



DEHN + SÖHNE

Coordinated Surge Protection

Red/Line

Coordinated Surge Protection
for Power Supply Systems

DS641/E/10.05

The Lightning Flood Wave

When lightning hits an installation, high impulse currents and impulse voltages come up within conductive systems which can be compared to an enormous "flood wave". If this "flood wave" is not broken, important electrical consumers will be destroyed.

The impact of this "flood wave" is described and defined in lightning protection standard series IEC 62305. The lightning flood wave is similar to an impulse current reaching its peak value within only 10 millionths of a second and reducing its value again by 50% within 350 millionths of a second.

Apart from the dynamic and thermal destruction caused by this "lightning flood wave" in unprotected installations, the lightning impulse current activates an electromagnetic field impulse.

This electromagnetic field impulse enters the structure, its systems and terminal equipment in a hardly sensible way and generates surges of several 1,000 V in conductor loops and circuits.

In order to control this lightning force successfully, a specified lightning and surge protection concept is necessary. The surge protective devices (SPDs) used must be designed for the loads at site. They have to be energy-coordinated among each other and with the equipment and terminal systems to be protected. Furthermore, their voltage protection levels must be coordinated with the insulating strength of the parts of the installation and the terminal devices.

These requirements are fulfilled with the DEHN Surge Arrester Family

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The safe Protection Concept

Safe lightning and surge protection is based on the lightning protection zones concept described in IEC 62305-4. The relevant organising principle of dividing the object to be protected into protection zones (so-called lightning protection zones (LPZ)) and defining the zone boundaries can be applied both to protect a detached house and a large-scale installation (e.g. a data processing centre).

The protection zones are divided up firstly from the outside area of the object to be protected and thereafter in the inside area. Surge arresters are installed at the boundaries of the different protection zones. As the physical relations are not important for whether lightning hits a detached house or a data processing centre, the lightning protection requirements on the SPDs are nearly independent from the installation site.

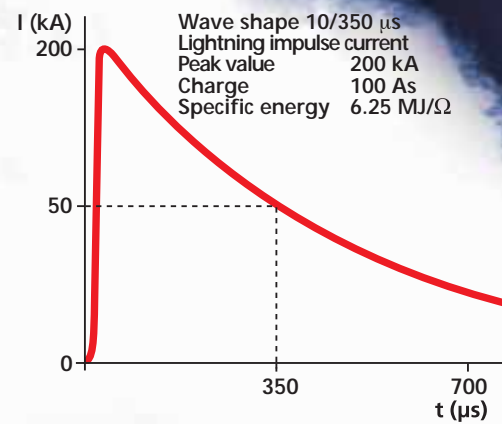
For SPDs for power supply systems, IEC 60364-5-53 complements the lightning protection requirements of the SPDs with the system-related requirements of the application field. As safety allows no compromises, the Red/Line product family of DEHN + SÖHNE provides the right SPDs for every type of installation. The first protective stage (LPZ 0_A - 1) requires a "wave breaker" to discharge the majority of the lightning current. The SPD used for this stage (SPD Type 1 according to EN 61643-11), is therefore also called lightning current arrester. Such impulse energies can be controlled safely by spark gaps only, as these "switch" the lightning impulse current wave and therefore reduce the pulse time. The function of the subsequent protective stages is to discharge the residual impulse currents of the lightning flood wave and to reduce the surges induced by the electromagnetic field to a bearable level for downstream equipment.

Type/Description \ Standards	IEC 61643-1: 1998	EN 61643-11: 2001
Lightning current arrester, Combined lightning current and surge arrester	SPD Class I	SPD Type 1
Surge arrester for distribution boards, subdistribution boards, fixed installations	SPD Class II	SPD Type 2
Surge arrester for socket outlets / terminal units	SPD Class III	SPD Type 3

Overview on the classifications of surge protective devices (SPDs) in the IEC and EN standards

While single- or two-stage protection concepts are designed for small-sized electrical installations, e.g. a mobile radio station, a three-stage protection concept has proven to be an economical and technical optimum for medium- sized and major installations. Often, the SPDs are used according to the already existing electrical "nodes" in main distribution boards, subdistribution boards and final electrical circuits or at terminal devices. The SPDs in the subdistribution boards and final circuits are distinguished between SPDs Type 2 and Type 3 according to EN 61643-11 and consist typically of varistors (voltage-dependent resistors).

