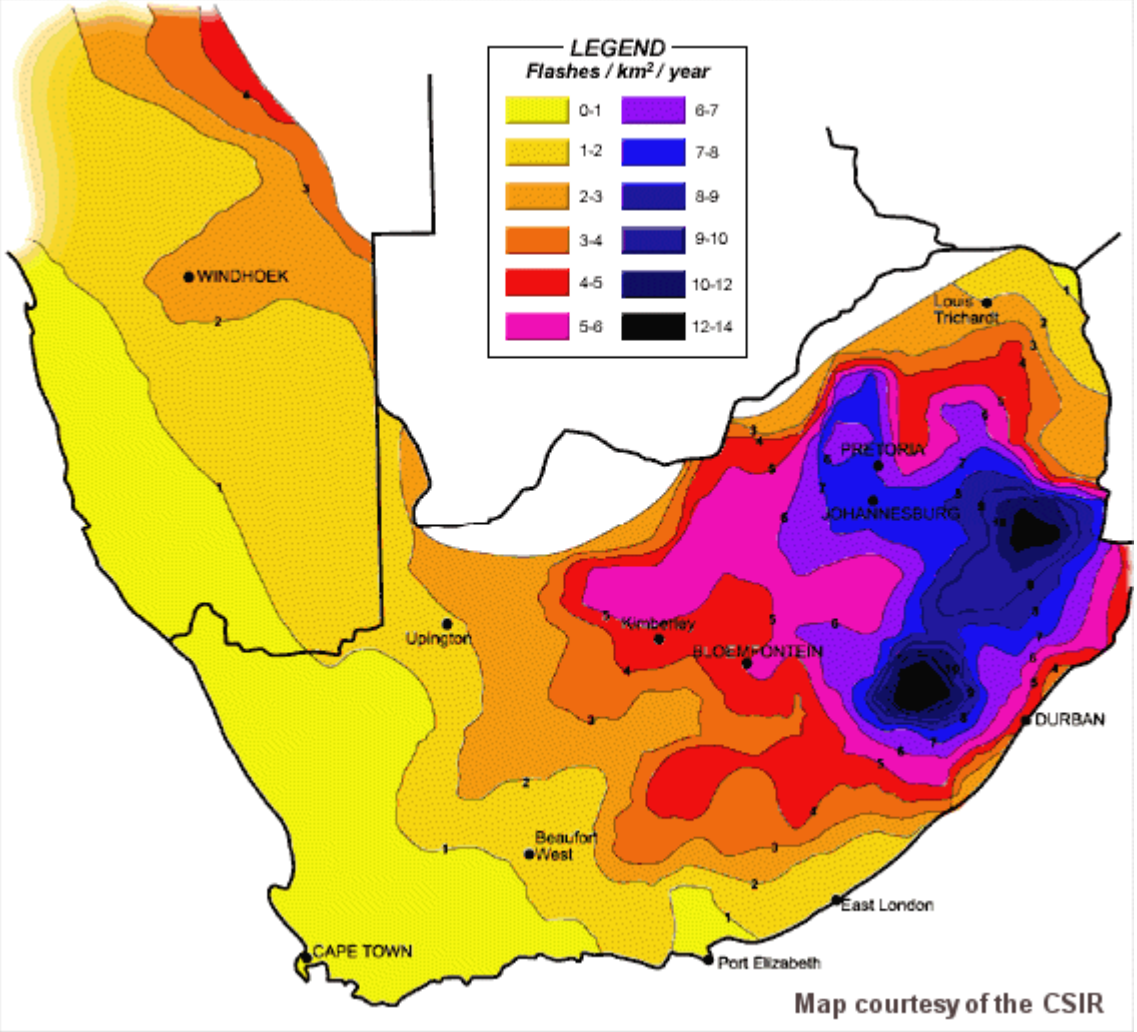
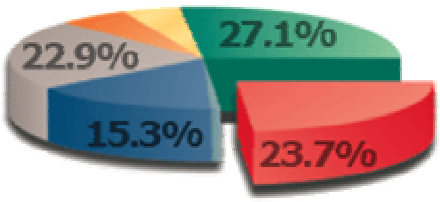
Making the Right Choices In Lightning & Surge Arrestors

