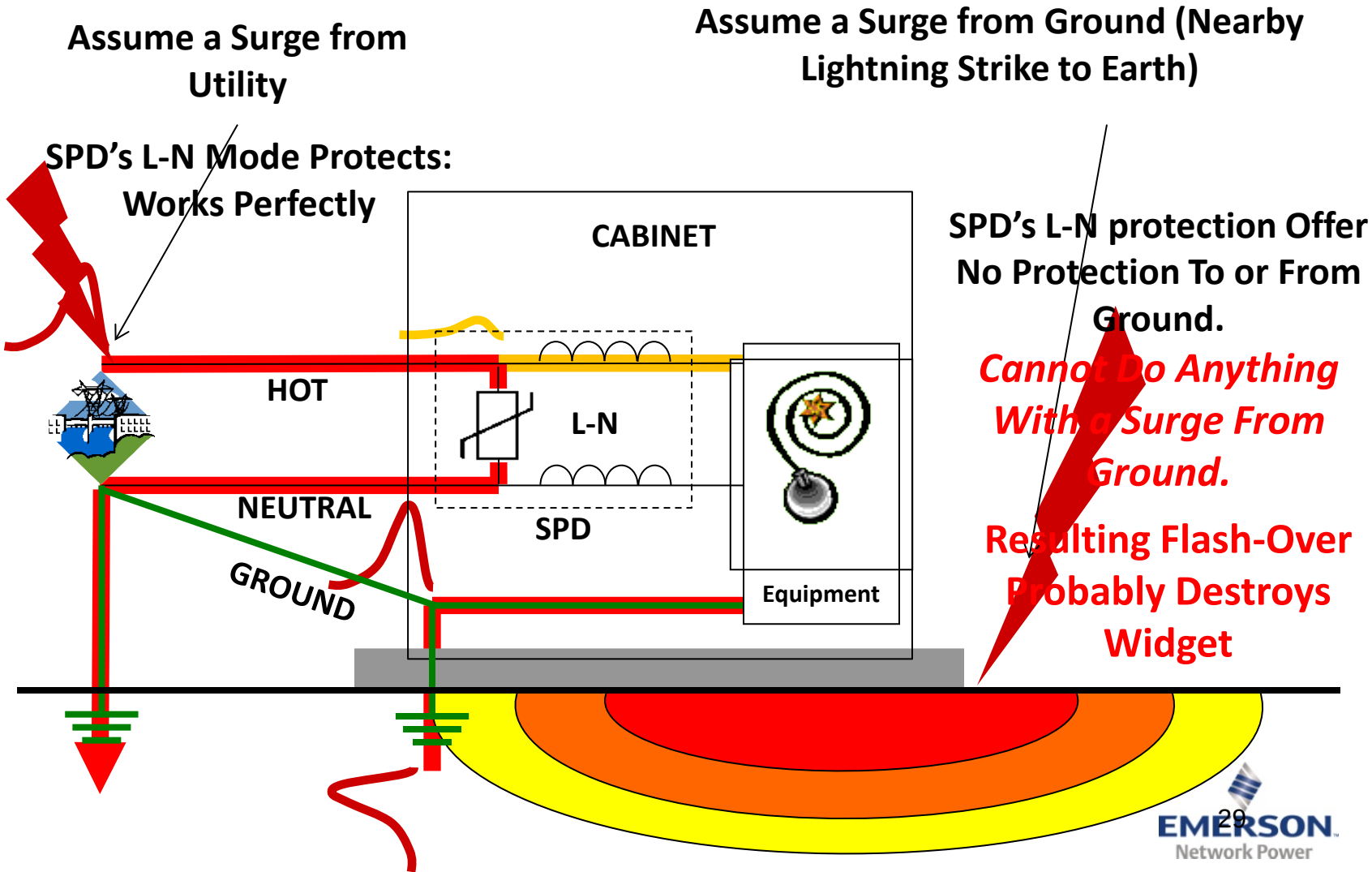


Downstream, adding L-G, N-G & L-L make sense

- **Why: They are farther away from N-G bond making each mode more separate, and/or equipment is more prone to 'backdoor' surge, GPR, etc. (more shortly)**

