

Changing of the guard

Polymer replaces porcelain for surge arresters

Torbjörn Skytt, Hans E. G. Gleimar

‘Standing guard’ may be the best description of what surge arresters do, but it says nothing about the qualities they need to perform and survive. Designed to protect power grid components against lightning and switching transients, the arresters themselves are exposed to hazards such as earthquakes and vandalism. Traditional porcelain doesn’t therefore sound like the best kind of material for their housing, and it isn’t.

ABB’s PEXLIM surge arrester with polymer housing not only overcomes this problem, it also offers a whole new range of benefits: Its weight is less than half that of a ceramic surge arrester, it offers better durability, and it is water-repellent, fire-retardant and resistant to aging. PEXLIM also provides better protection for ‘compact’ transmission lines, and is easier to use where there are problems with grounding. In addition to all this, it paves the way for new applications, for example in UHV power lines.



Surge arresters are safety devices which quickly and effectively limit the overvoltages that can arise in transmission networks following lightning, switching and other transient events. Without them, these surges could damage valuable equipment in the high-voltage grid. Utilities therefore install them routinely as a precaution.

Evolution of the surge arrester

The earliest form of overvoltage protection was a simple air gap between electrodes, but, inevitably, its breakdown voltage

varied with the weather. It was followed by a ‘conventional’ arrester with series-connected spark gap and voltage-dependent silicon carbide resistor, all enclosed in a porcelain housing.

These early devices have long since been superseded by a new generation of gapless arresters with series-connected, highly non-linear zinc oxide (ZnO) varistors. Each varistor block is a dense

Production surges!

To cope with rising demand caused by customers turning away from conventional solutions, ABB has had to double its production capacity for the PEXLIM surge arrester and at the same time fine-tune business and production processes. Some countries now order *only* polymer-housed arresters.

ceramic body made up of ZnO and small amounts of other metal oxides. ZnO, and the technology behind it, is proven in the field, and it serves its purpose well.

Traditionally, the housing of the arrester has been made of porcelain. For various reasons – porcelain arresters may shatter and have become a target for vandals – manufacturers have long sought a replacement material, one that is safer and easier to handle.

Now, ABB has introduced a new surge arrester to replace the porcelain type. Called PEXLIM (Polymeric EXcellent LIMiter), it has a very special housing made from a polymer, *silicone rubber*. The blocks of zinc oxide used in it are exactly the same as those used in the ceramic arresters.

Designed to break down

The varistors, which are stacked on top of each other, protect the high-voltage grid from overvoltages through a combination of semiconducting and insulating properties. During continuous high-voltage operation the varistors draw a current of around 1 mA. At this voltage level the current is almost purely capacitive. The resistive component of the current is just a few tens of microamps.

The surge arrest sequence is normally as follows: in the event of an overvoltage the arrester draws a higher current and limits the overvoltage to a value that is determined by its current-voltage characteristic. When the overvoltage disappears the current drops immediately.

Choosing an arrester is always a compromise – a trade-off between the

required protection level and the transient overvoltages that can be tolerated. The arrester is deliberately intended to be the ‘weakest link’ in the power grid, ie it is deliberately designed to break down in the event of an overload in order to protect other, more expensive equipment.

New ‘packaging material’ has better characteristics

The new, lightweight insulation material retains the effective basic function of the arrester while at the same time improving a number of other properties and considerably enhancing product safety and ease of handling.

It was developed in collaboration with ABB Corporate Research and leading polymer manufacturers.

The advantages of silicone rubber over ceramic include:

- *Considerably better durability.* Silicone rubber is resilient, yet solid and compact. Since its housing is not fragile, the PEXLIM arrester can even be placed in

1 Water droplets on a polymer arrester housing. Current is not conducted as easily as on a porcelain housing, where the water spreads out to form a uniform layer.



unfenced areas without any risk to people or animals.

- *Water-repellent.* Silicone has a hydrophobic surface, which repels water droplets. These join together and then run off, so the current is not conducted as easily as it is on surfaces where the water spreads out to form a smooth layer **1**.

