BIRD PROTECTION ON MEDIUM VOLTAGE POWER LINES

Gábor GÖCSEI
BUTE, Hungary
gocsei.gabor@vet.bme.hu

Bálint NÉMETH
BUTE, Hungary
nemeth.balint@vet.bme.hu

Richárd CSELKÓ
BUTE, Hungary
cselko.richard@vet.bme.hu

Dr. István BERTA
BUTE, Hungary
berta.istvan@vet.bme.hu

Balázs TORDA
E.ON, Hungary
balazs.torda@eon-hungaria.com

ABSTRACT

Bird protection became a more and more important topic on medium voltage power lines worldwide. There are many ways of wildlife protection, such as artificial nests, insulation of the phase conductors, use of extended insulators, flight diverters, etc. One of the most common methods is the application of rigid bird protectors because of its economic benefits.

In Hungary most of the bird protectors installed on the network are rigid-type covers. Reports from different territories of different DSOs shows that numerous failures are related to these type of covers: flashovers, discoloration of phase conductors, broken insulators, etc. are caused by them. These failures may occur even during normal operational conditions because of the distortion of the electric field.

Calculations, finite element simulations on complex 3D models and laboratory measurements on these bird-protector related issues have been executed in the High Voltage Laboratory of Budapest University of Technology and Economics (BUTE). Results of measurements – including measurements on aged samples – have proved the results of the calculations and simulations. Based on them recommendations can be made for the DSOs to decrease, or even eliminate these kinds of failures related to bird protectors.

Finding the preferred ways of wildlife protection is also an important topic of this paper. Pros and cons of different methods and risk evaluation was also the part of the research. Covering code created for different insulator-bird protector combinations has been accepted and is applied by most of the Hungarian DSOs. As a result of this kind of new regulation, the number of failures caused by bird protectors has decreased significantly.

INTRODUCTION

Protection of wildlife – especially protection of birds – is becoming more and more important around the power lines worldwide. Overhead lines are a preferred way of energy transport at all voltage levels:

- in case of low voltage networks, insulated conductor bundles are widely used; voltage range allows the insulating layer to have proper dielectric parameters; production and installation is economic
- medium voltage insulated overhead lines are relatively rare; because of the limited distances between the energized parts and grounded structures bird protection is essential at this voltage level
- phase conductors of high voltage lines usually generates high electric field around the conductors, but this field is high enough to keep the birds away – so protect them against the approach of the conductors.

The bird protection in the medium voltage grid can be executed by different principles and by many types of protective devices. One of the solutions is the deflector-type protector, which does not allow the birds to land at the critical points of the supporting structures, or pole-mounted switches. Besides deflectors, another category is the covering-type protector, which make the phase conductors and the grounded parts of the structure untouchable for birds at the same time. In addition, new bird-friendly support structures have been developed lately.

From the aspect of bird protection, different species are categorized by their size. In Hungary there are four categories as it is shown in Figure 1. Each category has predefined safety distances around different types of birds, which are required in order to avoid them against electric shocks. Shapes of prescribed gaps are defined based on the specific movements of the birds of each category.

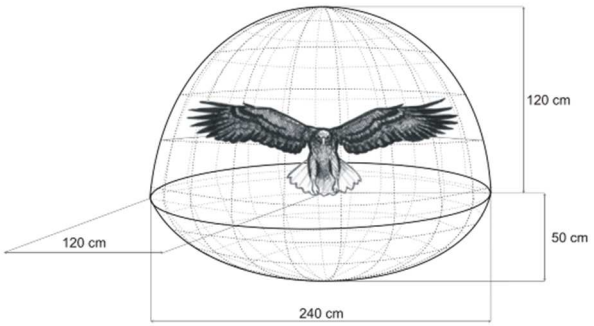

Figure 1. Safety distances around a "Category A"-sized bird

ISSUES

In Hungary there are several issues in the medium voltage grid related to bird protective covers:

- discoloration of phase conductors is common (see Figure 2); it cause both the electrical and mechanical properties of the phase conductors and connecting assemblies to decrease
- melted and broken insulators (especially epoxy resin ones) are usual and often cause phase-to-ground faults (Figure 3 shows an example); conductor or insulator break might cause the phase conductors to fall down and to endanger the safety of the vicinity of a power line.

Because of the phenomena mentioned above a research and development project has begun to clarify the root causes and find the possible ways of solutions.