To make the coordination of the individual protective stages possible, energy coordination is necessary. Like for the selective stages of fuses in heavy-current systems, also for lightning current and surge arresters, a "selectivity" must be achieved in order to prevent overloads on the SPDs connected in parallel and the devices to be protected.



The Wave Breakers

Lightning Protection Zones $0_A/1$ and $0_A/2$

In order to render the "impact" of the "lightning flood wave" harmless for the electrical installation affected, powerful creepage discharge spark gaps are used. With their unique capability to shorten the pulse time, these spark gaps are also called wave breakers.

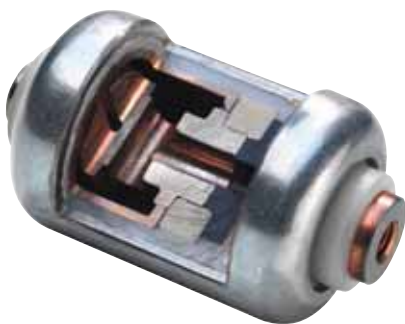
Alternative technologies like varistors fail because of the high energy transformation due to their continuous current-voltage characteristic at flowing lightning currents, waveform 10/350 μ s.

Modern creepage discharge spark gaps are completely encapsulated. The capsulation prevents the leaking of ionised gases and the resulting restrictions for application.

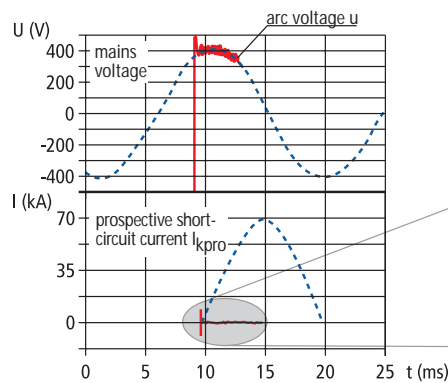
To ensure that ignited spark gaps will not cause a short circuit at the installation, only spark gaps with a high self-extinguishing capability and follow current limitation are used.

The "RADAX-Flow" follow current limiting and extinguishing procedure developed by DEHN + SÖHNE allows for a selectivity to small-sized installation fuses of 35 A gL/gG even at prospective installation short-circuit currents of up to 50 kA_{rms}.

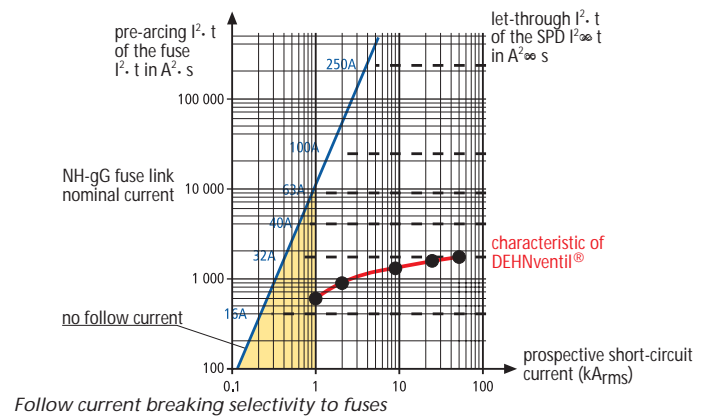
100 thousands of RADAX-Flow creepage discharge spark gaps of the Red/Line product family of DEHN + SÖHNE protect electrical installations worldwide from destruction and interruptions of operation.



