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Lightning Performance Improvement Of 123 kV Line Ston – Komolac By Use Of Line Surge Arresters

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SUMMARY

This paper presents HEP - Transmission System Operator Ltd. Line surge arrester (LSA) application pilot project on the Ston – Komolac 123 kV line.

This 44 km long single circuit shielded transmission line operates in the region with a high lightning activity (keraunic level about 70 thunder days). In addition, it was very difficult to obtain good footing resistance. For these reasons, considered line used to have very bad lightning performance.

It was decided to install Line surge arresters for line lightning performance improvement. In order to optimize arrester installation configuration sigma slp software simulations were performed. LSA are installed according to the results of the software simulations.

LSA are installed in summer 2007 (110 gapless, IEC-class II Line arresters). Sixty one LSA are equipped with Excount - II monitoring sensors (monitoring arrester leakage current and peak of the impulse current).

Based on the 8-month experience, LSA installation has improved line lightning performance. New line performance is close to the targeted once (improvement by 50 to 60 %). Surge arrester monitors collect very interesting information. Collected info will be compared with the software simulations.

KEYWORDS

Line surge arrester. Lightning performance improvement. Tower footing resistance.

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1. INTRODUCTION

There are several methods used for the improvement of the lightning performance of the existing transmission lines, such as: tower footing resistance reduction, increase of line insulation level, installation of additional ground and guy wires, addition of under-built ground wires, etc. Some of them have limited effect, while others are too expensive and unsuitable to application.

The use of line surge arresters for the quality of service improvement has increased over the last decade. Line surge arresters are mainly used for transmission line lightning performance improvement and for the reduction of double circuit outages on double circuit lines. Many line surge arresters are in operation and substantial experience has been accumulated. Thanks to the development of the polymer housed line surge arresters with and without an external gap it is possible to establish and maintain complete control on the line lightning performance.

It was decided to install Line surge arresters for line lightning performance improvement. In order to optimize arrester installation configuration sigma slp software simulations were performed. LSA are installed according to the results of the software simulations, statistics and outages data of the considered overhead line.

LSA were installed in summer 2007 (110 gapless, IEC-class II Line arresters). Sixty LSA are equipped with Excount - II monitoring sensors (monitoring arrester leakage current and peak of the impulse current).

2. 123 kV LINE STON – KOMOLAC

The Ston - Komolac 123 kV, 44 km long single circuit shielded transmission line operates in the region with a high lightning activity (keraunic level about 70 thunder days in the year). In addition, concerning composition of ground it was very difficult to obtain favorable footing resistance. For these reasons, considered line has a bad lightning performance.

Line was constructed in 1961, and major reconstruction has been done in 1994 due to increasing transmission power priority. Porcelain insulator strings were replaced by glass insulators, phase conductor and shield wire (single) has been changed and appropriate work has been done in order to improve tower footing resistance.

Line insulation critical flashover voltage of this line is 550 kV and tower footing resistance of some towers is still high (higher than 60 Ω).

Unfortunately, after the reconstruction work line outage rate remained rather high. Table 1 presents line outage rate for the last 11 years. Average line outage rate is 12,54 outages / year, which is equivalent to 28,50 outages / 100 km / year.

Table 1 - Line outage rate (O.R.)
[Outages / per year]

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
O.R.	13	5	17	18	13	9	18	11	10	11	13

3. LINE SURGE ARRESTERS

Used gapless polymer housed LSA has the following characteristics:

Rated voltage: 108 kV
MCOV: 86 kV
IEC Class: II
Nominal discharge current: 10 kA
Housing: Silicone rubber

LSA were installed in summer 2007 (110 gapless, IEC-class II Line arresters). LSA are installed by hanging from the phase conductors. Photo of the installed arresters is given in Figure 1.

