Surge Arresters

Recommended guiding principle:

A surge arrester is a combination of three main components -

1) Non-linear resistors
2) Housing (polymeric)
3) Strength member (typically a glass fibre structure)

The quality of the arrester is made up by all of them. If one of them is weak, the whole arrester will be weak. That's clear.

But the way how they are combined and how good they match is crucial too.

"We know which components to select and how to combine the individual features to create an outstanding performance of the final product offering more than the sum of performance of the individual components."

Product Range

Raychem surge arresters for medium voltage power distribution systems are designed to reliably protect your valuable asset from transient overvoltages. They withstand severe outdoor exposure over long operating lifetimes and help maintain service reliability in both overhead and underground installations:

- Arresters for outdoor applications
- Arresters for indoor applications (gas-insulated switchgears, busbars, ...)
- Arresters for motor & generator protection
- Arresters for special applications (high voltage cable sheeth protection, ...)
- Arresters for low voltage distribution systems
- Arresters for Railway applications

The offered product range may be used to demonstrate our technical competence to design products for many different applications, always considering the high demands made up on the products by that specific market.

Product Requirements

Advanced materials research and development and constant improvement programmes are helping us to increase our responsiveness to customer requirements and meet the demands of modern distribution networks:

- Compact design, easy to handle and install
- High reliability, low residual voltage & high energy absorption capacity
- Non-tracking & UV resistant polymer housing
- Excellent behaviour under polluted conditions
- Robust and tight against moisture ingress
- Non-explosive failure mode, safe for installer and environment
- International specifications, such as IEC, CENELEC and GOST

Our main thread running through product development.

Basic Design and Material Concepts

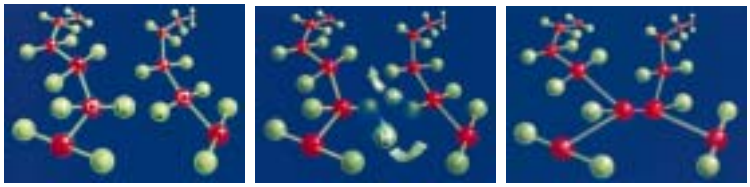
More than 30 years of systematic research into new materials for the needs of the electrical power industry resulted in a wide range of products with a unique combination of properties such as:

- Increased resistance to thermal ageing
- Excellent resistance to surface electrical activity
- Elevated UV performance
- Moisture blocking
- Void-free interfacial bonding
- Non-explosive Failure Mode
- Improved protection level

Our know-how and core competencies.

Increased Resistance to Thermal Ageing

One of the early developments of Raychem was to improve insulating materials' resistance to thermal ageing by cross-linking polymers. By creating additional bonds between polymer molecules, the physical properties of insulating materials can be enhanced for applications of more than 30 years of service, as required in the electrical power industry.



Excellent Resistance to Surface Electrical Activity

In the 1960s Raychem developed a polymeric material whose long-term resistance to surface electrical activity is comparable to that of porcelain.

Phenomenon of tracking and erosion

Dry zone results from leakage currents in conductive water films.

Conductive path created by arcing, bridges the dry zone. New dry zone emerging.

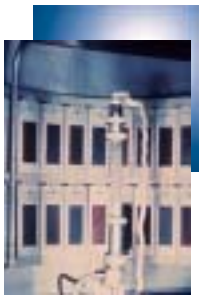
Growing of the tracking path until breakdown.

Example for Tracking & Erosion

Tracking & Erosion

Failed arrester installed at coastal area after 2 years in service

Elevated UV Performance



Weatherometer

Accelerates the action of UV, heat and humidity to enable the prediction of long-term product performance.

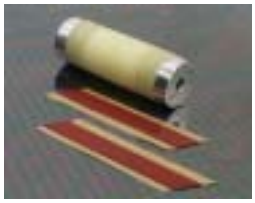
The need for non-tracking performance precludes the use of
ual UV absorbent in polymeric materials.
y researched alternative techniques for
UV performance and has been carrying
natural weathering test programmes in
years.