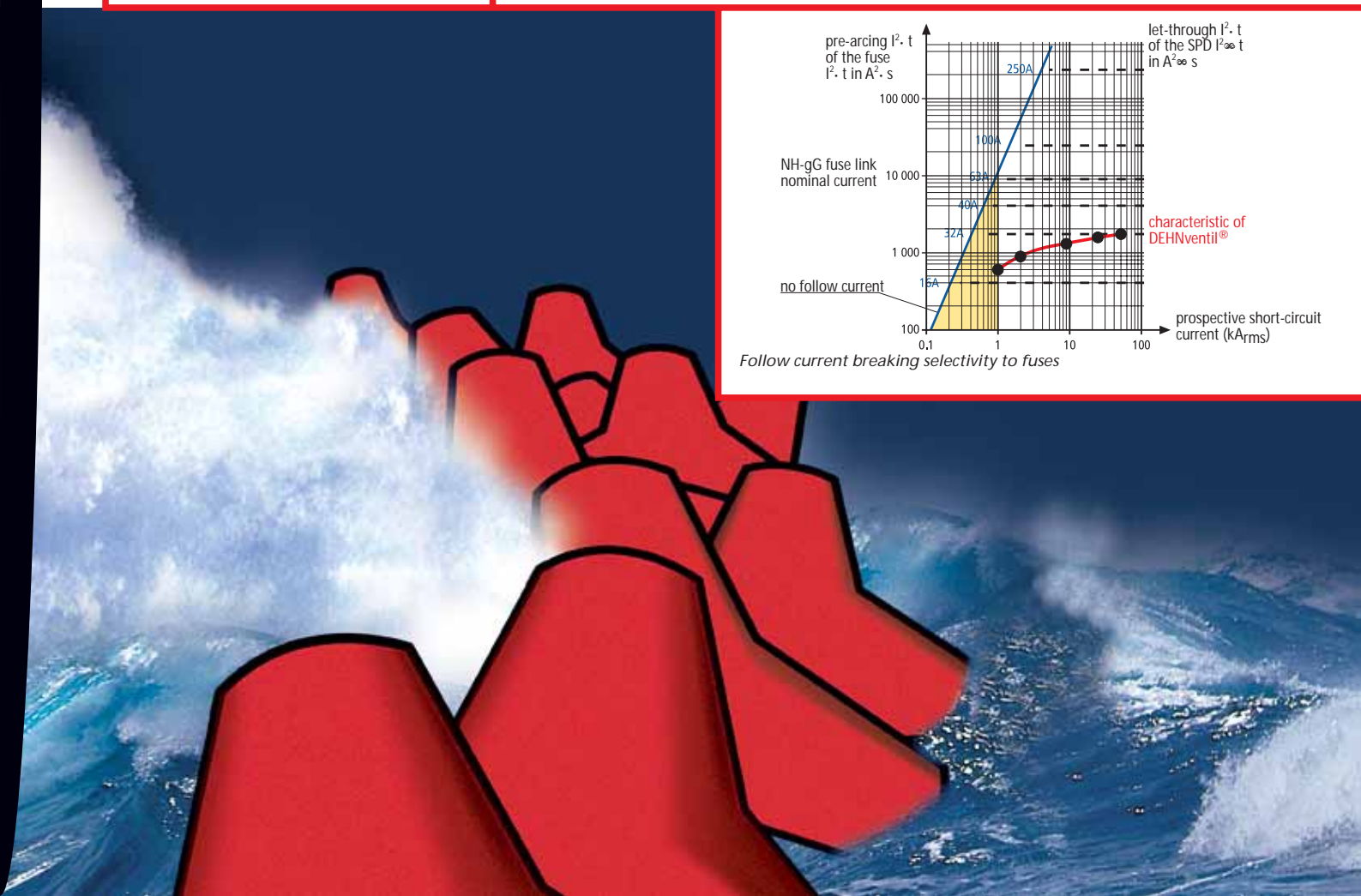
Section of DEHNventil® spark gap



Follow current limitation of a RADAX-Flow spark gap



Follow current breaking selectivity to fuses





DEHNventil® TNC

According to application, the DEHN “wave breakers” are designed as combined lightning current and surge arresters, coordinated lightning current arresters and lightning current arresters. With ranges DEHNventil®, DEHNbloc® Maxi and DEHNbloc®, the user finds the right solution for every type of installation.

DEHNventil® Combined Lightning Current and Surge Arrester

The 2-, 3- and 4-pole DEHNventil® devices are definite combined lightning current and surge arresters. Their capacity of discharging safely up to 100 kA of lightning impulse currents and ensuring the energy coordination to terminal devices and downstream SPDs Type 3 at the same time, makes them a market leader worldwide. These combined lightning current and surge arresters are, of course, also based on the RADAX-Flow spark-gap technology, like all SPDs Type 1 of DEHN + SÖHNE.



DEHNbloc® Maxi S

DEHNbloc® Maxi Coordinated Lightning Current Arrester

Whether as a DIN rail mountable device or for direct installation on conductor rails – the coordinated lightning current arresters DEHNbloc® Maxi ensure the keeping of the insulating resistance of the electrical installation with simultaneous capability of direct energy coordination to DEHNguard® surge arresters Type 2. Cable lengths or additional decoupling coils are not required for coordinated DEHNbloc® Maxi lightning current arresters.

