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Analysis Performance of Flashover Voltage for a Cap-pin type Insulators under Different Operating Conditions

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***Abstract* – Through this paperwork, the effect of different operating conditions on insulators analyze to achieve flashover voltage by creating different operating conditions and environment, taking into account the natural state. There various environmental conditions for testing such as, dry, wet and salt wet by immersion all insulators (one, two and three sheds) in salty water (NaCl) as the different concentration. In result test, flashover voltage was recalculated ten times to check credibility the average values calculated. If can be attributed to that by increasing the value of conductivity from 15 % to 35 % the flashover voltage decreased due to the percentage of salt concentration.**

***Keywords* – Porcelain Insulator, Flashover Voltage, Conductivity, Salinity, NaCl.**

I. INTRODUCTION

High voltage insulator plays an important role in an electrical power system including generation, transmission, and distribution of electricity. In addition to the mechanical support of the conductor their electrical role is to isolate the metal structure of the tower from the conductor which carries the power to be transmitted and distributed. As a result, many pollutants from different sources such as dust from industrial factories, saline from the sea and sand storms, may be deposited on the surface of the insulator. Contaminated high voltage insulator in presence of humidity due to fog and rain leads to leakage current, dry band arcing, and ultimately may cause full flashover, which result in power outage and associated cost. Inorganic materials such as porcelain have been used in outdoor insulator for a long time. Porcelain is still the most widely used outdoor insulating material for high voltages [1-5]. Porcelain is an inert and stable material that can take substantial amount of arcing without serious surface degradation, because of their capacity to withstand the heat of dry band arcing. However, these materials are highly wet table when exposed to wet conditions. Overhead line insulators can be damaged for various reasons during their service life. Porcelain or glass insulators once damaged can affect the reliability of power system networks. This paper presents the study of voltage and electric characteristics along the surface of a broken porcelain insulator. Porcelain insulators were being proposed and the analysis results on voltage and electric characteristics were individually collected [6-10].

In HV string insulator, the potential distribution experienced the most diminutive value when the broken porcelain insulator was located in the string near the ground. In addition, the potential distribution average was the least when the broken and perfect insulators were arranged alternately in the string [11].

In Egypt, the insulators of overhead transmission lines and substations are often subjected to the deposition of contamination substances from the desert. This can lead to serious reduction in insulator effectiveness, resulting in flashovers and outages of electricity supply. It is important to mention that a remarkably high rate of interruption of 500 and 220 kV transmission lines, in Egypt, are recorded during spring seasons in desert areas where occasional sandstorms occur (Khamassine) [12-14]. This interruption in the power system will lead to the delay of the development of the community. The flashover voltage characteristics are thoroughly investigated for porcelain insulators exposed to natural sandstorms, as well as to simulated sandstorms with and without charged grids.

To a large extent, insulators show a significant change in electrical performance when exposed to desert environmental conditions. Either natural or artificial sandstorms affect fast flashover voltage. Charged sand particles reduce the flashover voltage of insulators to a higher extent porcelain insulator flashover voltage by adding a metal ring on the insulator cap [15], which can not only effectively reduce the field strength of the steel cap, but also reduce the tangential field intensity of the umbrella group and inhibit the development of the discharge process, thus the flashover voltage can be increased. The surface strength calculation model of 110kV porcelain insulator is established by the finite element method (FEM) [16], and the parameters of the metal ring are designed by neural network genetic algorithm (BP-GA).

A new method to improve the flashover voltage has been proved by adding a metal ring at the porcelain insulator steel cap. The distribution of the electric field along the insulator with and without metal ring has been calculated by the finite element method. Over voltages due to switching or lightning may cause damage for the transmission line insulators, transformers and switchgear. The flow of overvoltage to earth through transmission system towers causes an increase in the potential of metal structure and the earth potential and may create back [17]. Flashover voltage causing failure to transmission system insulators in which transmission line outages occur. The effect of tower grounding surge impedance on the back [18]. The effect of different operating conditions on insulators cap-pin at flashover voltage. The tests for one shed insulator cap- pin type at dry condition, wet condition and salt wet condition and also for two sheds and three sheds and same different test to observe the effect of this condition of flashover voltage.

II. Simulations and Results

A. *Dry Condition Test*

Testing values of flashover voltage by using one, two and three sheds of porcelain insulators with ten tests different at dry condition illustrates in Table 1.

Table 1. Flashover voltage (kV) for (one, two and three) sheds.