Some Basics:

- It is a fact that the Highveld region of South Africa and Lesotho have amongst the highest lightning strikes per square km per annum in the world.
- On average every square km of South African Highveld and Natal receives 7 direct lightning strikes per annum.
- The facts are a that a direct or indirect lightning strike within a 1,5km radius of your home or office can generate as much as 120 million volts and up to 200 000 Amps, sending lethal surges ripping through power cables and telephone lines. The core temperature of a lightning strike is as high as 20 000 deg C or five times as hot as the surface of the sun.
- Statistics prove that as much as 80% of problems on electronic equipment are associated, directly or indirectly, with lightning and over-voltage surges.

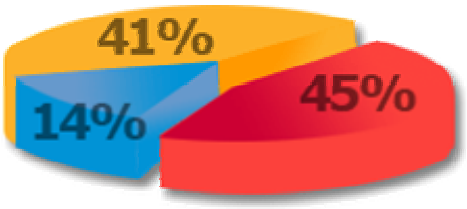


Loss reports of insurance companies show clearly that there is a need to address conditions both in the private (Fig.1) and the commercial (Fig. 2) sector.



15.3% Other causes
22.9% Negligence
5.6% Flooding
4.6% Fire
27.1% Theft, Vandalism
23.7% Surges Lightning Discharges

Fig. 1: Causes of damage to electronic equipment for 2001
Analysis of 7370 damage claims
(Ref.: Insurance Survey)



14% Unknown
41% Others
45% Lightning / Surges

Fig. 2: Average damage causes for the last years (Ref.: Insurance Survey – 10 Major European Companies interviewed 2001)

If your home or office building has a mast or external lightning protection rod then will this suffice? Not really, as the electromagnetic effects and induction will still cause damage to equipment within the building. In actual fact, if you install external lightning protection, you will actually require lightning current arresters and surge arresters to be able to withstand the induced energy. Lightning striking up to 1.5km away can cause damage to sensitive electrical and electronic equipment.

You've probably installed a lightening protection plug on all your computer, TV and telephone line, phone and fax machines. How well will this protect? Well, it depends on the choice of protection purchased. There are some good quality Class 3 arresters and in terms of SANS 10142-1:2003 and they should be used in conjunction with Class 2 surge arresters installed in the electrical distribution board.

Sources of interferences

Surges arising due to thunderstorms, are caused by direct / close lightning strikes or distant lightning strikes. Direct or close lightning strikes are strikes into the lightning protection system of a structure, into its immediate surroundings or into the conductive systems entering the structure (e.g. low voltage power supply, telecommunication and control lines.). Due to their amplitudes and energy loads, the arising impulse currents and impulse voltages represent a special risk for the system to be protected.

