88 SM 587-8
April 1989

Insulator Pollution Performance at High Altitude: Major Trends

Hubert P. Mercure, Member, IEEE
Institut de recherche d'Hydro-Québec (IREQ)
1800 montée Ste-Julie, Varennes, Québec, Canada J0L 2P0

Abstract—A survey of the data available from the literature was conducted in order to assess major trends in insulator performance with altitude. The literature comprised tests on individual insulator strings both under natural and artificial conditions along with actual live-in performance.

The major trends reported here suggest a pressure dependence $(p/po)^{0.35}$ for DC and $(p/po)^{0.5}$ for AC, of V_{50} for standard polluted insulators at altitudes lower than about 4 km ($p \sim 0.6$ atm). These pressure dependences impose a derating of the relative performance of leakage path length or flashover voltage with altitude, namely 6%/km for AC, 5%/km for positive DC and 4%/km for negative DC applied voltages. Dielectric breakdown, in contrast, imposes a 10.5%/km degradation of insulating air gaps with altitude.

Keywords: Insulator, high altitude, reduced air density.

Introduction

A recent literature survey indicated a scarcity of information on high-voltage performance at a controlled atmospheric pressure level in the range of interest, namely below 5000 m altitude (0.5-1 atm).

The literature on the pressure dependence of flashover voltage V_{50} for insulators shows very little reported work. Open-air insulation and strike distance performance with reduced air pressure is relatively better covered for full-scale testing [1].

It was elected along with other authors to account for the effect of pressure on the V_{50} value of various types of insulators using a relationship such as

$$V_{50}(p) = \left(\frac{p}{p_o}\right)^m \cdot V_{50}(p_o)$$

where p_o is the sea-level reference pressure.

Results

The author has used a 2-D electrolyte strip modeling scheme in an evacuated vessel in order to study critical flashover. The results have shown that the exponent $m = 0.35$ is representative of the reduced pressure dependence of critical flashover voltage for DC.

The V_{50} dependence on pressure was studied using tests under controlled laboratory conditions in evacuated vessels. In particular Ishii et al [2] have performed tests on half-scale cap-and-pin insulators. Their results can be summarized by exponent m values of 0.35 for negative DC and a larger pressure dependence under AC applied voltages, namely $m = 0.50$ and $m = 0.55$ for standard and antifog shapes, respectively.

Some tests on full-scale insulator strings have been reported using pre-contamination techniques at high-altitude locations in the People's Republic of China and in the USSR. Rudakova and Tikhodeev [3] in particular report on combined laboratory and high altitude tests. Their study involved a survey of natural contamination, field tests and evacuated vessel tests of artificially-polluted insulators.

Conclusions

Making use of linearized approximation of the $(p/p_o)^m$ dependences for $p/p_o > 0.6$ (<4 km) with respect to a reference temperature of 25°C simple derating factors are proposed for the insulator pollution performance of leakage length. They are reproduced on Fig. 1, namely

DC − (average)	:	4%/km
DC + (average)	:	5%/km
AC (standard shape)	:	6%/km
AC (antifog shape)	:	7%/km

In contrast the dielectric breakdown performance of air gaps is derated by about 10.5%/km.
Discusser: G. Carrara

References

[1] A. R. Hileman, "Weather and its Effect on Air Insulation Specifications," *IEEE Paper 84-WM-216-8*, Winter Meeting, 1984.

[2] M. Ishii, K. Shimada, T. Kawamura, T. Matsumoto, "Flashover of Contaminated Surfaces Under Low Atmospheric Pressure," *Fourth Intern. Symp. on High-Voltage Engineering*, paper #46.02, 1983.

[3] V. M. Rudakova and Prof. N. N. Tikhodeev, "Influence of Low Air Pressure of Fashover Voltages of Polluted Insulators: Test Data, Generalization Attempts and some Recommendations." *Paper to the CIGRE 33.87, WG 04 Committee*, Sept. 1987.

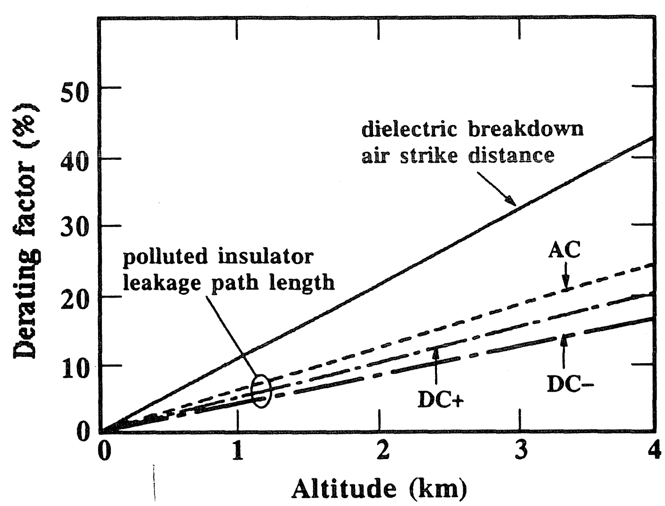

Fig. 1. Summary of the suggested derating factors with increasing altitude for the pollution performance of a given leakage-path length under AC and DC applied voltages. Relative air strike distance performance is shown for comparison.

88 SM 567-0
April 1989

Evaluation of the Effectiveness of Shielding and Filtering of HVDC Converter Stations

R. D. Daillaire, P. Sarma Maruvada, Fellow, IEEE
Institut de recherche d'Hydro-Québec
1800 montée Ste-Julie,
Varennes, Québec, Canada J0L 2P0

Abstract—The electromagnetic interference (EMI) generated by the periodic turn-on and turn-off of the valves is an important consideration in the design of HVDC converter