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Performance Of EPDM Cable Terminations Under Various Polluted Conditions

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Abstract: Ethylene-Propylene-Diene Monomer (EPDM) insulators are used as indoor and outdoor insulators for high and medium voltage applications. This paper presents detailed investigations of the electrical properties of EPDM cable terminations. The effects of different environmental conditions (Dry and Wet at different salinities) under the effects of various levels of the ultraviolet (UV) radiation on EPDM cable termination have been studied through this work. The effect of Silicon grease coating on the EPDM insulators is also studied at different environmental conditions in order to improve their performance.

Keywords: Flashover voltage – Cable terminations – Ultraviolet – EPDM – Electrical characteristics

I. INTRODUCTION

Outdoor insulators have been made from porcelain or glass for several decades because of their superior electrical, mechanical and their withstand to various weather conditions. Porcelain and glass were preferred materials for housing of insulators, bushings, terminations, surge arrestors, etc. for many decades. Since 1960, other polymeric insulators have been investigated to replace porcelain due to their ease of production and lighter weight in addition to their resistance to vandalism and reduced maintenance [1-3].

Recently, Silicone rubber (SiR) and ethylene-propylene-diene monomer (EPDM) became main high voltage insulating materials. They are especially used as weather sheds and stress reliefs which are intended to use in power cable terminations.

The problems of contamination on electrical insulators take place when the environment that surrounding them contains diverse substances, especially saline and industrial ones, which are deposited on insulator surfaces, forming polluted layers on their surfaces. In dry conditions, these layers do not cause great problems, but under the presence of light rain, humidity, dew or fog, the dielectric characteristics of the insulator surfaces are decreased, allowing leakage currents to flow between the insulators electrodes. The leakage current can increase itself until causing a failure on the high voltage electrical system. The probability and speed of this failure type depends on the type and material of the insulator, the climate of the area, the type and level of contamination, as well as the voltage under which the insulator is working. [4]

The effect of (UV) radiation is one of the most important factors that affect the insulator surface. The degradation effects of these radiations are accelerated if there is moisture on the polymer's surface. Thus polymer compounds used in outdoor applications should be evaluated in the combined presence of UV radiation and humidity. [5, 6]

This work presents the effects of different types of contamination on the electrical characteristics of EPDM stress relief cable ends such as the effect of ultraviolet radiation. To achieve this object, dry and wet flashover tests were carried out on the EPDM cable terminations. As well, the effects of salinity caused by exposure of these terminations near coastal areas were studied. Thus, this paper presents a study of the flashover voltage (kV) for cable terminations exposed to the weathering conditions such as ultraviolet radiations at different doses. A comparison of the Electrical characteristics of virgin and polluted specimens of ethylene-propylene-diene monomer (EPDM) cable terminations is carried out.

II. EXPERIMENTAL PROCEDURE

A. Specimens Specifications and Test Conditions

- Material: Ethylene Propylene Diene Monomer (EPDM)
- Size: GA applicable for cables which have diameter over insulation (19.7 up to 25 mm)

- 1*70mm2 AL/XLPE/PVC 18/30 (36) kV cable.
- The cable length 5m according to (IEC60502-4)
- Sets of samples were prepared to be tested as follows:

- 1st Set of samples tested under dry condition
- 2nd Set of samples tested under wet conditions without coating with silicon grease.
- 3rd Set of samples tested under wet conditions with coating with silicon grease.
- 4th Set of samples tested at different levels of ultraviolet radiation
- 5th Set of samples tested at different salinities.
- 6th Set of samples tested at different levels of ultraviolet radiation combined with different levels of salinities

B. Simulation of Ultraviolet radiation

Two UV lamps produced by General Electric Company (GEC) (60cm length –black light F20-20watt) were used

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to simulate the UV radiation and were installed inside wooden box coated by aluminium papers, the stress relief samples were subjected to ultraviolet to different durations (1000,2000,3000 and 5500 hours) as shown in Fig. 1.