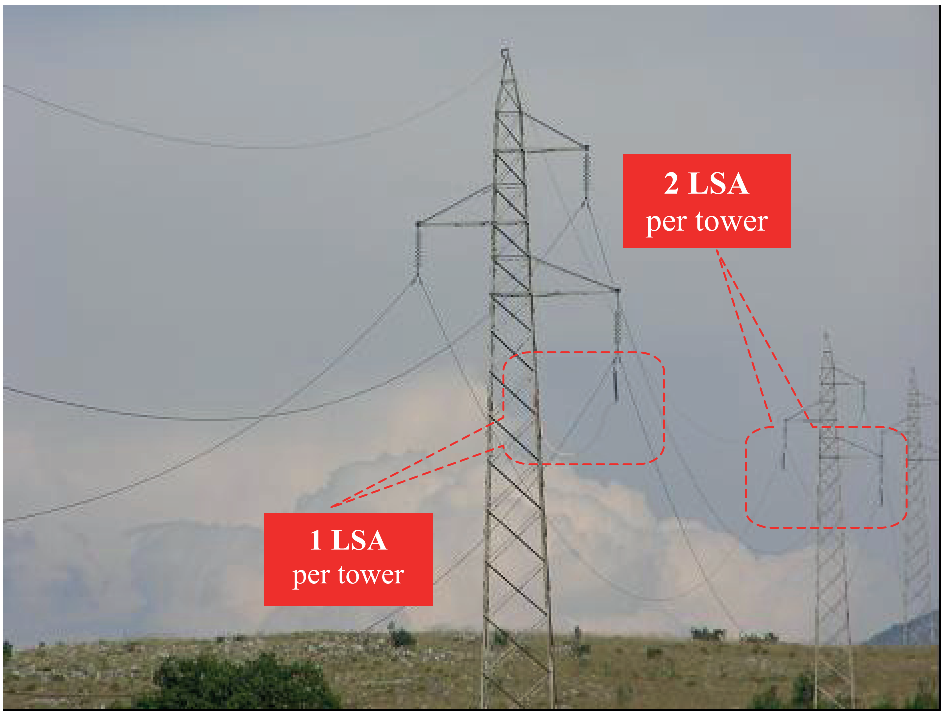

Figure 1 - LSA hanging from the phase conductors

4. LIGHTNING PERFORMANCE COMPUTATION

The Sigma slp software [2], [3] was used for the computation of the line lightning performance for different arrester installation configurations and different tower footing resistances. Detailed results of the software simulation, along with the line data are given in [6]. Here Line total flashover rate is given as a function of the tower footing resistance and different LSA installation configurations (Table 2). These results are graphically presented in Figure 2.

Table 2 - Line Total Flashover Rate
[Flashovers / 100 km / per year]

R(Ω)	ρ(Ωm)	LSA 0 (○ ¦ ○ ○)	LSA 3 (○ ¦ ○ ●)	LSA 2, 3 (● ¦ ○ ●)
10	400	3,4	1,11	0,39
20	800	17,22	9,97	3,9
30	1200	34,05	21,29	9,92
40	1600	52,89	33,83	16,38
50	2000	68,39	46,15	23,35
60	2400	77,7	56,96	30,71
70	2800	84,95	64,55	37,12