Figure 2. Discoloration of phase conductors under a rigid bird protective cover

Figure 3. Broken epoxy resin insulator under a rigid bird protective cover

The main reason of this phenomena is illustrated below. As it can be seen during humid weather conditions a continuous conductive layer appears on the surface of the bird protective cover (e.g. as a result of rain, snow, fog, mist, etc.) The potential of this layer – as an electrode – floats. In the vicinity of the phase conductor this electrode becomes energized and discharged in a capacitive way. High electric field between the conductor and the floating electrode may cause the surface of the conductor to damage. Arrangement is shown in Figure 4.

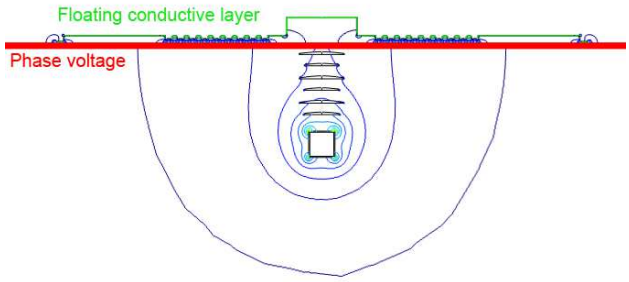

Figure 4. Principle of generation of high electric field under the cover

The same phenomenon might cause the electric field to be distorted around the insulators: in this area energized conductors are close to the grounded cross-arm structure, so the electric field strength has peak values in the vicinity of this section of the arrangement.

To prove these supposed processes a complex simulation using finite element method (FEM) has been executed. Result of it have been validated by numerous measurements in different arrangements in the High Voltage Laboratory of Budapest University of Technology and Economics.

FEM SIMULATIONS

Model of a typical Hungarian concrete pole-cross-arm-epoxy resin insulator arrangement equipped with a common type of rigid bird protective cover used for the simulations is shown in Figure 5.

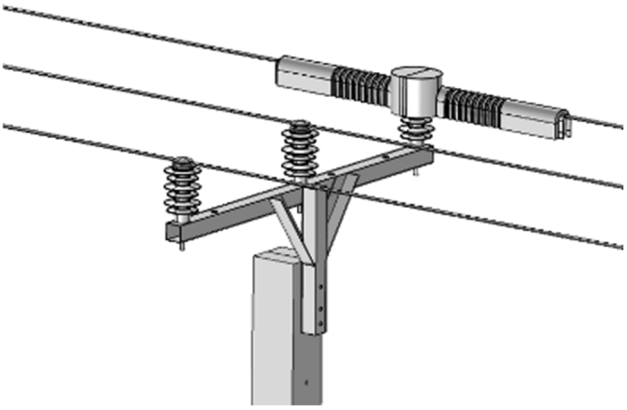

Figure 5. 3D CAD model for FEM simulations

Electric field distribution has been analyzed in two different planes: in parallel and perpendicular to the phase conductors.
Parallel plane (for results see Figure 6) shows the capacitive discharges – as the main reason of conductor discoloration – along the phase conductor. This phenomenon occurs even during normal operational conditions.

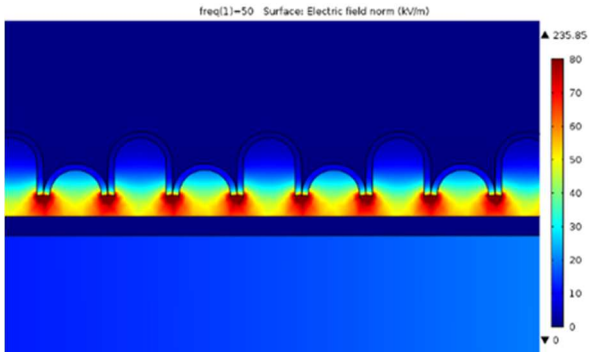

Figure 6. Results of electric field distribution (in parallel with the conductors)

Figure 7 shows the perpendicular plane with the electric field distortion around the insulators. As it can be seen critical electric field strength peaks got closer to the grounded structure, so dielectric properties of the air gap decreased significantly.

In case of an overvoltage wave probability of flashover on the surface of the insulators increase.

