Central Power Research Institute

Vol. 15(2)/136-144, July-December 2019
ISSN (Print) : 0973-0338
DOI : 10.33686/pwj.v15i2.150409

Power Research

Various Benefits for Line Surge Arrester Application and Advantages of Externally Gapped Line Arresters

Florent Giraudet

High Voltage Products, Siemens AG, Berlin, Germany; florent.giraudet@siemens.com

Abstract

The use of Line Surge Arresters is a well-known application. This cost-effective way has clearly shown the performance improvement for the electricity supply industry. However, there is often resistance to make it a common use. The reduction of outages due to lightning activity and poor grounding makes their application vital. Meanwhile, some users apply this technology also for security of population, switching surge control, line uprating and compaction or live-line working. Even though the use of Externally Gapped Line Arresters can achieve outstanding results by minimizing the investment, this smart protection device shows a mild growth excepting in some specific countries. The EGLA application does not only improve significantly the performance and the operation of the power systems but also improve the design and lower the costs of the construction and the maintenance. The financial benefits are easily demonstrated. Today, proactive maintenance and trend monitoring is a key point for the transmission lines operators. While existing solutions to assess the conditions of the surge arresters are not suitable and relevant, the new generations of Unmanned Aerial Vehicles (UAVs) are becoming extremely cost-efficient and accurate to inspect transmission line components. This paper intends to present Siemens latest innovations for compact and cost-efficient lightning-proof transmission lines.

Keywords: Cage Design, Externally Gapped Line Arresters (EGLA), Flashover Rate, Footing Resistance, Ground Flash Density, Innovation, Line Surge Arresters (LSAs), Monitoring, Non-Gapped Line Arresters (NGLA), Silicone

1. Introduction

Line Surge Arrester are today systematically combined with lightning performance improvement. Their application to improve the lightning flashover rate are simple and provide immediate benefits. Lightning flashovers are a major problem for many utilities. Lightning is actually the main cause of unforeseen outages on transmission lines (e.g. U.S.: 57%; Brazil: 50-70%; Japan: 70-80%; Denmark: 57%; Colombia: 47-69%). A lightning flashover on a transmission line requires breakers operation to eliminate the resulting short-circuit resulting in a voltage interruption. A brief power failure can cause important financial damages to the users and utilities. Consumers are becoming more demanding since their processes are dependent on a reliable power system. Around the world, the growing demand for power has resulted in the need for increasing line availability and power supply quality. Users and manufacturers are fully aware of the issues and are looking for cost-effective solutions to improve the situation.

LSAs are not mandatorily installed when utilities and Transmission System Operators (TSOs) are facing lightning outages. Quality of the grounding, shielding of the structures and proper insulation coordination must be investigated through a rigorous due diligence process. Arresters are generally used when conventional mitigation methods are inefficient. However, Line Surge Arresters application is today a reliable solution thanks to advanced design of the polymer-housed arresters and the performance of the metal oxide technology. Significant improvements have been done since Metal

*Author for correspondence

Oxide Technology appeared on the market in the early 1970s. Surge arresters are relatively low-priced while providing various benefits; it makes their use very cost-efficient. Non-Gapped Line Arresters (NGLA) are often automatically selected based on previous experiences and the comfort of applicable IEC/IEEE standards which are identical to substation arresters. NGLA might be sometimes the best option to fit into the existing structures. Anyway, utilities and TSOs are still reluctant to apply arresters on large scale due to several issues as failure, installation and expected performance. Today, the return on operating experience is very complete. It becomes necessary to enlarge our knowledge and actively share it with our business partners.

2. Main use of Line Surge Arrester for Lightning Performance

2.1 Mitigation Methods

In addition to the common ways of improving the lightning performance of certain overhead power lines, properly applied line surge arresters can effectively and economically help reduce line system failure rates.

2.2 Flashover Scenarios

These are the two basic scenarios to understand the principle of flashovers due to lightning activities. Back-flashover and Direct Flashover (also known as shielding failure).