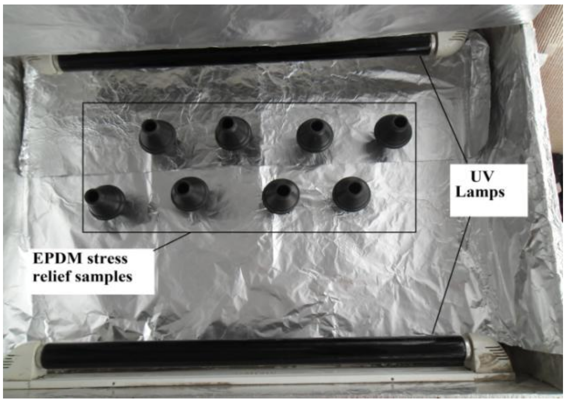

Fig. 1: Photograph of UV Device

C. Simulation of Coastal Conditions

In order to simulate the coastal conditions it is necessary to take into consideration the conductivity of the sea water which is around 54000µS/cm. [7]. Thus, different solutions were prepared using sodium chloride (NaCl) to create salty water having different conductivities.

D. Electrical Test supply and Test procedures

The AC high voltage was obtained from a single phase high voltage transformer. The output of the transformer was smoothly controlled by VARIAC regulator.

The virgin samples were cleaned with tissue to remove dust and other contaminating particles on the surface prior to the test.

The flashover voltage should be determined by the average of five flashover voltages on each sample according to (IEC1109).

III. RESULTS AND DISCUSSIONS

A. Comparison between Virgin Samples under dry and wet conditions.

Fig. 2 shows the relation between the flashover voltages for EPDM termination samples in case of there is no any kind of contamination condition and in case of wet condition (water with zero conductivity)

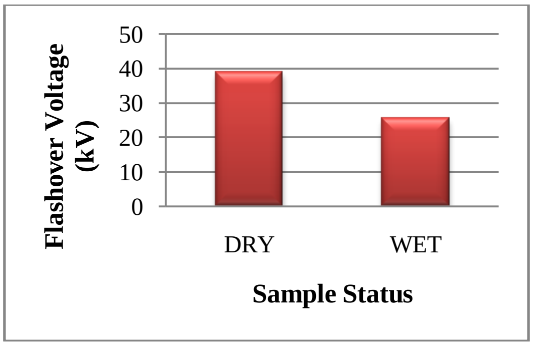

Fig. 2: Flashover voltage (kV) for dry sample and wet samples

It can be seen that the flashover voltage of virgin samples decreased from 39kV at dry conditions to 25.5kV at wet conditions with zero conductivity, thus the reduction of flashover voltage is 13.5kV i.e. the reduction percentage in flashover voltage reaches almost 35%. The reduction in flash over voltage could be due to increasing the leakage current paths and thus dry bands arcing increased conductivity.

B. Effects of Ultraviolet Radiation duration on the EPDM Cable Terminations

The effects of ultraviolet radiation duration (Hours) on the flashover voltage (kV) on the EPDM cable terminations is shown in the Fig. 3.

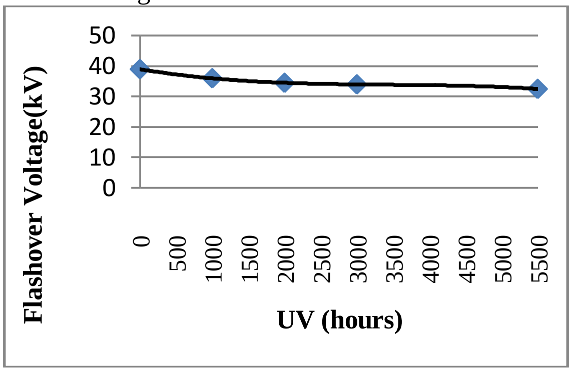

Fig. 3: Flashover voltage (kV) of cable termination subjected different UV radiation durations.

Further, Table1 shows the flashover voltages (kV) for different UV radiation durations and the reduction percentage referred to virgin condition

Table 1 Values of flashover voltages (kV) of cable termination subjected to different simulated UV radiations.