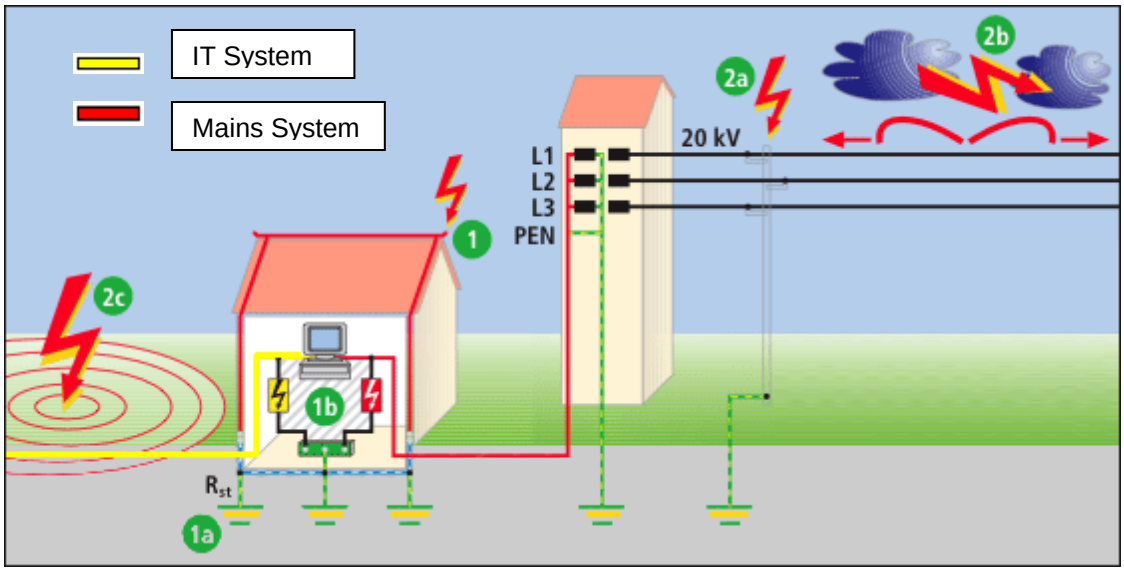


Fig. 3: Causes of surges at lightning discharges

1. Direct close lightening strike
   (a) voltage drop at the impulse earthing resistance R_{st}
   (b) inducted voltage in loops
2. Distant lightning strike
   (a) strike in medium voltage overhead lines
   (b) surge waves travelling on overhead lines due to cloud to cloud lightning
   (c) fields of the lightning channel.

With a close or direct lightning strike, the surges (Fig.3: Case 1a) are caused by a voltage drop at the impulse earthing resistance and the resulting potential rise of the structure towards the distant surroundings. This is the max. load on electrical installations in structures.

Additionally to the voltage drop at the impulse earthing resistance, surges arise in the electrical structure and the connected systems and equipment due to the induction effect of the electromagnetic lightning field (Fig 3: Case 1b). Distant strikes are lightning strikes from a distance to the object to be protected, lightning strikes into the medium voltage overhead line network or into its immediate surroundings, or lightning discharges from cloud to cloud (Fig. 3: Cases 2a, 2b and 2c).
In analogy to induced surges, the effects of distant lightning strikes on the electrical system of a structure are controlled by devices and components, which are designed accordingly for impulse current wave 8/20 µs.

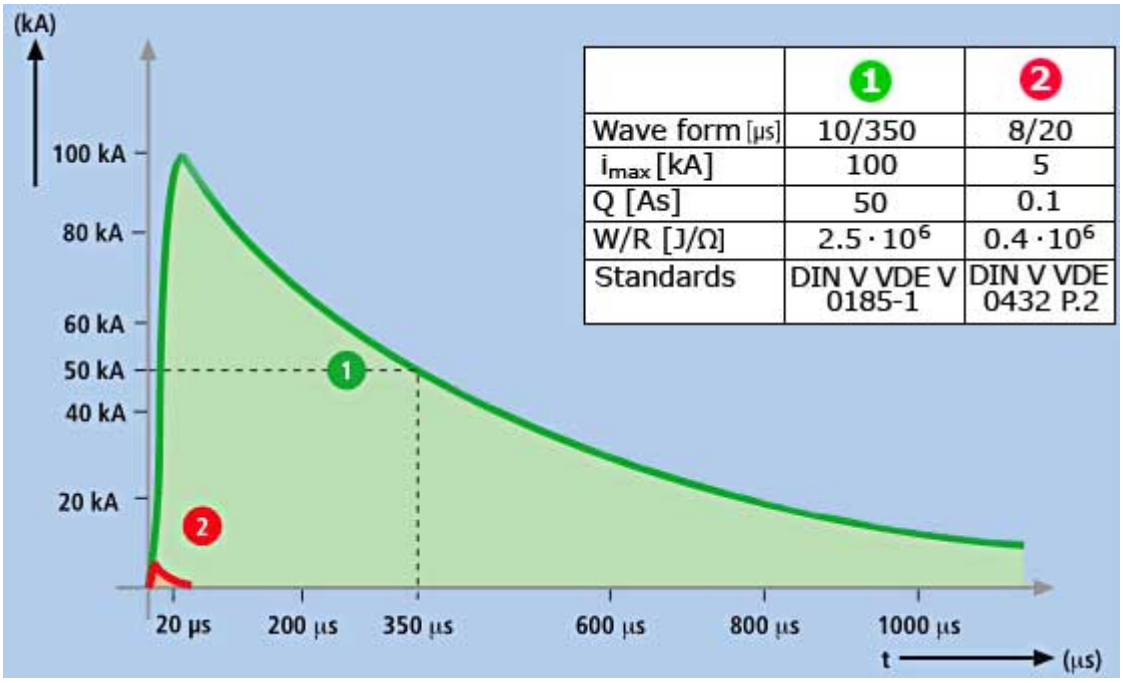
Surges due to switching operations (SEMP) are caused by e.g.:

- switching off inductive loads (e.g. transformers, coils, motors),
- ignition and interruption of electric arcs (e.g. arc welding device),
- tripping of fuses.

The power of these induced surges and the resulting impulse currents is considerably lower than the power of a direct lightning impulse current and is therefore only described with the impulse current wave 8/20 µs (Fig. 4). Components and equipment, which do not have to carry currents out of direct lightning strikes, are therefore tested with impulse currents of 8/20 µs.

The effects of switching operations in electrical installations of structures are also emulated for test engineering with impulse currents of wave form 8/20 µs.

The characteristic parameters of flowing impulse currents (peak value, rate of current rise, load, specific energy) can be described with the impulse-current wave form 10/350 µs (Fig. 4) and are defined in international, European and national standards as test currents for components and devices for the protection against direct lightning strikes.



	1	2
Wave form [µs]	10/350	8/20
i_{max} [kA]	100	5
Q [As]	50	0.1
W/R [J/Ω]	$2.5 \cdot 10^6$	$0.4 \cdot 10^6$
Standards	DIN V VDE V 0185-1	DIN V VDE 0432 P.2

Fig 4: **1 = Test impulse current for lightning current arresters**
2 = Test impulse current for surge arresters

Lightning Protection Zones Concept

The Lightning Protection Zones Concept enables designers, constructors and operators to plan, perform and control protection measures. Thus, all relevant devices, installations and systems are protected reliably and furthermore with economically acceptable efforts.

Protection philosophy

For ensuring a continuous availability of complex electrical and IT systems, even in case of a direct lightning effect, further measures for the surge protection of electrical and electronic installations are necessary, based on a building lightning protection system. Taking all causes of surges into consideration is very important. For this purpose, the Lightning Protection Zones Concept described in IEC 62305-4 (DIN V VDE V 0185-4) is applied (Fig. 5). A structure is subdivided in different risk zones. With these zones the necessary devices and components can be defined for the lightning and surge protection.

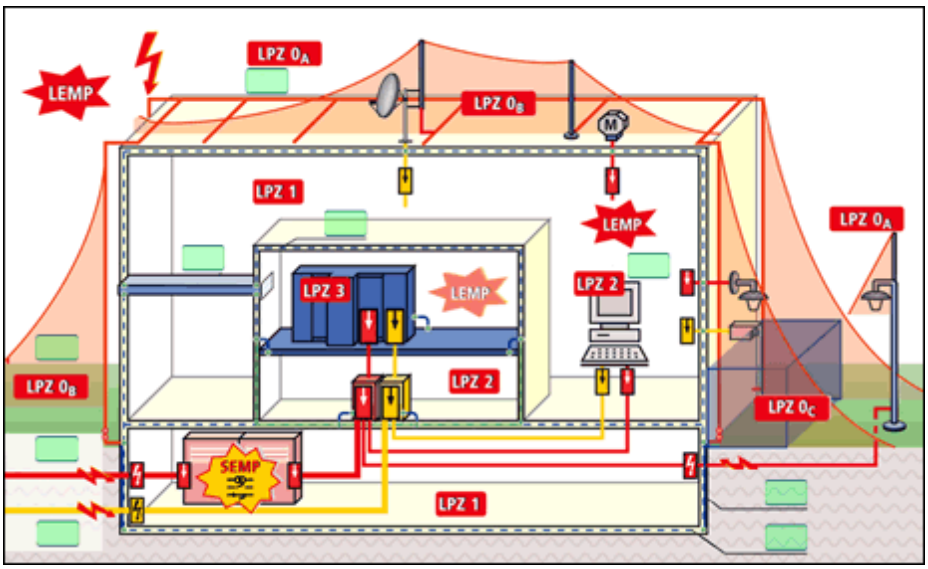


Fig 5. Lightning Protection Zones Concept

Part of an EMC-conforming lightning protection zones concept is an external lightning protection system (including air-termination system, down conductor system, earthing), equipotential bonding, spatial shielding and the surge protection for the power supply and IT systems.
The definition of the lightning protection zones is subject to the predeterminations made in Table 1.