Back-flashover is when the lightning strokes hit the shielding wire or the tower top. Insulator back flashover rates can be efficiently reduced in case of shielded overhead lines located either in high lightning activity areas or having poor footing resistance. These types of outages could be reduced by placing arresters in all phases or only on the phase(s) with lowest coupling factor to the shield wires which normally is the bottom phase in high footing resistance areas. In these areas, it is important to apply the arresters not only on structures in the areas of high footing resistances, but as well also one or two structures away from the high footing resistance areas. This will prevent flashovers at the low resistance structures caused by the arrester operations at the high footing resistance structures. The higher the footing resistance, the more energy is absorbed by the individual line arresters.

Direct flashover is when the lightning strokes directly hit the phase conductor. Insulator flashovers result from so-called shielding failures mostly observed on unshielded transmission lines and very infrequently in shielded lines that may experience lightning strokes direct to the high voltage conductor. For unshielded transmission/

Table 1. Comparison of mitigation methods

Method of lightning protection	Feasibility check	Economic viability
Add or extend shielding wire(s)	-Lines are generally unshielded for specific reasons -Strongly depends on tower design -Not effective for high footing resistance	-High material & labor costs -Power interruption is required **-Non-economical solution**
Increase BIL (insulator replacement)	-Strongly depends on tower design and system clerances -Leads to travelling / propagating waves on the line for high footing resistances!	-High material and labor costs -Power interruption might be required **-Non-economical solution**
Improved tower footing resistances	-Additional copper counterpoise might be completely inefficient with high soil resistance -Only efficient for shielded lines -Eliminates only backflashovers and doesn't influence shielding failures.	-Moderate installation costs -Improvement and cost-efficiency is not guaranteed
Install Line Surge Arresters	-Versatile and Large feasibility -Highest protective effectiveness even for high footing resistances in all terrains -Eliminate all types of lightning failures.	-Low material and labor costs -Live installation possible. -Cost-efficient solution.

distribution lines, those direct lightning strokes to the phase conductors will be much more frequent than for properly shielded lines, since these lines are simply not protected (shielded) against lightning at all. In such cases, line arresters can also be used to address shielding failure flashovers by applying the arresters on the exposed phases.

Other problems may occur. Underbuilt distribution lines or double-circuit towers may be severely impacted by lightning strokes.

Double circuit outage reduction: Line arresters may also be used on all three-phases on one of two circuits to prevent reliably simultaneous double-system faults. This approach can be effectively used for all system voltages, including EHV systems[4].

Underbuilt distribution lines: If a distribution line shares a tower or a pole with a shielded transmission circuit, the underbuilt distribution conductors are not likely to be struck directly. However, the distribution line is vulnerable to back flashovers, because the coupling between distribution conductors and shield wires is weak. The insulation strength on the distribution line is also weaker. Once a distribution conductor flashes over, coupling to the transmission conductors will increase and make a back flashover less likely on the transmission circuit. The transmission circuit's lightning performance may improve at the expense of the distribution circuit's lightning performance. The situation can be remedied with line arresters on the distribution circuit. Usually arresters are needed at every tower or pole, on at least one phase.

3. Line Arrester Protection Effectiveness

The effectiveness of line arresters strongly depends on the protection configuration selected. An intuitive and experiential approach might be enough in some specific cases, but it cannot replace a scientific approach. It is highly recommended to perform a study to evaluate the expected benefits. Although the installation of line surge arresters on every tower along the entire line as well as on every single phase ensures complete lightning protection, an optimal selection of line surge arresters, especially in terms of their quantity and installation locations, can have a significant impact on a system's long-term benefits. With this approach, the user only needs to equip particular phases or individual line segments with line surge arresters and can still ensure sufficient lightning protection of the overhead line and reduce network failures. One particular benefit of this approach is that outstanding results can be achieved while investing only a fraction of the amount that would otherwise be required to install the maximum amount of equipment.