Outdoor test facilities

Longer term UV and weathering testing is carried out at our outdoor test facilities. Material performance can be monitored and correlated to accelerated test procedures.

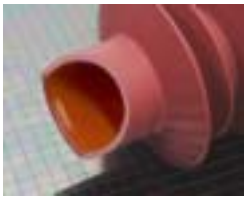
Moisture Blocking

Moisture ingress has caused in the past many arresters to fail in service. Both, arresters with porcelain and with polymeric housing were affected. Hot melting mastics are used to ensure that moisture is reliably kept away from areas where it may damage the arrester.



Arrester Module & Mastic Tapes

Mastic tape is wrapped around the electrodes of the module to seal the ends against moisture ingress.

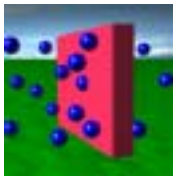


Arrester Housing coated with Mastic

Mastic inside the housing ensures that the interface between the housing and the modules remains void-

The combination of polymeric housing and non-linear resistor (including then strength member in that case) has to be done in a way to ensure reliable operation over many many years. We focused our attention right from the beginning on moisture blocking. This paid off for all our customers in the past and it will in future.

Void-free Interfacial Bonding



Moisture ingress may also be caused by vapour leaking through the polymeric housing.

Key features to prevent moisture from seeping in:

- Low vapour transmission rate of polymer
- Void-free moulding by evacuated moulds
- Primer agents, to ensure reliable bonding

Many Polymeric materials take up moisture and let moisture go through them. Some of them more, some other less. This “vapour transmission rate” is typically high for silicones.

This isn’t going to cause any problems as long as there are no voids inside the housing material or at critical interfaces (for example at the interface between non-linear resistors and the housing) where the vapour may condense, filling the void or interface with water.

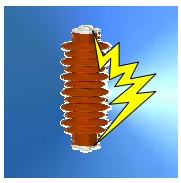
To prevent from moisture ingress the listed points have to be considered:

1) the vapour transmission rate of the polymeric material should be low

2) the bulk material of the housing needs to be porous-free/void-free (which can be achieved by evacuating the mould)

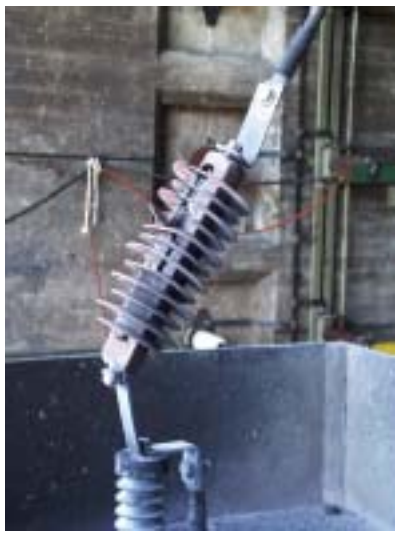
3) ensure good bonding between the housing, the non-linear resistors and the strength member (using primer agents for directly moulded arresters and hot melting adhesives for arresters with heat shrink housing)

Non-explosive Failure-Mode



Failures of surge arresters can not be precluded.

The design of Raychem surge arrester accounts for this very rare case too.



Short-Circuit Test of Surge Arrester

electrically pre-failed arrester after application of 20 kA short circuit current for 0.2 seconds.

On one hand the arrester shall be mechanically strong enough to withstand sever stresses not only caused by rough handling, but also occurring in service.

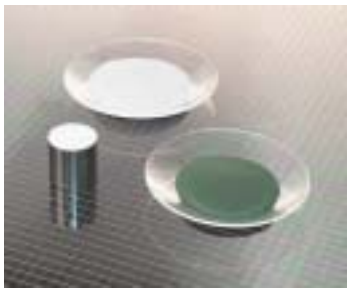
On the other hand it needs to be “weak” enough to allow the power arc, which can be found in case the arrester fails (due to overload or excessive AC voltage stress), to break through the housing and the strength member.