○ - Without arrester
● - Arrester installed

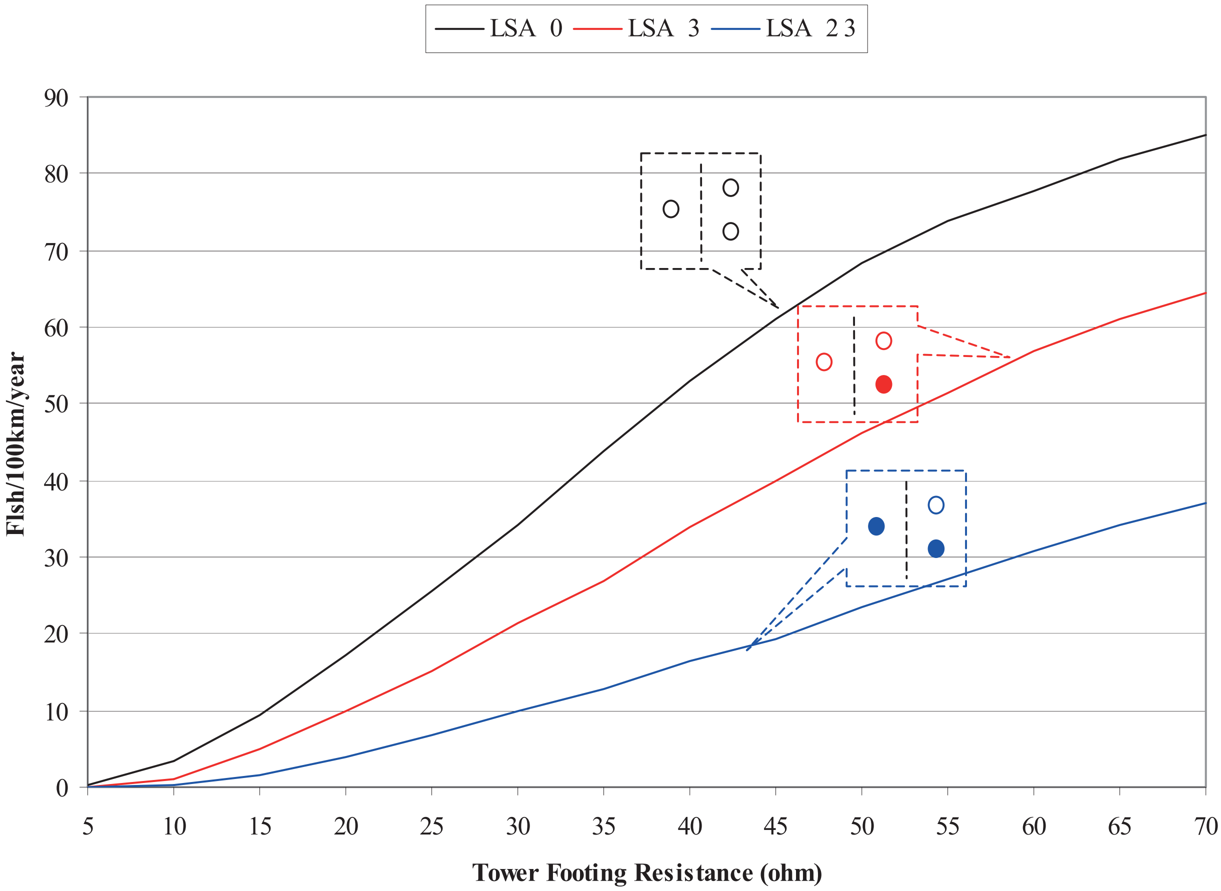

Figure 2 - Line lightning performance for different tower footing resistances and different LSA installation configurations

5. ARRESTER INSTALLATION STRATEGIES AND FIELD EXPERIENCE

Line Ston - Komolac consists of 144 towers. Tower footing distribution along the line was available (measured).

Using the so called 'Multiple study' option of the sigma slp software it was possible to determine line composite performance, taking in account different tower footing resistance of each tower.

Based on the real tower footing resistance distribution and on the simulation results presented in Table 2, line composite performance of the line before LSA installation is calculated, being equal to 10,91 flashovers / year or 24,79 flashovers / 100 km / year. These values are in rather good agreement with the filed experience for the considered line (12,54 and 28,50).

It was reason to improve line lightning performance using 110 LSA only. The target was to improve line performance by 50 % to 60%. The following installation strategy was adopted:

a) No LSA (tower footing resistance ≤ 10 Ω)

b) Bottom conductor LSA (tower footing resistance > 10 Ω and ≤ 30 Ω)

c) Middle and Bottom conductor LSA (tower footing resistance > 30 Ω)

According to the available tower footing resistance values and adopted LSA installation strategy, sigma slp software line lightning composite performance tool is used to get line performance after LSA installation (Figure 3).

