



Guide to  
Surge Protection Devices



# Introduction

The whole nature of how electrical equipment is used in homes and at work has evolved; with everyday activities relying on electronic equipment. Products such as computers, printers, flat screen televisions, industrial control equipment such as PLC's, alarms, microwaves and washing machines are common place. These can all be vulnerable to transient overvoltages, which can significantly reduce the equipment's lifespan through degradation and damage.

This guide expands upon some of the requirements found in the 17<sup>th</sup> Edition of the IET Wiring Regulations and other standards, related to the protection of electrical equipment from electrical surges. It considers protection against voltage transients on the electrical installation only. Consideration should also be given to the protection against transient overvoltages transmitted by data transmission systems. BS EN 50174 refers.

Note: this guide does not ensure compliance with BS 7671 or indeed guarantee that equipment is protected against electrical surges. The electrical specifier should use their own judgment, consulting BS 7671 and the BS EN 62305 series (protection against lightning) to determine the need and correct selection of surge protection devices.

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# Risks of electrical surges

Surge protective devices (SPD) assist in the protection of valuable electrical and electronic equipment against transients, originating from lightning and also from switching sources.

These transients can cause damage ranging from the premature ageing of equipment, logic failures and down time, to the complete destruction of equipment within the entire electrical installation. Products such as LCD screens, data servers and industrial equipment such PLC's are critical to business activity. Protecting this equipment may now be a necessity.

The Hager SPD range of solutions may offer protection to prevent damage to this sensitive equipment by diverting the damaging transient over-voltages. In the majority of cases this will eliminate equipment failures and reduce downtime.

The choice of a surge protective device depends upon:

- The exposure of the building to lightning transients
- The sensitivity and value of the equipment that requires protection (it is recommended that the contractor should discuss the installations requirements with the customer)
- The location and therefore the exposure level of the installation
- The equipment used within the installation and whether this equipment could generate switching transients

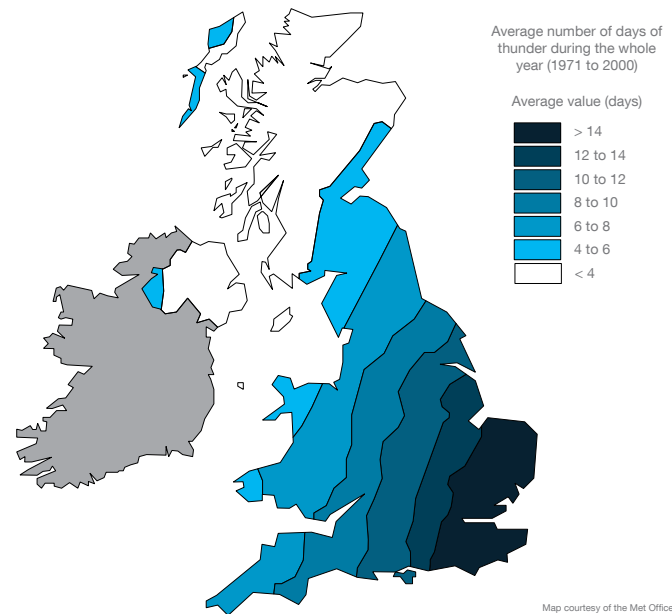
# BS 7671 and the AQ criteria method

Lightning discharges could contain currents of 200,000A which if struck at or near power transmission lines would generate a significant voltage transient. This voltage transient could cause significant damage to both domestic and commercial electronic equipment.

The UK regional map illustrates the likely lightning activity caused by the number of thunderstorm days across the country.

Protection against over-voltages is the subject of section 443 of BS 7671. Here the AQ criteria method is introduced which is based on the likelihood of the equipment being subjected to over-voltages caused by lightning strikes, taking account of the probable number of lightning strikes per year.

For electrical installations in the UK, the map shows that the probable number of thunderstorm days per year in any given location is less than 25, and therefore condition AQ1 applies.



Where this is the case and for installations being supplied by overhead lines, Regulation 443.2.2 indicates that provided the impulse withstand voltage of the equipment is not less than the values given in Table 44.3 (see Table 1 for installations rated at 230 V to Earth), no additional protection by a SPD is required. However, where higher levels of equipment reliability or higher risks (e.g. fire) are expected, additional protection by an SPD against over-voltage may be required.

Similarly, for an installation having overhead lines, no additional protection against overvoltages is required if the equipment meets the minimum voltage withstand values in table 44.3.

