



Lightning Protection  
Surge Protection  
Safety Equipment

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and services e.g.

- Surge Protection  
main catalogue
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- Appointment with  
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# Coordinated Surge Protection

System protection + Terminal equipment protection =  
System availability

**Red/Line**  
Coordinated Surge Protection  
for Power Supply Systems

DS641/E/0810

# 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 (EN 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.

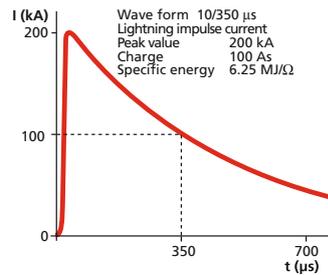
Apart from the dynamic and thermal destruction caused by this "lightning flood wave" in unprotected installations, the lightning impulse current releases an electromagnetic field impulse. This electromagnetic field impulse enters the structure, its systems and terminal equipment in a hardly sensible way and generates surges of several 1000 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 coming up on 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

## Red/Line

Coordinated Surge Protection for Power Supply Systems



Lightning impulse current 10/350 µs

# The Safe Protection Concept



Safe lightning and surge protection is based on the lightning protection zones concept described in IEC 62305-4 (EN 62305-4). The relevant organising principle of dividing the object to be protected into protection zones (known as 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). First the outside area of the object to be protected is divided up into protection zones, then 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.

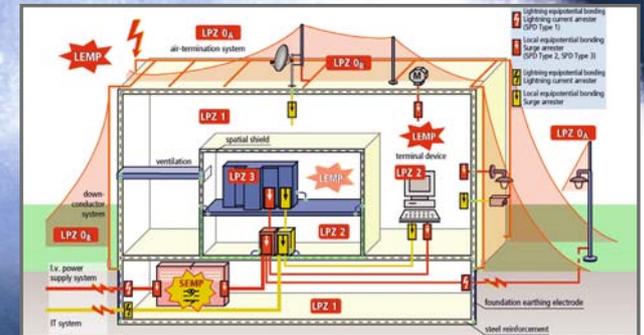
For SPDs for power supply systems, IEC 60364-5-53 complements the lightning protection requirements of the SPDs with the system-related requirements of the application field. As safety allows no compromises, the Red/Line product family from DEHN + SÖHNE provides the appropriate SPDs for every type of installation.

The first protective stage (LPZ 0A - 1) requires a "wave breaker" to discharge most of the lightning current. Therefore, the SPD used for this stage (SPD Type 1 according to EN 61643-11), is also called lightning current arrester. Such impulse energies can only be controlled safely by spark gaps, as these "switch" the lightning impulse current wave and thus reduce the pulse time. The function of the

downstream 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 an acceptable level for downstream equipment.

While single-stage or two-stage protection concepts are designed for small-sized electrical installations, e.g. a radio base 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 typically consist of varistors (voltage-controlled resistors).

To make the coordination of the individual protective stages possible, energy coordination is required. Like for the selective stages of fuses in power lines, "selectivity" also has to be achieved for lightning current and surge arresters in order to prevent from being overloaded on the SPDs connected in parallel and the devices to be protected.



Lightning protection zones concept according to IEC 62305-4

# The Wave Breakers

## Lightning Protection Zones 0<sub>A</sub>/1 and 0<sub>A</sub>/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 reduce the pulse time, these spark gaps are also called "wave breakers".

Alternative technologies such as varistors fail because of the high energy transformation due to their continuous current-voltage characteristic when lightning currents, waveform 10/350 μs, flow.

Modern creepage discharge spark gaps are completely encapsulated. The encapsulation prevents the leakage of ionised gases and the resulting limitations on use.

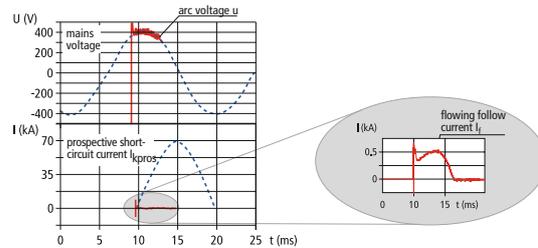
To ensure that ignited spark gaps will cause no short circuits at the installation, only spark gaps with a high self-extinguishing capability and follow current limitation are used.

The "RADAX Flow" follow current limiting and extinguishing technology developed by DEHN + SÖHNE allows for a selectivity with respect to small-sized installation fuses of 20 A gL/G even in case of prospective installation short-circuit currents up to 50 kA<sub>rms</sub>.

