Major Changes to Surge Protection Standards

March 16, 2009
Agenda

- Review of existing terminology
- Surge protection standards with recent changes and updates
- Review of major changes to UL 1449
Terminology review

- TVSS – Transient Voltage Surge Suppressor
- Secondary Surge Arrester
- Lightning Arrester
- Single Impulse Testing Surge Current Test
- IEEE C62.41 Waveforms
  - A1, A2, A3
  - B1, B2, B3
  - C1, C2, C3
- SVR – suppressed voltage rating
Changes to standard and terminology

• Numerous changes to a number of surge protection documents have been made:
  • UL 1449 – mandatory compliance 9/29/09
  • NEMA LS-1 – to be published in 2009
  • IEEE C62.41 - 2002
  • NEC 2008
  • UL 96A – Master Lightning Certificate
• Many terms used in the past are now obsolete or will become obsolete in the near future
Timeline – UL 1449 – Safety Standard

- 3rd Edition Published Sept 29, 2006
- 3rd Edition Compliance Mandatory Feb 9, 2007
- First 3rd Edition products listed by UL January 2008
- Overlap period – both 2nd and 3rd Edition products are available and can be manufactured
- Mandatory UL 1449 3rd Edition Compliance. TVSS and Secondary Surge Arrestors can no longer be manufactured Sept 29, 2009

Timeline:
- 2007
- 2008
- 2009
Three key changes to UL 1449 3rd Edition

- Terminology
  - SPD Types
- Voltage Protection Rating
- Nominal Discharge Current
Terminology and how to specify – 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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**EATON | Cutler-Hammer**

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
UL 1449 3rd Edition - Terminology

- The SPD type refers to the location where the SPD can be used
  - Type 1 – before the service disconnect overcurrent device
  - Type 2 – after service disconnect overcurrent device
  - Type 3 – a minimum 10m (30 ft) of conductor between service disconnect overcurrent device and SPD
In relation to old terminology, i.e. pre-September 2009, the following general comparisons can be made:

- Type 1 – secondary surge arrester
- Type 2 – Transient Voltage Surge Suppressor
- Type 3 – plug-in surge strips, surge receptacles
Current acceptable locations for TVSS and Secondary Surge Arrestors (2005 and 2008 NEC)

Secondary Surge Arrestor
Before service disconnect

TVSS (Arrestor permitted)
After service disconnect

TVSS (Arrestor permitted)
Locations for SPD Types

**Type 1**
Before service disconnect

**Type 2 (Type 1 permitted)**
After service disconnect

**Type 3 (Type 1 and 2 permitted)**
Minimum of 30 feet of conductor between service disconnect and SPD
UL category codes for low voltage (1000V and below) – Valid until September 2009

- **UL category code XUHT**
  - UL 1449 2\(^{nd}\) Edition
  - Transient Voltage Surge Suppressors
  - NEC Article 285 (2005 and 2008 NEC)

- **UL category code OWHX**
  - ANSI/IEEE C62.11
  - Secondary surge arrestor
  - NEC Article 280 (2005 NEC only)
Surge standards for low voltage (1000V and below) – Valid today and after September 2009

- Category code VZCA
  - UL 1449 3\textsuperscript{rd} Edition
  - Surge Protective Devices
  - NEC Article 285 (2008 NEC only)
Category OWHX

- Low Voltage (<1000V) UL Category OWHX devices can no longer be manufactured after September 29, 2009
- There are currently availability issues with OWHX surge arrestors from many manufacturers
How to determine if an SPD is listed

- Go to ul.com and click on the “certifications” link
- Type in the category code
  - XUHT – TVSS
    - 165 results as of 3/16/09
  - OWHX – Surge Arrester
    - 34 results as of 3/16/09
- VZCA – SPD
  - 32 results as of 3/16/09
National Electrical Code implications

• **Article 280 – Surge Arresters, over 1kV**
  • Per 2008 NEC Article 280 now only applies to voltages over 1kV.
    • 2005 NEC Article 280 applied to all voltages

• **Article 285 – Surge-Protective Devices (SPDs) 1kV or less**
  • Per 2008 NEC Article 285 now applies to all surge devices less than 1kV including, surge arresters, TVSS, Type 1, 2 and 3 SPDs
    • 2005 NEC Article 285 applied only to TVSS
Impact on Lightning Protection Systems