3.1 Simulation Softwares

Manufacturers, utilities and consultants are using software analysis to examine and conduct preliminary tests of existing applications as a way of determining the optimal and cost-effective solution. There are different commercial lightning softwares available having their own assets[12]. Main programs are Sigma SLP, IEEE Flash, EPRI flash and STRI Line Performance Estimator. There are differences in algorithms and simulation tools that can result in varying line performance. Sigma SLP was specifically developed to enable the design of transmission/distribution lines including the application of line surge arresters. The simulation takes the following factors into consideration:

Line parameters: operating voltage, number of three-phase circuits, ground wire data, length, span length and sag of the line, conductor type, diameter, and clearances. Tower data: Tower surge impedances and footing resistance, tower geometry (position and distances of the individual phases and any existing ground wires), as well as soil impedance. Insulator data: Arcing distance, connection length, rated lightning impulse withstand voltage Lightning activity: Ground flash density (lightning strokes per year and km^2) or keraunic level (thunderstorm days per year) Operator's priorities: Fewer short interruptions, prevention of phase and multisystem short circuits, elimination of ground wires

SLP software individually simulates different installation cases regarding positions of the line surge arresters in the phases to be protected to determine the most effective configuration. In addition, the software can divide the line into segments (depending on the line topology or distribution of the tower footing resistances along the line) and varies the installation of the line surge arresters depending on the number of towers to be equipped. After the simulation runs, a second phase of the analysis evaluates all the data. In a third phase, proposals are developed for an optimal solution.

4. Comparison of 2 Different Applications: Ngla Vs. Egla

Non-Gapped Line Arresters (NGLA) is a basic adaptation of the substations arresters used to protect valuable equipment like power transformers. The active part is directly connected between the phase conductor and the grounded structure. The residual voltage of the MOV column will limit the overvoltages across the insulators and prevent flashover when the BIL is exceeded. NGLA requires a clamping system to the conductor, a Ground Lead Disconnector (GLD) and in most cases a grading ring with a corona ring. The mechanical and mounting consideration is an essential step while designing NGLA. They are installed and used under harsher service conditions than other surge arresters at substations. The complete assembly is permanently stressed over its life. NGLA installation is made in such a way that they may move due to wind and/or line swinging and vibration. Users and manufactures must pay a special attention to avoid premature mechanical failures. Thanks to their high energy absorption capability and switching impulse residual voltage, today's non-gapped line arresters offer a reliable protection level to reduce switching surge factors and optimize the structure designs above 245kV system voltages. To galvanically isolate the line surge arrester from the line voltage in the unlikely event of a fault or thermal overload, a disconnector is installed in series. It automatically and immediately disconnects the line surge arrester from the line voltage. This allows the affected overhead line to be reenergised and operated until convenient replacement can be scheduled[4]. Relevant standards: IEC 60099-4 / IEEE C62.11. Application Guide IEC 60099-5 / IEEE C62.22, IEEE 1243 (lightning performance improvement).

Externally Gapped Line Arresters (EGLA) have an external spark gap placed in series that galvanically isolates the active part (SVU – Series Varistor Unit) of the line surge arrester from the line voltage under normal conditions. In case of lightning, the spark gap is ignited, and the overvoltage is safely discharged through the resulting arc. The active component (SVU) limits the subsequent current to ensure that the arc is extinguished within the first half-cycle of the operating power-frequency voltage. After this, the line surge arrester immediately returns to standby condition. The active component can have either one or two SVUs (on each side) depending on the system voltage level and user's requirements. Relevant standards: IEC 60099-8

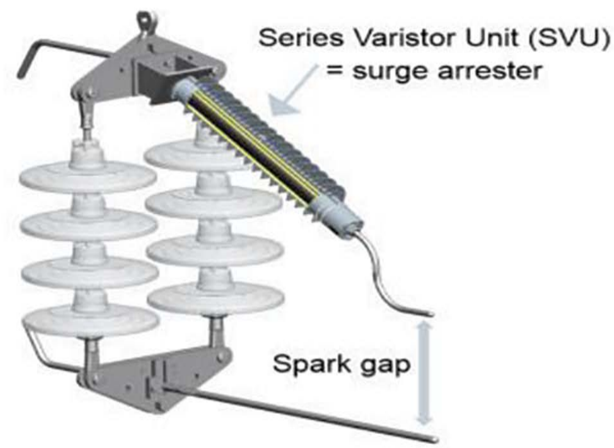

Figure 1. EGLA - Isolated from line through a series gap.

