IV^th International Scientific Symposium ELEKTROENERGETIKA 2007, 19.-21. 9. 2007, Stará Lesná, Slovak Republic

Krystian Leonard Chrzan

Application of silicone coatings on porcelain insulators in Poland, a case study

Abstract

Silicone coatings have been used to improve insulating properties of outdoor insulators under polluted conditions for over 30 years. In Poland this method was used for the first time in 1995. This paper presents Polish experiences and analyzes the usefulness of such coatings. Changes in pollution emission and their influence on outdoor insulation performance were taken under consideration.

INTRODUCTION

The room temperature vulcanizing silicone rubber coatings were used for the first time in USA over 30 years ago. This method is more convenient than the hand cleaning of insulators or application of vaseline or silicone pastes. The porcelain insulators with a 0.3 – 0.6 mm thin silicone coating have similar properties to composite insulators with a thicker silicone housing. A 0.3 mm thin silicone layer is able to transfer the hydrophobic properties to the pollution layer. As a result, the leakage current decreases and the flashover voltage increases. The material development, price decrease, application possibility under operating voltage, a long-term experience and preparation of IEEE standard [1] have led to a wider use of this technology [2].

The experience with silicone coatings in Poland is rather limited. They were applied at 110 kV station adjacent to a smelting plant in 1995 and at 400 kV station of an electric power plant in 1998. Additionally, the silicone coatings were used in a few places on a very small scale. The silicone coatings should be used in such cases where, under severe pollution, the insulation is too weak and, when they offer an interesting solution compared to insulation exchange (the use of stronger porcelain insulators) or application of composite insulators. It seems this is an obvious opinion. However, in this paper the examples will be shown, where the application of silicone coatings was unnecessary.

I. GLOGOW POLLUTION TEST STATION

In the following chapters the silicone coatings application at given places will be shown and reasons for taking such particular decisions will be explained.

The simplest method of insulators covering was tested at Glogow pollution test station in 1995. The 110 kV insulators were hand painted using simple brushes. Two post insulators SWZP, two line long rods LP75/27W, one long rod LP75/37W, one bushing and one housing of surge arrester were covered. The flashover voltage was measured on post insulators with coatings and without coatings seven years later [3]. The flashover voltage of post insulators with silicone coatings was 25% higher than that of insulators with the bare glazes. These results given as withstand specific leakage distance measured in different months are shown in fig. 1. The silicone coatings preserve their hydrophobic properties after seven years of service or even longer [4].

The insulators at Glogow test station were covered by silicone coatings only for research purposes. The withstand voltage measured in the years 1986 and 1987 was sufficiently high. There was no need to increase it. Three flashovers were noted on SWZP post insulators with specially shortened leakage distances in 1987 (tab. 1).

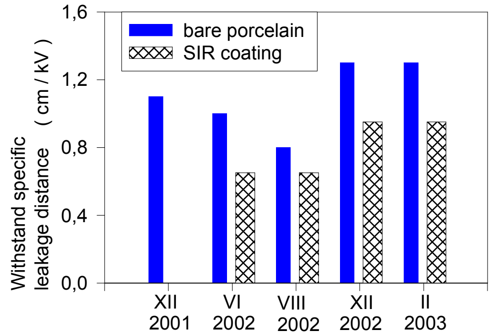

Fig. 1. Withstand specific leakage distance on SWZP post insulators as measured in different months of 2001-2003.

The critical flashover took place on insulator with bridged 6 sheds in December 1987. Note, the SWZP post insulators have 20 sheds. The current greater than 50 mA_{peak} but smaller than 140 mA_{peak} was recorded on the insulator with bridged 4 sheds. The current on full insulators without bridged sheds, was smaller than 50 mApeak (tab. 1). The withstand specific distance in 1987 amounted 1,8 cm/kV and in 2003 – 1,3 cm/kV. It seems that in 1995, when the coatings were applied, the withstand specific distance amounted 1,5 cm/kV. That means the specific leakage distance of full insulators was 0.9 cm/kV longer than their withstand leakage distance.