- UL 96A – Installation Requirements for Lightning Protection Systems
- UL 1449 2nd Edition TVSS can **NOT** be used to meet requirements of UL96A Master Lightning Protection Certificate unless specifically tested for Lightning Protection Systems
- UL 1449 3rd Edition Type 1 and Type 2 SPDS meet the requirements of UL 96A if properly rated
Terminology and how to specify – required marks

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

![EATON Cutler-Hammer Surge Protective Device](image)

**Eaton Cutler-Hammer**

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- Contains no servicable parts.
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- 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
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”
Terminology and how to specify – required marks

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

**Model #: CVX100-208Y**
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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
Applicable current ratings for SPDs

• Peak surge current rating
  • Measure of life or longevity expectations of SPD
  • Also referred to as “single impulse rating”, “maximum current rating” or “life rating”

• Nominal discharge current rating
  • Measure of ruggedness or durability of SPD in the electrical system

• Short circuit current rating SCCR
  • Measure of how much current the electrical utility can supply during a fault condition
Peak surge current rating

- This is how virtually all manufacturers rate or size their SPDs
- 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!!!
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 rating curve for 8kA MOV

- 1 hit at 8000 Amps
- 2 hits at 5000 Amps
- 10 hits at 2800 Amps
- 100 hits at 1200 Amps
- 1000 hits at 520 Amps
- 10,000 hits at 220 Amps
- 100,000 hits at 120 Amps
- 1,000,000 hits at 60 Amps
- Unlimited hits at 30 Amps

Standard 8x20µs wave
How much life do you need?

- On average electrical equipment has a design life of 30 years.
- Experience has shown that 250kA – 300kA SPD at a service entrance can last the life of the electrical equipment in a high surge or high lightning area.
- At a sub panel 120kA – 160kA provides good protection and life.
- Point of use SPDs rated at 80kA – 100kA perform well.
kA per Mode – kA per Phase

- A “mode” is a potential path for a surge to be diverted to
- Typical modes:
  - L-N, L-G, N-G
- The number of modes depends on the configuration of the electrical system
  - 1Φ, 3 Φ, WYE, DELTA, etc
- NEMA standard nomenclature requires manufacturers to state their SPD units using kA per mode
- Many manufacturers also state their kA per phase
  - Purpose of listing kA per phase is to express the maximum amount of surge current a SPD can shunt to ground during a surge event on one phase
3 Phase – 4 Wire System

N-G Bond @ Service Entrance

N-G Bond @ Service Entrance
3 Phase – 4 Wire System

200kA Surge on Phase A

Surge Current splits evenly between L-N and L-G MOV’s due to MOV matching and same MCOV

100kA per mode = 200kA per phase
Nominal Discharge Current - $I_n$

- New rating introduced with UL 1449 3rd Edition
- Measure of the “ruggedness” or “robustness” of an SPD
- Measure of how the SPD performs when installed and subjected to operating scenarios closer to real life situations
- “Stress test” – SPD is subjected to 15 surges, one minute apart, with rated voltage applied between surges
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 they want to test with:
  - 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)
- Measured let through voltage for a 6000V 3000A surge is recorded
- SPD is subjected to 15 surges at chosen current one minute apart with rated voltage applied between surges
- Measured let through voltage for a 6000V and 3000A surge is recorded again – let through voltage must not deviate more than 10% from original voltage
\( I_n \) compared to other ratings

- **Nominal Discharge Current Ratings – UL 1449**
  - Type 1 – 10kA or 20kA
  - Type 2 – 3kA, 5kA, 10kA or 20kA

- **NFPA 780 (Lightning Protection Systems)** requires 20kA nominal discharge current

- **IEEE C62.41** – 200Amps to 10,000Amps
## IEEE C62.41 Waveforms

### 100kHz Ring Wave

<table>
<thead>
<tr>
<th>Location Category</th>
<th>Peak Values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Voltage</td>
<td>Current</td>
</tr>
<tr>
<td>A</td>
<td>6kV</td>
<td>200A</td>
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<tr>
<td>B</td>
<td>6kV</td>
<td>500A</td>
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</table>

### Combination Wave

<table>
<thead>
<tr>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>Voltage</td>
<td>Current</td>
</tr>
<tr>
<td>A</td>
<td>6kV</td>
<td>500A</td>
</tr>
<tr>
<td>B</td>
<td>6kV</td>
<td>3000A</td>
</tr>
</tbody>
</table>

