ELECTROMAGNETIC FIELD ANALYSIS FOR MEDIUM VOLTAGE NETWORKS FAILURE INVESTIGATION

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Abstract: In this paper the failures named as tracking, observed on aerial medium voltage networks, are investigated using electromagnetic field analyses. The objective of the “electromagnetic fields analysis” is to make possible the fast analysis of the tracking failures presented on aerial networks known as “spacer systems”. This analysis includes the use of software designed for electromagnetic field evaluation, which makes the analysis of the results easy. The use of mathematical tools applied on engineering problems produces results with high accuracy. The line voltage, dimensions, materials of the components and external contaminants of the system are discussed in order to identify the variables that impact on the integrity of the system. Performing laboratories studies, the tests are evaluated and compared with real cases on utilities systems. Many questions are clarified. Keywords: tracking, electromagnetic fields analysis, aerial medium voltage networks, spacer systems, computation analysis.

1 INTRODUCTION

The aerial medium voltage networks known as “spacer systems” defined in this paper is a compact distribution of 3-phase power with a messenger supported primary distribution system using covered conductors in a close triangular configuration. The system voltage considered was from 15 kV to 35 kV.

However, as the electric field of this type of cable is not confined, surface currents may appear that give rise to the phenomena of electrical tracking and erosion, depending on the harshest environment in the region of installation. The occurrence of electrical tracking and erosion of the polymer coating of the cables in the contact points of the spacer compact network (due to the existence of the corona effect) produces interruption and disconnections undesirable, additional cost to the Utility in charge of the line (replacement of cables and accessories) and safety risk for people around the installation.

The electromagnetic field evaluation provides the evaluation necessary for the analysis of the tracking failures and numerical methods are the most powerful design tools with highly developed computer programs. The analysis presents on this paper includes the use of software designed for electromagnetic field evaluation, which makes the analysis of the results easy.

2 AERIAL MEDIUM VOLTAGE NETWORKS

Figure 1 and 2 shows the aerial medium voltage networks analyzed on this paper. The messenger wire supports the tensile strength, as well as the loads caused by both wind and conductor weight, tied to polymeric spacers. The so called covered conductors are insulated conductors but are treated like bare conductors from point of view of handling in service and safety.

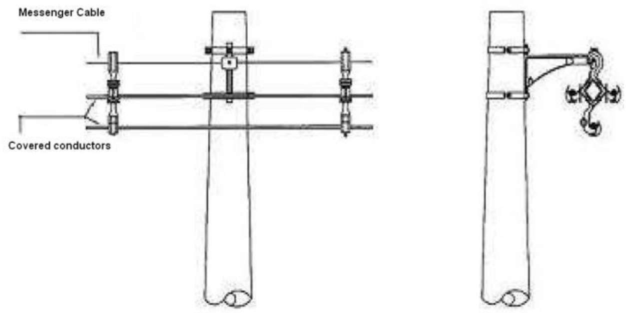


Figure 1: spacer system representation

Figure 2: spacer system example

3 ELECTRICAL TRACKING AND EROSION

The failures presented on this paper are the combination of two phenomena’s named “Electrical tracking” and “Erosion”. The figure 3 shows the defects presented on the system. The position of the failure is on phase indicated on figure 4 (position “S”).

3.1 Electrical tracking

The degradation process of a dielectric that produces burned tracks as a result of electrical discharges at or near the surface of the insulating material.

3.2 Electrical tracking resistance

It is the capability of insulation to resist the formation of burned tracks. The term "Electrical tracking resistance" is usually related to the time required to develop burned tracks according to particular request.

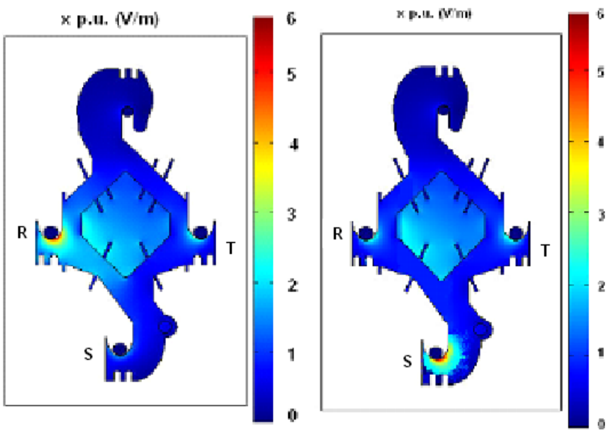
3.3 Erosion

It is limited and gradual loss of mass due to the action of electric discharges.

Figure 3: Sample of electrical tracking and erosion

4 ELECTROMAGNETIC FIELD EVALUATION

Most of the engineering problems as described above are solved by using numerical methods. There are two main classes of methods: Finite-difference and Finite element methods. Numerical methods are particularly used to design electrical equipment. The numerical method is the one selected for the solution of electrostatic field distribution analysis of present paper. The figure 4 shows the results considering two conditions. The situation 1 considers the system without contaminant and situation 2 with contaminant. The contaminant was appropriated specified: SiO_2 (58 to 76%), Al_2O_3 (14 to 30%) and Fe_2O_3 (2 to 6%).



Situation 1 Situation 2

Figure 4: Electromagnetic field figures for situation 1 and 2

The results are presented in a multiple of specified value named as p.u. (per unit). The situation 2 deserves special attention, because the tracking are observed in the region of the lower phase (indicate as “S”), where exactly has the highest concentration of electric field lines. On the other hand, without the contamination, the concentration is on left phase (indicate as “R”).

The contamination was confirmed based on field observation due to the contrast of the cable that has a dark surface with a white coloration of the contaminant.

When the cable is replaced with other one with highest insulation thickness or conductor it is observed low variation on the results but not significantly to change the analysis above.

5 ANALYSIS AND LABORATORY TESTS

The contamination was confirmed by performing tests on sample collected on installation and performing tracking test on laboratory with and without the contaminant.

Samples	Results
With contaminant	Less than 3 kV
Without contaminant	Higher than 3 kV

Table 1: tracking tests results

The tracking tests were carried out at the PDIB Laboratory, Brazil. The figure 5 shows the test equipment. This test is standardized as per Brazilian specification, IEC and ASTM. It was used the NBR11296.

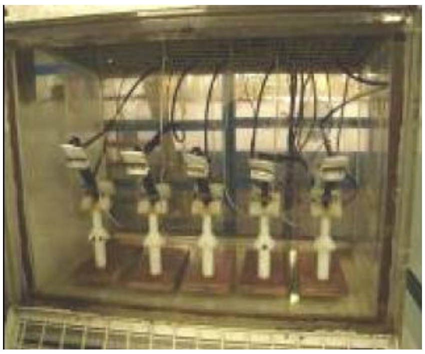


Figure 5: Test equipment for tracking test

The high value of surface resistivity of insulating polymers usually used in “spacer systems” limits the movement of surface currents responsible for the phenomenon of tracking. Superficial contamination by conductive material reduces dramatically surface resistance of the insulation, thus creating conditions for current flow between points of different potentials. Surface currents flowing continuously through the conductor film (created by contamination), form the called dry bands preferentially at the contact points of the cable with grounded objects on the aerial medium voltage networks.

6 CONCLUSION

The electromagnetic field evaluation can provide a easy evaluation of the system and assist the correct determination of root cause of the failure. The case presented by the authors in this paper shows the presence of contaminants on the surface of the system (including cables) as the external factor that caused the electrical tracking observed.

7 ACKNOWLEDGMENTS

The authors would like to acknowledge the contributions for the technicians and engineers at PDIB for the very good work on carrying out the tests and field evaluations.