TABLE I

The currents and flashovers recorded on post insulators at the Glogow station in 1987. Test voltage 70 kV. The number “1” means that the current exceeded the triggering level of 20, 50 or 140 mApeak, the arrow ↓ ≡ flashover

Reading Data	Number of not shortened sheds				
	12	14	16	18	20
	Specific creapage distance in cm/kV phase to earth				
	2,4	2,8	3,2	3,6	4,0
	cm/kV phase to phase				
	1,4	1,6	1,8	2,0	2,4
6.01.1987	**1** ↓ **1** **1**	1 1 0	1 0 0	1 0 0	1 0 0
15.04.1987	**1** ↓ **1** **1**	0 0 0	0 0 0	1 0 0	0 0 0
23.12.1987	1 1 0	**1** ↓ **1** **1**	1 1 0	1 0 0	1 0 0

The environmental improvement in the vicinity of the test station was the reason for the increase of flashover voltage. The dust deposit density decreased from 9 g/m^2 a day in 1980 to 0,4 g/m^2 a day in 2003 (fig. 2).

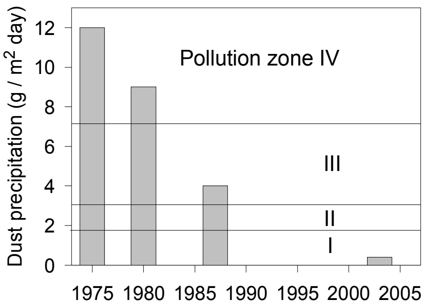

Figure 2. Dust deposit density at Glogow test station

The pollution class "very heavy" was found up to 1983, "heavy"- up to 1990, "middle" - up to 2000 and "light" - after 2000 (fig. 2). The dust emission from the neighboring smelting plant was reduced 80 times between 1980-2005 (fig. 3). The dust precipitation at the test station decreased "only" 20 times in the same period. The dust deposition at the test station originates also from other sources.

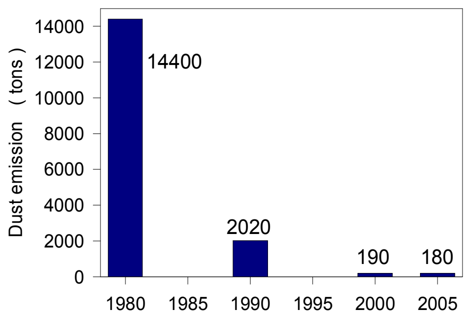

Fig. 3. Annual dust emission of smelting plant from 1980 to 2005

II. 110 KV STATION AT A SMELTING WORKS

A few flashovers on 6 kV bushing insulators were noted at this station in 1993 and 1994. The very high switching over-voltages or over-voltages caused by grounding faults of 6 kV underground cables were responsible for flashovers of bushing insulators [5]. Therefore, the coatings were applied on 110 kV and 6 kV porcelain insulators (about 130 pieces) in 1995. However, the cause for the very high over-voltages, that could reach a value of 5.0 p.u. was an operational error. The grounding resistor of the transformer neutral point was switched off. The over-voltages with a grounded neutral point are lower and can reach a value of 2.5 p.u. [5]. To avoid the flashovers on 6 kV bushing insulators, the neutral point should be grounded through resistor first. Additionally, the bushing insulators should be cleaned and eventually, covered with silicone coatings.

Surprisingly, all the 6 kV post insulators and even 110 kV insulators were covered with silicone coatings. Additionally, the application of silicone coatings was justified by the fact, that there was a very high pollution at the station. In a report, it was written that an unrealistic value of dust deposit density of 67 g/m^2·day was measured. In fact, the analysis of dust deposit density in the former and later years suggests that this parameter was 30 times smaller. Probably, the monthly dust deposit density was misleadingly taken as daily dust deposit density. The real value was in the range of 2 g/m^2·day. This is the medium pollution class but not very heavy.

III. 110 KV STATION OF A HEAT AND POWER PLANT

Three porcelain housings of 110 kV GXA106 metal oxide surge arresters installed at the block transformers were covered with silicone coatings (fig. 4).

Fig. 4. GXA106 surge arrester with hydrophobic coating

The pollution class "light" has been found at the 110 kV station since 1980 (fig. 5). There is no pollution flashover possible under these clean conditions. Author has measured the leakage currents on porcelain insulators LP 75/12 by means of special counters in 1985 and 1986. Under operating voltage of 63 kV, the currents on the long rod with 3-bridged sheds were greater than 10 mA but smaller than 35 mA. The currents on the long rod LP 75/12 covered with a silicone paste were greater than 5 mA and smaller than 10 mA (tab. 2).