Ultraviolet radiation hours	0	1000	2000	3000	5500
Flashover voltage (kV)	39	36	34.5	34	32.5
Reduction %	0	7.5	11	13	16.5

From Table 1, it can be seen that the flashover voltage decreased nonlinearly from 39kV at virgin condition to 36KV after the first 1000hours of simulated UV radiation, thus the reduction in flashover voltage is 3kV which mean that the reduction percentage of flashover voltage is almost 7.5% for the first 1000hours only.

By increasing the ultraviolet radiation duration the value of the flashover voltage (kV) is decreased. This gives an indication that the UV radiation decreases the performance and lifetime of these terminations. This may be due to the increase of surface degradation by increasing the exposure time to ultra violet radiation.

C. Effect of Salinity on EPDM Cable Termination

Fig. 4 shows the relation between flashover voltages (kV) of cable termination subjected to different water conductivities.

It can be seen that the flashover voltage (kV) decreases by increasing the water conductivity that subjected to the EPDM termination surface.

It can be seen that the flashover decreased from 39kV at virgin condition to 20KV at the wet condition with conductivity 60000µs/cm (sea water conductivity) thus The reduction percentage of flashover voltage is almost 48.5%.

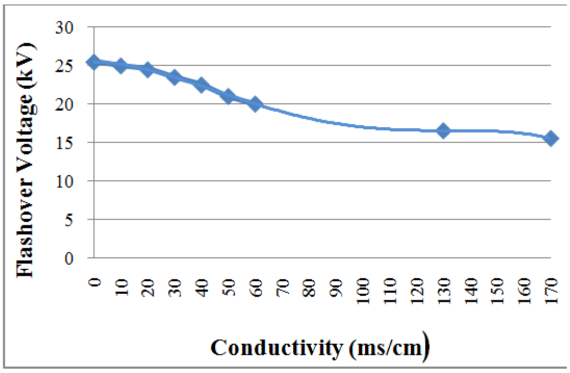

Fig. 4: Flashover voltages (kV) of cable termination subjected to different water conductivities

This decreasing in the flashover voltage may be due to the increase of the leakage current and the dry bands formed because of the water conductivity increased. From the above data one can investigate that the water is most dangerous on the cable termination than the UV radiation because only water with conductivity zero µs/cm can make a reduction in the flashover voltage by 34.5% from virgin flashover voltage which is more than double the UV radiation effect in 5500hours.

D. Effect of Salinity Combined With Simulated UV Radiation

Fig. 5 presents the relation between the flashover voltages (kV) of cable termination subjected to different ultraviolet radiation durations under different water conductivity (µS /cm) values.

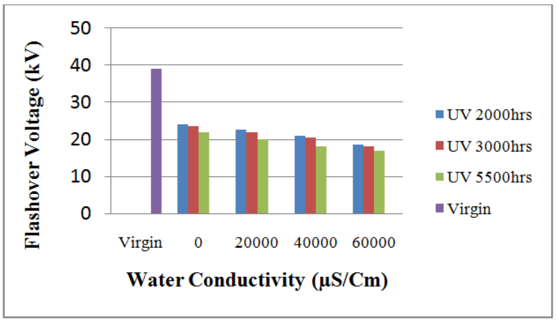

Fig. 5: Comparison between the effects of different UV radiation duration combined with different water conductivities (µs/cm) on the flashover voltage (kV)

It can be observed that the combination between the two kinds of contamination makes the flashover voltage occur faster than exposing to only one kind of contamination, Example: When exposing to only 2000hours of UV radiation the flashover voltage is 34.5kV, When exposing to only water conductivity of 60000 µs/cm (sea water conductivity) the flashover voltage is 20kv and the combination between 2000hours of simulated UV radiation with water conductivity of 60000 µs/cm the flashover voltage decreased to 18.5kV