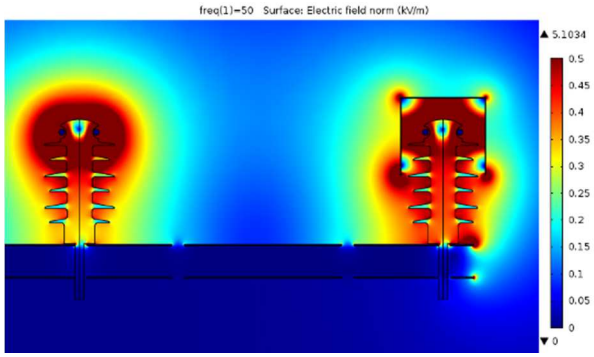

Figure 7. Results of electric field distribution (perpendicular plane to the conductors)

VALIDATION OF RESULTS IN LABORATORY ENVIRONMENT

Many types of different bird protecting covers are used worldwide. Some of the common Hungarian types have been inspected in the High Voltage Laboratory of BUTE according to the IEEE 1656:2010 standard. Two types of partial discharge measurements have been carried out: with and without a cover of conductive material (which demonstrates the conductive layer caused by e.g. the rain). The bird protectors were also subjected to a two week-long aging cycle. For aging both temperature cycles and UV radiation have been used. The measurements were carried out both before and after the aging.

Figure 8 shows an example for a measurement arrangement.

Figure 8. Measurement arrangement

Table 1 shows the results of the measurements for the basic and for the aged conditions.

	Before aging [V]	After aging [V]	Increase of PD
Bird protector *A*	2.15	2.86	33,0 %
Bird protector *B*	2.63	3.44	30,8 %
Bird protector *C*	0.498	0.725	45,7 %

Table 1. Partial discharge measurement results after and before aging of covers (nominal voltage level)

During the measurements significant partial discharge has been observed in all cases when the bird protectors were covered by the conductive material. Averaged partial discharges compared to the position of the 50 Hz sinusoidal waveform is shown in Figure 9 and Figure 10.

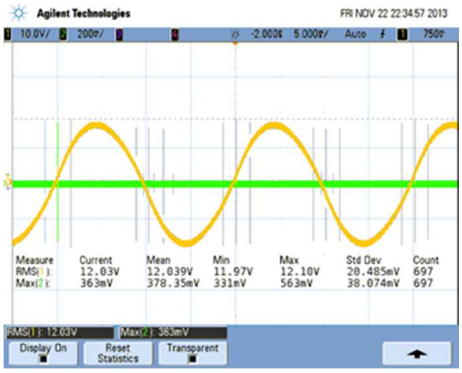

Figure 8. Partial discharge (PD) measurement results without conductive layer on the cover

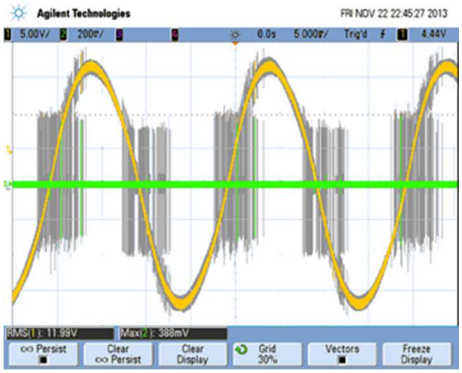

Figure 9. Partial discharge (PD) measurement results with conductive layer on the cover

As it can be seen in the figures above in case of a rigid bird protector with a dry surface partial discharges are negligible, but when the surface becomes wet, amplitude and frequency of discharges increases significantly.

POSSIBLE SOLUTIONS

Most of the supporting structures used do not ensure proper distances between the phase conductors and/or the grounded elements. In this cases a possible way of bird protection might be to ensure safe places to land. Another solution might be the using of suspended insulators instead of conventional ones (Figure 10). In this case birds can land on the top of the grounded cross-arms and phase conductors become out of the minimal clearances defined by the category of a given bird.

Figure 10. Bird-friendly supporting structure with suspended insulators

Instead of the conventional head structures made of conductive material, use of insulating materials is also possible. In this case, both the full head structure and the cross-arm might be made of non-conductive material. In the Hungarian medium voltage grid there are new experimental structures and cross-arms meeting the recent regulations and guidelines (an example is shown in Figure 11).

Figure 11. Bird-friendly support structure with insulated cross-arms

It is also preferred to use rigid covers only on the cross-arms themselves (Figure 12). They neither distort electric field around the insulators, nor generate capacitive arcs on the surface of the conductors. Note that for proper protection cross-arm insulators have to be installed on the whole length of the metal structures.