These basically conflicting requirements are both important to meet so that the combination of the strength member and the housing has to be done in a very clever and sensible way.

Improved Protection Level

The quality of over-voltage protection provided by the arrester is determined by its residual voltage. The lower the residual voltage the better the protection of your asset.

- Protection level according to VDE standard (3.33 x U_c)
- perfectly suited for systems equipped with Petersen coils (arc suppression coils) and systems with isolated neutral



ZnO Powder & Resistor

Intensive research was performed to reduce the residual voltages of all resistor blocks.

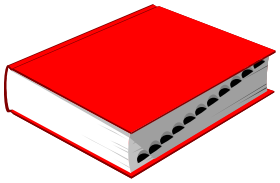
Sorting of MO-resistors is the commonly used method to improve the protection performance of an arrester. However, sorting is always a source of errors and trouble and finally it is hard to check if the arrester really meets the requirement.

Intensive researched was therefore done on the powder formulation to bring down the residual voltages on all non-linear resistor blocks enabling us to do a “blind picking” of blocks during assembly. That means that both the non-linear resistor blocks and the assembled arresters have got the same specification with respect to residual voltage. The ratio Ures / Uc is identical.

To keep out moisture long-term porous-free insulating materials and a void-free interfacial bonding between electrically differing materials are important as well. Although the polymeric material developed by Raychem has got a much lower vapour transmission rate than other commonly used plastics our moulds are evacuated before injecting the polymer to avoid bubbles in the bulk material and at the interfaces. The primer agent and the mastics make sure that the interfaces remain void-free during the whole expected life of the arrester.

In Compliance with latest Amendment of IEC 60099-4

IEC 99-4



- Amendment 2 published in October 2001
- Specifies requirements on GIS arresters
- Specifies requirements on polymeric arresters
  - Weather ageing of housing
  - Tightness against moisture ingress
- Modified Short circuit testing
- Reduced partial discharge level (10 pC)

  Increased stress during accelerated ageing test

13

In October 2001 amendment 2 of IEC 60099-4 was published.

Since then polymeric housed surge arresters and GIS arresters are fully covered by this standard.

Regarding polymeric arresters the

weather ageing test (1000 hrs salt fog test / 5000 hrs cycle test)

tightness test (boiling water test)

have been introduced (mandatory)

Short circuit testing has now been included in the amendment (so far reference was made to IEC 99-1 dealing with gapped type arresters!) but it is included in the informative section only.

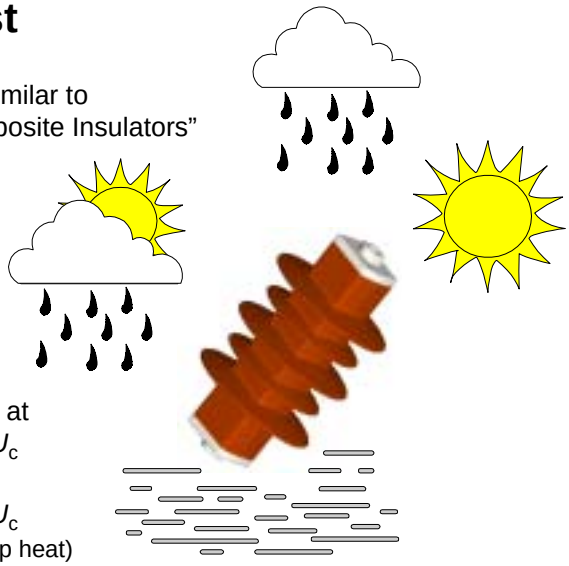
Reason for that is that the test procedure may be difficult to follow for HV surge arresters. For MV surge arresters the specified procedure can be used without any hick-ups and so customers should refer to the procedure.

The requirement on partial discharge level has been changed from 50 pC to 10 pC (which we use as a limit since the beginning).

The test voltage during accelerated ageing has been increased from 5% per meter height of the arrester to 15% (was considered with the NA type already!)