4.1 EGLA, a smarter protection. Advantages

4.1.1 Material

Less material is needed since the energy handling requirements are lower than NGLA (smaller diameter of MOVs). MOVs must not handle TOVs and switching overvoltages which is not relevant for lightning performance. Medium or High-Gradient MOVs can be used to reduce the housing size (more compact). Additional hardware (support, counterweights) might be required for retrofit application if the existing strings do not allow differently. For new transmission lines, the "smart" integration of the EGLA makes the solution compact and cost-effective. The additional hardware can be eliminated. EGLA are specifically designed to improve lightning performance. NGLA are an adaptation of the station class arresters which is not optimized. NGLA requires a clamping system to the conductor, a Ground Lead Disconnector (GLD) and a grading ring in most cases.

4.1.2 Costs

Less material means lower costs. Significant cost savings must be considered depending on the final design of the mounting hardware. Installation costs have been reported to be lower from different utilities. Operation and maintenance costs are also lower due to the reliability and long-term stability of the design.

4.1.3 Installation

The weight of the complete EGLA solution is lighter than NGLA. The SVU can be pre-assembled on the ground on the insulator strings (or directly on the tower structure) to ease the installation on site. The installation generally does not require the use of helicopters and cranes as it is for NGLA installation. Immediate vicinity to the insulator simplifies the final configuration and guarantees a proper installation. There are more options for installation in live conditions for existing lines. The pre-assembly of a complete set (EGLA + Insulators + Hardware) can be prepared by the supplier to optimize the mounting time and be lifted up on the structure while reducing the risk of losing components.

4.1.4 Maintenance /Operation

Basically, no maintenance is required. The EGLA design is rigid and stable. There are no moving parts. The ground lead and the mechanical stress (vibration/galloping) of the NGLA reduce the reliability in comparison to an EGLA. The compact design of the EGLA allows installation and lightning protection even on existing towers with very small clearances, as it is mostly the case in multi-circuit towers[4]. High resistance to vibration and mechanical stress as seismic activities can be demonstrated, especially with 2 SVUs on the insulator string or 1 SVU solidly fixed on the structure. SVUs failures do not influence continuous operation of the line due to the gap that isolates from the system. There is no need of immediate replacement. EGLA cannot fail due to line fault. The gap is dimensioned to withstand power-frequency and switching overvoltages even in the unlikely event of a failed SVU as considered in the type tests. No need to monitor the leakage current and to perform frequent specific visual inspections. Fault indicators might be used to ease the identification of a failed SVU but are not specifically recommended.

4.1.5 Electrical Performance

Metal Oxide Varistors are not continuously under voltage. There is no leakage current and no electrical stress. EGLA is cannot be subjected to ageing, therefore a long service life is expected. Japanese utilities have EGLA installed on their network for more than 25 years which are still in good condition. EGLA is a smart solution which is specifically designed to improve lightning performance.

5. Type Tests Overview IEC 60099-8

5.1 Type Tests Overview IEC 60099-8

In order to ensure the proper operating principle of the EGLA and to verify the insulation coordination between the gap and the insulator string, there are three main concepts or requirements to be verified. The IEC standard 60099-8 defines the procedure and the pass criteria for the tests[5].

5.1.1 EGLA shall not Operate at any Switching Surge due to Re-Closing Operations

For the switching impulse wet withstand voltage test, the EGLA must be tested under wet conditions and modelling a failed SVU simulated by shorting the SVU with a copper wire. The test must demonstrate that EGLA does not operate under switching surge overvoltage with peak value equal to the switching withstand voltage of the insulator to be protected. This verification is essential to define the minimum spark gap distance. The test procedure consists of two steps. At first the 50% flashover voltage of the gap is determined by the up-and-down method according to IEC 60060-1. Standard switching voltage impulses with a wave shape of 250/2500 μs in positive and negative polarity are tested. The withstand voltage of the EGLA is calculated with the following formula:

$$U_{10,\,EGLA} = U_{50,\,EGLA} \times (1\text{-}1.3 \times 0.06)$$

The verification is performed subsequently by applying for both polarities 15 impulses with a peak value of the calculated $U_{10,\,EGLA}$ in order to verify that no spark over occurs in the spark gap.

