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Pollution test station Glogow, twenty years of research

Krystian Leonard Chrzan
Wroclaw University of Technology, Poland

Abstract: The evaluation of electrical stress of polluted outdoor insulators was carried out at the field test station located at a copper smelting plant Głogów in 1987 and 2002. Leakage current and flashover voltages were recorded on porcelain long rods of different types. A simple impulse counters having three different trigger levels were used for current measurements. The special fuses with an explosion mixture were applied for detection of flashovers. Additionally, the measurements of ESDD on insulator surface or dust deposition density were carried out.

During last ten years the industry dust emission in Middle Europe decreased considerably due to progress in environmental protection. Therefore the similar measurements were repeated with the aim to asses the current state of electrical stress of outdoor insulators.

1. Introduction

The pollution flashover voltage of insulators is usually measured under laboratory conditions according to IEC 507 standard (salt fog or solid layer tests). These tests are performed on heavily contaminated and intensively wetted insulators, therefore, many flashovers are recorded.

However, under natural conditions the insulators often are less contaminated and wetted, so the only small surface discharges appear. The continuous operating voltage have to be much less than the pollution flashover voltage because flashovers are not allowed in the power system. The evaluation of insulator pollution performance in the field is based often on measurement of leakage currents on whole or shortened insulators. These experiments can be made on selected line insulators or station insulators. The measurements of electrical strength is more complicated and is only possible on special pollution test stations equipped in the flashover registration system and power transformer.

2. Test station

The station at copper melting plant Glogow was equipped with the transformer manufactured by TUR Dresden and put in operation in 1980. The main source parameters are as follows: nominal current 10 A, voltage 6/200 kV, power 2 MVA, short circuit voltage 8.5%, short current 150 A. The power is delivered through three transformers: the symmetry transformer ESDOM 6/1 kV (supplied by three 6 kV phases) regulation transformer FT/D/EO 1000/10 AL and high voltage transformer 6/200 kV. The voltage can be fluently adjusted by core rotation of the regulation transformer. During the test carried out in 1987 the voltage amounted 70 kV, 11% higher than nominal phase to earth voltage of 110 kV system. The plan of the test station is shown on the fig. 1.

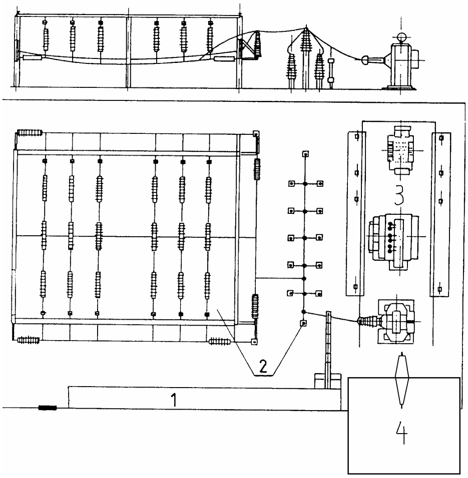

Fig. 1: Plan of pollution test station in copper plant Głogów: 1 – command room, 2 – field of post and suspension insulators, 3 – transformers, 4 – fog chamber

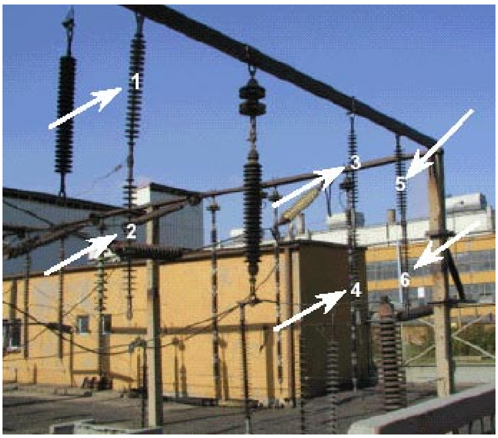

Fig. 2. Fragment of test station in copper smelting works Glogow. 1 – 6 : new silicon rubber insulators

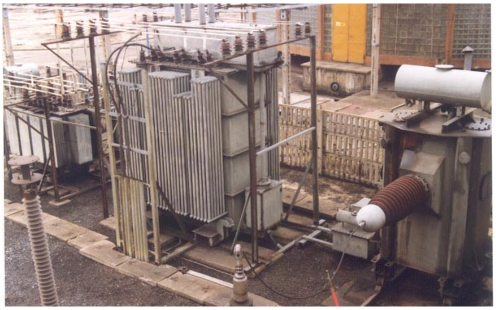

Fig. 3. Supply transformers. From left to right: the symmetry transformer (supplied by three 6 kV phases), regulation transformer and high voltage transformer 6/200 kV

The research on the test station can be divided on 4 subjects. First the physical and chemical properties of pollutans were studied. It was found that pollutans contain salts with limited solubility [1] and with different hygroscopic properties [2]. The special field measurements enabled also to evaluate the role of gases, especially SO_2 in the pollution problem of outdoor insulators [3].