Results of the simulation (after 110 LSA installation) gives line lightning performance of 5,07 flashovers / year, which is an improvement for 54 % (close to the target improvement of 50% to 60%).

LSA installed in mentioned line are in operation for 8 months. It is too early to draw general conclusions from the field, but in this 8-month period, 4 lightning produced outages were registered. This is equivalent to 6 flashovers / year, meaning that the field experience indicates 52 % improvement in the line lightning performance (close to the target improvement).

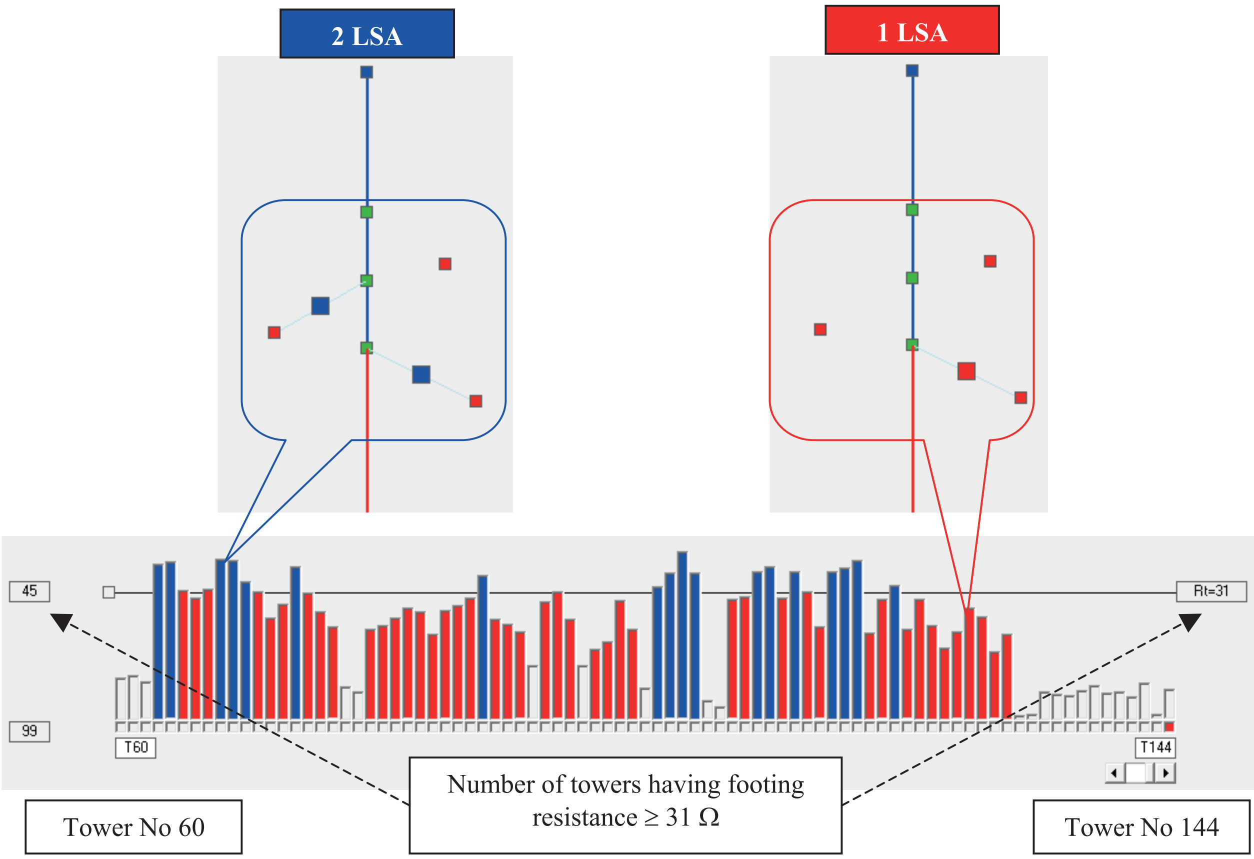

Figure 3 - Tower footing resistance distribution and the selected arrester installation configurations [From Tower No 60 to Tower No 144]