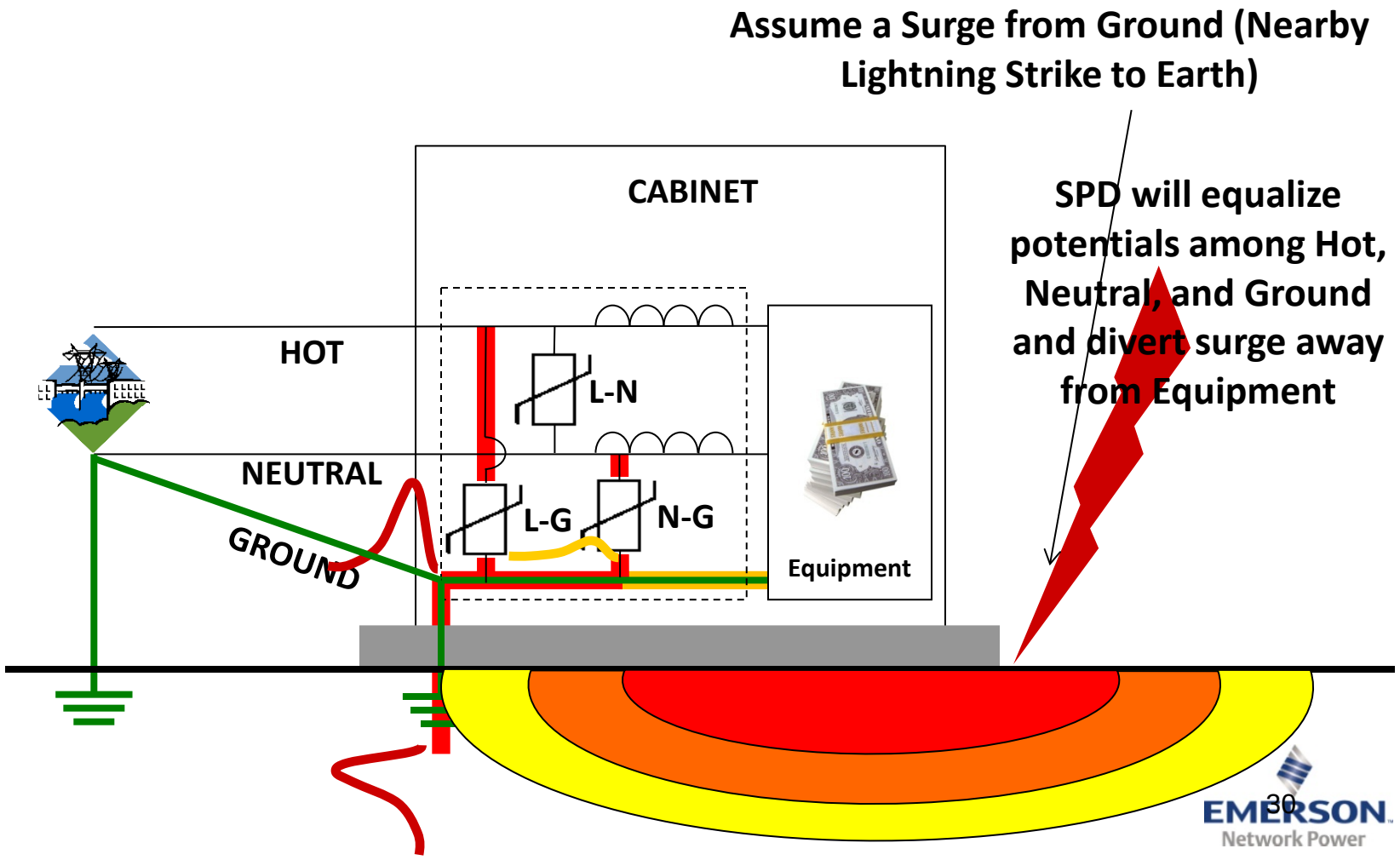
Visualization of How Different Modes of Protection Matter