	No of shed		
	One	**Two**	**Three**
FOV (kV)	64.11	115.21	171.39
	64.02	113.91	180.1
	65.27	117.64	175.42
	63.81	118.28	176.29
	66.7	114.37	173
	84.21	114.91	177.23
	67.07	119.03	176.98

	No of shed		
	One	Two	Three
	68.23	120	74.11
	63.13	113.96	176.5
	72.4	118.3	178.17

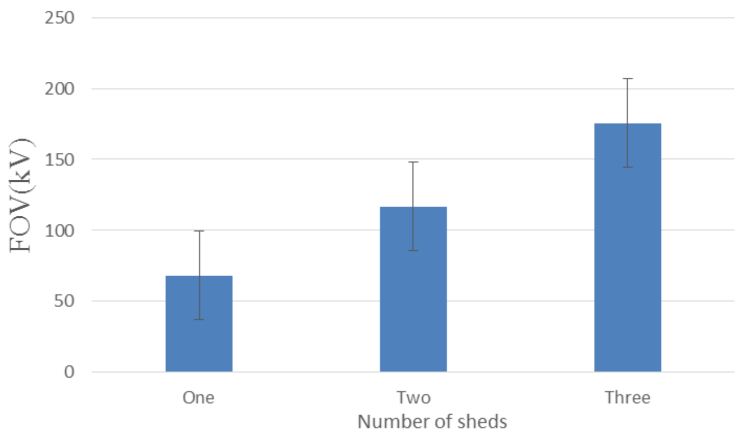

Fig. 1. Average of flashover voltage (kV) against the number of sheds (one, two and three) sheds at dry condition test.

Test two at dry condition, the value of flashover voltage at one shed is 66.7kV. This value increases at two sheds to 114.37kv and at three sheds this value increases to 173kV.

The average value of flash over voltage for one shed at dry condition test is 67.89 kV, the average value of flash over voltage for two sheds at dry condition test is 116.56 kV and the average value of flash over voltage for three sheds at dry condition test is 175.66 kV. The average value of flash over voltage at two sheds is greater than average value of flash over voltage for one shed this increased for value is not double. The average value of flash over voltage at three sheds is greater than average value of flash over voltage for one shed this increased for value is not triple.

B. *Wet Condition Test*

Wet condition test with conductivity of 15 %, 25 % and 35 % ms/cm. The testing value of flashover voltage by using one, two and three sheds of porcelain insulator with different test under wet test condition illustrates in Table 2.

Table 2. Flashover voltage values (kV) in wet condition test at different Conductivity.

Conductivity (ms/cm)	FOV (kV)		
	One	Two	Three
15%	62.322	102.555	149.531
25%	56.432	93.794	131.615
35%	49.584	83.936	120.758

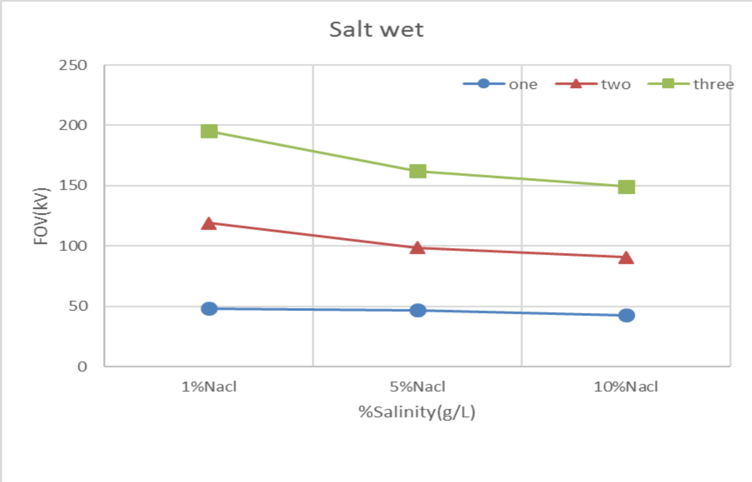

Fig. 2. Flashover voltage (kV) against the number of sheds (one, two and three) sheds at wet condition with different value of conductivity (15 %, 25 % and 35 %) ms/cm.

The average value of flashover voltage for one shed at wet condition test with conductivity 15% ms/cm is 62.322 kV, at conductivity 25 % ms/cm is 56.432 kV and at conductivity 35% ms/cm is 49.584 kV. from this result, the average value of flashover voltage at one shed is increased when decrease the value of conductivity for example the average value of flashover voltage at conductivity 15 % ms/cm is greater than conductivity 25 % ms/cm by 10.43 %, and the average value of flashover voltage at conductivity 35%ms/cm less than conductivity 25% ms/cm by 13.8 %.

The average value of flash over voltage for two sheds at wet condition test with conductivity 15% ms/cm is 102.55 kV, at conductivity 25% ms/cm is 93.97 kV and at conductivity 35% ms/cm is 83.93 kV. From this result, the average value of flashover voltage at two sheds is increased when the value of conductivity decrease for example the average value of flashover voltage at conductivity 15% ms/cm greater than conductivity 25% ms/cm by 9.34%, and the average value of flashover voltage at conductivity 35% ms/cm less than conductivity 25% ms/cm by 11.45%.