An absolute novelty is DEHNbloc® Maxi S which can be mounted onto current busbars: The backup fuse integrated into the protective device allows for use in medium- and high-capacity switchgears without additional installation of separate backup fuses. DEHNbloc® Maxi S can be installed upstream of the circuit breaker into the so-called termination panel. Thus, only very short cable lengths are required for connecting SPDs. Furthermore, the low voltage protection level of DEHNbloc® Maxi S can be optimally transferred to the switchgear installation.



DEHNbloc® Maxi and DEHNbloc® H

DEHNbloc® H Lightning Current Arrester

The lightning current arresters of the DEHNbloc® range have provided maximum protection at boundaries between lightning protection zone (LPZ) 0_A and 1 for years. DEHNbloc® H replaces the approved pressure-controlled encapsulated creepage discharge spark gap by a modern RADAX-Flow spark gap. Also here, system availability has top priority. Like all DIN rail mountable RADAX-Flow spark gaps of the Red/Line product family, also DEHNbloc® H has double terminals for protection- and cost-optimised connection of the device in the distribution board of the installation.

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Coordinated Surge Protection
for Power Supply Systems

N-PE Surge Arresters Type 1 Lightning Protection Zones 0_A/1 and 0_A/2

DEHN + SÖHNE has used 3+1 circuits even for TT systems already for more than 20 years. This type of circuit has also met the approval of international standard committees within the scope of our cooperation. The three phase conductors are connected with e.g. DEHNBloc® Maxi to the neutral conductor with creepage discharge spark gaps – an N-PE spark gap is installed between the neutral conductor and the protective conductor.

What is the function of N-PE surge arresters Type 1?

SPDs for lightning equipotential bonding (Type 1) have to be installed as close to the service entrance as possible.

For TT systems, this means an installation upstream of the residual current device (RCD). If an earth fault comes up in this area, the upstream fuse would have to assume the disconnection. In case of unfavourable earthing conditions, however, this is not ensured.

In case of a fault, the N-PE surge arresters used in a 3+1 circuit would cause a short-circuit current between the phase conductor and neutral conductor, which can be isolated by the fuse within the provided period of time.

No matter, if the N-PE surge arresters Type 1 are designed as a lightning current arrester (DEHNgap BN), coordinated lightning current arrester (DEHNgap Maxi) or as part of a combined lightning current and surge arrester (DEHNventil®) – for all applications, these SPDs must provide maximum performance. Depending on the type of lightning protection system, these surge arresters discharge the total current of the inducted “lightning flood wave” of up to 100 kA (10/350 μs) without destruction.

Additionally, these high-capacity creepage discharge spark gaps maintain also the safe electrical isolation between N and PE.

The N-PE surge arresters Type 1 of the Red/Line product range fulfil this task even under consideration of worst application environments like existing neutral displacement voltages in three-phase systems or at upcoming temporary overvoltages (TOV) due to earth faults on the high-voltage side of the installation or distribution transformer.



