BEHAVIOUR OF INSULATORS AND SURGE ARRESTERS AT GŁOGÓW POLLUTION TEST STATION

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ABSTRACT

The paper reports on the pollution performance of different insulators and surge arresters at Glogow test station from 1981 up to 2004. The environmental protection progress and technology modernization caused a significant decrease of dust and gas emission at a nearby copper smelting plant. As a result, the pollution severity of the area changed from pollution level IV (very heavy) in 1980s to pollution level I (light) after 2000. The flashover voltage was measured on porcelain post insulators under natural conditions in 1987 and, after insulator wetting with a water spray, in 2002-2004. The electrical strength of porcelain insulators was compared with insulators coated with a silicone rubber layer and with insulators coated by fluorourethane layer StaClean. The aging of insulator glazes and corrosion flanges are described. The external and internal charge records and temperature on metal oxide surge arresters with porcelain housing are also presented.

Keywords – pollution flashover, outdoor insulation, ESDD, DDD

INTRODUCTION

Severe contamination in the Legnica Cupper Region caused pollution flashovers on outdoor insulation in the winter 1978/1979. As a result, the pollution test station was built in 1981. The station is supplied through a 2 MVA power transformer manufactured by TUR Dresden which delivers any adjustable voltage from 0 to 200 kV. More technical details about the test station were given in a previous paper [1]. Similar stations were built in many countries, e.g. Dungeness (UK), Frieseninsel, Boxberg (Germany), Anneberg (Sweden), Martigues (France), Shiobara (Japan) and Koeberg (South Africa). The performance of insulators under natural conditions is normally studied at these special test stations. The artificial pollution test on HV insulators according to IEC standard 60507 (salt fog, solid layer method) or accelerated aging tests of polymer insulators as per IEC 601109 do not model all factors controlling insulator behaviour in the field.

POLLUTION CONDITIONS AT THE GLOGOW TEST STATION

The contamination severity at the Glogow station decreased significantly after 2000. The dust and sulphur dioxide emissions in the year 2000 were about 20 times smaller than the emissions in 1985. Therefore, the dust precipitation which in 1980 amounted to 9 g/m^2 per day decreased in 2003 to 0.4 g/m^2 per day (Fig.1). Note that according to Polish standard PN-E-06303 (June 1998), this area can be classified with the pollution level IV (very heavy) in 1980 and in the year 2003 – with pollution level I (light).

It was found that industrial dusts (including that from the copper smelting plant in Glogow) contain salts with limited solubility, e.g. $CaSO_4$. As a result, the relation between the surface conductivity and ESDD could be a non-linear function. This topic is very important for the evaluation of pollution severity [2,3]. The research carried out in 1985 has shown that in spite of very heavy SO_2 concentration, the gases are less important than the solid pollutants [4].

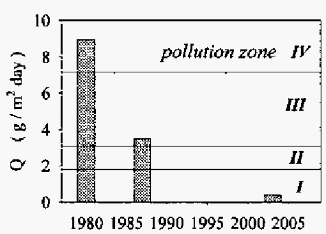


Fig. 1. The dust precipitation at the test station in 1980, 1987 and 2003

TESTS ON PORCELAIN INSULATORS

The current magnitude and flashover recordings became possible in 1986 after the fault localization on the string of cap and pin insulators LKZ 280/170. From 7 discs in the string, 5 discs were broken. Due to this damage, many flashovers on two sound LKZ 280/170 discs caused the switchgear operation. The voltage was switched-off many times.

The equivalent salt deposit density ESDD and dust deposit density DDD measurements have shown that these parameters strongly depend on the insulator profile, e.g. the DDD on the long rod VKL 75/14 was about 10 times smaller than DDD on the post SWZP4 [1]. Additionally, the bottom part of post insulators was more contaminated than the middle and upper part (Fig.2). In 2000, similar results were found on the column of three post insulators manufactured from polymer concrete. The stack was mounted 50 cm above the ground. The ESDD amounted to 9, 16, and 30 µg/cm on the upper, middle and bottom insulator respectively. The measurements on both post insulators have shown that the ESDD (collection of contaminants) depends more on the insulator height above ground than on the electrical stress. It should be noted that, for post insulators, the highest electrical stress is at the top and the lowest stress is at the bottom. This statement is supported by the ESDD and DDD measurements on the string of cap and pin insulators which was mounted 3 m above ground (Fig. 3). The ESDD and DDD weakly depend on the disc number. The surface conductivity on the upper part of the sheds measured by a local probe is shown in Fig. 4. The medium value was calculated from measurements carried out on the sheds in few places around the circumference.

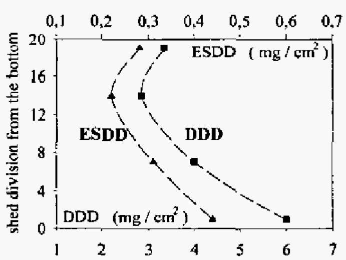


Fig. 2. ESDD and DDD on upper part of sheds. Post insulator SWZP4, results from 1987.