SPD installed within Cabinet with only L-N protection



Visualization of How Different Modes of Protection Matter

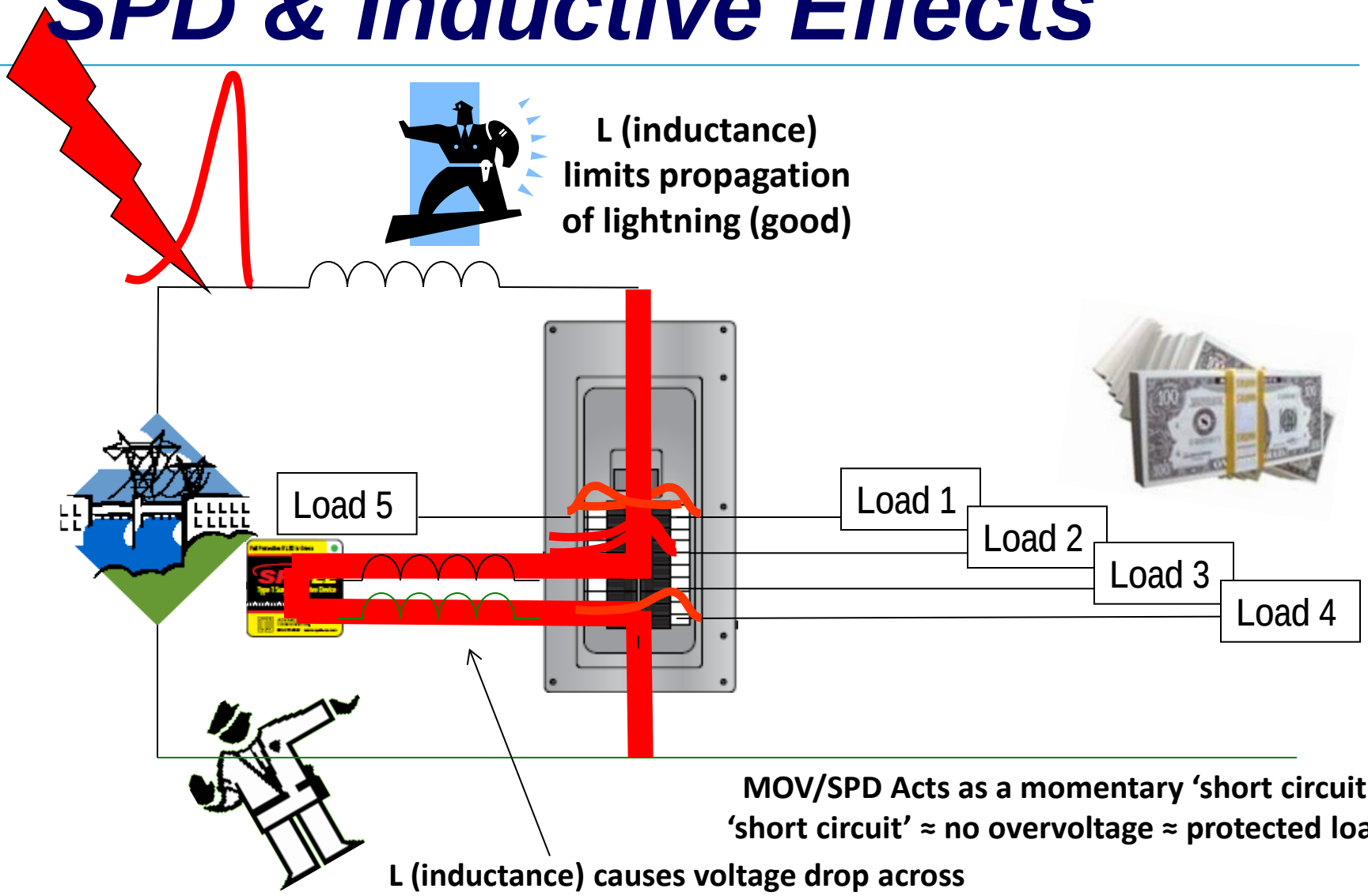
SPD installed within Cabinet with L-N, L-G, & N-G protection



Inductance & Surges

- *Inductance: Electrical Property Whereby Instantaneous Current Changes Are Opposed*
- Wire's inductance at surge frequencies is good and bad
- Inductance of wire is about 0.75µH/m (very low)
- Good because large surges cannot propagate far
  - Lightning generally effects very localized area, not large areas
- Bad because of effects on SPD installation
  - Long leads hurt SPD performance – Need Short SPD Leads

SPD & Inductive Effects



Industry typically states: Each foot of conductor adds ≈100 - 170V to clamping voltage