DEHNgap BN

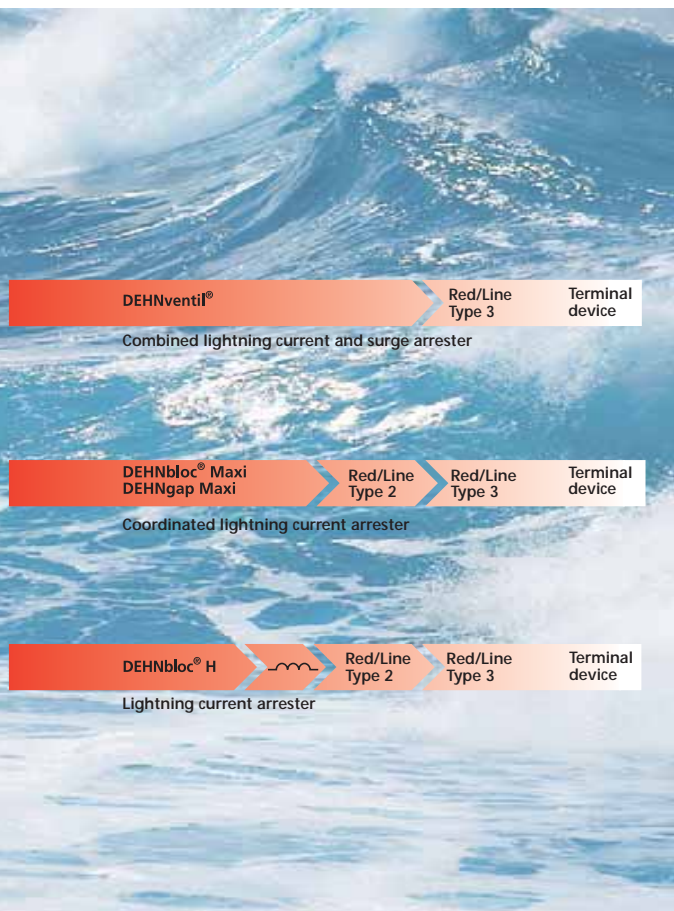


DEHNgap Maxi

Internal design of DEHNventil® TT N-PE spark gap



Energy Coordination Lightning Protection Zone 1



Energy coordination is the selective effect of all surge limiting modules in an electrical installation. Of course, this includes SPDs installed at boundaries of lightning protection zones. Moreover, energy-coordinated surge protection starts with the SPD Type 1 at the service entrance and ends at, or better within, the device to be protected. Energy coordination is not only serial mounting of surge arresters into electrical installations in accordance with their voltage protection levels. On the contrary, this choice alone would have fatal consequences in case of upcoming high-energy impulse currents. This wrong interpretation would lead to an overloading of individual protective stages at simultaneous failure of the installation. Energy coordination can only be achieved, if the performance of the different surge arresters, the installation, the equipment and the terminal devices to be protected are known for upcoming surges and impulse currents. Experience of decades and commitment to the elaboration of product and installation standards has enabled DEHN + SÖHNE to include the system characteristics of energy coordination into a product family: Red/Line – energy-coordinated surge protection for power supply systems. Energy coordination in a product family can only be realised, if lightning current arresters or combined lightning current and surge arresters are capable of breaking the high-energy “lightning flood wave” and rendering it harmless. Only spark-gap based surge arresters have this “wave-breaking” performance and only with these characteristics the surge arresters type 2 and 3, which have been tested with impulse currents (8/20 μ s), can be adapted to protect the terminal devices.

Depending on the protective cascade to be realised in the installation to be protected, the Red/Line product family provides three different SPDs Type 1:

- > Lightning current arrester
- > Coordinated lightning current arrester
- > Combined lightning current and surge arrester

For coordinating the lightning current arresters (DEHNbloc® H) with downstream SPDs Type 2 (DEHNguard®), the installation line of min. 15 m is used.

The coordinated lightning current arresters (DEHNbloc® Maxi) are aligned directly with DEHNguard® Type 2 surge arresters. By developing these surge arresters as a protection system, spark gaps can no longer be circumvented (so-called Blind Spot), and a damaging of the downstream surge arrester Type 2 can be avoided.

The combined lightning current and surge arresters (DEHNventil®) of the Red/Line family provide even more features: Their power-flow-controlled RADAX-Flow spark gap is dimensioned for energy coordination to terminal devices, i.e. one device combines the characteristics of a complete chain of SPDs in one single device. In specially compact electrical installations this means a transition from LPZ boundaries O_A to 2 in only one step.

In expansive electrical installations, the combined lightning current and surge arresters can, of course, also be coordinated with downstream surge arresters Type 2 (DEHNguard®) or Type 3 (DEHNrail) as described above.

Surge Arresters installed into Distribution Boards

Lightning Protection Zone 1/2

Surge arresters installed into distribution boards have a central function especially in expansive electrical installations, like office buildings. Being the second protective stage in the protection concept, it connects also the lightning current arrester in the main distribution board of the building and the protection of the terminal device. The resulting relations to the different arrester technologies have especially to be taken into consideration when designing this protective stage. In coaction with lightning current arresters, the SPDs Type 2 assume a part of the inducted lightning energy.

But the surge arresters in the distribution board have a further difficult function. They eliminate surges inducted by the enormous electromagnetic field impulse of lightning into the conductor loops of the installation. Their quick action protects also against surge impulses as they can arise due to switching operations in electrical installations.