5.1.2 EGLA shall Operate at any Lightning Surge Overvoltage above the BIL Level of the Insulators

The purpose of the standard lightning impulse spark over test is to verify the proper operation of the EGLA with respect to the specified gap distance in order to prevent all possible flashovers on the insulator string. Standard lightning voltage impulses with a wave shape of 1.2/50 μs in positive and negative polarity are tested. This test must be performed on the EGLA- insulator assembly with intact SVU and under dry test condition. After the determination of the 50% lightning flashover voltage $U_{50, EGLA}$ of the EGLA spark gap, the 90% lightning impulse spark over voltage of EGLA $U_{90, EGLA}$ is calculated according to the following formula:

$$U_{90,\ EGLA} = U_{50,\ EGLA} \times (1+2.5 \times 0.03)$$

The verification is performed subsequently by applying for both polarities 15 impulses with a peak value of the calculated $U_{90,\ EGLA}$. The gap distance must be increased until spark overs cease to occur. Afterwards, 15 lightning impulses of each polarity must be applied to the EGLA in order to verify that no flashover will take place in the insulator assembly. All these 15 lightning impulses shall not lead to a gap spark over and no insulator flashovers shall be observed.

5.1.3 EGLA shall Interrupt the follow Current within a Half Cycle

This test is necessary to ensure the proper design of the EGLAs residual voltage. In case of a sparkover due to lightning impulses, the SVU must interrupt the follow current within half a cycle of the rated power-frequency voltage. This test also clarifies the performance of the EGLA under polluted conditions by considering the current that would flow over the surface of the SVU housing due to the presence of a wet pollution layer. Therefore, this test covers also the question regarding the creepage distance of the housing, where the conventional definition, as normally applied to equipment under permanent voltage stress, is not applicable.

6. Various Benefits for Line Surge Arresters Application

6.1 Switching Surge Control - Lower Clearances and Optimize Structures

Switching overvoltages are typically associated with high speed reclosing on EHV transmission lines. Strategically placed, surge arresters have been used instead of closing resistors and/or controlled switching schemes to control switching over-voltages along EHV transmission lines. Unlike lightning related applications, where arresters may be installed on consecutive structures, arresters to control switching surges are only needed at specific locations along the line. Transient simulations should be performed to determine the amount of energy absorbed by the arresters. Line arresters for this application are typically used for system voltages of 245 kV and above. However, with the increasing use of compact or upgraded line designs, this application is no longer reserved just for EHV levels[9].

It is mandatory to use NGLA application to control switching overvoltages since EGLAs are not designed to handle switching impulses.

6.2 Line Upgrading and Compaction

Line upgrading involves increasing the system voltage by keeping the existing structure. In general, for such a modification, several issues must be considered as phase clearances or insulator length. Line Surge Arresters become extremely helpful and economically justified to convert the existing lines or substations to higher voltages without changing the clearances and insulator strings.

Due to the necessity for the utilities to build discrete and aesthetic line structures and the development of the composite line post and long rod insulators, compact line designs are a realistic alternative to the standard line designs[9]. Line arresters are controlling overvoltage stresses on the line insulation.

6.3 Safety Concerns - Prevent Population Injury and Equipment Damages

Line arresters may be used in urban areas in order to significantly reduce the risk of having dangerous touch or step voltages due to power frequency earth potential rise following the insulation flashover. This application have been adopted and experienced for example by RTE France. Issues of touch potential coordination become especially important when surge arresters are used to substitute shield wires as the only form of lightning protection on MV and HV lines[9].

6.4 Live Line Working - Temporarily Reduce Minimum Approach Distance

It becomes more and more common to execute maintenance tasks when the system is energized, especially in North America. Most of the American utilities are at the experimental stage but they are probably taking the lead for this specific dangerous work in live conditions.