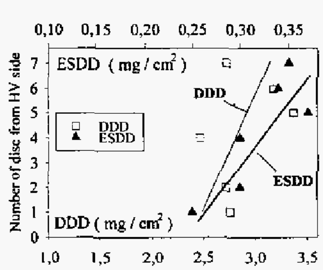


Fig. 3. ESDD and DDD under the disc insulators PS 16 B.

The flashovers were recorded by means of special fuses shown in Fig. 5. The withstand specific creepage distance of posts SWZP4 estimated in 1987 amounted 18 mm/kV (of phase to phase voltage). Due to cleaner environment in 2002, the flashover voltage increased and the withstand specific creepage distance decreased to 13 mm/kV [1].

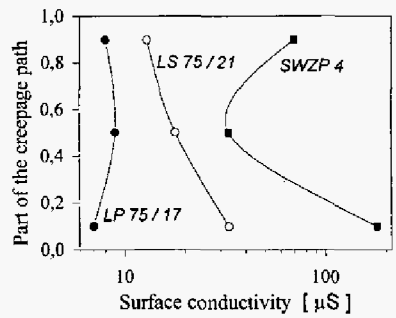


Fig. 4. Surface conductivity on three insulator types. Measurements on the upper part of sheds. 0.0 – lower flange, 1.0 - upper flange.

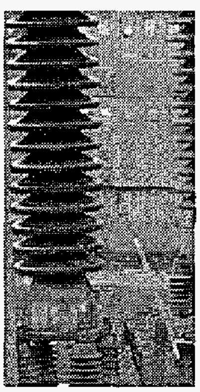


Fig. 5. The post insulator SWZP4 with a special fuse

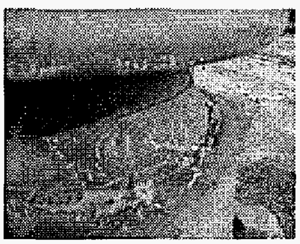


Fig. 6. The loss of binder and chemical changes at the bottom flange of post SWZP4

After 24 service years, the aging has changed on the insulator glazes and the rust on the flanges became visible (Fig. 6).

PERFORMANCE OF SILICONE COATINGS, FLUOROURETHANE COATINGS AND HYDROPHOBIC GLAZES

RTV silicone coating, Sylgard, was applied on post insulators SWZP4 and line insulators LP 75/27 by J. Wańkowicz in 1995 [5]. A. Tymań covered the same type of insulators by fluorourethane coatings StaClean in 1996 [6]. There are three modifications of post insulators SWZP4 at the test station since 1996: a) with original, old glaze surface, b) with silicone coatings and c) with fluorourethane coatings.

To compare the electrical strength of post insulators, a modified up-and-down method was applied. First, few sheds were bridged by a metal wire. Then, the insulator was sprayed by water having a conductivity of 100 µS/cm and a voltage of 100 kV was applied. Next, the test was conducted at the same voltage of 100 kV but with shorter or longer insulator. The specific leakage distances for three post types measured in 2001-2003 are shown in Fig. 7. The specific leakage distance is given in cm divided by kV of phase to phase voltage (the probe voltage of 100 kV was multiplied by $\sqrt{3}$).

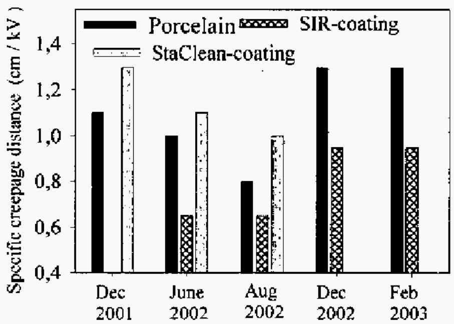


Fig. 7. The specific leakage distance of post SWZP4 with bare glazes (porcelain), with silicone coating (SIR coating) and with fluorourethane coating (StaClean coating)

The specific distance was determined as 13 mm/kV for insulators with bare glazes. This parameter was about 30% lower for insulators with silicone coatings. This difference was attributed to hydrophobic properties of silicone surface. It is worth to emphasize that the flashover voltage of silicone surface depends on the experimental procedure. The hydrophobicity decreases with the number of spraying events (wetting time) and on the wetting intensity. It was observed that the critical weather conditions for silicone surfaces are the long drizzles. The silicone surface can lose its hydrophobic properties after a long wetting time.

The specific leakage distance of insulators with fluorourethane coating was about 10% longer than the specific leakage distance of insulators with bare glazes. The fluorourethane surface, even when clean, is very hydrophilic. The hydrophobic properties were lost after 7 years of service. Additionally, the heavy surface-degradation occurred on the core. These changes were probably caused by electrical discharges.

