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Trending now

Surge Protection Devices (SPD)- Key Characteristics

Consider a pressure relief valve in a water based system. Under healthy conditions the valve remains passive, having no effect on the normal operation of the system.

Under a fault condition, the valve is designed to open at a pre-set water pressure in order to protect vessels and equipment from being subjected to pressures that exceed their design limits.

To achieve this, the valve creates a secondary path to relieve the excess water pressure, diverting it away from the equipment. Its function only lasts for a very short time period, after which the valve recloses and returns to its original state in readiness for the next event.

The function of an electrical surge protection device works in a similar way. It is designed to limit transient over voltages and divert the resulting surge current, with the aim to prevent irreparable damage and down time to load equipment connected to the distribution network.

Many devices of various designs are available in the market. All feature a number of key characteristics which must be considered by the system designer in order to select the most appropriate item for an installation;

Device types

Type 1 devices offer protection against the effects of a lightning surge. The devices must be installed at the origin of the electrical installation, where they guard against direct lightning currents entering the system from outside the premises. They must be able to withstand large amounts of charge and energy.

Type 1 devices must be installed where buildings include a lightning protection system, or the building is fed from overhead power lines (which themselves are at direct risk of lightning strike).

Regulation 443.4 and 443.5 of 18th Edition wiring regulations give the relevant criteria along with a risk assessment calculation to determine whether protect against surges of atmospheric origin (i.e. lightning) is required for installations within the UK.

If the risk assessment is not carried out, then surge protection must be installed by default.

The lightning impulse waveform is designated 10/350µS

Type 2 devices cannot offer protection against the effects of a direct lightning surge.

These devices can be installed at the origin of an installation only where there is little or no risk from direct lightning strike (as determined by the risk assessment calculation). They are primarily suitable for buildings located in an urban area, without an external lightning protection system, and fed from an underground power source

Type 2 devices essentially offer protection against the effect of electrical surges of lower magnitude than direct lightning strikes, which can be generated from within an installation. Examples include switching of equipment such as LED drivers / motors / refrigeration equipment / lifts etc., or when power is switched or re-established by the utility company following a substation outage or distribution network fault.

Switching surges are an everyday constant source of stress for fragile electronic components. These stresses slowly degrade or erode the electronic components, considerably shortening the life span of expensive appliances in which they are used. The switching surge waveform is designated 8/20µS

Type 2 devices also provide a second level of protection for sub distribution boards within a building where it is protected at its main intake board by a type 1 lightning surge device.

Type 3 devices are the third level of protection, and can only be installed locally to a piece of equipment e.g. a computer, to protect that individual appliance against switching surges. Type 3 devices are the ‘weakest’ of the 3 types available.

Utilising a type 2 device at the origin of the installation can offer a significant advantage over the use of multiple type 3 devices, as it can protect equipment connected to all circuits within the installation in one go rather than just a single item or small group of items. (* refer to notes on how to install a SPD).

Maximum Continuous Operating Voltage (Uc)

This value should be at least 120% of the nominal system voltage to which the surge device is connected.

This will provide adequate tolerance for temporary over voltages that may occur on the supply system.

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SPDs with an MCOV that are precariously close to the nominal system voltage are more susceptible to such over voltages which can lead to premature SPD aging and subsequent end-of-life.

In the UK, the declared voltage and upper tolerance for a single phase electrical supply is 230V +10%, hence the MCOV of the surge protection device would be required to be in the order of 275-280V

A prolonged over voltage condition in excess of the MCOV rating can cause degradation or destruction of the surge protector.

This value is also of importance when installing SPDs in countries where the power quality is not reliable and suffers from significant voltage fluctuations.

Temporary Over Voltage (TOV)

This is the momentary over voltage that the surge protector can withstand safely for a pre-defined short time period.

Temporary over voltages can typically last for several seconds, and usually originate from switching operations or wiring faults.

The surge protector should have a TOV capability in the order of 145% of the nominal operating voltage of the system, e.g. 335V / 5sec on a 230V system.

Voltage Protection Level (Up)

This is the maximum voltage that appears across the terminals of the surge protector when it is activated. This voltage is reached when the current flowing through the SPD = I n

The voltage protection level must be below the over voltage withstand capability of the load equipment connected. IET 18th Ed. wiring regulation 443.2 prescribes that sensitive electronic equipment e.g. alarm panels, computers, & home electronics have a rated impulse voltage withstand of 1.5kV when installed on a 230/400V supply

The lower the value of the voltage protection level, the better the performance specification of the device, and the increased chance of continued operation of load equipment following a surge event.

Nominal Discharge Current (I n); only declared for a Type 2 SPD

This represents the peak value of current that the surge protector is capable of discharging multiple times (on an 8/20µs waveform in accordance with the test sequence designated within IEC61643-11)

Essentially, the higher the value of I n, the longer the service life of the surge protector.