For such live-line working, Line Arresters can be used to reduce the minimum approach distance. A practical way must be found to ensure the arrester integrity prior the execution of the maintenance tasks. The light weight of line arrester is an advantage. The application is similar to protective gap. The crest value of the overvoltages which might exist at the work site is determined by the arrester rating. The arrester offers the advantage of protecting the workers from power-arc radiation compared to a protective air gap. The installation of arresters on all phases on structures adjacent to the work (work site structure not being equipped with LSA) site may be sufficient to protect workers, depending on surrounding grounding conditions. As a switching surge is a slow front surge with low dV/dt, the overvoltage present at work site structure will be higher but just slightly over the protective level of the arresters with little dependence on the separation distance between the work site and the LSA installation. When the protective level of arresters, corrected for separation distance, is lower than the slow front impulse flashover voltage of line insulators and live line tools, flashover at work site has a negligible probability of occurrence. Line Arrester should be used without a disconnection device in this application to ensure better worker protection[3,9].

6.5 Lowering Costs and Losses in your System

A promising study conducted by arresterworks.com has demonstrated the possibility to lower the construction costs and losses on Transmission Lines by installing EGLA on each tower and each phase instead of using Over Head Ground Wires (OHGW). For instance, the results show that total savings can reach up to ~9.5 Million USD over 30 years for a double circuit 230kV lattice tower equipped with 2 shield wires (100 miles). ~5 Million USD are immediate capital savings and ~4.5 Million USD are OHGW power loss savings. The integration of EGLA in the insulator string at the design stage for new transmission lines projects can significantly reduce the installation costs and reduce the time needed for the constructions since OHGW are no longer required and the grounding is simplified. As a positive consequence, withstand level of the insulator string can be reduced and the line becomes 100% lightning proof.

We might expect in a near future a new generation of transmission lines fully equipped with Externally Gapped Line Arresters[1].

Some specific tower designs with "triangular" phase conductors might not be equipped with OHGW; therefore EGLA can be used to "protect" the topmost phase from flashover and effectively acting similar to a shield wire when the topmost phase intercepts a lightning stroke.

6.6 Extending Life of Breakers at Substations

Since a lightning flashover on a transmission line requires breaker operation, the Application of Line Arresters along a transmission line reduces stress on breakers at substations and extends their service life.

Furthermore, during a multi-reclosing operation, switching impulses can enter the station while the circuit breaker is still open to clear the fault. Such an event has a low probability, but the risk of long-term damage is pretty high for the line side bushing of the circuit breaker[3].

6.7 Extended Protection of Substations

By locating arresters on towers near a substation, it is possible to eliminate the risk of flashover near or in the substation. This leads to a reduction of the stress on substation equipment due to incoming travelling waves. In some cases, the need for additional expensive metal enclosed arresters can be reduced. However, the protective performance of line arresters such as residual voltage needs to be evaluated properly, as it may not be equivalent to substation arrester ratings. Detailed modelling of incoming surges suggests that Line Arresters tend to reduce the steepness of incoming waves[3].

7. Monitoring, Condition Assessment and Recommendation

The failure rate of the surge arresters is estimated to be far lower than 0.1% / year. It is actually very difficult to provide enough accuracy and perform statistic calculations since the majority of the failures are not reported and the cause is not identified. Surge Arresters are among the most reliable components on the grid and there are currently no major developments in arrester monitoring devices. Line Surge Arresters are generally installed in remote area and are difficult to access without helicopter, cranes or specialized industrial climbers. A systematic monitoring for NGLA is not always necessary because they might not provide meaningful information and complex monitoring devices might not be economically justified. For EGLA, monitoring devices are not applicable since there is no leakage current through the MOVs. Instead, Fault Indicators and regular Line Inspection can be used to detect the failure of the active part. However, it becomes a necessity for the users to increase reliability and being proactive in maintenance.

The line operators often want to record the amplitude and the frequency of overvoltages that occur on the transmission line. Different solutions are available in the market. Basic devices like surge counters are often used for Station Class arresters to get statistical analysis of the overvoltages but they will not provide any information of the arrester condition. The Metal Oxide Varistors can withstand an unlimited number of overvoltages without being damaged. If required, Surge Counters can be equipped with a leakage current meter to measure the total leakage current flowing through the surge arrester. The total leakage current, mainly capacitive, can be easily influenced by the pollution layer on the arrester housing for instance. Therefore, it cannot be used to monitor the health status of Metal Oxide Varistors (NGLA) and is not relevant for EGLA since there is no leakage current.