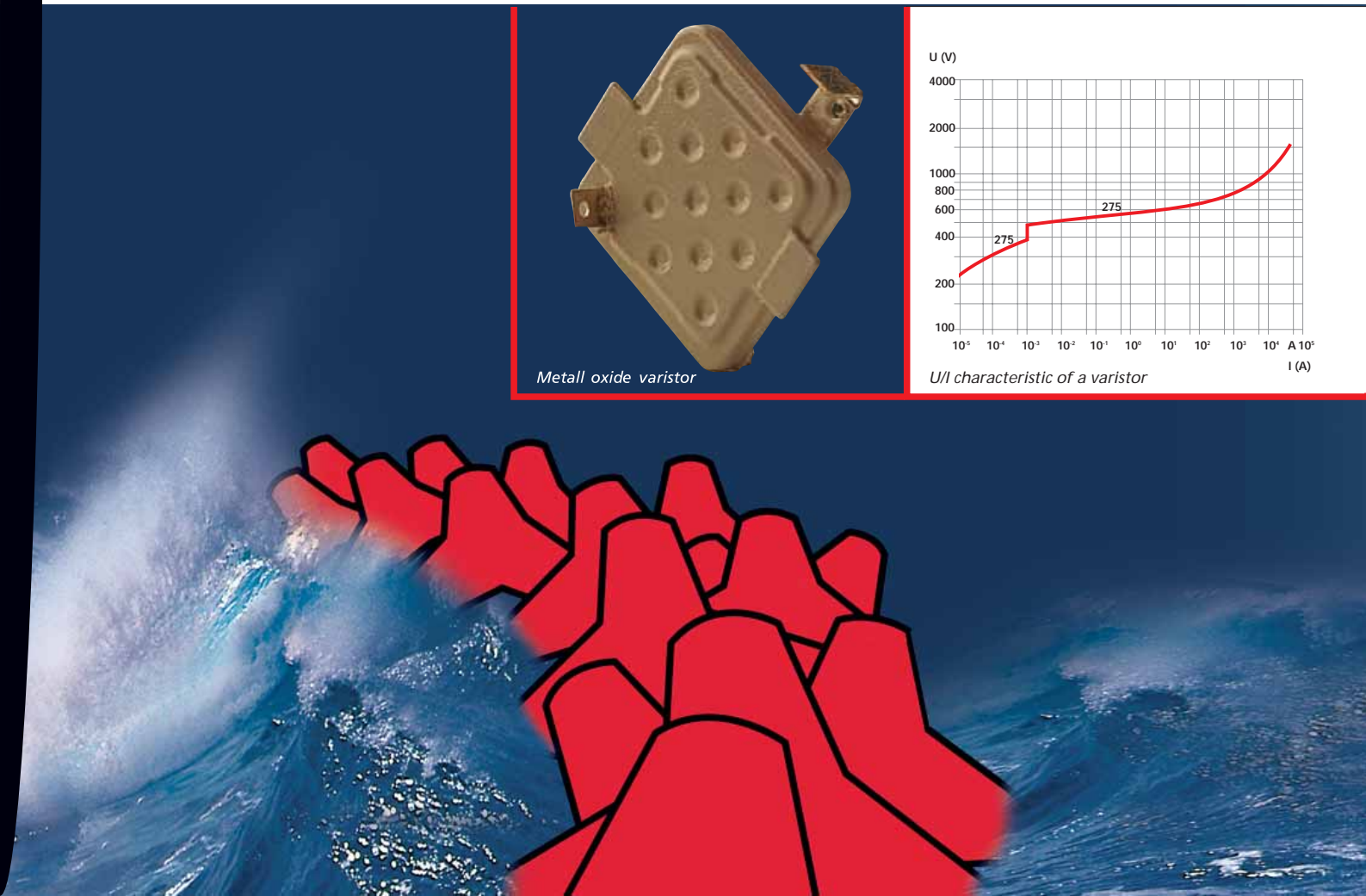
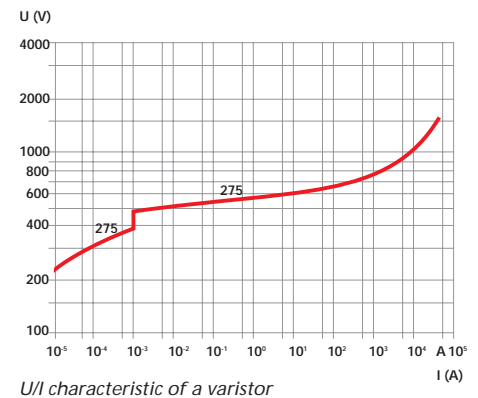
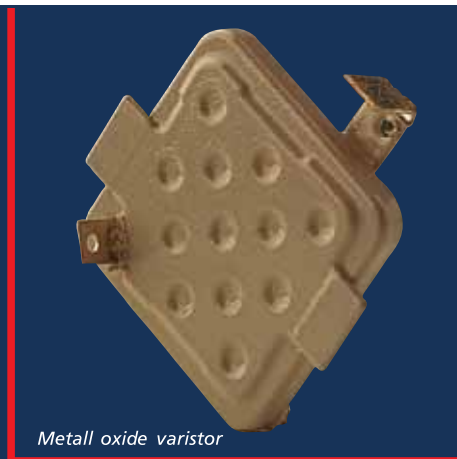
Metal oxide varistors (MOV) are ideal protection elements for SPDs Type 2. These voltage-controlled resistors are constantly active and register even minimal surges. These U/I characteristics ensure a response of the protection element in some billionths of a second. There is no way for surges any more!