Prototype insulators with special hydrophobic glazes have been tested at the station for two years. The glazes were modified by chemical treatments or by electrical discharges. The technology of third glazes type is unknown [7].

PERFORMANCE OF POLYMERIC INSULATORS

Prototype Polish composite insulators have been tested since 1981 [8]. Most insulators were made from silicone rubber; the original construction from EPDM designed by Cyraniak has been tested since 1984. 20 kV epoxy insulators with thick silicone coatings Polastosil MV were tested from 1986 to 1990. A column consisting of 3 post insulators having the leakage distance of 3 × 60 cm, were tested successfully under a voltage of 70 kV (specific distance 15 mm/kV). Using the same set up, a column of 3 post insulators manufactured from a polymer material with a leakage distance of 3 × 43 cm was tested under 77 kV in 2000 and 2001. After 2 years, the bottom insulator was damaged. Its bottom shed was broken and additional severe erosion was observed on the surface due to arcing. The specific leakage distance was found to be 10 mm/kV.

There were also tests of fiber glass rods with silicone coating. The rods have no sheds. The experiments started by Z. Pohl showed that a vertical rod having a length of 100 cm and a diameter of 2.5 cm was destroyed after few months. In contrast, the same horizontal rod has been working under a voltage of 77 kV for 10 years.

The surface of the traction string composite insulator LTKC-25 manufactured by the Electrotechnical Institute, Division III in Międzylesie was degraded by tracking just 30 days after the insulator was put into service (Fig. 8). The insulation length is 77 cm which gives the specific leakage distance of 6 mm/kV. In spite of this very short leakage distance, and the visible tracking in the vicinity of both flanges, the insulator was not damaged and the tracking was not extended for next 8 months.

Fig. 8. The erosion on the traction string composite insulator LTKC-25

The column of 4 post insulators manufactured by Vantico from a hydrophobic epoxy has been tested since April 2003 (Fig. 11). The leakage distance is 4 × 60 cm. During the first year of operation, no surface erosion has been found.

SURGE ARRESTERS

The gapped surge arresters GZSb-96 and GZSMW-96 were tested by J. Lisiecki and E. Sojda in 1980s. The prototype gapped arrester GZSbk-96/2 with silicone housing with a height of 2.2 m was a very interesting solution at that time (Fig. 10). The metal oxide arresters GXA 96 and GXAS 96 in a porcelain housing have been tested since 1996. The external and internal electrical charges were measured by current pulse integrator CPI-1 manufactured by TransiNor As. The results were reported in [9]. The varistor temperature was measured by means of digital loggers TINYTALK

[10]. Owing to a mistake, a very high voltage was applied to the test yard. That voltage was much higher than the maximum operating voltage of 77 kV. The temperature inside two arrester units 2 GXA 48 exceeded 160 °C. Both temperature loggers were destroyed and few varistor discs broke up into two or three fragments (Fig. 11). The channel of the temperature breakdown has a white colour (Fig. 11.b). This type of varistor damage is significantly different from a damage caused by current surges [11].

Fig. 9. Hydrophobic epoxy insulators

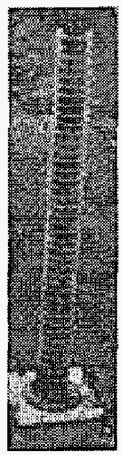
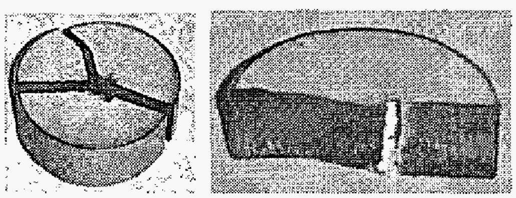


Fig. 10. Gapped surge arrester with a polymer housing



a) b)

Fig. 11. Damaged varistor
a) complete damaged block
b) breakdown channel

CONCLUSIONS

The dust precipitation at the test station decreased systematically and is 0.4 g/m^2 per day today. As a result, the area which had a pollution level IV (very heavy) 20 years ago has now a pollution level I (light). Therefore, the insulators selected for heavy pollution can be replaced by insulators with a shorter leakage distance.

Silicone coatings were not degraded and still have their hydrophobic properties after 9 years of service. The flashover voltage of silicone coating is about 30% higher than that of bare glazes.

The fluorourethane coating lost its hydrophobicity and was partly degraded after 8 years of energisation. Its flashover voltage is about 10% lower than the flashover voltage of bare glazes.

The traction silicone insulator without sheds having a very short specific leakage distance of 6 mm/kV worked successfully for 8 months in the horizontal position in spite of tracking at both flanges.

The charge and temperature measurements on porcelain metal oxide surge arresters confirm their excellent behaviour during the 8 years of operation

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