The justification of silicone coating application under so light pollution could be theoretically, a danger of single dry band formation and partial discharge onset inside the surge arrester [6]. Author has measured the varistor temperature inside of the same surge arresters at Glogow test station throughout a few years. These measurements have shown that under light pollution, the occurrence probability of such phenomenon is very low. Therefore, the hydrophobic coatings on porcelain surge arresters are unnecessary.

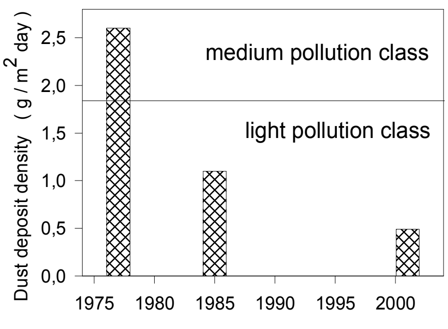

Fig. 5. The dust deposit density at 110 kV station between 1977 and 2002

TABLE II

The currents measured on the long rod insulators in 1985 and 1986

Insulator	Exceeded current levels (mA)			
	> 1	> 5	> 10	> 35
LP75/12 with 3 bridged sheds	yes	yes	yes	no
LP75/12 covered by a silicone paste	yes	yes	yes	no

IV. 110 KV STATION OF A COPPER MINE

The additionally mined table salt was stored on a pile about 200 m away from the 110 kV station. During windy weather, the salt dust from the pile, contaminated the insulators. Therefore, the discharges were observed under high humidity or drizzle conditions. To limit the discharges and to check the efficiency of silicone coatings, a few long rod insulators were covered in 1995. The leakage current measurements on porcelain post SWZP without coating were carried out two years later. Additionally, the surface conductivity was measured by means of a strip paper probe [7]. The current pulse integrator CPI-1 manufactured by TransiNor was adopted for current measurement. The trigger levels on four channels was set to 0.24; 0.5; 2; and 5 mA. The CPI-1 recorder integrates the current when its value overcomes the trigger level and calculates the maximum charge which was flowing during 0.5; 1; 2 and 3 hours. Figure 6 shows the most interesting records from December 1997.

Between 29.11.1997 and 01.12.1997 the current was higher than 2 mA and also higher than 5 mA. However, the charges of 0.01 As only were recorded in 2 mA and 5 mA channels. The channels with trigger levels of 0.24 and 0.5 mA recorded the charge of 1 As during a half hour (fig. 6). It means, that the current with the amplitude greater than 5 mA flowed for a very short time. Assuming the sinusoidal current shape and its amplitude of 5mA, the time of current occurence would be 2.9 seconds only.

The average value of surface conductivity measured on a few different porcelain insulators in October 1997 was in the range 2 – 5 µS. The maximum value on bushing insulator of 40 µS was found. However, this value was measured on a very small surface, the remaining insulator surface was clean (surface conductivity of 2 – 5 µS).

The measurements have proved the pollution class „light“ at the station . Therefore, the application of silicone coatings there is useless. Additionally the mining of table salt was stopped after the year 2000 and the danger of salt contamination dissappered.

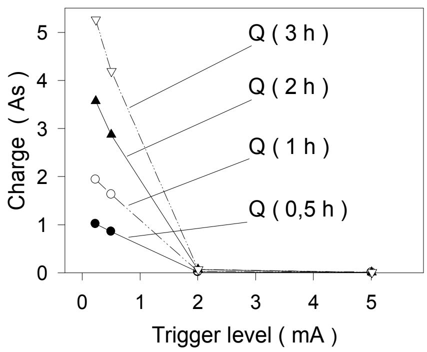

Fig. 6. The charges recorded on SWZP post insulator in December 1997

V. 400 KV STATION OF A POWER PLANT [8]

The 400 kV block lines TB 9 and TB 10 between the power plant and 400 kV station were built at the end of 1970s. The chains consisted of three porcelain long rods LG 75/24 sv and LG 85/24 sv were installed. The parallel lines were suspended over the steam boiler building (fig. 7) and close to a coal pile. The first pollution flashovers were noted in December 1997 on the line TB 9. The arc traces were found on the insulators and arcing horns on the pole built on the roof of the boiler building. The insulators on the poles close to the steam boiler were significantly polluted in spite of the fact that they were cleaned in the summer. A thick dust layer was found on the roof of the boiler building.