DEHN + SÖHNE has used powerful ZnO varistors with a nominal discharge capacity of 20 kA (8/20 μ s) already for many years. The protective element must endure this load at least 20 times without destruction and modification in performance.

If this load is exceeded due to unfavourable conditions, e.g. due to lacking upstream spark-gap based lightning current arrester, and the varistor is therefore overloaded, it must automatically be disconnected from mains. With a dual monitoring system, i.e. Thermo Dynamic Control, surge arresters of DEHN + SÖHNE can be controlled. This prevents a faulty surge arrester from interfering with the operation of the system. The fault can be indicated by remote signalling, locally by an indicator or optionally by a floating changeover contact.

With the intelligent SPD control Pro-Active Thermo Control it is now possible to detect a damage to the varistor structure on time and to anticipate an upcoming failure of the SPD by exchanging the protection module. This intelligent monitoring system is used for the first time for surge arresters Type DEHNgard® LI.

In analogy to SPDs Type 1, also N-PE surge arresters Type 2 installed into distribution boards for use in TT systems are subject to high requirements. In order to ensure safety for the installation and persons, only spark-gap based surge arresters are used here.



Whether single- or multipole, compact or pluggable, with or without remote signalling - with products of the DEHNgard® family, there is the right surge protection for every type of installation.

Apart from universally usable devices, many customised protective circuits, e.g. for photovoltaics, can be provided. The product range goes from 75 V units to rated voltages of 1000 V for ac and dc applications. Especially the range of multipole DEHNgard® devices is becoming more and more popular for designers and users. Their product performance provides maximum safety and convenience. The application-orientated product description makes the choice of the complete prewired units considerably easier. Reduced installation mistakes and simultaneous saving of installation work are unbeatable benefits for the customer. Both the dual monitoring unit of every path with Thermo Dynamic Control and the coding of the pluggable protection modules set by the manufacturer characterise the maximum safety of the devices. Damage due to wrong supply by the installer or the user is most improbable.

The Thermo Dynamic Control disconnecter is integrated into every DEHNgard® device and ensures that the SPD changes to an isolated state not only in case of an overload according to the standards. It also remains safe at significant exceeding of the parameters of the SPD.

Therefore, the Thermo Dynamic Control monitoring and disconnecting unit evaluates not only the surface temperature of the high-capacity varistor, but also "monitors" the intensity of the discharge current.

Apart from the standard visual indication with green and red colour, the DEHNgard® ... FM types have a 3-pole terminal for remote signalling. The remote signalling contact, being a floating changeover contact, can be used as a break or make contact, according to the circuit concept applied. The surge arresters of the DEHNgard® TNC/ ...TNS/ ...IT product family provide multifunctional terminals for connecting conductors and busbars for easy wiring in connection with other DIN rail mountable devices.



DEHNgard® T



DEHNgard® TT



DEHNgard® Y PV 1000

Red/Line

Coordinated Surge Protection
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Energy Coordination Lightning Protection Zone 2

For energy coordination of SPDs in distribution boards with surge arresters at the terminal equipment to be protected, it is necessary to match

- > the types of protection elements
- > the protective circuits
- > the response performance of the protection elements and
- > the discharge capacities

among each other.

If this is not taken into account, this could lead to an overload of the surge arrester at the terminal devices and thus to a needless disturbance of the operating safety.

Usually, metal oxide varistors and gas discharge tubes are used as protection elements for the surge arresters at the terminal equipment.

The varistors are installed between phase conductor and neutral conductor for limitation of cross voltages. They must be adapted to the upstream surge arrester in the distribution board regarding their sparkover performance (voltage-/current characteristics), their voltage protection levels (residual voltage) and their discharge capacities.

The gas discharge tube is installed between the active conductors and the protective conductor in form of a Y-shape circuit. This makes it unnecessary to disconnect the surge arrester for testing the isolation in an electrical installation.