There are some words of caution in the notes to this section where it is recognised that transient over-voltages transmitted by the supply distribution system are not significantly attenuated. So an induced voltage some distance away could easily manifest itself at the electrical installation and cause potential harm to the equipment within. It is also worth considering that the AQ data is for thunderstorm days NOT lightning strikes. One storm will usually contain many lightning flashes which could lead to an over-voltage on the installation causing damage to equipment.

“where higher levels of equipment reliability or higher risks (e.g. fire) are expected, additional protection by an SPD against over-voltage may be required.”

Impulse withstand category	Example of equipment in category (note 1)	Required minimum impulse withstand voltage (note 2)
I (low impulse voltage)	Sensitive electronic equipment connected to the fixed installation.	1.5 kV
II (normal impulse voltage)	Domestic appliances and portable power tools connected to the fixed installation.	2.5 kV
III (high impulse voltage)	Equipment intended to be installed in a part of the fixed installation where a high degree of availability of overvoltages is expected, such as distribution boards, circuit-breakers and wiring systems.	4.0 kV
IV (very high impulse voltage)	Equipment intended to be installed at or near the intake to the installation, such as the energy meter.	6.0 kV

Table 1: Required minimum impulse withstand voltage for equipment where installation rated voltage is 230V to Earth (based on tables 44.3 and 44.4 of BS7671)

Notes:

1. Table 44.4 of *BS 7671* gives a fuller list of examples of equipment falling into each category.
2. This table applies only for installations of rated voltage ( $U_n$ ) 230V. For installations of other rated voltages, see Table 44.3 of *BS 7671*.

# Terminology & selection criteria

Surge protection devices are classified according to their standard into different types

- Type 1 - SPD which can discharge partial lightning current with a typical waveform 10/350  $\mu$ s. Usually employs spark gap technology.
- Type 2 - SPD which can prevent the spread of over-voltages in the electrical installations and protects equipment connected to it. It usually employs metal oxide varistor (MOV) technology and is characterized by an 8/20  $\mu$ s current wave.
- Type 3 – These SPDs have a low discharge capacity. They must therefore only be installed as a supplement to Type 2 SPD and in the vicinity of sensitive loads. Type 3 SPD's are characterised by a combination of voltage waves (1.2/50  $\mu$ s) and current waves (8/20  $\mu$ s).

$I_{imp}$  – Impulse current of 10/350  $\mu$ s waveform associated with Type 1 spd's

$I_n$  – Surge current of 8/20  $\mu$ s waveform associated with Type 2 spd's

$U_p$  - The residual voltage that is measured across the terminal of the SPD when  $I_n$  is applied

$U_c$  - The maximum voltage which may be continuously applied to the SPD without it conducting

# Selection of suitable devices

BS 7671 section 534 gives the requirements for correct selection of devices against overvoltages. Regulation 534.2.1 prescribes that where required by Section 443 or otherwise specified, SPD's shall be installed:

- (i) near the origin of an installation, or
- (ii) in the main distribution assembly nearest the origin of an installation

The notes to this regulation give further guidance, stating that a Type 1 or a Type 2 SPD may be used at the origin whilst Type 2 and Type 3 are also suited for locations close to the protected equipment.

Type 1 SPD's are often referred to as equipotential bonding SPD's and are fitted at the origin. A lightning protection system employing these devices only, offer no effective protection against failure of sensitive electrical and electronic systems. In order to achieve this, additional coordinated devices will have to be employed.

In summary, a Type 1 SPD is used at the origin of the installation, a Type 2 SPD is used at distribution boards and a Type 3 SPD is used near terminal equipment.

Surge protection needs to be selected such that their voltage protection level ( $U_p$ ) is lower than the impulse withstand capability of the equipment to be protected. 534.2.3.1.1 suggests that this value should be referred to category II of Table 44.3. This for a 230/400V installation suggests that the value should not exceed 2.5kV. However 534.2.3.1.2 suggests that to protect sensitive and critical equipment, then consideration should be given to reduce this value to that required for category 1 equipment (ie 1.5kV).