The prototype composite insulators which were manufactured in Poland in 1970s are tested since 1980 [4]. It was found that pollutans absorbs significantly solar UV radiation [5]. The performance of gapped surge arresters under natural pollution was checked in 1980s. Similar test was repeated for metal oxide arresters [6]. The method for resistive current measurement was modified [7].

The insulator performance under natural pollution conditions was studied for different insulator types. Semi-conducting glaze cap and pin insulators and silicon rubber insulators from abroad are tested. Special care was taken for washing up effect of insulators. The most accurate study was carried out on post insulators SWZP4 in 1987 and in 2002. The paper shows the measurement results of these experiments.

3. Research objects and experimental procedure

The currents on 5 support insulators SWZP4 with 20 sheds were measured on test station. The leakage path was shortened from zero to 8 sheds. The supports were connected with special explosion fuses to enable the flashover registrations. The currents were also measured on insulator VKL 75/14, LPZ 75/27 with alternating sheds and bridged 3 shed divisions and on the glass cap and pin insulators PS 16B. The insulator data are given in the table 1.

The contamination parameter of atmosphere were measured: the dust precipitation Q (non-soluble and soluble part) and the indicator of water conductivity increase $\Delta\gamma_i$ according to the polish standard PN-E-06303/1998 [8]. Additionally the equivalent salt deposit density ESDD and dust deposit density DDD on insulator surface were calculated. The current was recorded using three simple electromechanical counters for three current level. When current amplitude exceeded the trigger level of 20, 50 or 140 mA_{peak} the impulse number on the display of the counter was increased.

Table 1: Insulator data

Insulator type	Length of insulation part [mm]	Shed diameter [mm]	Creepage distance [mm]	Form factor
LP 75/12	1020	150	1720	5,9
LP 75/14	1070	150	1860	6,45
LPZ 75/27	1060	175/150	3000	9,1
SWZ P4	1020	220	2760	5,8
PS 16 B		280	7 × 390	

The measurement of withstand voltage, dust precipitation Q and indicator of water conductivity increase $\Delta\gamma_i$ were repeated in 2002. The withstand voltage of naturally contaminated insulators SWZP4 were measured this time according to a changed procedure. First, few sheds were bridged by a metal wire. Then the insulator was sprayed by water having the conductivity of 100 μS/cm and the voltage of 100 kV was switched on. Next test was conducted at the same voltage of 100 kV but with shorter or longer insulator.

4. Results

Tab. 2 shows the readings of impulse counters at the station Glogow. The count number is not of great importance therefore in the table the exceed of trigering level was signed as “1” and as “0” the opposite situation. In the year 1987 three flashover were noted marked as the vertical arrows. The withstand specific creepage distance was estimated as 3,2 cm/kV phase to earth voltage (1,8 cm/kV phase to phase voltage). Taking into account the 30% security margin and the factor 1,12 = 123/110 kV for the highest voltage of the system, the estimated minimum specific creepage distance amounts 2,62 cm/kV phase to phase voltage. According to the IEC Publication 815 [10] 2.5 < 2,62 < 3,1 cm/kV therefore, the area of the station shall be considered as pollution level III “heavy”.

The maximum dust precipitation Q amounted 4,1 [g /m^2·day] and according to the polish standard PN-E-06303: 1998 [8] the area represents also pollution level III “heavy”. The indicator of water conductivity increase $\Delta\gamma_i$ according to the polish standard PN-E-06303/1998 was estimated as 10,3 μS/cm · day and the area is classified again to the III pollution level. It can be concluded that the three classification methods (minimum creepage distance, Q and $\Delta\gamma_i$) give the same result.