If the SPDs fulfil the aforementioned conditions, the basis for a selective energy-coordinated surge protection would be given.

In analogy to the application of combined lightning current and surge arresters and coordinated lightning current arresters of the Red/line product family, energy coordination between SPDs Type 2 (DEHNgard®) and SPDs Type 3 of the Red/Line family have already been taken into account for the design of the system within the product range. Additional decoupling coils or a minimum length of the installation conductor are usually not required any more.

Surge Arresters for Terminal Equipment Lightning Protection Zone 2/3

Surge arresters Type 3 are required, if

- > inducted surges between the upstream distribution board and terminal device can come up
- > the terminal device is connected to the information technology system.

The induction of overvoltages due to the electromagnetic field impulse of lightning depends considerably on the kind of measures taken for room and conductor shielding and on the distance between the affected conductor sections and lightning current carrying conductors, e. g. conductors of external lightning protection systems.

From unshielded cable lengths of 5 m, an additional surge arrester would be recommendable for combined lightning current and surge arresters Type 1 at the terminal device. 2-stage concepts with a lightning current arrester in the main distribution board and surge arresters in the subdistribution board require additional protection for the terminal equipment for final circuits with cable lengths > 10 m.

When connecting and disconnecting consumers, surges can also come up between phase and neutral conductor, which can be hazardous for the terminal device. If a terminal device has a further connection, e.g. an information technological connection, apart from its power supply connection, potential differences can come up in case





DEHNrail

of interferences. These often result in disturbances or even destruction of the terminal equipment.

This can be prevented with DEHN surge arresters Type 3 for terminal devices.

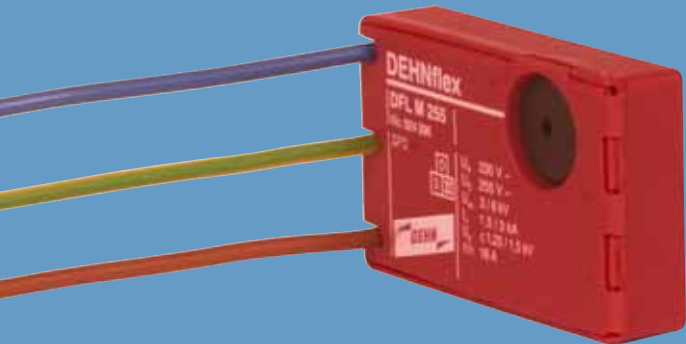
The surge arresters of the DEHNrail family are especially designed for protection of terminal equipment in industrial electronic systems. The low voltage protection level as well as the comprehensive protection from common-mode and differential-mode interferences are characteristic for the DEHNrail devices. In order to provide the low voltage protection level for the terminal device in an optimal way, the devices with input and output terminals are designed for serial connection. Thus, DEHNrail can be installed ideally into the cable run upstream of the terminal devices without requiring additional terminal blocks.



SPS Protector

The SPS Protector surge arrester combines surge protection and interference suppressor filter in one compact design. Therefore, the device provides ideal protection for sensitive terminal devices in industrial automation. The coordinated surge protection and filter functions complement one another and prevent the core saturation of the filter at powerful transients. The separate input and output terminals ensure that the protective effect is provided optimally for the device to be protected.

With its compact design, DEHNflex M provides optimum protection for cable ducts and devices boxes, which are the most common installation fields. It shows also impressively, that compact design does not automatically mean low capacity. Being a two-pole surge arrester, it is the right protective device for electronic consumers in final circuits. The Y-shape circuit used is protected against polarity reversal, even if the phase and neutral conductor are not clearly defined. Despite of the powerful Y-shape circuit, the compact enclosure of DEHNflex M has still enough space for a disconnecter and an acoustic fault indicator.



DEHNflex

The adapters S, SF and SFL Protector are designed for flexible use at socket outlets.

These devices of the S/SF Protector family realise surge protection of electronic consumers in final circuits at socket outlets. In SF Protector, the high-capacity surge protective circuit of the S Protector has been complemented by a interference suppressor filter with balanced or unbalanced effect. With a nominal current carrying capacity of 16 A, S and SF Protector devices can be used flexibly in final circuits. Both in these devices and with the surge protective multiple socket outlet with filter, i.e. SFL Protector, the polarised Y-shape circuit ensures safe surge protection and high safety of devices.



S Protector

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DEHN + SÖHNE

Lightning Protection
Surge Protection
Safety Equipment

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