SELECTION OF SURGE PROTECTION DEVICES

NOT IMPOSSIBLE
CONTENTS

This presentation will discuss and explain the key performance yardsticks that one can use, in making the appropriate selection of SPD’s.


These yardsticks can be used by specifying and switchboard engineers

These yardsticks are well defined and discussed by IEC61643 standards. There is mention of these in AS1768.
WHAT DO YOU MEAN WHEN YOU SAY 100kA Surge Diverter?
Let me Confuse You a BIT MORE in This Presentation
Purpose of a SPD

• Control the amplitude of Surges and Transients, which are very high in amplitude but short in durations.

• Typical Test Waveforms Discussed Later
Common Topologies

SHUNT
- Most Common
- Independent of Load Current
- May Use Multiple Tiers

SERIES
- For Sensitive Loads
- Sized for Load
- Lower dv/dt
Some Relevant Standards

- IEC 61643-1 : SPD Performance requirements and testing methods
- IEC 61643-12 : SPD Selection and application principles
- AS1768-2007: Lightning Protection
- IEC62305 – LP (Application of SPD’s)
- UL1449-Edition 3
- ANSI/IEEE C62.41
Key Selection Criteria

- Maximum Surge Current, Imax \textit{(IEC 61643-1) (AS/NZ1768)}
- Nominal Surge Current, In \textit{(IEC 61643-1) (AS/NZ1768)}
- Impulse Current, Iimp \textit{(IEC 61643-1)}
- Voltage Protection Level, Up \textit{(IEC 61643-1) (AS/NZ1768)}
- Maximum Continuous Operating Voltage, Uc \textit{(IEC61643-1) (UL1449 Edition 3). (AS/NZ1768)}
- Voltage Rise Time, dv/dt \textit{(AS/NZ1768)}
- Alarm and monitoring features \textit{(User preference)}
- Physical features. \textit{(User preference)}
STANDARD WAVEFORMS

Current I
8/20 µs
10/350 µs
In Imax and Iimp Test

- SPD Needs to first withstand 15 impulses of In 8/20us with rest periods. (Loosely called to 15 shot rating in industry)
- Imax is loosely equates to 1 shot rating but testing needs to be to IEC standards method which involves several impulses of lesser magnitude applied before hand.
- After In testing apply 10%, 25%, 50%, 75%, 100% Imax, In. 8/20us
- Iimp Tested with 10/350us
Metal Oxide Varistors

![Expected Surge Life Graph](image)

- Imax
Voltage Protection Level, $U_p$ (Typical 1-1.5kV)

Clamp $V$ (typical 275V rms)

$V_p = 6kV$

0.3 $V_p$

0.5 $V_p$

0.9 $V_p$

1.2 µs

50 µs

STANDARD WAVEFORMS

Voltage 1.2/50 µs

MOV
Up and Uc

Voltage Protection Level measured at In

- In AS1768 Also measured at 3kA
- Eg  Up@ 3kA = 850V  Up @ In =1.2kV

- Uc – Maximum Continuous Operating Voltage
  - Maximum rms or DC voltage that can be applied continuously
  - There is more rigorous testing for over-voltage under UL1449-Edition 3.
  - A product that is UL1449-Ed3 Listed is expected to robust against all types of failure modes.
WAYS OF MITIGATING HIGH CONTINUOUS VOLTAGE

1. Repetative Clamping Causes SPD to Heat Up, Possibly Exploding or Causing a Fire

2. TOV Condition

3. SPD in Conduction

4. Nominal Clamping Voltage on 50/60 Hz
Voltage Rise Time
\[ \frac{dv}{dt} \]

0.3 \( V_p \)
0.5 \( V_p \)
0.9 \( V_p \)

\( V_p = 6 \text{kV} \)

\( \frac{dv}{dt} \text{ approx } 5000 \text{V/us} \)

\( \frac{dv}{dt} \text{ approx } 30 \text{V/us} \)

Clamp V
MOV

Surge Reduction Filters, SRF

Voltage
1.2/50 \( \mu \text{s} \)