Fig. 7. 400 kV long rods over the roof of the steam boiler building

The dust got out from the boiler building through many orifices. Additionally, the air humidity over the boiler was increased by fog originated from cooling towers. During the windy weather, a lot of dust was raised and deposited on the insulators. To increase the electrical strength, over 600 insulators on both lines were covered by silicone coatings in 1998. The insulators were not cleaned any more and flashovers were not observed in the next few years. Perhaps the best solution was introduced very late. In the frame of cyclic repairs, the boiler building was renewed and sealed up. This way the contamination source was rejected and the problem was finally solved.

VI. EVALUATION OF SILICONE COATINGS APPLICATIONS

The examples of silicone coating applications show, that the coatings preserve hydrophobic properties over 10 years. However, this observation is limited mainly to light pollution class. The application of silicone coatings is not justified in two presented cases. The evaluation of pollution severity should be made carefully to avoid errors and not to apply coatings where they are useless. The emission of industrial contamination in Poland has been decreasing for a very long time, since 1985 [9]. The importance of these very significant changes has probably been not sufficiently known. The best example is the Glogow pollution test station. In the span of nearly 20 years, the pollution severity at this place changed from very heavy to light (fig. 2). After application of silicone coatings the pollution class decreased from medium to light. The decision about the application of silicone coatings should take into account the possible trends in the development of local contamination immission. The tab. 3 summarizes the above described examples.

TABLE III

Summary and evaluation of silicone coatings application

Location	Year	Voltage, number of insulators	Usefulness evaluation
Test station, Glogow copper smelting plant	1995	110 kV, 5 pieces.	Very good, only for research purposes
Smelting works	1995	110 kV, 130 pieces	bad
Heat and power plant	1996	110 kV, 3 surge arresters	bad
Copper mine	1996	110 kV, kilka sztuk	difficult to evaluate
Power plant	1998	400 kV, 600 pieces	good

ACKNOWLEDGMENT

Author thanks Mr. Ryszard Przybylowski, PSE Wschod and Dr. Henryk Belka, Wroclaw University of Technology for many important information.

REFERENCES

[1] IEEE standards 1523, Guide for the application, maintenaince and evaluation of room temperature vulcanizing (RTV) silicone rubber coatings for outdoor ceramic insulators, March 2003.

[2] D. Devendranath, K.A. Aravind, A. Ramulu, A.K. Tripathy, Accelerated aging test for RTV-coated insulators: analysis of electrical and material properties. IEE Proc. Gener. Transm. Distrib. Vol. 152, Sept. 2005, pp. 635-644.

[3] K.L. Chrzan, Pollution test station Glogow. Twenty years od research. Int. Symposium on HV Engineering. Delft 2001, paper abstract on page 202

[4] A. Tymań., J. Wańkowicz, K. Wieczorek, Własności hydrofobowych pokryć izolatorowych poddanych długotrwałej eksploatacji. Sympozjum Problemy Eksploatacji Układów Izolacyjnych Wysokiego Napięcia, Krynica 2005, s. 283-286

[5] H. Belka, Wroclaw University of Technology, private information

[6] K. Chrzan, W. Koehler, K. Feser, Behaviour of zinc oxide surge arresters under pollution. Int. Symposium on High Voltage Eng., New Orleans, 1989, paper No. 26.01

[7] K. Chrzan, M. Farzaneh, Probes for measurement of spot surface conductivity on polluted insulators. Int. Symposium on High Voltage Eng., Beijing 2005, paper D76

[8] Przybyłowski R., PSE Wschod, private information

[9] Chrzan K.L., Kałużny A., Subocz L., Banaszak S., Aktualny stan środowiska w Polsce w aspekcie narażenia i doboru izolacji napowietrznej. Sympozjum Inżynieria Wysokich napięć IW, Poznań-Będlewo 2004, s. 50-53

ADDRESS OF AUTHOR

Krystian Leonard Chrzan, Wroclaw University of Technology, Department of Electrical Engineering, Institute of Electrical Engineering Fundamentals, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland, krystian.chrzan@pwr.wroc.pl