LEMP protection of structures with electrical and electronic systems in accordance with DIN V VDE V 0185-4 (VDE V 0185 Teil 4): 2002-11	
Lightning Protection Zone	**Description**
LPZ 0_A	Threat by direct lightning strikes, impulse currents up to complete lightning currents and the entire lightning field.
LPZ 0_B	Protected against direct lightning strikes. Threat by impulse currents up to partial lightning currents and the entire lightning field.
LPZ 0_C	Threat of contact and pace voltages for living beings. Defined on earth level within a height of 3 m and a distance of 3 m outside of a structure (see DIN V VDE V 0185-3 (VDE V 0185 Part 3).
LPZ 1	Impulse currrents are further limited by current distribution and SPDs situated at the zone boundaries. The lightning field is mostly attenuated by spatial shielding.
LPZ 2	Impulse currents are further limited by current distribution and SPDs situated at the zone boundaries. The lightning field is mostly attenuated by spatial shielding.

Table 1: Definition of the lightning protection zones (LPZ)

In correspondence with the requirements and loads on surge protective devices regarding their installation site, these are classified as lightning current arresters, surge arresters and combined arresters.
The highest requirements regarding the discharge capacity are made on lightning current and combined arresters, which realise the transition from Lightning Protection Zone 0A to 1 or 0A to 2.

These arresters must be able to conduct partial lightning currents, wave form 10/350 µs several times without destruction in order to prevent the penetration of destructive partial lightning currents into the electrical installation of a building. At the boundary from LPZ 0B to 1 or downstream of the lightning current arrester at the boundary from LPZ 1 to 2 and higher, surge arresters are used for the protection against surges. Their function is to further reduce both the residual load of the upstream protection levels and limit the inducted or own surges.

The aforementioned lightning and surge protective measures at the boundaries of the lightning protection zones apply to both power supplies and IT systems to the same extent.

Due to the entirety of the measures described in the EMC-conforming Lightning Protection Zones Concept, a permanent system availability of a modern infrastructure can be achieved.

What are we talking about in terms of 'Classes' of surge arrestors?

There are 3 x main categories of lightning surge arresters.

Class 1 / A - (10/350) lightning current arresters, which can withstand direct lightning
Class 2 / B - (8/20) surge arresters, to protect against induced surge currents
Class 3 / C - (8/20) surge arresters, to protect against induced surge currents

Lightning Current Arresters / Surge Arresters

According to their different tasks the protective devices are divided into "Lightning Current Arresters" and "Surge Arresters".
In order to maintain complete protection in the field of surges have to be taken into consideration "Power Supply Systems" as well as "Information Technology Systems".

Surge protection - Power Supply

These products offer comprehensive protection to the power supply side provided there is an external lightning protection installation.

Lightning current arresters (Class 1/A) are installed inside the distribution board. They protect low-voltage installations against surge voltage also in case of direct lightning strikes.

Surge arresters (Class 2/A) are installed in the sub-distribution board. They provide protection against surge voltages due to distant lightning strikes or peak voltages arising in the electrical power system.

A decoupling element must be installed for subsequent installation of lightning current arrester and surge arrester with cable lengths under 15 metres. (Fig. 6)

Under the IEC 61312-1 arrangement, a lightning current arrester is fitted at the power entry panel of the facility, followed by a decoupling element, terminating in a class 2 surge arrester at the power distribution board.