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



Section of DEHNventil® spark gap



Follow current limitation of a RADAX Flow spark gap



DEHNventil® M TT

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 DEHNventil®, DEHNbloc® M and DEHNbloc®, the user will find the right solution for every type of installation.

### DEHNventil® M Combined Lightning Current and Surge Arrester

The 2-, 3- and 4-pole DEHNventil M devices are definite combined lightning current and surge arresters. Their capacity of safely discharging up to 100 kA of lightning impulse currents and ensuring 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 RADAX Flow spark gap technology, like all SPDs Type 1 of DEHN + SÖHNE.



DEHNbloc® Maxi S

### DEHNbloc® M Coordinated Lightning Current Arrester

Whether used as a DIN rail mounted device for direct installation on busbars - coordinated DEHNbloc® M lightning current arresters ensure the keeping of the insulation 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® M lightning current arresters.

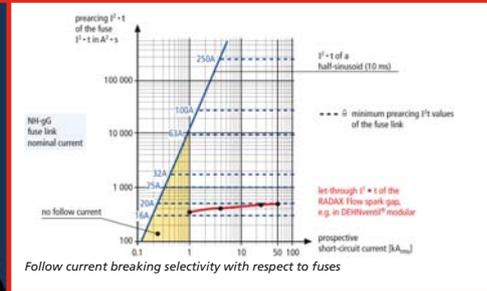
DEHNbloc® Maxi S which can be mounted onto busbars is an absolute innovation: The backup fuse integrated into the protective device allows for use in medium- and high-capacity switchgear installations without the need of separate backup fuses. As DEHNbloc® Maxi S can be installed upstream of the circuit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



DEHNbloc® M

### DEHNbloc® H Lightning Current Arrester

For years, the lightning current arresters of the DEHNbloc® range have provided maximum protection at boundaries between lightning protection zone (LPZ) 0<sub>A</sub> and 1. With DEHNbloc® H, the approved pressure-controlled encapsulated creepage discharge spark gap is now replaced by a modern RADAX-Flow spark gap. Also here, system availability is a top priority. Like all DIN rail mountable RADAX Flow spark gaps of the Red/Line product family, DEHNbloc® H has double terminals for protection-optimised and cost-effective connection of the device in distribution boards.



Follow current breaking selectivity with respect to fuses

# Red/Line

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

What is the function of N-PE surge arresters Type 1? SPDs for lightning equipotential bonding (Type 1) have to be installed as close as possible to the service entrance. For TT systems, this means installation upstream of the residual current device (RCD). If an earth fault came up in this area, the upstream fuse would have to assume disconnection. In case of unfavourable earthing conditions, however, this is not ensured.

In case of a fault, the N-PE surge arresters used in 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.

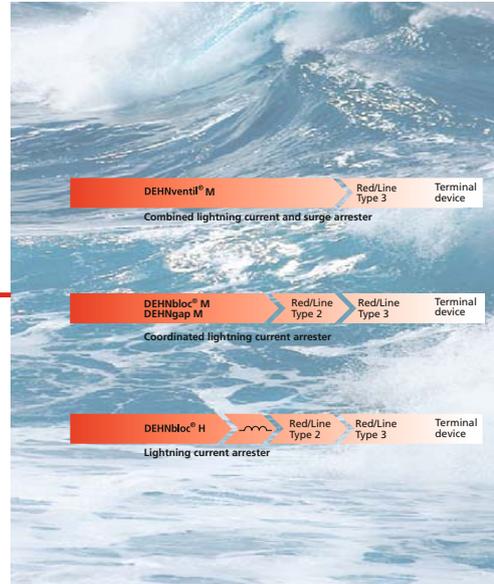
No matter if N-PE surge arresters Type 1 are designed as lightning current arresters (DEHNgap BN), coordinated lightning current arresters (DEHNgap M) or as part of a combined lightning current and surge arrester (DEHNventil) – these SPDs must provide maximum performance for all applications. Depending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

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

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



# Energy Coordination Lightning Protection Zone 1



Energy coordination is the selective interaction of all surge limiting modules in an electrical installation. Of course, this includes SPDs installed at the 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 according to their voltage protection levels. On the contrary, this choice alone would have fatal consequences in case of upcoming high-energy impulse currents. This misinterpretation would lead to an overload of individual protective stages and simultaneous failure of the installation. Energy coordination can only be achieved if the performance of the different surge arresters, installation, equipment and terminal devices to be protected are known in the event of 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 provide 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  $\mu$ s), can be adapted to protect the terminal devices.

According to 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 line between the installation sites of the SPDs (minimum 15 m in length) is used.