Weather Ageing Test

Test procedure similar to
IEC 61109 “Composite Insulators”



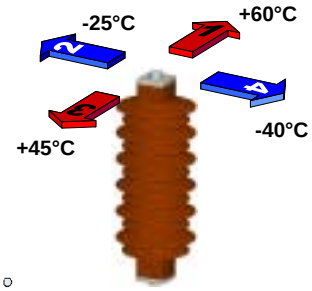
- 1000 hours continuous salt fog at continuous operating voltage U_c
- 5000 hours cycle test at continuous operating voltage U_c
  (salt fog, solar radiation, rain, damp heat)

The weather ageing test is similar to the salt fog test specified for polymeric insulators. The test voltage however is different. Surge arresters need to be tested at Uc (cont. operating voltage) whereas insulators are tested at lower levels (i.e. with 14 kV in case of a 24 kV insulator).

The 1000 hrs salt fog test is mandatory. The 5000 hrs does not replace the 1000 hrs test.

The cycle needs to be agreed upon with the customer. Typically the EdF cylce is used.

Tightness Test (Moisture ingress)



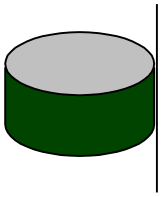
- Terminal torque Pre-conditioning
- Thermo-mechanical pre-conditioning (4 x 24 hours)
- Boiling in salty water

42 h

We are using the boiling water test for a long time already to check the design for tightness against moisture ingress.

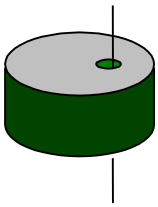
The amendment requires to do apply mechanical stress at different ambient temperature before boiling the arrester in salty water in order to check if the seal of the arrester may break during this thermo-mechanical cycling.

Short Circuit Test

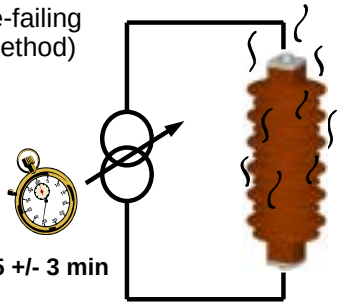


- Fuse wire method according to IEC 99-1

- Fuse wire method according to amendment 2



- Electrical pre-failing (preferred method)



The short circuit test (in the past called “pressure relief test”) shall demonstrate that the arrester does not shatter violently in case of a failure. As long as porcelain housings with pressure relief devices were used the fuse wire method was appropriate.

Modern surge arresters may have a compact design without any free air or gas volume inside. They don’t need to have a pressure relief device and therefore the test procedure based on a fuse wire short circuiting the non-linear resistors does not make much sense any longer.

Therefore 2 procedures have been developed: “Pre-electrical failing” or “Fuse wire inside the block”

The pre-electrical failing method is the more realistic one and therefore the preferred method in IEC 60099-4.

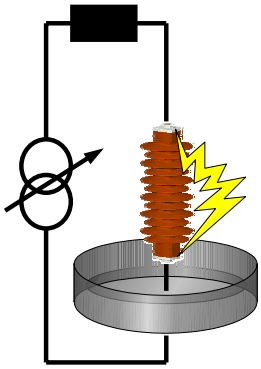
On one hand the arrester shall be mechanically strong enough to withstand sever stresses not only caused by rough handling, but also occurring in service.

On the other hand it needs to be “weak” enough to allow the power arc, which can be found in case the arrester fails (due to overload or excessive AC voltage stress), to break through the housing and the strength member.

These basically conflicting requirements are both important to meet so that the combination of the strength member and the housing has to be done in a very clever and sensible way.

Short Circuit Currents

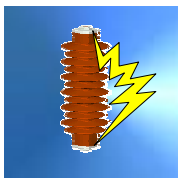
	HDA-NA	NDA-NA
Rated	**20 kA, 0.2 s**	**16 kA, 0.2 s**
Reduced	12 kA, 0.2 s	6 kA, 0.2 s
Reduced	6 kA, 0.2 s	3 kA, 0.2 s
Low	600 A, 1 s	600 A, 1 s



0.2 s / 1 s

These current levels have been used to test the NA-type series of arresters. The pre-electrical failing method was used to do the test.