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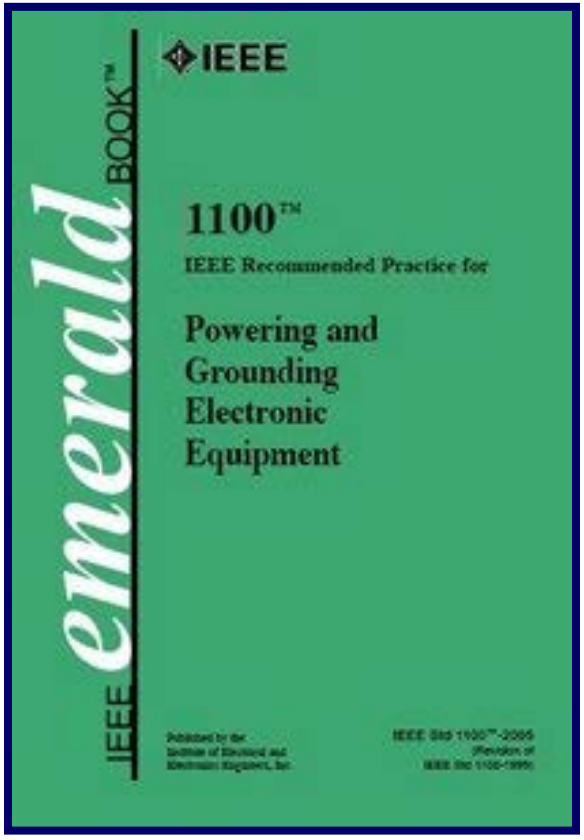
IEEE Emerald Book – Standard 1100 Data & Exterior Loads



Section 8.6.6

"Electronic equipment containing both ac power and data cabling should be properly protected via surge protective devices on both the ac power and data cables."

Section 8.6.8

"All exterior mechanical systems (e.g., cooling towers, fans, blowers, compressors, pumps, and motors) should be considered as targets for a lightning strike. It is recommended practice to individually provide surge protection on both the power input and data circuits connected to all such equipment."

VII.) Emerson/APT Products

- Why Emerson APT SPDs
- AC Power Entry SPDs
- Data/Communications SPDs
- BNC Coax SPDs

AC Power - APT

- UL 1449 Listed and Labeled
- Type 1 Device
- 20kA I-nominal
- 100kA - 200kA Short Circuit Current Ratings (SCCR)
- Low UL 1449 Voltage Protection Ratings (VPRs)
- Large 34mm square TPMOVs
- Surge Current Ratings from 50kA up to 1000kA
- Standard 7 modes of protection
- Full selection of options: Dry Contacts, etc.
- 10 year warranty

AC Power – Emerson (Edco) SHA-1235FS

- **UL 1449 4th Edition Recognized**
  - **First UL Listed/Recognized series wired SPD/Filter specifically designed for traffic controller cabinets**
  - **Complies with NEC Article 285.5 (SPDs shall be a listed device)**
- **Type 4 Device**
- **Maximum Continuous Current Rating: 30A**
- **I-nominal Rating: 20kA**
- **Short Circuit Current Rating (SCCR): 65kA**
- **Voltage Protection Rating (VPRs): 500V**
- **Thermally Protected MOVs - PTMOVs**
- **Surge Current Rating: 50kA/mode**
- **Modes of protection: L-N, L-G, & N-G**
- **LED & Dry Contacts**

AC Power – Emerson (Edco)

- Series SPD (common in traffic cabinets)

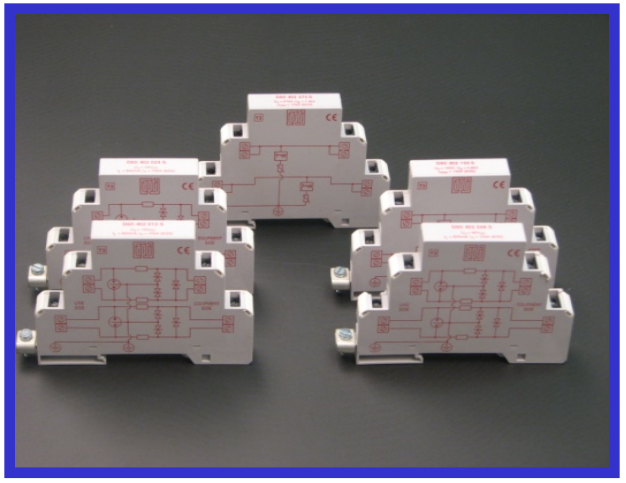
- DRS (DIN Rail Series)
  - Nominal operating parameters
    - 120 vac, 60 Hz, 2W+G
  - 40kA