- *Large reduction in weight.* Silicone rubber is much lighter than porcelain, which reduces the overall weight of the

Technical data for PEXLIM arresters

| | | | |
|---------------------------|-----------|-----------|-----------|
| System voltage | 52–170 kV | 52–420 kV | 52–420 kV |
| Rated voltage* | 30–162 kV | 30–360 kV | 30–360 kV |
| Nominal discharge current | 10 kA | 10 kA | 20 kA |
| Line discharge class | Class 2 | Class 3 | Class 4 |

**The rated voltage is the parameter on which operational and safety characteristics are based. The choice of rated voltage for an arrester is a compromise between the desired degree of protection and the tolerance vis-à-vis the transient overvoltage. Selection of a higher rated voltage increases the ability of the arrester to cope with transient overvoltages, but reduces the safety margin for the specific insulation level.*

2 Installing polymer-housed surge arresters on a transmission line – now a safer and simpler task



3 Earthquake-resistant surge arrester with polymer housing



arrester. In fact, ABB has succeeded in reducing the weight by a full 50%, making the arresters easier to transport and handle. Mounting PEXLIM arresters on transmission pylons or hanging them on transmission lines is also safer and easier. Another advantage of PEXLIM over heavier arresters is that they permit alternative locations and methods of installation **2**.

■ *Better for the environment.* Silicone rubber does not contain any environmentally harmful substances, and once it has reached the end of its useful life it can be used as filling material (eg, for construction work), or it may be incinerated (400–500°C), leaving only harmless sand.

■ *Good resistance to aging and harsh weather conditions.* During develop-

ment of the arrester ABB improved the manufacturing process as well as the properties of the housing material. PEXLIM arresters show good resistance to aging and high operational reliability, even in harsh weather conditions.

■ *Repels dirt and contaminants.* The silicone rubber surface repels dirt and contaminants, enabling them to be washed away by rain.

■ *Good electrical properties, resistance to light, UV radiation and fire.* The silicone rubber used by ABB contains components that improve its fire retardance and resistance to light and UV radiation, reduce salt-induced erosion and ensure good electrical properties. Silicone rubber also copes well with leakage currents due to good electrical

load bearing ability and insulation properties.

New applications

The properties of the PEXLIM arrester make it highly suitable for use in earthquake-prone areas. Its low weight and excellent ability to absorb earthquake stresses ensure that the arrester is not shattered by tremors. Where extra-long arresters are used, any harmonic oscillations can be controlled by suitable bracing arrangements **3**.

In addition, the new, lighter arresters can replace more expensive and maintenance-intensive equipment. They can be hung from transmission pylons and at various points along the line to further safeguard the availability of the grid **4**. Porcelain-housed arresters are

too heavy for most applications of this kind and could be a hazard should they become damaged.

ABB is also collaborating with others in the development of 'compact' transmission lines. These are lower and narrower and have weaker magnetic fields, and the lighter PEXLIM arrester is of vital importance to their performance.

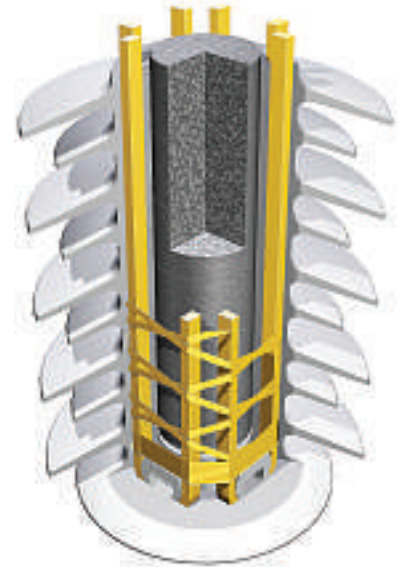
And for transmission grids where grounding, and therefore availability, has been a problem in the past, the polymer arrester also offers an attractive solution. Because of the risk of falling porcelain this would not be a feasible option without the shatter-proof PEXLIM arrester.

New material – integrated production

Silicone rubber is a highly reactive substance and its production requires special expertise, clean manufacturing conditions and constant climate conditions. All of this makes the production process relatively complex.