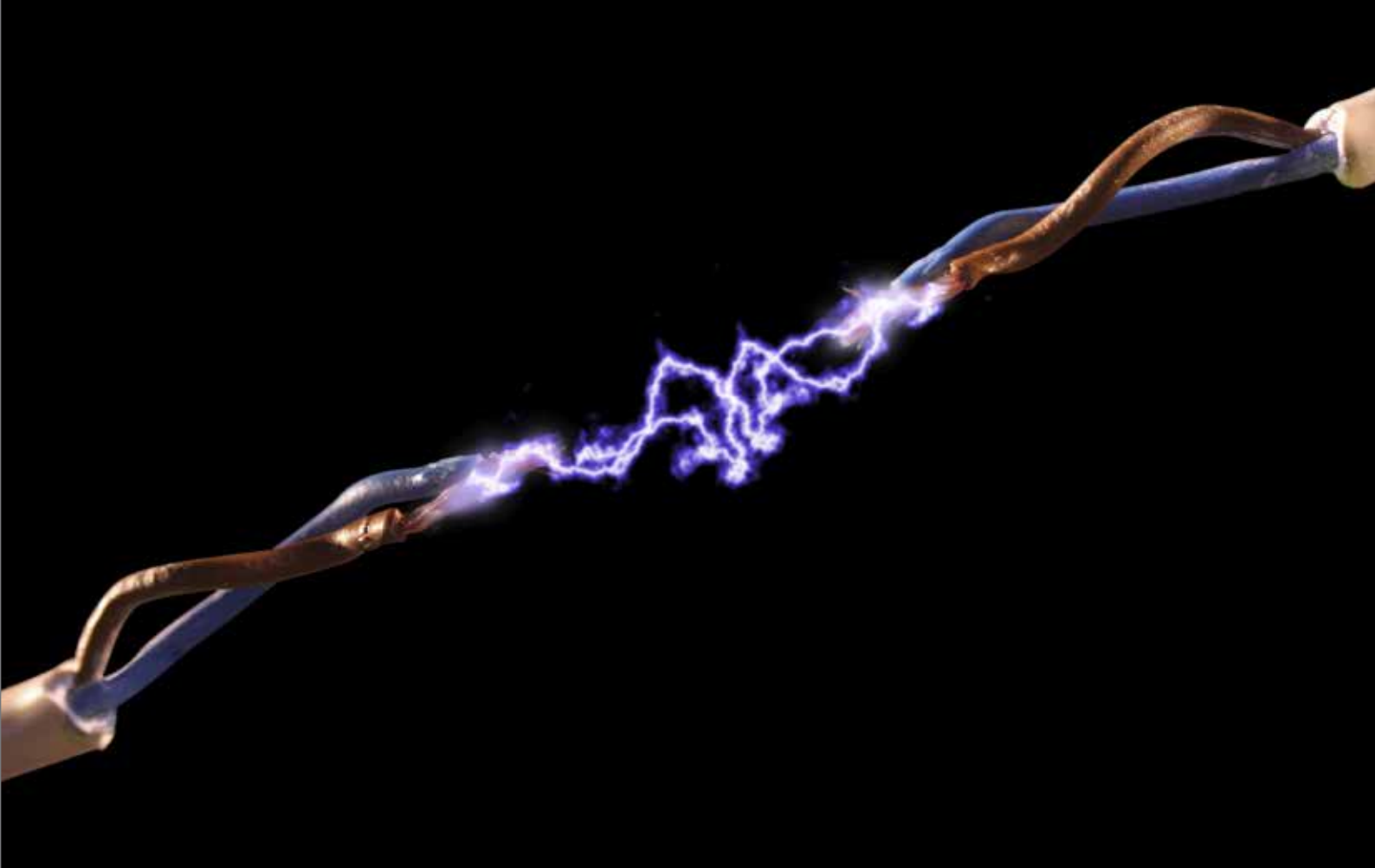
534.2.3.4 also gives guidance as to the selection of an appropriate device.

The specifier should ascertain from BS 7671 which connection type is preferable (CT 1 or CT 2). Hager manufacture devices with connection type CT2.

Type 1 devices need to be selected such that the value of  $I_{imp}$  is not less than that which shall be calculated in accordance with BS EN 62305-4. However if this cannot be calculated then this value shall be not less than 12.5kA. Also, due to the connection method, the value of  $I_{imp}$  between the neutral conductor and the protective conductor shall be not less than 50kA for three phase systems and 25kA for single phase where the value cannot be calculated.

For Type 2 devices the value of  $I_n$  shall be not less than 5kA and the value between the neutral and protective conductor shall be not less than 20kA for three phase systems and 10kA for single phase. Larger values may be required as classified in BS EN 61643-11.

“The specifier should ascertain from BS 7671 which connection type is preferable. Hager manufacture devices with connection type CT2.”



