FLASHOVER PERFORMANCE OF INSULATION SURFACES UNDER COMBINED DC STRESS AND AIR FLOW

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Abstract: The effect of air flow on the flashover voltages of diverse insulation surfaces was investigated. The specimens used for the experiments are designed according to a standardized form, which is used for the determination of tracking erosion of outdoor insulating material. It was found that with increasing air flow speed the flashover voltages of the insulators increases too.

1. INTRODUCTION

The surface of an outdoor insulation system is subject to weathering effects like moisture, temperature, UV rays, particles deposition and air flows. For special purposes insulation surfaces in apparatus may be also stressed by effects similar to environmental conditions like wind or contamination caused by air flow. The reported investigations were limited to the effect of air flow with its consequences like deposit of particles and the air flow itself [1, 2]. The deposit of particles seems to be the most important factor to reduce the breakdown performance of an insulator under service condition, whereby the deposit is a direct consequence of the air flow and the relevant speed. Therefore it is necessary to perform long time tests, but to understand the mechanism short time tests are also required. The effect of air flow can be identified within a short time, because the deposit of particles can be neglected in the short period due to the fact, that the deposit of particles needs a longer time to influence the flashover performance of the insulation surface.

A series of tests were carried out on epoxy plates as specimens with the recommended specimen configuration according IEC 60587 [3]. These samples were allocated indoor under air flow and at the same time stressed by a high voltage DC up to the surface flashover. The surface was allocated in a perpendicular direction to the air flow in order to be able to observe the effects in a better way. The speed of the air flow is the parameter for the determination of the breakdown performance.

The available information reveals some physical fundamental aspects and show that the particle deposition and the air flow speed have different effects on the insulator performance. The effect of the air flow speed has a more transient or reversible characteristic, whereby the effect of the particle deposition shows a more stable characteristic, because the particles stay on the insulator surface until cleaning.

2. LITERATURE SURVEY

The literature survey brought relative little information concerning the influence of the air flow on the surface flashover voltage of insulators. One publication deals with the influence of the air pressure on the leakage current of an insulator surface. The results were gained during fogging tests, which are typical tests for outdoor insulations systems. The air pressure can be understood as consequence of an air flow which generates pressure on the surface of the insulator. Therefore the results of these investigations may be useful in the estimation of the influence of air flow on the flashover voltage. Increasing pressure and increasing fogging causes an increasing leakage current as shown in Figure 1. The fogging amount is expelled by nozzles and an increase in fogging given in l/min is equivalent to an increase of the speed of the fogging. Therefore the information from Figure 1 may be relevant for the evaluation of the flashover investigations of insulating surfaces.

Another publication refers to the influence of wind speed to the deposit of salt particles at the surface of an outdoor porcelain insulator. The salt accumulation is taken as a measure of the wind speed, because as higher the wind speed as more particles are collected on the insulator surface. The main information derived from Figure 2 is the fact, that the shape of the insulator surface plays an important role on the amount of salt deposit as function of the wind speed. The different insulator shape leads also to a different angle between the surface and the air stream which demonstrates that the orientation between insulation surface and air flow direction should be taken into account within the investigations.
3. SPECIMENS AND TEST SETUP

The test specimens are insulating plates with the dimensions shown in Figure 3. For comparison with other test results the test setup described in detail in IEC 60587 [3] was used.

The DC voltage was generated by a standard half-wave rectifier in combination with a smoothing capacitor in order to have a more or less stable amplitude of the DC voltage. The insulator represents a high ohmic load and therefore the voltage drop was negligible.

Figure 4 shows the schematic diagram of the voltage source. The measurement of the DC voltage was done by a resistive divider with a ratio of about 2000.

Figure 5 shows the arrangement of the nozzle for the air flow. There are two types of streaming; turbulent and laminar. The turbulent flow means that the flow contains some eddies which is usually not desirable. The laminar flow means that no eddies exist and the flow is even in parallel to the insulator surface. The laminar flow is therefore the ideal case, but the imperfection of the nozzle and the ambient conditions do not allow to reach this ideal configuration [4]. The practical arrangement consists of a mixture of turbulent and laminar flow, whereby the laminar flow dominates.