<500V
### TABLE 5.1
**RECOMMENDED SURGE RATINGS FOR A.C. POWER SYSTEM SPDs PER PHASE**

<table>
<thead>
<tr>
<th>Category</th>
<th>SPD location</th>
<th>$I_{\text{max}}$ rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Long final subcircuits and electricity supply outlets</td>
<td>3 – 10 kA</td>
</tr>
<tr>
<td>B</td>
<td>Major submains, short final subcircuits and load centres</td>
<td>10 – 40 kA</td>
</tr>
<tr>
<td>C1</td>
<td>Service entrance, other than below</td>
<td>40 kA</td>
</tr>
<tr>
<td>C2</td>
<td>Service entrance, building fed by long overhead service lines, or is a large industrial or commercial premises</td>
<td>40 – 100 kA</td>
</tr>
<tr>
<td>C3</td>
<td>Service entrance, building in a high lightning area, or fitted with a LPS</td>
<td>100 kA</td>
</tr>
</tbody>
</table>
Sample Specification of a Main Switch Board SPD

Protection:
Maximum Discharge Current, $I_{max}$, shall be 100kA. (OR You may specify $I_{imp}$ when using TSG or For Class I)
Nominal Discharge Current, $I_n$, shall be 40kA per line.
Voltage Protection Level Up shall be < 1000V at 3kA and less than 1500V at $I_n$.
Maximum Continuous Operating Voltage, $U_c$ >310 Volts.
The products shall be UL listed under UL1449-3 standard.

Wiring and Fusing
The wire lengths connecting to the SPD shall be less than 300mm where possible. In any case the total length of wire on the active and neutral side shall not exceed 1 metre.

The SPD shall be fused in accordance with the manufacturers recommendations. In the absence of such guidance the size of the fuse or CB shall 63 Amps. Either HRC fuses or motor rated circuit breaker shall be used.

Alarms and Indicators:
The surge diverter shall have visual indication and voltage free contacts.

Standards:
IEC61643
UL1449 Edition 3,
AS1768

•DB spec will have lower $I_{max}$, $I_n$ ratings
•SRF will have added line for $dv/dt$
SUMMARY - Selection Criteria

- Maximum Surge Current, Imax (IEC 61643-1) (AS/NZ1768)
- Nominal Surge Current, In (IEC 61643-1) (AS/NZ1768)
- Impulse Current, Iimp (IEC 61643-1) (AS/NZ1768)
- Voltage Protection Level, Up (IEC 61643-1) (AS/NZ1768)
- Maximum Continuous Operating Voltage, Uc (IEC 61643-1) (UL1449 Edition 3) (AS/NZ1768)
- Voltage Rise Time, dv/dt (AS/NZ1768)
- Alarm and monitoring features (User preference)
- Physical features. (User preference)
Voltage Drop on TEE lead

<table>
<thead>
<tr>
<th>CSA</th>
<th>d</th>
<th>Volt drop (per kA per meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1mm²</td>
<td>3.2mm</td>
<td>77.1V</td>
</tr>
<tr>
<td>100mm²</td>
<td>14.3mm</td>
<td>33.9V</td>
</tr>
<tr>
<td>1mm²</td>
<td>50mm</td>
<td>236V</td>
</tr>
<tr>
<td>100mm²</td>
<td>50mm</td>
<td>116V</td>
</tr>
</tbody>
</table>

Series inductance increases voltage protective level by \((l_1 + l_2) \frac{di}{dt}\)
<table>
<thead>
<tr>
<th>Device</th>
<th>Energy Withstand, Imax</th>
<th>Voltage Protection Level, Up</th>
<th>Multiple Shot, In</th>
<th>Follow on Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Spark Gaps And GA</td>
<td>✓ ✓ 100 -200kA</td>
<td>△△ 3-4kV</td>
<td>✓ ✓ Typically 80% of Imax</td>
<td>△△</td>
</tr>
<tr>
<td>Metal Oxide Varistors, MOV</td>
<td>✓ 3-200kA</td>
<td>✓ 800V-1.6kV</td>
<td>✓</td>
<td>✓ ✓ Minimal</td>
</tr>
<tr>
<td>Zener or Silicone Diodes</td>
<td>△△ &lt;3kA</td>
<td>✓ ✓ 800V-1.3kV</td>
<td>△△ &lt;3kA</td>
<td>✓ ✓ Nil</td>
</tr>
<tr>
<td>Triggered Spark Gaps</td>
<td>✓ ✓ 100 -150kA</td>
<td>✓ 2kV</td>
<td>✓ ✓ Typically 80% of Imax</td>
<td>✓ Minimal</td>
</tr>
</tbody>
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