The minimum value for I n stipulated within IET 18th Edition wiring regulations is 5kA for a type 2 device (534.4.4.4.1)

Impulse Current (I imp); only declared for a Type 1 SPD

This represents the peak value of current that the surge protector is capable of discharging at least one time (on a 10/350µs waveform)

The minimum I imp value stipulated within IET 18th ed. wiring regulations is 12.5kA for a type 1 device (534.4.4.4.2)

Maximum discharge current (I max)

This represents the peak value of current that the surge protector is capable of discharging once.

Example: If you compared two type 2 surge protectors, each featuring the same I n value, but with different I max values, the SPD with the higher I max value features a higher safety margin, i.e. the capability to withstand a higher surge current without being damaged.

Maximum back up fuse

Surge protection devices must be connected via an overcurrent protection device (OPCD) (e.g. fuse), with a rating specified by the SPD manufacturer.

Some devices incorporate a suitable fuse as an integral part of the surge protector, whilst others require an external OPCD.

The fuse is not installed to protect the surge device, but instead it is required to protect the mains from a failure of the SPD as a result of a lightning strike or over voltage which causes the SPD to reach end of life status;

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When the surge device reaches its end of life it is damaged irreparably, and can no longer perform its operational duty. The normal characteristic of the SPD changes from a high impedance device to a low impedance device, and as a result it starts to draw a considerable amount of current, therefore causing the fuse to operate for safe disconnection.

Another requirement for provision of a fuse is to provide isolation of the SPD from the power lines in the event of a replacement or maintenance operation.

The ratings and characteristics of external OPCDs for protecting the SPD assembly shall be the highest permissible rating to provide a high surge current capability for the complete assembly whilst not exceeding the ratings and characteristics as required in the SPD manufacturer's installation instructions for the maximum overcurrent protection.

An under rated fuse would fail as soon as a large surge current was present, thus reducing the nominal discharge current and therefore limiting SPD operating function.

A miniature circuit breaker (MCB) may be used in substitution for a fuse, however, whilst fuses have always been considered to have very similar technical characteristics between manufacturing brands, MCB's can differ in their internal inductance values between manufacturing brands.

This inductance can cause the value of the voltage protection level of the installation to rise, meaning that the protected appliances would therefore need to withstand the voltage protection level of the SPD + the voltage drop of the installation (MCB + cabling).

It is important to utilise an MCB with a rating as specified by the surge protection manufacturer.

One product fits all applications?

Most devices available within the market for the protection of AC power circuits comprise a metal oxide varistor (MOV), which is the technology most commonly used. The surge current rating of an MOV is related to its cross sectional area and its material composition. Generally, the larger the cross sectional area of the MOV, the higher the kA rating of the device.

Devices that comprise of a single MOV are only suitable for power distribution systems with a TN-C-S earth arrangement, however it does not offer protection on the neutral wire – hence you really need two of them.

Devices that are suitable for TN-S earth systems feature 2x MOV. These can also be used on TN-C-S systems.

Surge protectors that can be installed on both TN (TN-S & TN-C-S) and also TT earth arrangements feature an additional element; a gas discharge tube (GDT), connected internally between the neutral and earth conductors.

The combined TN/TT device is considerably more flexible in its design, as this device can be deployed into any system no matter which earthing arrangement is utilised.

What determines the life span of a SPD

Surge protection devices degrade and subsequently fail when subjected to a large number of high capacity voltage surges over a period of time. There is no real guarantee of life span as these devices are sacrificial in their duty, although in practice the reality is that surge devices have a service life typically between 5-10 years.

Factors which can influence the life span of a device are;

- Rate of occurrence of surges
- Sustained over voltage events
- The energy content of surges (a result of the surge voltage and current values and time duration)
- Surges that exceed the SPDs ratings for surge current
- The time lapse between each surge. Where the device is allowed to cool between surges, its lifespan can be increased dramatically

At end of life failure the device structure must remain fully intact (i.e. IP20 classification), without destruction or burning. This is important where the device could potentially cause damage to other circuit protection devices installed adjacent to or within the same enclosure as the SPD.

Purchasing considerations

Many surge protection products are available in the market place having similar technical specifications, although may vary considerably in purchase cost.

One key point with surge protection devices is that they cannot be functionally tested by an installer using portable testers. Essentially the user is purchasing a 'black box'.

In order to test the performance characteristics of a SPD in accordance with the product standard requires specialist laboratory equipment.

Buyers should exercise caution when considering 'cheap' devices in the market which claim to offer protection levels which they may be unable to meet when subjected to such laboratory testing.

It is always considered best practice to select a device which originates from a reputable manufacturer, thus better guaranteeing the items quality and performance.