Short Circuit Test



Short-Circuit Test of HDA-NA Surge Arrester

electrically pre-failed arrester after application of 20 kA short circuit current for 0.2 seconds.

This is one of the test samples.

The arrester was heavily damaged and looked like a heavily damaged sample from the field.

The test was positive. No parts have been ejected and all flames self-extinguished within 2 minutes.

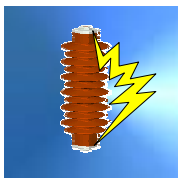
The sample maintained its mechanical integrity.

The sample shows heavy erosion along all the arrester. This is because the arrester blocks inside have been destroyed electrically causing a low impedance. So the power arc was able to burn the whole surface of the arrester.

This is not the case when the fuse wire method is used.

The end electrodes however are not affected as much as with the fuse wire test method.

Short Circuit Test



Short-Circuit Test of HDA-NA Surge Arrester

arrester prepared with fuse wire according to IEC 99-1 after application of 20 kA short circuit current for 0.2 seconds.

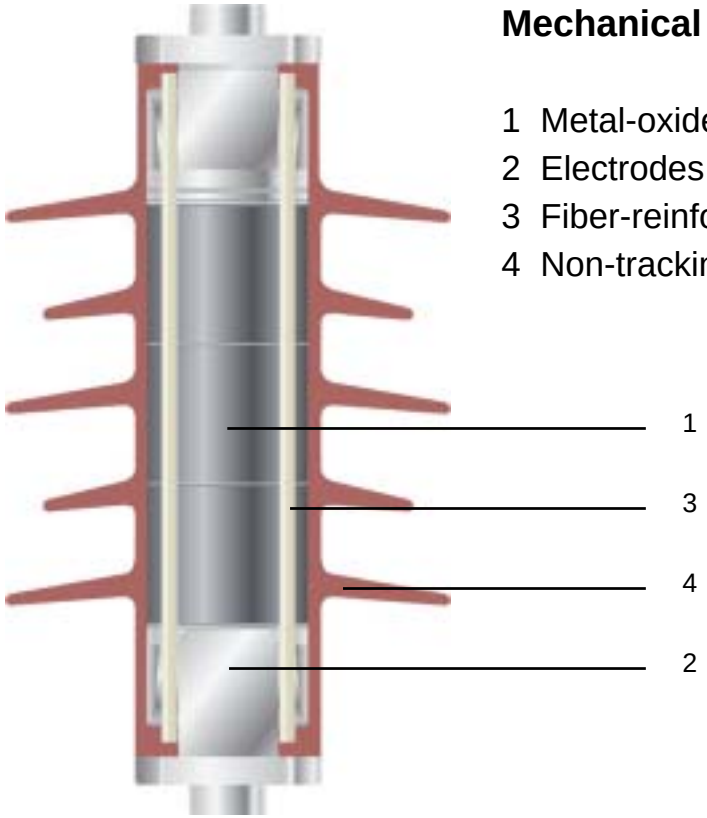
The position were the fuse wire was placed is clearly visible.

As the blocks were not really destroyed the arc was burning only at the end electrodes causing heavy erosion.

This demonstrates that the fuse wire method should not be accepted by customers any longer.

The pre-electrical failing method gives more realistic results.