The air flow was supplied by a compressor. The pressure was about 1500 kPa, and with diverse nozzles with different diameter air speeds from 0.5 m/s up to 40 m/s could be reached. The measurement of the air speed was made by an anemometer type RS-AVM-09.

Ion order to protect the anemometer from the electrical field the measurement of the air flow was done before and after the test to confirm the constant air flow during the flashover tests.

The position of the nozzle influences strongly the type of air flow. Therefore tests were carried out to reach the best position of the nozzle with almost laminar flow and with the greatest impact on the surface flashover voltage.

The test procedure for surface flashover voltages starts with carefully cleaning of the insulation surface. After assembling the test setup with the specimen under test...
the air flow starts and was measured. The air flow was adjusted by a valve according to the measurement and the desired air flow.

Then the DC voltage was increased with a rise of 1 kV/s until the flashover appears on the insulator surface. After switching off the DC voltage the specimen was examined and if no flashover traces were found the voltage was again increased up to the flashover voltage. The voltage test was repeated three times for every specimen.

4. TEST RESULTS

The test results show not only an influence of air flow in the flashover voltages but also the damages of the insulating surface during the application of air flow and electrical stress. Normally the surface’s damages are characterized as a tree-like distribution of the discharge traces, which appear on the surface of the insulating materials. Fig. 6 shows the traces without the electrodes and Figure 7 the traces in the complete test arrangement. These traces were considered as normal discharge traces for surface flashover.

The shape of the traces is different for flashover tests with and without air flow. Further tests were carried out with other insulating materials which show more or less no flashover traces on the surface.

Figure 8: Discharge traces in specimens with air flow

The material as well as the air flow has an influence on the surface traces. The extent of the traces was in a good agreement with the surface flashover voltage that means more intensive surface traces lead to a lower surface flashover voltage. This result is not surprising but shows that the flashover voltage differ between the different materials.

The air flow has also an important influence on the surface flashover voltage, independent on the insulation material. Figure 10 shows the surface flashover voltage of a material with strong traces for positive and negative DC voltage as function of the air flow. The positive DC voltage without air flow is the reference value for flashover voltage at both polarities. The negative DC voltage shows always a higher surface flashover voltage than the positive. The relative increment of the surface flashover is higher for positive DC and in the range of 18 %. The negative flashover voltage is already higher as the positive without air flow.

Figure 7: Electrode arrangement and discharge traces in specimens without air flow

The application of air flow changes the flashover traces as shown in Figure 8 and 9. The traces do not show anymore the tree-like form. They follow only a unique direct way, interrupted in the position of the nozzle caused by the strong air flow in this position.
flow and the relative increment is in the same range as for positive DC.

Figure 11 shows the test results for another insulating material without or much less surface traces. Again the positive DC surface flashover voltage is the reference value, which differs from the reference value of the other material in Figure 10. The difference between positive and negative surface flashover voltage without air flow is smaller compared to the other material. The relative increment for the positive surface flashover voltage is less and in the range of about 5 %. The relative increment of the negative surface flashover voltage is in the range of about 22 %.

For all materials the negative DC voltage leads to higher surface flashover voltage compared to positive DC voltage. The speed of the air flow has a remarkable influence on the surface flashover voltage due to the removal of the charges. For a material with strong traces the relative increment of the surface flashover voltage as function of the air speed is independent form the polarity. For a material without traces the relative increment of the surface flashover voltage is small for positive polarity. For negative polarity the relative increment is larger than for the materials with traces and in the range of about 22 %.

The different behaviour of the materials regarding flashover traces lead in combination with different air flow to different relative increment of the surface flashover voltage.

5. CONCLUSIONS

The flashover voltage of insulating surfaces under DC stress shows a clear polarity effect.

The surface flashover voltage is higher for negative DC than for positive DC.

The relative increment of the surface flashover voltage is in the range of 18 % for a material with strong traces and for both polarities.

The relative increment of the surface flashover voltage is in the range of 22 % for a material without traces and negative polarity.

The relative increment of the surface flashover voltage is in the range of 18 % for a material without traces and positive polarity.

The surface flashover voltage is influenced by the combination of the materials behaviour and the air flow.

6. REFERENCES