The average value of flashover voltage for three sheds at wet condition test with conductivity 15 % ms/cm is 149.55 kV, at conductivity 25 % ms/cm is 131.61 kV and at conductivity 35% ms/cm is 120.75kV from this result the average value of flashover voltage at three sheds is increased when the value of conductivity is decreased as the average value of flashover voltage at conductivity 15% ms/cm is greater than conductivity 25% ms/cm by 13.62 %, and the conductivity 25% ms/cm by 8.99%.

Average value of flash over voltage at conductivity 35% ms/cm less than.

At conductivity 25% ms/cm the value of flashover voltage at one sheds is 56.43 2 kV and this value Interleafed to 93.75 kV at two sheds this value is not double of the flash over voltage at one sheds and at three sheds increased to 131.6 is this value is not triple of the flashover voltage at one shed.

C. *Salt Wet Condition Test*

Salt wet condition test with salinity 1%, 5% and 10% of NaCl (*g/l*).

Table 3 below represents the testing value of the flashover voltage by using one, two and three sheds of porcelain insulators at salt wet conditions with 10 % salinity of NaCl at different tests values of flashover volta-

-ge at salt wet condition with salinity 1 %, 5 % and 10 % of NaC are shown in Table 3.

Table 3. Flashover voltage values (kV) in salt wet conditions test with salinity (1 %, 5 % and 10 % *g/l* of NaCl) for one, two, and three sheds.

Salinity of NaCl (*g/l*)	**FOV (kV)**		
	One	**Two**	**Three**
1%NaCl	48.26	70.86778	76.284
5%NaCl	46.91778	51.889	63.518
10%NaCl	42.93222	47.88	58.49778

The average value of flashover voltage for one shed at salt wet condition with salinity 1% NaCl (*g/l*) is 48.26 kV, at salinity 5 % NaCl (*g/l*) is 46 kV and salinity 10 % NaCl (*g/l*) is 42.93 kV. from this result the average value of flashover voltage at one shed is increased when decrease the value of salinity decrees for example the of salinity a average value of flashover voltage at salinity 1% NaCl (*g/l*) greater than salinity 5% NaCl (*g/l*) by 2.86 %, and the average value of flashover voltage at salinity 10% NaCl (*g/l*) less than salinity 5% NaCl (*g/l*) by 9.28%.

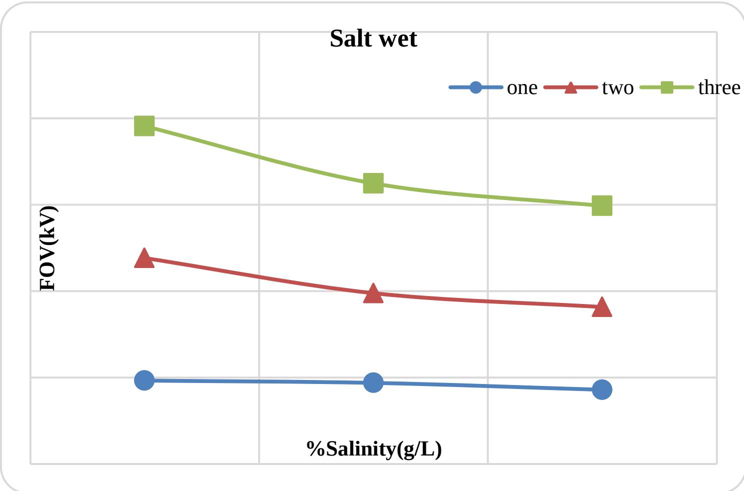

Fig. 3. Flashover voltage (kV) against the number of sheds (one, two and three) sheds at salt wet condition test with different value of salinity (1 %, 5 % and 10 %) ms/cm.

The average value of flashover voltage for two sheds at salt wet condition test with salinity 1% NaCl (*g/l*) is 70.86 kV, at salinity 5 % NaCl (*g/l*) is 51.88 kV , and at salinity 10% NaCl (*g/l*) is 47.88 kV from this result the average value of flashover voltage at two sheds is increased when the value of salinity decreased for example the average value of flashover voltage at salinity 1% NaCl (*g/l*) greater than 5% NaCl (*g/l*) by (36.57%) and the average value of flashover voltage at salinity 10% NaCl (*g/l*) less than salinity 5% NaCl (*g/l*) by 8.37%

The average value of flash over voltage for three sheds at salt wet condition test with salinity 1 % NaCl (*g/l*) is 76.28 kV, at salinity 5% NaCl (*g/l*) is 63.51 kV, and salinity 10% NaCl (*g/l*) is 58kV. From these results the average value of flashover voltage at three sheds is increased when the value of salinity is decreased as the average value of flashover voltage at 1% NaCl greater than salinity 5% NaCl (*g/l*) by (20.8 %) and the average value of flashover voltage at salinity 10% NaCl (*g/l*) less than salinity 5% NaCl (*g/l*) is 8.58%1 kV, at salinity 5% NaCl (*g/l*) the value of flashover voltage at one shed is 46.91 kV and this value increased to 51.88 kV at two sheds this value is not double of flashover voltage at one shed and at three sheds increased to 63.51 kV this value is not triple of flashover voltage at one shed.