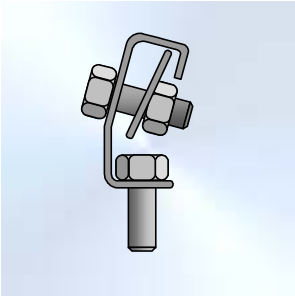
Medium Voltage Surge Arrester



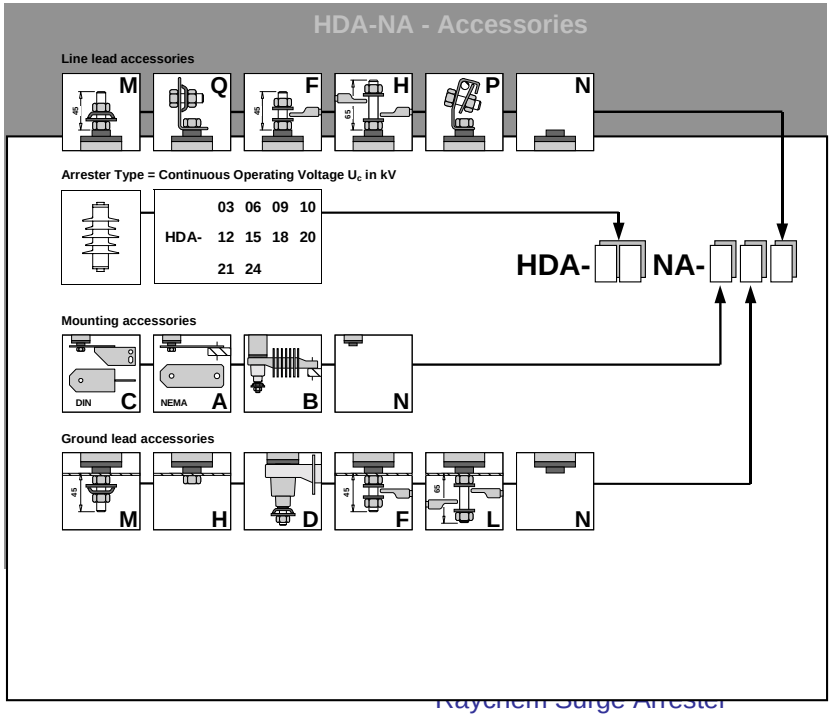
Mechanical design

1 Metal-oxide varistors
2 Electrodes
3 Fiber-reinforced composite structure
4 Non-tracking polymer housing

Mechanical Connecting Accessories



In response to the demands for easy and reliable installations, Raychem offers a wide range of mounting and connection accessories.



Medium Voltage Surge Arrester for Indoor Use

Compact Design

with insulated line lead
when space is limited

for use with RICS adapter in
gas-insulated switchgear

Medium Voltage Surge Arresters for Motor & Generator Protection

Arresters for
High Voltage Cable Sheeth Protection

Rugged Mechanical Design

easy to install in cross-bonding cubicles

Arresters for Railway Applications

Surge Arrester for DC Railway Systems

Rugged, compact design, withstanding extreme mechanical stress (vibrations, shocks, pressure, torque).

Excellently suited for for applications on rolling stock.

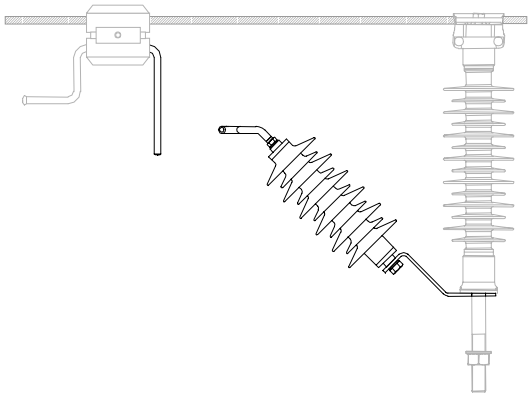
Surge Arrester for AC Railway Systems

Improved short circuit current performance.

Protection of Covered Conductor Lines

Current Limited Arcing Horn

preventing covered conductors from melting and falling down due to localised power arcing



Low Voltage Gapless Arresters

Sturdy Weatherproof Design

with thermal
disconnecting & indicating device

Our Low & Medium Voltage MO-Varistors

High Homogeneity
High Energy Handling Capacity
Low Residual Voltage
Close Mechanical & Electrical Tolerances

Ø38 mm and Ø42 mm

IEC 60099-4:
5 kA or 10 kA class 1