7.1 Third Harmonic Method (Resistive Current)

In order to go further, the line operators are generally more interested to monitor the condition of the arrester's active part. Recent monitoring solutions (digital devices including wireless communication) can be mounted on the Line Surge Arresters. These monitors will assist the users in the early detection of relevant changes. The monitoring device performs two basic functions. The first is measuring total leakage current and determining the resistive leakage current component by analyzing the leakage current's 3rd harmonic. The second function is registering surge current impulses, as well as detecting and registering the overall number, level, and duration of impulses. That information can then be used to perform a precise analysis of arrester activity. This advanced solution is additionally equipped with wireless communication for evaluating long-term measurements, counter history, and energy summation. It might be interesting for some specific cases, especially for system voltages from 245kV and above.

In general, below 245kV, the complete monitoring solution might be more expensive than the arrester itself. Therefore, it might be installed only at specific locations but not on each arrester.

7.2 Thermal Imaging

The permanent leakage current through the Metal Oxide Varistors dissipates energy. Under normal operation, the temperature is close to the ambient value. If the surge arrester shows an abnormal behavior, the leakage current will increase and then a significant temperature gradient will be easy to identify. It is recommended to perform analysis without sunlight and during the night to make sure the overall temperature cools down and to increase the accuracy of the measurement. Some maintenance processes must be defined by the users to select and follow-up the arresters showing abnormal behaviors. There is no existing guidance for this purpose, but expertise can be provided by consultants, users and specialized infrared thermographers. The data can be collected quickly from relatively long distances depending on the infrared camera. We might imagine soon some specific drones collecting thermal profiles instead of going physically in each substation to collect the data[2].

There is no official guideline to monitor line surge arresters. The guidance in IEC 60099-5 and the experience from the operators and the manufacturers can provide an overview of the different methods. Thermal imaging and third harmonic method (resistive current) remain the best ways to assess the health of the surge arresters (only NGLA). Anyhow, it is not economically viable to equip line surge arrester with monitoring devices in order to systematically assess health condition[11]. Thermal Imaging might be the most cost-efficient solution to monitor health condition of the surge arresters.

7.3 Line Inspection – UAVs

Overhead line inspection has just been revolutionized. The Unmanned Aerial Vehicles (UAVs) replace the helicopters that are being used today. Siemens is developing a new generation of line inspection with unique UAV that are not only cost-effective but that carry best-in-class multi sensor systems. Innovative software uses machine learning and artificial intelligence to automatically analysed hundreds of gigabytes of data. With this pioneering service, Siemens SIEAERO offers the fastest, most automated, best integrated and by far the most accurate overhead line on the market.

EGLA must be considered as additional power line components. There is no reason to specifically inspect them more frequently than the other items on the lines.

8. Conclusion

The electricity supply industry is a conservative sector. New technologies and innovative solutions are in general experienced progressively. Currently, the majority of the activities are related to lightning outages reduction. The application of Line Surge Arresters does not only improve the performance and the operation of the power systems but also improve the design and lower the costs of the construction and the maintenance. The financial benefits are easily demonstrated. This device is still misunderstood and not systematically used when applicable. The communication might be an important way of enhancement to widely share the knowledge and experience. It would be very welcome from the main grid operators and utilities to better communicate the outstanding achievements that have been reached through a mid-term assessment. For line upgrading and compaction, the opportunities and the advantages are significant for the industry. Unfortunately, the applications are underutilized because the engineers have the responsibility to redefine the ratings that have applied for the last century[2]. Each revolution passes through three stages. First, it is ridiculed as replacing the OHGW by EGLA for instance[1]. Second, there will be a clear opposition from the major players in the sector. Third, it will be accepted as being self-evident. LSAs application will certainly become a standard component for the distribution and transmission lines in a near future. A promising Working Group has been founded in order to define a “global” standard for the application of Line Surge Arresters.

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