Table 2: The current and flashover records at the station Glogow in 1987 on post insulators SWZP4. Test voltage 70 kV. The number "1" means that the current exceeded the trigering 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
11.02.1987	1 1 0	1 1 0	1 0 0	1 0 0	1 0 0
24.03.1987	1 0 0	1 0 0	1 0 0	0 0 0	0 0 0
15.04.1987	**1** ↓ **1** **1**	0 0 0	0 0 0	1 0 0	0 0 0
5.06.1987	1 1 1	1 1 1	1 1 0	1 0 0	1 1 0
25.07.1987	1 1 0	1 1 1	1 1 0	1 0 0	1 0 0
15.10.1987	1 1 0	1 1 0	1 0 0	1 0 0	1 0 0
23.12.1987	1 1 0	**1** ↓ **1** **1**	1 1 0	1 0 0	1 0 0

Table 3: Maximum and minimum value of ESDD or DDD in mg/cm^2 measured on insulators at pollution station Glogow in 1987

Pollution severity	Insulator type			
	LP75/14	LPZ75/27	PS16B	SWZP4
ESDDmax	0,08	0,14	0,37	0,45
DDDmax	0,64	1,4	3,37	6,0
ESDDmin	0,02	0,025	-	0,16
ESDDmin	0,11	0,14	-	2,3

The maximum and minimum value of equivalent salt deposit density ESDD or dust deposit density DDD measured on insulators in 1987 are given in table 3. There is a big dependence of pollutans accumulation on insulator geometry. The maximum DDD on post insulator SWZP4 (with 20 sheds) is nearly 10 times greater than maximum DDD on insulator LP75/14 with 14 sheds.

ESDD value on post insulators SWZP4 amounted from 0,16 to 0,45 mg/cm^2, the withstand specific creepage distance was evaluated as 1,8 cm/kV. These results can be compared to value measured in the laboratory during the test according to solid layer method on similar long rod with 22 sheds, 296 cm overal creepage distance. For specific creepage distance 2,0 cm/kV the maximum withstand salt deposit density of 0,08 was found [9]. This ESDD value is two times smaller than the minimum ESDD measured in the field.

The main reason for this discrepancy is probably the amount of weak soluble salts in natural pollutans. Under critical wetting in the field only a part of salt could be diluted. On the contrary, during test in the laboratory the whole amount of NaCl on insulator surface salt will easy be disolved [1].

The table 4 shows withstand specific creepage distances in the year 2001 and 2002 on post SWZP4. The maximum value of 1,3 cm/kV measured in December 2002 is lower than the maximum 1,8 cm/kV measured in 1987. The big increase of electrical strength of about 40% is caused by huge environmental improvement. Dust precipitation Q in year 2002 decreased nearly 10 times and parameter $\Delta\gamma_i$ decresed about 3 times compared to 1987 (tab 5). The very low flashover voltages were noticed in winter (see table 2 and table 4). Note that the highest electrical strenght in March 2002 is two time greater than the lowest one in December 2002.

Table 4: Withstand specific creepage distance L_W (phase to phase voltage) measured in 2001 and 2002.

Month, year	L_W cm/kV	Ambient temperature °C
Oct 2001	0,9	+ 5
Dec 2001	1,1	- 4
Feb 2002	1,0	+ 2
March 2002	0,6	+ 4
Jun 2002	1,0	+ 28
Aug 2002	0,8	+ 20
Dec 2002	1,3	- 5

Table 5: Dust precipitation Q and the indicator of water conductivity increase $\Delta\gamma_i$ in 2001 and 2002

Measurement period	Q g/m^2 day	$\Delta\gamma_i$ µS/cm	Pollution zone
Sept - Oct 2001	0,35	3,5	I
Nov - Dec 2001		3,2	I
Dec 2001- - Jan 2002	0,61	4,75	I
Feb - May 2002	0,45	2,8	I
Jun – July 2002	0,30	3,3	I
Aug – Oct 2002	0,36	4,0	I

Conclusions

1. The withstand creepage distance of insulators SWZP4 amounted 2,6 cm/kV phase to phase in the year 1987. The maximum dust precipitation Q amounted 4,1 [g /m^2·day], the indicator of water conductivity increase Δγ was estimated as 10,3 [μS/cm · day].
2. The above three methods classified in compliance the station Glogow as pollution level III "heavy".
3. The withstand creepage distance of insulators SWZP4 amounted 1,3 cm/kV phase to phase in 2002 as a result of environmental improvement.
4. The ESDD and DDD values depends strongly on the insulator shape. The contamination density on insulator LP 75/14 was nearly 10 times lower than on insulator SWZP4.
5. The impulse counters can be used as a cheep tool for evaluation of pollution severity. The current amplitude on insulator SWZP4 shortened by 4 sheds (withstand level) did nod exceed 50 mA. The current amplitude on insulator SWZP4 shortened by 2 sheds did nod exceed 20 mA. Therefore the value 50 mA can be recognised as a warning level. When the current exceeds this value the countermeasures should be undertaken e.g. washing up of insulators.

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Author address: Krystian L. Chrzan
Wroclaw University of Technology
Institute I – 7
50 – 370 Wroclaw, Poland
Email: chrzan@elektryk.ie.pwr.wroc.pl