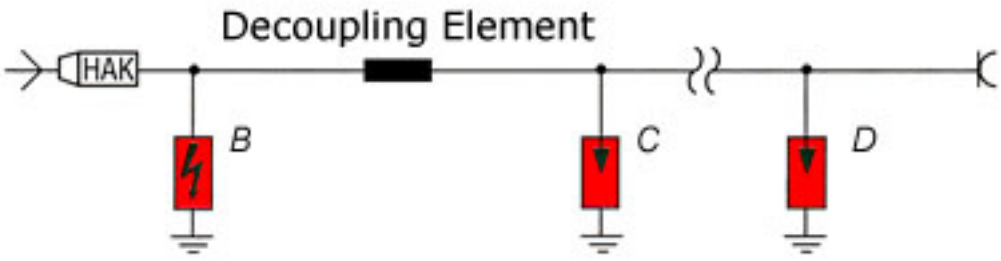


Fig. 6. Typical single phase element. Tripled-up in 3 phase unit

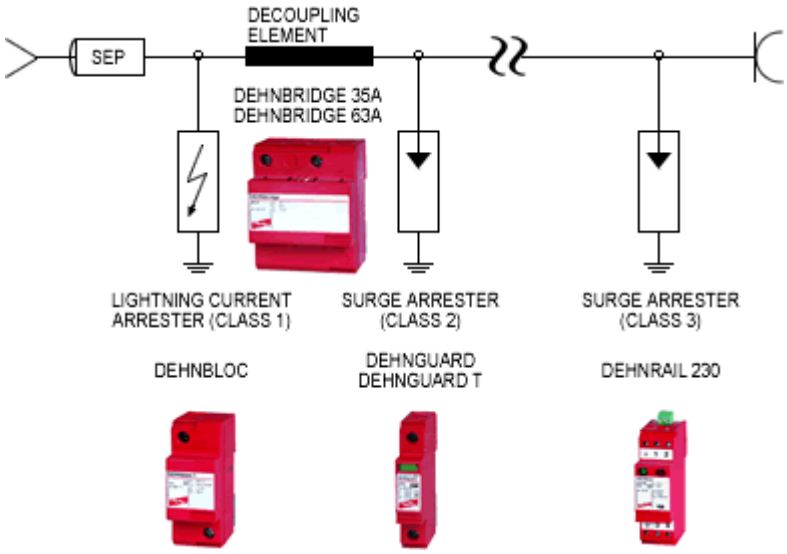


Fig. 7. Class 1 current surge arrester arrangement to comply with the requirements of IEC 61312-1 Protection Zone Concept within the OA-1 bounder. Courtesy Dehn (Locally supplied by Sinetech)

Surge protection devices (Class 3/C) are installed at the terminal equipment absorbing the residual energy and providing protection against surges due to internal switching operations.

Surge protection - IT-Network

Surge protective devices for information technology systems

Failure of telephone, fax, computer or even complex computer controlled systems and machines is a risk too high to accept.
A percentage of more than 25% of the damage in information technology systems is caused by surge voltages due to electromagnetic interference. Double conversion On-Line UPS devices should protect all IT systems or networks. On-board circuitry provides Class 3 protection.

Protect your systems!

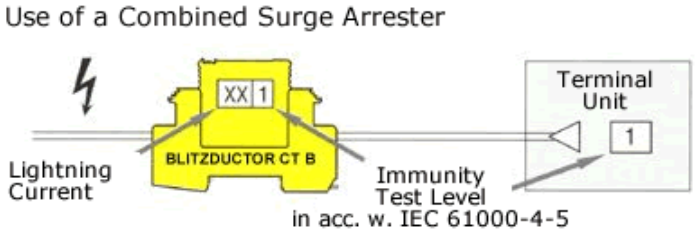
Protection Device Quick Selection by using coordination characteristics (KK):

