Selection an installation of SPDs in a facility

1. Determining the protective zone (per PN-EN 62305, part 1) and the boundary transitions.

The boundary transitions of protective zones, and the service installation MB, SB, SA, are locations where SPDs should be installed.

**Boundary transitions across protective zones**

At the MB (main distribution board) which is the boundary transition 0<sub>4</sub>/1 (i.e. subject to the effects of a partial direct lightning strike), a test class 1 SPD should be installed. A test class 1 SPD is intended to handle a lightning impulse with 10/350 µs waveshape.

2. Determination of the expected surge current for typical examples.

2.a. Example of an exposed structure (e.g. radio base stations, waterworks, RTV transmitter, etc.)

Assume lightning current sharing as:

- 50% to LPS, 50% to the power supply pole

\[
\frac{I_{\text{imp}}}{2} / n = \frac{(200 \text{ kA} / 2)}{4} = 25 \text{ kA} 10/350 \mu s
\]

\[
I_{\text{imp}} / \text{pole} = 25 \text{ kA} 10/350 \mu s
\]

where:

- \( n \) - number of conductors (to simplify calculations, the influence of gas, water and other conductors are omitted).

In each conductor a maximum current value of 25 kA 10/350 µs can be expected.

2.b. Example of two adjacent structures (with same earthing resistance)

Assume lightning current sharing as:

- 50% - LPS

\[
50\% \cdot I_{\text{imp}} = \left( \frac{I_{\text{imp}}}{2} \right) / (1 + R_A / R_B) = 100 \text{ kA} / 2 = 50 \text{ kA} 10/350 \mu s
\]

\[
I_{\text{imp}} / \text{pole} = I_{\text{imp}} / n = 50 \text{ kA} / 4 = 12.5 \text{ kA} 10/350 \mu s
\]

In this example we can expect the same distribution in both structures and in all conductors and a maximum expected current \( I_{\text{imp}} \) of 12.5 kA per conductor.

2.c. Example of two structures not in close vicinity (earthing resistance is not the same)

Assume lightning current sharing as:

- 50% - LPS

\[
50\% \cdot I_{\text{imp}} = \left( \frac{I_{\text{imp}}}{2} \right) / (1 + R_A / R_B) = 100 \text{ kA} / 1.25 = 80 \text{ kA} 10/350 \mu s
\]

\[
I_{\text{imp}} / \text{pole} = I_{\text{imp}} / n = 80 \text{ kA} / 4 = 20 \text{ kA} 10/350 \mu s
\]

\[
I_{\text{imp}} = \left( \frac{I_{\text{imp}}}{2} \right) / (1 + R_A / R_B) = 100 \text{ kA} / 5 = 20 \text{ kA} 10/350 \mu s
\]

\[
I_{\text{imp}} / \text{pole} = I_{\text{imp}} / n = 20 \text{ kA} / 4 = 5 \text{ kA} 10/350 \mu s
\]
Example 2. c is the most common distribution of current: i.e. 40% to the structure having the lower earthing resistance and 10% to the one with the higher resistance, and equivalent distribution of current along the individual conductors. In reality the specific installation to be protected may not be identical to one of the preceding examples, in which case the closest one should be chosen and the maximum expected current / pole of the SPD used.

General rules to be adopted:

For three-phase TT systems select:  
\[ I_{\text{N-PE}} = 4 \times I_{\text{imp}} / \text{pole} \]

For single-phase systems select:  
\[ I_{\text{N-PE}} = 2 \times I_{\text{imp}} / \text{pole} \]

3. Establish the electromagnetic immunity class for the SPD.

<table>
<thead>
<tr>
<th>Class (PN-EN 61000-4-5)</th>
<th>( U_{\text{OC}} ) (1,2/50)</th>
<th>( I_{\text{SC}} ) (8/20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 kV</td>
<td>2 kA</td>
</tr>
<tr>
<td>2</td>
<td>2 kV</td>
<td>1 kA</td>
</tr>
<tr>
<td>3</td>
<td>1 kV</td>
<td>0,5 kA</td>
</tr>
<tr>
<td>4</td>
<td>0,5 kV</td>
<td>0,25 kA</td>
</tr>
</tbody>
</table>

\( U_{\text{OC}} \) and \( I_{\text{SC}} \) are values with which EMC immunity is tested.