III. Conclusion

Through this paper work, the performance of flashover voltage (kV) for cap-pin type insulators has been calculated and varied according to:

1. Number of sheds and pollutant conditions.
2. String of cap-pin type porcelain insulators has decreased as a result of increase the wet conductivity from 10 % to 35 %.
3. Salinity of NaCl (*g/l*) decreased flashover voltage of cap-pin type insulators up to 10 % due to the surface.

References

[1] Haddad and Harid, “The performance of Nano Coating for High Voltage Insulators”, UPE 2011.46th international universities power Engineering Conference, 5-8th September 2011.soest. Germany.
[2] S. Kim, E. A. Cherney, and R. Hackam, “Effects of filler level in RTV silicone rubber coatings used in HV insulators", IEEE. Transactions on Electrical Insulation Vol. 27 No. 6, December 1982.
[3] S. Kato, Hideyo Asaob Takuma Jkeda Masato Oki, Masaaki Sakaguchi and Ryosuke Matsuoka, "Wetting characteristics of various kinds of insulators” Proceedings of the 6th International conference on properties and applications of dielectric materials June 21-26, 2000, Xi’an Jiaotong University, China.
[4] S. pakpahan and suwarno, “Improving outdoor insulator performances installed at coastal area using silicone rubber coating”, 2012 IEEE International Conference on Condition Monitoring and Diagnosis 23-27 Bali, Indonesia September 2012,
[5] Suwarno and J. Parhusip, "Effects of humidity and fog conductivity on the leakage current waveforms of ceramics for outdoor insulators'”, 2010WSEAS Transactions on Systems, Vol. 9. No. 4, 2010, pp. 442-452.
[6] Besztercey G, Karger J, Szaplonczay P, Kimata R., “Erosive wear of electrically insulating rubber compounds by solid particles,” *Eleventh International Symposium on High Voltage Engineering,* London, UK, 27-23 August 1999.
[7] Topalis, F.V., I.F. Gonos, and I.A. Stathopulos. *IEE Proceedings-Generation, Transmission and Distribution* 4, 2001, pp. 269-274.
[8] P. Yadee and S. Premrudeepreechacharn, “Analysis of tower footing resistance effected back flashover across insulator in a transmission system,” *International Conference on Power Systems Transients* (IPST’07), Lyon, France, June 4-7, 2007.
[9] P. Chowdhuri, “Parameters of lightning strokes and their effects on power systems,” *IEEE/PES Transmission and Distribution Conference and Exposition*, Atlanta, GA, USA, 02-02 Nov. 2001, pp. 1047-1051.
[10] Thottappillil R., “Electromagnetic pulse environment of cloud-to ground lightning for EMC studies”, *IEEE Transactions on Electromagnetic Compatibility*, Vol. 44, No. 1, Feb. 2002, p. 203-213.
[11] Munz D and Fett T, “Ceramics: mechanical properties, failure behaviour, materials selection,” Springer Science & Business Media, vol. 36, 2013.
[12] Mathis H. A, “Technical Article,” Shock Vib. Dig., vol. 25, no. 6, pp. 10–14, 1993.
[13] “Catalog No. 8255, Suspension Insulators Ball and socket type” Gamma Insulators Corp., United States.
[14] “Disc insulator-QuickField FEA Software,” [Online]. Available: http://www.quickfield.com/advanced/insulator.htm. [Accessed: October, 2016].
[15] Rahimnejad A, Asadpoor M.B, Akbari E, and Mirzaie M, “Finite element analysis of disc insulator type and corona ring effect on electric field distribution over 230-kV Insulator Strings,” Iranian Journal of Electrical & Electronic Engineering, vol. 9, no. 1, March 2013.
[16] Anjum S, “A Study of the detection of defects in ceramic insulators based on radio frequency signatures,” UWSpace, 2014.
[17] Shinohara A.H, et al, “Defects detection in electrical insulators and breaker for high voltage by low cost computed radiography systems,” International Symposium on Digital industrial Radiology and Computed Tomography. Lyon, France. 2007.
[18] R. Krishnan, S. Samanta, R. Sudha, and K. Govardhan, “Electric field analysis of high voltage insulators,” pp. 31–35, 2012.

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