During 8 months of the operation surge arrester monitors have collected a lot of interesting data. These data is under a separate study and will be presented during the Colloquium. Collected data will be also compared with the software simulation results.

Table 3 presents LSA lightning strokes related currents collected by the surge arrester monitors.

Table 2 - LSA lightning strokes related currents

Current Range (kA)	Number of readings
> 10	2
5 - 10	1
1 - 5	9
0,1 - 1	5
< 0,1	89

No change in the arrester leakage currents is registered. Resistive component of the leakage currents is in the range of 40 μA, while arrester total leakage current is in the range of 400 μA.

In order to monitor LSA current shapes it was decided to install on the most exposed towers remote real time surge arrester monitoring system.

Based on data related to operation and outages for the considered line, including monitoring data, the effects and possibilities of LSA application will be estimated. This experience is of the great importance for the application of this technology to the other lines in transmission network.

6. CONCLUSIONS

1. In order to improve transmission line lightning performance of 123 kV line Ston – Komolac, 110 polymer housed LSA were installed in summer 2007. LSA rated voltage is 108 kV.
2. LSA installation strategy is based on the sigma slp software simulations. There is a rather good agreement with the field experience and software simulations (for both: before and after LSA installation).
3. According to the 8-month field experience line lightning performance is improved for 52 % (target improvement was between 50% to 60 %).
4. Intelligent current sensors are installed for LSA monitoring (61 monitors installed). During 8 months of the operation surge arrester monitors have collected a lot of interesting data. This data is now under a separate study and will be presented during the Colloquium.
5. In order to monitor LSA current shapes it was decided to install on the most exposed towers remote real time surge arrester monitoring system.
6. Depending on the results of this LSA application pilot project, it will be decided about future applications of this technology to the other lines.

7. BIBLIOGRAPHY

[1] M. Puharic, S. Sadovic, "Implementation of surge arresters on the 123 kV line Ston-Komolac", Technical Study, Energy institute "Hrvoje Pozar" [in Croatian], Zagreb, Croatia, 2003

[2] S. Sadovic, R. Joulie, S. Tartier, E. Brocard "Use of Line Surge Arresters for the Improvement of 63 kV and 90 kV Shielded and Unshielded Transmission Lines", IEEE Transactions on Power Delivery, Vol. 12, No. 3, July 1997, pp. 1232 – 1240

[3] S. Sadovic, R. Joulie, S. Tartier, E. Brocard "Line Surge Arresters and Unbalanced Insulation in the Reduction of Double Circuit Outages on a 225 kV Transmission Line", X International Symposium on High Voltage Engineering, August 25-29, 1997, Montréal, Canada

[4] S. Sadovic, R. Joulie, S. Tartier, "Transmission Lines Lightning Performance Improvement by the Installation of Line Surge Arresters ", Ninth International Symposium on High Voltage Engineering, Graz Austria 1995, paper 6731

[5] M. Babuder, M. Kenda, P. Kotar, E. Brocard, S. Tartier, R. Joulie, S. Sadovic, "Lightning Performance Improvement of 123 kV Transmission Line by use of Line Surge Arresters", XI International Symposium on High Voltage Engineering, August, 1999, London, U.K.

[6] M. Puharić, M. Lovrić, J. Radovanović, Ž. Ćosić, S. Sadović, "Line Surge Arrester Application Pilot Project", 27th International Conference on Lightning Protection, ICLP 2004, Avignon, France, 2004