4. Determining distance (\( \ell \)) between the SPD and device to be protected.

- \( 0_A \) zone of direct lightning strike
- \( 0_B \) zone of partial direct lightning strike
- \( 0_B/1 \) installation of SPD Class I / Type 1
- \( \ell \) distance between the SPD and device to be protected

Selection of SPD fulfilling the following demands

\[ \text{Uprot} \leq U_i \]

\[ \text{Uprot} = U_p + \Delta U \]

where:

- \( U_p \) protection level of SPD [kV]
- \( \Delta U \) inductive voltage drop \( \Delta U = \frac{L \times di}{dt} \)
- \( U_i \) dielectric strength of device [kV] in accordance with installation category (from I to IV)
- \( \text{Uprot} \) voltage sensed by the device

Dielectric withstand according to category

<table>
<thead>
<tr>
<th>Category</th>
<th>Dielectric withstand</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>6 kV</td>
</tr>
<tr>
<td>II</td>
<td>4 kV</td>
</tr>
<tr>
<td>III</td>
<td>2,5 kV</td>
</tr>
<tr>
<td>IV</td>
<td>1,5 kV</td>
</tr>
</tbody>
</table>

Dielectric withstand category must be given by the manufacturer.
The protection level of SPDs also determines the length of the conductors.

The length of the conductors contributes an additional inductive voltage drop as follows:

A typical conductor has a distributed inductance of approximately 1 µH/m, which at a current rate of rise of 1 kA/µs contributes approximately 1 kV per meter length.

\[ \Delta U = \frac{(L \times \frac{di}{dt})}{dt} \]

\[ \Delta U = 5 \, \mu H \times \frac{(1 \, kA / \mu s)}{1 \, kA / \mu s) = 5 \, kV} \]

To eliminate the effect of lead length, these should be kept as short as possible, or a V-type connection to the SPDs should be used, as shown below:

Rule: the cross sectional area of the earthing conductor used to install and SPD should be not less than:

- 16 mm² - SPD class I
- 6 mm² - SPD class II, III

or in accordance with the manufacturer’s instructions.

5. Relationship between Up [kV] and surge current [kA] for Relpol S.A. SPDs (Uc = 320 V).

Note: manufacturers usually only provide the value of Up and In. A complete graph as provided above is more useful (see beside) as it allows for more precise coordination of the SPD and the withstand level of the equipment to be protected.

1. Up for 8/20 µs waveshape (indirect lightning)
2. Up for 10/350 µs waveshape (direct lightning)
6. At the MB (main-distribution board) install SPDs of test class I.
   Such devices are intended to protect equipment classified for installation in categories I and II (6 kV and 4 kV). Determine the distance between this SPD (MB) and the device to be protected. If the condition $U_{prot} \leq \frac{U_i}{2}$ is not achieved, install an additional SPD.

7. At the SB (sub-distribution board) install SPDs of test class II.
   Such devices are installed to protect against the effects of induced voltages. The SPDs must comply with the requirements of:
   - $I_n \geq 5$ kA, $NPE > 10$ kA (for connection 1+1),
   - $NPE > 20$ kA (for connection 3+1).
   Test class II SPDs can only be used at the zone I / II boundary and must always follow a test class I SPD.

8. Determine the distance between SPDs (class II) at the SB and the device to be protected.
   Condition for proper protection: $U_{prot2} \leq \frac{U_i}{2}$
   If achieved the test class II SPD has successfully protected installation category II and III.
   **Note:** test class II SPDs can only be installed if the incoming utilities are within the protected zone 0B.

9. At the SA (the point directly in front of the device to be protected) install SPDs of test class III.
   These should only be installed after a test class I and II SPD. The correct order of SPD installation is required to ensure effective protection.

Flow chart showing how to select an SPD:

```
In point MB install SPD class I (LPZ 0B/1)

Determine dielectric strength $U_i$ of protected devices

Select $U_p$ (protection level SPD class I),
determine $U_{prot} \leq \frac{U_i}{2}$

YES

PROTECTION COMPLETE

NO

At point SB install SPD class II (LPZ 1B/2)

Select $U_{p2}$ (protection level SPD class II),
determine $U_{prot2} \leq \frac{U_i}{2}$

YES

NO

At point SA install SPD class III (LPZ 1B/2)
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