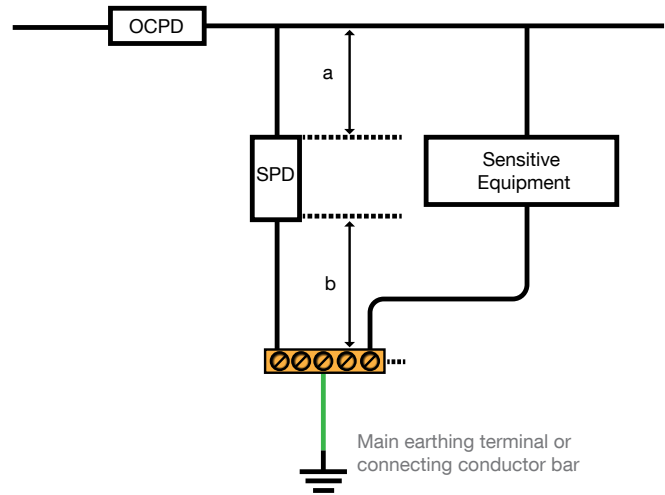
# Connection

To gain maximum protection from the SPD, the connecting conductors should be kept as short as possible. This is to minimise any additive voltage drops on the connecting cables.

The connecting conductors of the SPD shall have a cross sectional area of not less than 4mm<sup>2</sup> copper and the total connecting lead length (a+b) should preferably not exceed 0.5m but shall in no case exceed 1m.

Where Type 1 devices have been installed the cross section area shall be not less than 16mm<sup>2</sup> copper. Manufacturer's instructions shall be followed.

Some devices have dual line & neutral terminals. This connection method reduces any additional voltage drop in the connecting cables thereby obtaining the best possible  $U_p$  to the installation. There are conditions to this connection method however. With Hager devices it is suitable for installations having a maximum demand up to 125A.



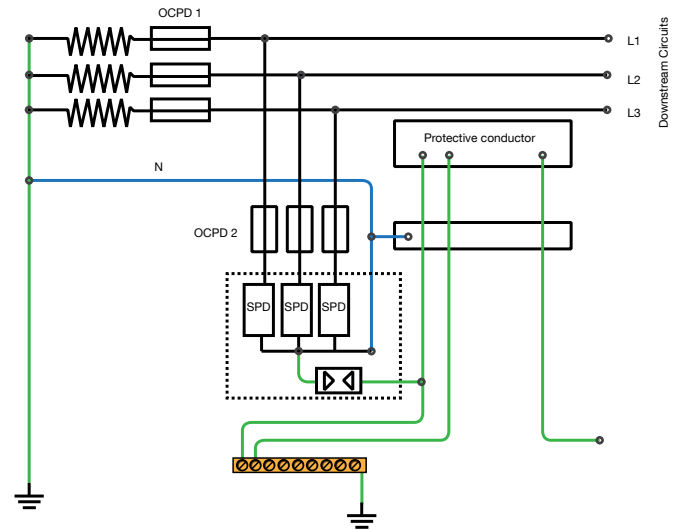
OCPD = overcurrent protection device  
SPD = surge protection device

Should the distance between the SPD and the sensitive equipment to be protected be greater than 10m, oscillations could lead to higher voltage values appearing at the equipment. Consideration should be given to additional coordinated surge protection devices closer to the equipment. Again manufacturer's instructions should be followed

Protection against SPD short circuits is often provided by an over-current protective device such as a fuse or circuit breaker. This device must of course permit the flow of surge current through the device without operating. Manufacturers will give instructions as to which device is recommended. In certain circumstances this secondary over-current device may be omitted if the upstream over-current device meets certain conditions.

Should RCD's be required in the installation as additional protection or to ensure the requirements of fault protection are satisfied, then the SPD will need to be installed upstream

of the RCD. Where this cannot be avoided, the RCD should be of the time-delayed or S-type.



# Cascading

Cascading is the term used to describe the method of combining several levels of surge protection devices into the one installation.