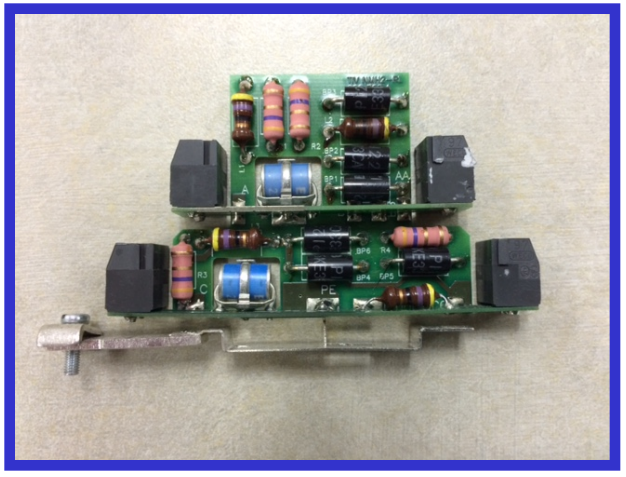
- RM (Rack Mount Series)
  - Nominal operating parameters
    - 120 Vac, 60 Hz, 2W+G, 15 & 20 A
  - 40kA

Data/Communication Din Rail Products

- Double density packaging providing protection for up to 4 conductors per module
- Available voltages: 5VDC, 12VDC, 24VDC, 48VDC, 60VDC
- UL Listed, IEC & CE Compliant
- Maximum discharge current (Imax) of 15kA
- Bandwidth Frequency up to 35MHz
- Applications
  - RS-232
  - RS-423
  - RS-422
  - RS-485
  - Modbus

– 5 year warranty





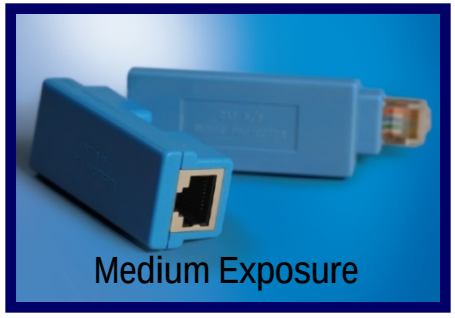
BNC Coax SPDs

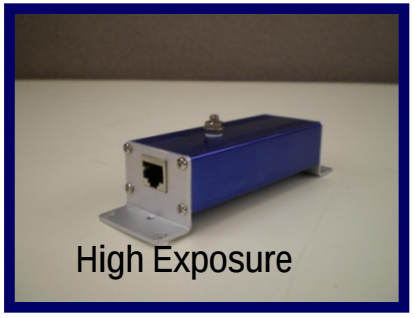
- **BNCA10kA intended for Severe Service BNC coaxial connections for video equipment**
  - **3 Stage Series Hybrid Design**
  - **Includes separate protection modes for Pin to Shield and Shield to Ground preventing SPD ground loops**
  - **Mounts via DIN Rail**
  - **5 year warranty**
- **BNCB5kA Primary Protector Kit for Coaxial Comms lines**
  - **Includes SAVFFF UL 497C Listed Coaxial SPD and 2 F to BNC connectors**
  - **Protects from lightning and power induced overvoltage surges**
  - **Good for camera lowering devices**
  - **5 year warranty**

TS2 & POE

- TS2 Port 1 SDLC
  - RS 485
  - SRS-BIU-15 (15-pin)
  - % VDC
  - <0.1 dB at 20 MHz
  - SAD Technology

- CAT6-5POE
  - 60 Volts, 300 mA applications
  - <.1 db Insertion loss
  - 10baseT, 100baseT, 1000baseT
  - 300 watts peak surge current


Medium Exposure


High Exposure

- CAT6-16/48R POE
  - 16-48 Channel
  - 10baseT, 100baseT, 1000baseT
  - 10kA peak surge current
  - L to G for EMP & EMI Finish

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Broadband & Lighting

- **120 VAC Broadband Over Power**
  - **120VAC**
  - **18kA /Mode**
  - **All Modes**
  - **<0.1 dB**
  - **LED Monitoring**

- **Highway Lighting**
  - **120, 240, 480 VAC**
  - **36kA Peak Surge Protection**
  - **LED Monitoring**

EMERSON
Network Power

End of the Seminar,
Beginning of Ongoing Support

APT is Always Here to Help:
(800) 237-4567

- **Specification Assistance**
- **Training**
- **Sounding Board for issues**
- **Competitive crosses or analysis**
- **General Help**
- **On-Line webinar services**
- **Forensic Testing & Analysis of failed SPDs**
- **Etc.**

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MOBILITY & TRAFFIC EXPERTS

2016

Advancements in Surge Protection

Outline:

- Basics
  - Transient Overvoltages
  - How an SPD works
  - Industry Standards
- Applying/Installing AC Voltage SPDs
- Emerson/APT Products

February 2, 2016