The coordinated lightning current arresters (DEHNbloc M) are directly coordinated with DEHNguard Type 2 surge arresters. By developing these surge arresters as a protection system, spark gaps can no longer be bypassed (known as Blind Spot), and damage to the downstream surge arrester Type 2 can be avoided.

The combined lightning current and surge arresters (DEHNventil M) 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 surge arrester 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  $0_A$  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 M) 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, such as office buildings. Being the second protective stage in the protection concept, they also connect the lightning current arrester in the main distribution board of the building to 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, 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 induced by the enormous electromagnetic field impulse of lightning into the conductor loops of the installation. Their quick reaction 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 respond to even minimal surges. These UA characteristics ensure a response of the protection element in some billionths of a second. There is no way for surges any more!

Already for many years DEHN + SÖHNE has been using powerful ZnO varistors with a nominal discharge capacity of 20 kA (8/20 μs). The protective element must endure this load at least 20 times without destruction and change in performance.

If this discharge capacity is exceeded due to unfavourable conditions, e.g. due to a 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 from DEHN + SÖHNE can be monitored. 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. 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-pole or multipole, compact or pluggable, with or without remote signalling - the DEHNguard family provides the appropriate surge protection for every type of installation. Apart from devices for universal application, many application-specific protective circuits, e.g. for photovoltaic installations, can be provided. The product ranges from 75 V units to rated voltages of 1200 V for a.c. and d.c. applications.

The DEHNguard® M YPV SCI product family was specifically designed for protecting equipment in photovoltaic systems. The combined disconnecting and short-circuiting device with safe electrical isolation in the protection module, prevents fire damage due to d.c. arcs.

Especially the range of multipole DEHNguard devices is becoming more and more popular with designers and users. Their product features provide maximum safety and easy application. The application-orientated product designation 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 circuit 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 incorrect supply by the installer or user is unlikely.

The Thermo Dynamic Control disconnecter is integrated into every DEHNguard surge arrester and ensures that the SPD changes to an isolated state not only in case of a "standard" overload. It also remains safe in case of significant exceeding of the parameters of the SPD. Therefore, the Thermo Dynamic Control monitoring and disconnection device 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 markings, the DEHNguard ... 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 DEHNguard M TNC/ ...TNS/ ...TT product family provide multifunctional terminals for connecting conductors and busbars for easy wiring in connection with other DIN rail mounted devices.



## 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 an unnecessary 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 the 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), voltage protection levels (residual voltage) and discharge capacities.

The gas discharge tube is installed between the active conductors and protective conductor in form of a Y-shaped 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 is 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 (DEHNguard) 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 may come up
- > sensitive electrical and electronic devices are used.

The induction of surges 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.

If combined lightning current and surge arresters Type 1 are used, and additional surge arrester should be installed at the terminal device for unshielded cable lengths of more than 5 m. A 2-stage protection concept with lightning current arresters installed in the main distribution board and surge arresters installed into the subdistribution board, however, are assumed to require an additional terminal equipment protection for cable lengths of the final circuits of more than 10 m.

When connecting and disconnecting consumers, surges can also come up between the phase and neutral conductor, which can be hazardous to the terminal device. If an IT line is additionally connected to the terminal equipment, potential differences may come up in case of interferences and can lead to disturbances or even destruction of the terminal equipment.



DEHNrail M



SPS Protector



DEHNflex M



DEHNnpro DPRO 230  
DEHNnpro DPRO 230 F

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

The surge arresters of the DEHNrail M 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 of DEHNrail M devices. In order to provide the low voltage protection level for the terminal equipment in an optimal way, the devices with input and output terminals are designed for serial connection. Thus, DEHNrail M can be installed ideally into the cable run upstream of the terminal devices without requiring additional terminal blocks for outgoing cables.

SPS Protector 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 core saturation of the filter in case of 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 device 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 appropriate protective device for electronic consumers in final circuits. The Y-shaped circuit used is protected against polarity reversal, even if the phase and neutral conductor are not clearly defined. Despite of the powerful Y-shaped circuit, the compact enclosure of DEHNflex M has still enough space for a disconnecter and an acoustic fault indicator.

The adapters DEHNpro are designed for flexible use at socket outlets.

These devices of the DEHNpro family realise surge protection of electronic consumers in final circuits at socket outlets. In DEHNpro 230 F, the high-capacity surge protective circuit of the DEHNpro 230 has been complemented by an interference suppressor filter with balanced or unbalanced effect. With a nominal current carrying capacity of 10 A, DEHNpro 230 devices can be used flexibly in final circuits. Both in these devices and in the surge protective multiple socket outlet with filter, i.e. SFL-Protector, the Y-shaped circuit ensures safe surge protection and high safety of devices.

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