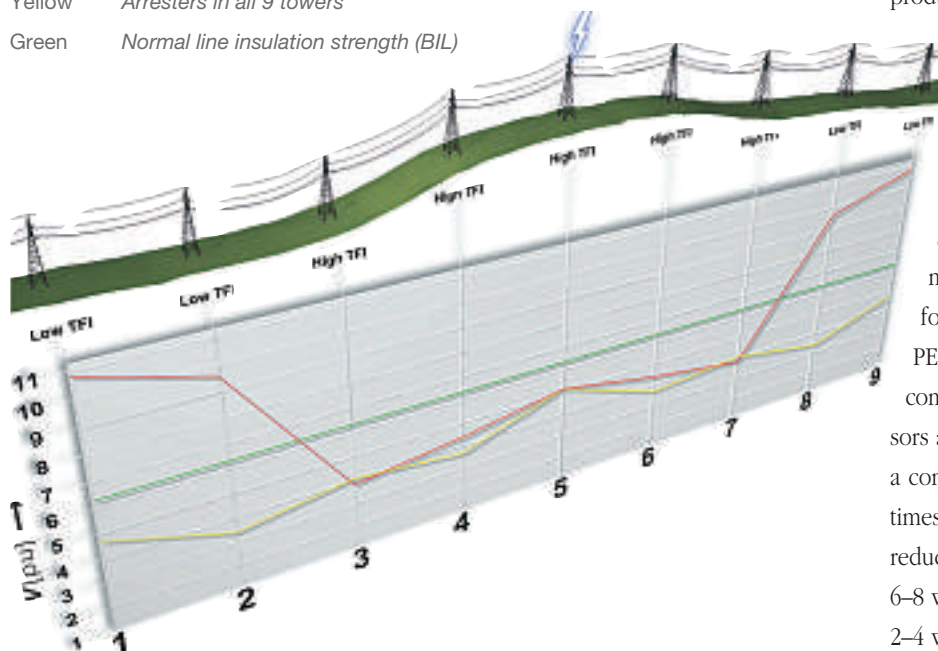
The silicone rubber is cast in a single piece around the stack of zinc oxide blocks forming the active component. The adhesion properties of silicone rubber are very important, as there are not allowed to be any holes in the finished product. The injection-molding process for the polymer housing

5 The polymer housings of PEXLIM surge arresters have fewer components than the previous generation of arresters with porcelain housings.



4 Result of installing surge arresters along a section of transmission line with high tower footing impedance (TFI). It can also be seen that arresters are needed at the low TFI towers at the ends of the section.

- V Voltage across insulators
- Red Arresters in towers 3-7
- Yellow Arresters in all 9 towers
- Green Normal line insulation strength (BIL)



has been tested in collaboration with key suppliers and now meets high standards of reliability and productivity.

ABB Switchgear is currently manufacturing the third generation of PEXLIM products by means of a proprietary production process, specially designed tools and a silicone rubber compound that has to meet very strict manufacturing requirements. As a result, ABB is able to guarantee high quality at every stage of manufacture. The new material also offers opportunities for design improvements.

PEXLIM arresters have fewer components than their predecessors and their manufacture is based on a common platform **5**. Delivery times ex-factory could therefore be reduced considerably; from around 6–8 weeks for a porcelain arrester to 2–4 weeks for a PEXLIM arrester.

6 PEXLIM arresters installed on transmission lines in a 400-kV grid. The hollow insulator is also made of polymer.



Tests on finished arresters are carried out using special test equipment and are the same as those for arresters with porcelain insulation.

Spin-off benefits for ABB include a much better understanding of polymer technology and the properties of silicone rubber. This knowledge will also be valuable in many other areas of the power transmission field **6**.

An investment in the environment

Installing arresters to protect other, usually more expensive, equipment lets utilities transmit heavier loads over their power grids, reducing the need to invest

in new lines and avoiding all the problems associated with them. In fact, the new arresters offer benefits for the environment throughout their life cycle, from production to disposal. The lower weight itself means that transport and handling have less impact on the environment, while also permitting installation close to the protected equipment, saving space and cost. In addition, ABB's integrated production process is emission-free.

Growing market share

After achieving a successful breakthrough in the lower voltage systems, PEXLIM arresters are now rapidly gaining

ground at the higher voltage levels. ABB has already supplied PEXLIM arresters to the USA for use in an 800-kV grid.

When ABB began selling polymer arresters the technology was still relatively expensive, but in the meantime it has become very competitive. Delivery times are short and the product has gained a reputation for excellent technical performance.

Utilities are changing from porcelain to polymer insulation at a fast rate, and ABB has doubled production capacity for PEXLIM to meet growing market demand. The lead times have been considerably shortened by fine-tuning the process parameters and by introducing statistical methods and leaner logistics. Some countries now ask *only* for polymers.

Last year, PEXLIM constituted over half of arrester production for applications up to and including 245 kV. This dramatic success is fueled by a growing market share and by replacement of ABB EXLIM porcelain arresters.

Author

Torbjörn Skytt
Hans Gleimar
ABB Power Technology Products AB
SE-771 80 Ludvika
Sweden
hans.gleimar@se.abb.com
Telefax: +46 240 78 39 90