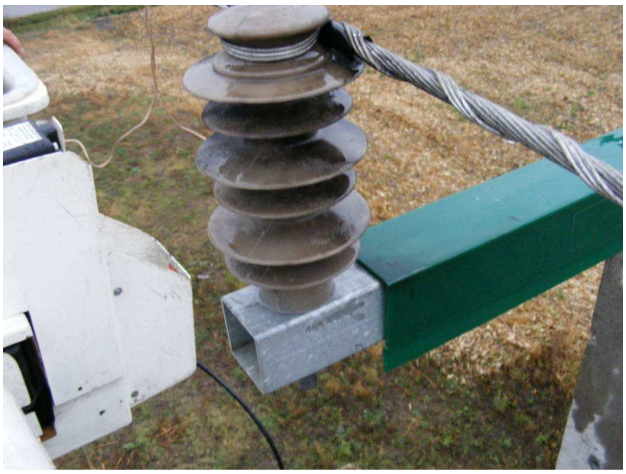

Figure 12. Insulated cover on the cross-arm

As it can be seen there are many alternative solutions of bird protection besides the application of rigid protective covers. Because of the numerous practical failures related to this way of wildlife protection installation of covers to the phase conductors is not supported (especially when the bird protector does not fit on the insulator, which might be common because of the various insulator-connector-phase conductor geometries).
There is another practical issue related to the covering of the insulators or the phase conductors themselves: from the aspect of live-line maintenance this way is not supported at all. Visual inspections – as an important part of any kinds of live-line activity – are not possible, so in this case safety of the work is endangered by the protective covers.

SUMMARY

In case of existing grids, bird protective covers may be the most economical solution of protection of medium voltage overhead lines. Many circumstances might occur (e.g. weather conditions, installation problems or the faulty selection of protector) which can make the bird protective cover ineffective, or even to endanger the operational safety of the grid. There are many other ways of protection which might have a better long-term technical and economic balance from the aspect of both the side of wildlife protection and the network as well. In Hungary – based on the results of this study – rigid bird protective covers became not supported in the medium voltage grid; other types of protectors or use of special cross-arms is recommended instead.

REFERENCES

[1] Preventive Measures to Reduce Bird-Related Power Outages - Part I: Electrocution and Collision IEEE Task Force on Reducing Bird Related Power Outages; IEEE Transactions on Power Delivery, Vol. 19, No. 4, October 2004

[2] Preventive Measures to Reduce Bird-Related Power Outages - Part II: Streamers and Contamination; IEEE Transactions on Power Delivery, Vol. 19, No. 4, October 2004

[3] J. T. Burnham, “Bird streamer flashovers on FPL transmission lines”, IEEE Trans. Power Delivery, vol. 10, pp. 970–977, April 1995

[4] P. V. Taylor, P. Naidoo, D. A. Hoch, and A. C. Britten, “An investigation into anomalous flashovers of transmission lines,” in Proc. CIGRE 3rd - Southern Africa Regional Conf., May 1998

[5] Guidelines For Mitigating Conflict Between Migratory Birds and Electricity Power Grids, Tenth Meeting Of The Conference Of The Parties, Bergen, Agenda Item 19, 20-25 November 2011

[6] Review Of The Conflict Between Migratory Birds And Electricity Power Grids In The African-Eurasian Region, 10th Meeting Of The Conference Of The Parties, Bergen, Agenda Item 19, 20-25 November 2011

[7] Position Statement on Birds and Power Lines On the risks to birds from electricity transmission facilities and how to minimise any such adverse effects adopted by the BirdLife Birds and Habitats Directive Task Force on 10 May 2007

[8] Diego Rubolini , Enrico Bassi, Giuseppe Bogliani, Paolo Galeotti, Roberto Garavaglia: Eagle Owl Bubo bubo and power line interactions in the Italian Alps, Bird Conservation International (2001) 11:319–324

[9] IEEE Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices on Overhead Power Distribution Systems Rated up to 38 kV; IEEE Standars Association, IEEE Power & Energy Society, USA; 28 February 2011

[10] IEEE Std 1656™-2010: IEEE Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices on Overhead Power Distribution Systems Rated up to 38 kV, IEEE Power & Energy Society, 28 February 2011

[11] Szügyi Kálmán: Új hálózatkép: Függőszigetelős KÖF szabadvezeték-hálózat és madárvédelem kompromisszumok nélkül, Megawatt Mérnökiroda Kft., VILL-ENERGO Kft., MEE Vándorgyűlés Mátraháza, 2013. szeptember 11 - 13.

[12] G Göcsei, B Németh, R Cselkó, I Berta: Bird protector -related issues on medium voltage overhead networks, 11th ICOLIM, Budapest, Hungary, Paper 312. 6 p. ISBN:978-1-4799-5993-8