This is of particular importance when considering the high monetary value of the load equipment that the product is working to protect in the majority of installations.

Surge protection is also a relatively complex subject which is often a cause of confusion for electrical installers. When selecting a surge protection device, it is of significant benefit to purchase from a company who are able to offer technical advice and after sales support on the selection and installation of such products.

In the vast majority of cases the installation of a surge protector within the system is recommended, as one load appliance can be several times the purchase cost of the surge device, and significantly increase the potential lifespan of the appliances.

Warranty period

Surge protectors are sacrificial products, designed to absorb the electrical surges that can occur on a power system over a period of time, therefore protecting the valuable and sensitive electrical /electronic appliances connected to it.

Although their job leads to ultimate failure of the device by its very nature, they do carry a warranty period which ranges typically from 1-5 years; depending on the manufacturer and technical specification of the device.

Manufacturer's product range

Offering a range of surge protection devices with varying specification levels presents installers with the ability to select the correct device for the application, or set up a surge protection network (i.e. combining multiple surge protection devices of different types to form a system) in buildings featuring multiple distribution boards, or with cable runs that route in and out of the building structure (potentially introducing a risk of direct lightning strike).

Product selection options exist where the supply is either single (230V) or three phase (400V), and the device classification is taken from types 1, 2, and 3.

Selection is governed firstly by the necessity to incorporate lightning protection (type 1), and secondly by the requirement to include protection against the effects of switching surges (types 2&3).

Regulation 443.4 of the 18th edition refers

How to install a SPD

There are various approaches, depending on the type of installation and the value (both monetarily and importance) of the equipment that you are trying to protect.

The first approach may be to provide a surge protector only at the origin of the mains source into the installation. You may think that all of your surge problems are solved in one go, but this approach may not always work.

The second approach may be to provide surge protection individually at critical items of equipment.

This would work well for surges of low magnitude, but may fail to guard against higher energy surges.

The third approach is to combine a number of SPDs working as a system, both at the mains origin and at the individual items of critical equipment, or sub distribution boards.

Where a building features a main intake board and also sub distribution boards, at a distance of more than 10M apart, surge protection must be provided at each of the sub boards as well as the main intake board. This is due to oscillations which could lead to higher voltage values appearing at the load equipment.

Wiring connections

Regulation 534.4.8 of the 18TH Edition wiring regulations specify that consideration must be given to the total wiring length of conductors between connection points of the SPD assembly, which should preferably not exceed 0.5 metre, and in no case exceed 1.0 metre. This measurement is made between the live bus bar and the earth terminal, incorporating the connection from the live bus bar to the SPD MCB or fuse, the fuse to the SPD, and the SPD to the earth terminal.

The reason for the restriction in length is to minimise any voltage drop on the connecting cables, which can have a direct effect the voltage protection level.

Regulation 534.4.10

Conductors between SPDs and the main earth terminal or the protective conductor shall have a cross sectional area not less than;

- 6mm^2 copper for type 2 devices installed at or near the origin of an installation
- 16mm^2 copper for type 1 devices installed at or near the origin of an installation

Line or load side of an RCD?

Where the power distribution system incorporates RCDs, transient activity could cause RCDs to operate and hence loss of supply. Surge protective devices (SPDs) should wherever possible be installed **upstream of RCD to prevent unwanted tripping caused by transient over voltages.**

Where SPDs are installed on the load side of an RCD, an RCD having an immunity to surge currents of at least 3kA 8/20µS shall be used.

Note that type S (time delayed) RCDs in accordance with EN61008-1 and EN61009-1 satisfy this requirement.

In case of a surge current higher than 3kA 8/20µS, the RCD may trip causing interruption of the supply.

Installation of type 1 SPDs downstream of an RCD is not recommended.

Inspection and testing

During commissioning or periodic inspection, an electrical installation is normally subjected to insulation resistance testing, typically at 500VDC for installations operating from a 230/400VAC supply (as specified in table 64 of 18th Edition wiring regulations).

The surge protector plug in cartridge must be either removed or disconnected for the duration of the test, as it will give incorrect readings. This is due to the SPD starting to conduct as the maximum continuous operating voltage is exceeded.

The maximum voltage at which insulation resistance testing can be conducted with the surge protector in circuit is 250VDC.

The SPD also features a coloured flag indicator to signify whether the device is healthy/operational, or has reached end of life; where green = healthy and red = end of life. When the flag turns red, the device must be replaced as it no longer offers any protection against the effects of surge.

Some surge devices also incorporate a volt free changeover contact which changes its status when the device reaches end of life. This is particularly useful in a large installations where the signal can be used to initiate an alarm signal, either locally via lamp or buzzer, or as an input to a building management system.