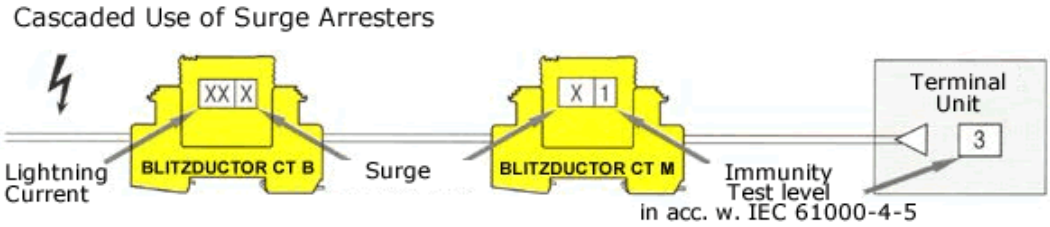
When choosing the surge protection device take a voltage protection level VP which is below the surge immunity level of the terminal equipment installed downstream in the communication/signalling circuit.
Since this level is often unknown it is necessary to use other means of comparison instead.
According to tests for electromagnetic compatibility (EMC), electrical and electronic equipment must have a certain immunity level against line-conducted disturbances (surges). The test set-up and the requirements for testing are stipulated in EN 61000-4-5 (VDE 0847 Part 5).
Installation classifications from 0 to X stand for certain electromagnetic environmental conditions. Depending on these installation classifications, different immunity levels (1-4) of the equipment are determined regarding the immunity against surges.
Equipment tested according to the test level 1 has the lowest surge immunity and equipment tested according to level 4 has the highest surge immunity. The test level is normally indicated in the specification of the equipment or can be inquired with the manufacturer.

With regard to the protection provided by the surge protective device this means that the let-through energy must be below the immunity level of the equipment to be protected.

Coordination characteristics (KK)

The first mark (here XX) gives information about the let-through energy of the surge protective device, the second mark (here X) about the required surge immunity level of downstream equipment or the let-through energy of another downstream surge protective device.
The coordination characteristics describe the let-through energy of the surge protection device and the required surge immunity level of downstream equipment (or the let-through energy of another downstream surge protective device).





For trouble-free operation, the indicated test level of terminal equipment (e.g.) 3 must be higher than or similar to the test level demanded by the coordination characteristics of the protective device (e.g. 1, 2 or 3)

Some FAQ's

So by installing surge arresters in my electrical distribution board will I never have damage again?

By installing surge arresters in your electrical distribution board you are dramatically reducing your risk of suffering damage via the power only, but not eliminating the risk.

Will the surge arresters in my electrical distribution board be damaged by a direct strike?

Most probably as they are only designed to withstand induced surges of up to 40kA. A direct strike has far more energy, which could destroy the surge arresters, but they will still offer some protection. Due to the fact that your risk of a direct strike is so small you should worry about the regular induced surges.

If the supply voltage increases to 250 Volts, will the surge arresters protect my equipment?

No, as they are designed to protect against high energy, high voltage surges and not to operate as voltage regulators. In this case a voltage regulator or better a “ On-Line double conversion sinewave UPS should be installed.

Once the surge arrester has disconnected can it be re-set?

No, it needs to be replaced.

If the electrical distribution board has a fault current rating of 15kA must I use 20kA surge arresters?

The kA rating of the surge arresters has nothing to do with the fault current rating of electrical distribution board. You can fit a 40kA surge arrester in a domestic board with a fault current rating of less than 5kA. In larger panels with high fault current ratings you must pre-fuse the surge arresters to co-ordinate and protect the surge arresters.

Does it help to fit 2 x surge arresters in parallel to increase the surge handling capabilities?

Not really, as the surge arresters will not conduct evenly and thus by installing 2 x 40kA surge arresters does not mean that you can handle a surge of 80kA. You may be lucky to handle a surge of 65kA.

What is the difference between a surge arrester marked 40kA (8/20) and 65kA (4/10)?

These 2 x units are actually the same but (4/10) is half the energy of (8/20) and thus the manufacturer can claim higher kA ratings. To overcome this problem all manufactures must publish their surge handling ability at (10/350) for lightning current arresters and (8/20) for surge arresters.

If I install lightning current arresters Class 1 will I get a better level of protection than using surge arresters Class 2?

No, if you install Class 1 then they must be used in conjunction with Class 2 surge arresters to offer complete protection.

If I install only plug-in type surge arresters such as the Class 3 range will I be protected?

A Class 3 arrester terms of SANS 10142-1:2003 should be used in conjunction with Class 2 surge arresters installed in the electrical distribution board.

Must I unplug my computer or modem if there is lightning and I have a Class 3 protector installed?

No, the Class 3 protector is designed to withstand induced surges and it also requires the electrical plug to be plugged in to supply the earth discharge path.