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Power Surge Protection as Part of a Lightning Protection System

According to BS EN 62305 surge protection is looked at in 2 stages, a service entrance system and a co-ordinated system. Whilst both work in a similar fashion, the desired end result is a little different:

Service entrance - Section 6.2 of BS EN 62305-3 (equipotential bonding of services) states that all conductive services which enter or leave a structure that is fitted with a lightning protection system shall be bonded to the main earth bar [at the instant of strike]. With non-electrical services this is as simple as clamps onto the pipes and then through the earthing system back to the main bar. However, simply bonding a live conductor to earth cannot be done which is why a Surge Protection Device (SPD) is used to accomplish this. They work by temporarily creating a low impedance short circuit between a conductor with a surge on it and earth and rely on the fact that the route through the SPD is of lower impedance and resistance than the load. This diverts the surge to earth and the SPD resets. It also ensures that clause 6.2 is satisfied as, at the instant of strike, that conductor is connected to the building earthing system.
Both power protectors and data protectors work in this way although the surge ratings are a little different, which brings up the next point, deciding what surge rating to use for these service entrance SPDs.

Each lightning protection level (calculated via the initial risk assessment process) has a maximum surge current associated with it. The external lightning protection system dissipates half this current leaving the remainder to be dissipated via the conductive services connected to the building. As a worst-case scenario, BS EN 62305 states that the minimum a structure is expected to have connected to it is a 3 phase and neutral power supply with plastic gas and water pipes. Data is to be taken care of, in this worst case, via fibre optic lines. This leaves just 4 conductive routes (3 phase lines and 1 neutral) for the remaining surge current to be further sub-divided over.

For levels 4 and 3 this maximum current is 100kA (type 1 or 10/350µs surge waveform – simulating a direct lightning current), half is dealt with via the external conductor system leaving 50kA to be split 4 ways over the lives and neutral leading to a 12.5kA type 1 rating required for the SPD on the mains supply.

Level 1 lightning protection systems have a maximum rating of 200kA which is divided as before leading to 25kA per line.

Level 2 is the strange one in that it has a maximum rating of 150kA which breaks down to 18.75kA. There are very few SPDs made with an 18.75kA type 1 rating so the 25kA units are used instead.

This means that the 4 levels are broken down into two groups, one for 12.5kA units and one for 25kA.

With regards to the signal level SPDs, BS EN 62305 states that, due to the smaller cable sizes attenuating the surge, the maximum amount of surge current that would be dissipated via these lines is 2.5kA (type 1 again) regardless of the level of lightning protection. Handily this means that the vast majority of signal level SPDs will be designed with these ratings in mind.

As can be seen from the examples above, the more conductive services connected to a building, the lower the surge current present on any one line becomes.

Service entrance SPDs are generally not intended to provide protection to more sensitive electronic equipment within the building. They are intended to provide equipotential bonding of the electrical and electronic lines which enter or leave the building in order to prevent internal sparking, fires and so on. In order to give this additional protection the next stage is:

Co-ordinated SPDs - A co-ordinated surge protection system is designed to do the same job as above but with additional protection on sub distribution boards and closer to end equipment in order to prevent disruption to the operation of electronic systems.

A co-ordinated system of SPDs will typically have service entrance units as described above to deal with the main brunt of a surge but with the addition of secondary devices positioned at locations and distribution boards which are feeding the equipment on which the continued operation of the business / facility depends.

The surge ratings of these units are of less importance as they are now going to be dealing with a much-reduced surge current after the involvement of the first line of SPDs. It is at this point that the type 2 and 3 ratings are of more importance and especially the let through voltage resulting from the type 3 rated protection systems.

This let through voltage ideally should be less than 750v (on a 230v L-N system) which will allow the SPD to be designated as an enhanced unit which will give the best level of protection and also allow for the greatest mitigation factor to be used in the initial risk assessment calculations.

The final aspect to be mindful of is the oscillation protective distance, as a transient surge is a high frequency pulse, even after attenuation through the SPDs, electrical oscillations will be set up in the cables afterwards. Over distance, these oscillations will increase in magnitude and can result in end equipment 'seeing' double the voltage which was let through by the SPD. For example, SPDs which are designed for sensitive protection typically let through just under 600v of a surge, not normally enough to bother equipment at all, however this let-through voltage will rise rapidly with distance between the SPD installation and the end equipment. This oscillation protective distance can be ignored for distances of up to 10m, but after this a small calculation can be used to verify the distances involved:

$$I_{po} = \frac{U_w - U_{p/f}}{k}$$

Where I_{po} = Oscillation Protective Distance in metres
U_w = Withstand voltage of end equipment
$U_{p/f}$ =Let through voltage of installed SPD
K = Constant = 25v/m

Note that $U_{p/f}$ is comprised of two parts, the innate let through voltage of the SPD (U_p) plus the inductive voltage drop in the connecting leads (ΔU). For instances where the surge is of an inductive nature only (type 2 ratings) ΔU can be disregarded leading to $U_{p/f}$ becoming U_p – the specified let through voltage of the SPD.

This has not covered everything there is to do with SPD system design as there are always going to be individual factors which need to be taken into account in any installation such as the position of supply company meters, roof mounted equipment and the feeds to them, other communication equipment such as dishes and antennae and so on.