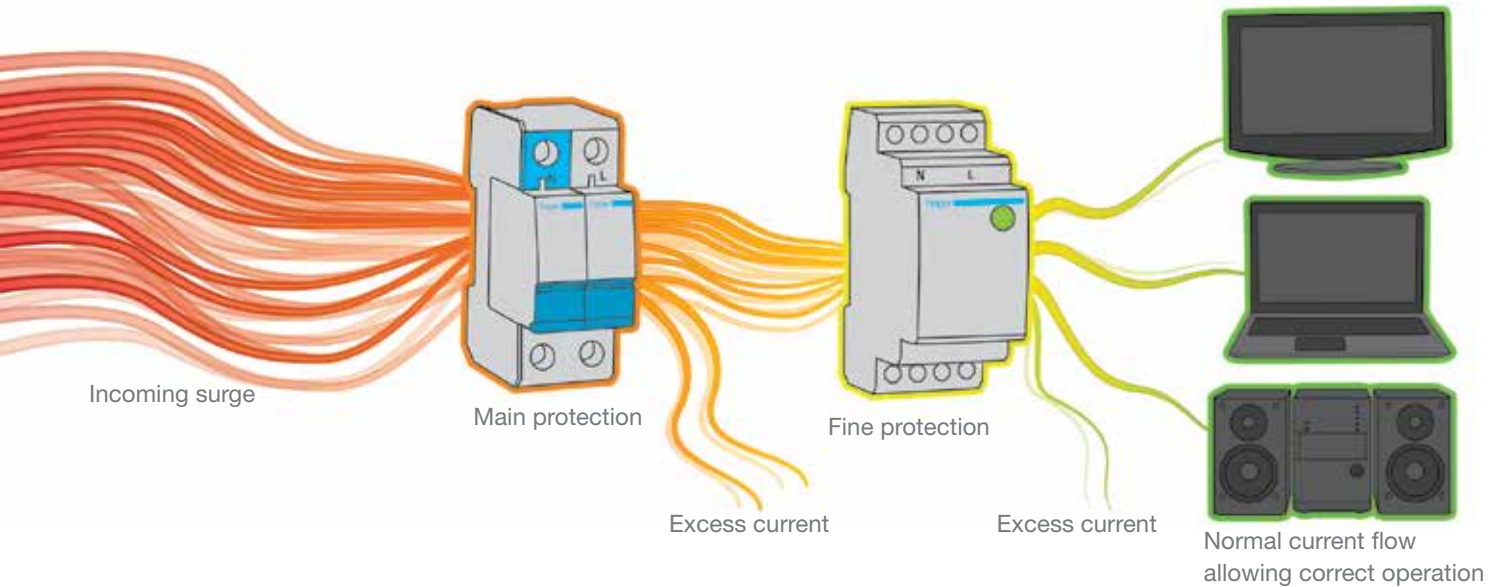
This takes advantage of the best features of each device to improve the protection level for the equipment. Hager recommends using a high surge current capacity device to divert the bulk of the transient over-voltage at the origin of the installation.

In the case of a Class 1 & 2 device this would be either the spark gap arrester or a high current capacity MOV. Should finer protection be required, the next step is to install a Class 3 device SP202N near the terminal equipment.

Cascading increases the current diverting capacity of the SPD system whilst maintaining a low voltage ( $U_p$ ) to ensure the best protection for valuable equipment.

Selecting SPD of the same manufacturer or make will ensure correct co-ordination between devices

“Cascading increases the current diverting capacity of the SPD system whilst maintaining a low voltage ( $U_p$ ) to ensure the best protection for valuable equipment.”



# Inspection & Testing

During the Initial Verification or as part of a periodic inspection & test, the SPD should be inspected to ensure it is operational. Any over-current protective device associated with the SPD should be intact and should be as instructed by the manufacturer.

There is usually some kind of visual indication on the SPD that the device is still operational. This may be indicated by a GREEN visual indicator window. Should this window indicate RED then it is an indication that the device has reached its 'End of Life' and needs replacing. With some products, this will involve the replacement of the device, but on many of the products in the range, this can simply be carried out by replacing the removable cartridge.

An insulation resistance test of 500V dc carried out with the SPD connected will produce incorrect readings. This is due to the SPD starting to conduct as the value of  $U_C$  may have been exceeded. This test then should be conducted without the SPD connected. Alternatively this test can be conducted at the reduced test voltage of 250V dc.

“There is usually some kind of visual indication on the SPD that the device is still operational. This may be indicated by a green visual indicator window.”