E. Effect of Coating EPDM with Silicon Grease on Flashover Voltage

Fig. 6 shows the values of the flashover voltage for EPDM cable termination in case of coating with silicon grease and without coating when subjecting the two samples to the wet condition (water with zero conductivity), noting that sample was coated first by silicon grease then subjected to wet condition

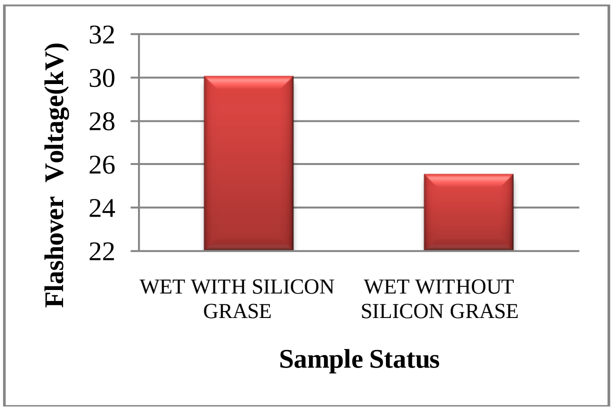

Fig. 6: Flashover voltage (kV) for Wet sample with and without silicon grease.

It can investigated that the Silicon grease increases the flashover from 25.5kV to 30kV which means that the silicon grease enhances the performance of the termination and increases the flashover voltage by 4.5kV which means the enhancement in the flashover voltage is almost 17.5%. This increase of the flashover voltage may be ascribed to the effect of silicon grease nature that repels water, forming water droplets other than continuous water layer that can lead to dry bands and enhance flashover voltage.

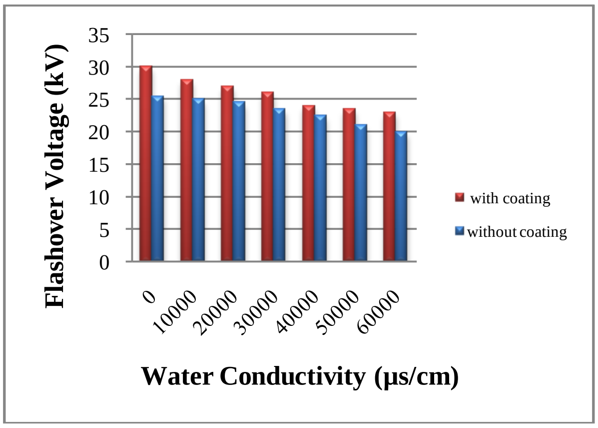

Fig. 7: Flashover voltage (kV) for different water conductivities subjected to sample with and without silicon grease.

Further, Fig. 7 illustrates that the flashover voltage for samples which coated with Silicon grease is higher than the samples without coating which mean that the silicon grease coating could be used to improve the flashover voltage of EPDM cable terminations.

IV. CONCLUSION

The following conclusions may be drawn from the present investigation:

A- The flashover voltage of the EPDM cable termination decreases with the increase of the exposure period to ultraviolet radiation due to the increase of surface degradation.

B- The flashover voltage decreases with the increase of water conductivity on the termination surface due to the increase in leakage current and dry band arcing.

C- The reduction in flashover voltage under wet condition with water conductivity of zero µs/cm is 34.5% which mean that in the coastal regions the creepage distance must increase than the dry regions

D- The reduction of flashover voltage of cable terminations due to exposure to 2000, 3000 and 5500 hours of simulated ultraviolet are 11%, 13% and 16.5% respectively. While the reduction in case of wet sample with zero µs/cm 34.5% which mean that water is more dangerous on EPDM termination than ultraviolet radiations.

E- The flashover voltage of coated cables terminations is higher than flashover of uncoated cables terminations.

F- The reduction of flashover voltage of coated cable termination due to wet condition with water conductivity of zero µs/cm compared to uncoated cable termination is 17.5% thus the silicon grease coating increase the flashover voltage due to salty wet condition.

G- Silicon grease coating could be used to improve the flashover voltage of EPDM cable terminations.

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