### Combination Wave

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<tr>
<td></td>
<td>Voltage</td>
<td>Current</td>
</tr>
<tr>
<td>C low</td>
<td>6kV</td>
<td>3kA</td>
</tr>
<tr>
<td>C high</td>
<td>10kV</td>
<td>10kA</td>
</tr>
</tbody>
</table>
Recommendation

• All things being equal, customers and specifiers should choose I_n of 20kA

• Energy = I^2*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 our recommendation is to choose the 20kA SPD
Short Circuit Current Rating

• 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

• Typical available short circuit currents are:
  • Residential – 5-10kA
  • Small commercial – 14-42kA
  • Large commercial/industrial – 42kA-65kA
  • Large industrial/utility/downtown in large cities – 100kA-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
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

• 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
System voltages and frequency

- It is very important to select the correct voltage configuration for the application
  - Wye or Delta? Single phase or three phase?
- Applying an SPD with too low of a voltage rating will result in SPD failure
- Applying an SPD with too high of a voltage rating will result in high let-through voltages, reduced protection and diagnostics failure
Terminology – required marks

- SPD Type
- NRTL listing mark
- Peak surge current per phase (not required)
- Short circuit current rating
- Nominal Discharge Current Rating
- System voltages
- System frequency
- Voltage Protection Rating
UL 1449 Voltage Protection Rating

- VPR is a rating published and marked on all UL 1449 listed SPDs
- Residual voltage for a 6000 V, 3000 A 8/20 µs surge waveform impulse
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
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.

<table>
<thead>
<tr>
<th>Measured Limiting Voltage</th>
<th>Voltage Protection Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>330 or less</td>
<td>330</td>
</tr>
<tr>
<td>331 - 400</td>
<td>400</td>
</tr>
<tr>
<td>401 - 500</td>
<td>500</td>
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<tr>
<td>501 - 600</td>
<td>600</td>
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<td>601 - 700</td>
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<td>701 - 800</td>
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<td>801 - 900</td>
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<td>1501 - 1800</td>
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<td>1801 - 2000</td>
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<tr>
<td>2501 - 3000</td>
<td>3000</td>
</tr>
<tr>
<td>3001 - 4000</td>
<td>4000</td>
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<tr>
<td>4001 - 5000</td>
<td>5000</td>
</tr>
<tr>
<td>5001 - 6000</td>
<td>6000</td>
</tr>
</tbody>
</table>
Typical VPR values

- Typical VPR values based on manufacturer’s data on UL.com
  - 120/240V system – 700V L-N
  - 277/480V system – 1200V L-N
- In other words, you could expect the residual let-through voltage to be 700V when an SPD is subjected to a 3000Amp impulse on the L-N mode
- VPR gives an indication of the quality of construction and expected performance
Voltage Protection Rating

• Voltage Protection Rating (3rd Edition) replaces Suppressed Voltage Rating (2nd Edition)

• Suppressed Voltage Rating – 2nd Edition
  • 6000 Volt 500 Amp 8x20µs

• Voltage Protection Rating – 3rd Edition
  • 6000 Volt 3000 Amp 8x20µs

• This results in higher Voltage Ratings
  • Higher current results in higher suppressed voltage
# VPR vs. SVR

<table>
<thead>
<tr>
<th>Typical SVRs</th>
<th>Typical VPRs for same device</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/208V Y</td>
<td>120/208V Y</td>
</tr>
<tr>
<td>- L-N = 400V</td>
<td>- L-N = 700V</td>
</tr>
<tr>
<td>- L-L = 700V</td>
<td>- L-L = 1500V</td>
</tr>
<tr>
<td>277/480V Y</td>
<td>277/480V Y</td>
</tr>
<tr>
<td>- L-N = 800V</td>
<td>- L-N = 1200V</td>
</tr>
<tr>
<td>- L-L = 1500V</td>
<td>- L-L = 2000V</td>
</tr>
</tbody>
</table>
Summary

• Many changes in key surge protection standards
  • UL 1449
  • NEMA LS-1
  • IEEE C62.41
  • National Electrical Code
• Major changes to UL 1449 are:
  • New terms – SPD types
  • New parameter -nominal discharge current rating
  • Changed measured limiting voltage test - VPR