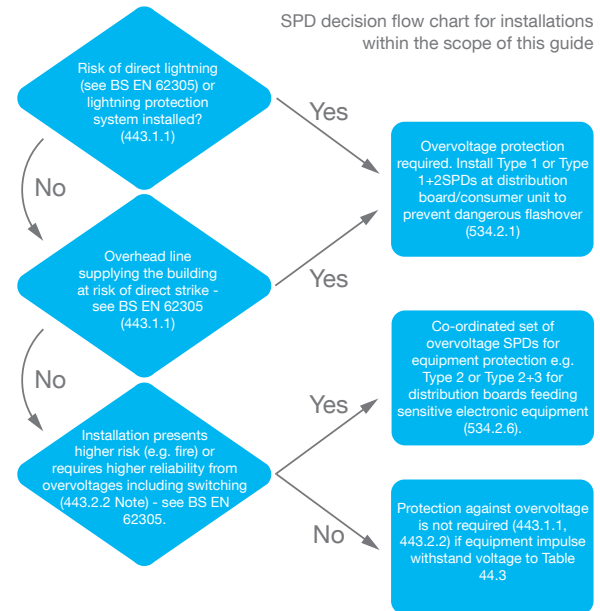
# SPD quick selection guide

The following is a quick selection guide which may assist in choosing whether SPD's are required and the correct type of device

- Does the installation contain a lightning protection system?
- Is the installation adjacent to any tall structure, tall trees or near a hill top in a lightning prone area?
- Does the installation contain equipment where higher reliability from overvoltages is required

If the answer is YES in the above to the first two questions, it is recommended to install a Type 1+2 device. This will provide protection against surges caused by direct lightning strikes and provide protection against transient over-voltages caused by indirect lightning strikes or by switching events.

If the answer is YES to the third question then it is recommended to install Type 2 devices to provide protection against transient over-voltages caused by indirect lightning strikes or by switching events.



**Note:** For larger installations beyond the scope of this guide, a risk assessment method used to evaluate the need for SPDs is given in Section 443 of BS 7671:2008(2011)

# Benefits of using Hager SPD's

- All applications are covered with a full range of compatible devices. Protection for high rise towers; commercial buildings with essential computer data and expensive office machinery; domestic dwellings with entertainment and computer systems.
- Advanced warning that the device needs replacing. Remote indication option means an audible or visible alarm can warn the user that the cartridge needs replacing.

“Remote indication option means an audible or visible alarm can warn the user that the cartridge needs replacing.”

## Product configuration

- Thermal and dynamic disconnection
- Increases equipment life (by providing clean power)
- DIN mounted devices
- Removable tabs on replaceable cartridges to give the contractor the option of allowing the consumer to replace the cartridge
- IP20
- Does not disconnect your installation from supply when experiencing a transient over-voltage
- Conforms to BS EN 62305-2 BS / EN 62305-3 / BS EN 61643-11



<b>Type 1 + 2 (Combined in a single device) (with lifetime indicator)</b>													
Poles	$I_{imp}$ L-N	$I_{imp}$ N-PE	$I_n$ L-N	$I_n$ N-PE	$U_p$ kV	$U_c$ V	Width (mm)	Single or Three phase	TNS	TNC-S	TT	Cat. Ref.	(with remote contact)
2	12.5	25	-	-	≤ 1.5	255 V ac	35	Single	✓	✓	✓	SPA201	-
3	12.5	37.5	-	-	≤ 1.5	255 V ac	70	Three	×	✓	×	SPA400	-
4	12.5	50	-	-	≤ 1.5	255 V ac	70	Three	✓	×	✓	SPA401	-
3	25	75	-	-	≤ 1.5	255 V ac	105	Three	×	✓	×	SPN800	SPN800R
4	25	100	-	-	≤ 1.5	255 V ac	140	Three	✓	×	×	SPN801	SPN801R
4	25	100	-	-	≤ 1.5	255 V ac	140	Three	×	×	✓	SPN802	SPN802R
<b>Class 2 (with lifetime indicator)</b>													
2	-	-	5	15	≤ 1.2	275 V ac	35	Single	✓	✓	✓	SPN215D	SPN215R
2	-	-	15	40	≤ 1.5	275 V ac	35	Single	✓	✓	✓	SPN240D	SPN240R
4	-	-	5	15	≤ 1.5	275 V ac	70	Three	✓	✓	✓	SPN415D	SPN415R
4	-	-	15	40	≤ 1.5	275 V ac	70	Three	×	✓	×	SPN440D	SPN440R
<b>Class 3 (fine protection) (with lifetime indicator)</b>													
2	-	-	3	-	≤ 1.5	255 V ac	35	Single	✓	✓	✓	SP202N	-
<b>PV Applications (dc side) (with lifetime indicator)</b>													
3	-	-	12.5	25	≤ 4	1000 V dc	52.5	-	-	-	-	SPV325	-
<b>Consumer Unit Kit Type 2 SPD Kit with SPN215D (with lifetime indicator)</b>													
2	-	-	5	15	≤ 1.2	275 V ac	35	Single	✓	✓	✓	VA02SPD	-

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