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Effect of High Altitude on DC Flashover Process on an Ice Surface

M. Farzaneh*, Y. Li and J. Zhang
Industrial Chair on Atmospheric Icing of Power Line Equipments, Université du Québec à Chicoutimi, Québec, Canada

ABSTRACT

Using a triangular ice sample, the effects of low air pressure simulating high altitudes as well as applied voltage polarity on the flashover process on an ice surface were investigated. The critical flashover voltage and leakage current as well as the arc propagation velocity of ice samples were determined under various air pressures for both DC+ and DC–. The results obtained contribute to a better understanding of the high-altitude effects on the flashover phenomenon on actual insulators under icing conditions.

INTRODUCTION

The insulator flashovers and consequent power outages in cold climate regions under the influence of contaminated ice or snow, combined sometimes with low air pressure at high altitudes, have been reported by several researchers in North America (Melo et al., 1988; Kawai, 1970), Europe (Meier and Niggli, 1968; Fikke, 1990) and Asia (Su and Hu, 1988; Makkonen et al., 1991).

In general, the researchers agreed that the presence of a polluted water film on the surface or inside the accumulated ice and snow are the major parameters decreasing the critical flashover voltage of outdoor insulators, V_c, during cold periods (CIGRE Task Force 33.04.09, 1999; Farzaneh, 2000). They also agreed that the decrease in air pressure lowers the critical flashover voltage of insulators at high altitudes (Kawamura et al., 1982; Rudakova and Tikhodeev, 1989; Mercure, 1989). The rate of the decrease generally depends on voltage type, insulator profile, pollution severity and even voltage application methods (Ishii et al., 1983; Guan and Huang, 1994). For polluted insulators, the change of arc E-I characteristics was considered a main reason for the decreases in flashover voltage under high-altitude conditions (Kawamura et al., 1982; Ishii et al., 1983). Because high-altitude regions are normally subjected to ice and snow conditions during cold periods, under such environmental conditions the decrease in critical flashover voltage becomes more severe and, sometimes, results in flashover on the insulators.

Up to now, most of the studies on the flashover performance of ice-covered insulators used on AC or DC power lines have been performed only under the reference pressure (sea level). It has been reported that the flashover voltage of ice-covered insulators under DC– is lower than under DC+ (Watanabe, 1978; Bui et al., 1984) while the value of minimum flashover voltage, under AC, falls between those of DC+ and DC– (Farzaneh, 1990, 1991). There is almost no fundamental study on the flashover on ice surfaces under high-altitude conditions.

These existing gaps have motivated the present investigation with the following objectives:

- To study the process of arc propagation on an ice surface and determine the arc propagation velocity as well as the critical flashover voltage of an ice sample under DC applied voltage.
- To study the effect of voltage polarity and low air pressure on both arc propagation velocity and critical flashover voltage of an ice sample.

TESTING FACILITIES AND ICE SAMPLES

The experiments were carried out in an evacuated chamber (Fig. 1). A cylindrical chamber 610 mm in diameter and 760 mm high was constructed to achieve the low pressure found at high altitudes. Using a vacuum system, the internal air pressure can be lowered to any given value between 101 and 30 kPa, thus simulating any altitude from sea level to 9000 m. The chamber is transparent, allowing visual observations and photography. Air temperature control was achieved by placing the evacuated chamber in a temperature-controlled room as described in a previous paper (Farzaneh and Kiernicki, 1997).

Instead of an iced insulator of complex shape, a plane triangular ice sample was used to eliminate the influence of insulator profile on flashover performance. Also, this geometry ensures initiation of only 1 arc, and this from the top electrode propagating toward the bottom electrode. This makes it possible to study the arc propagation process. Fig. 2 shows the shape of the ice sample

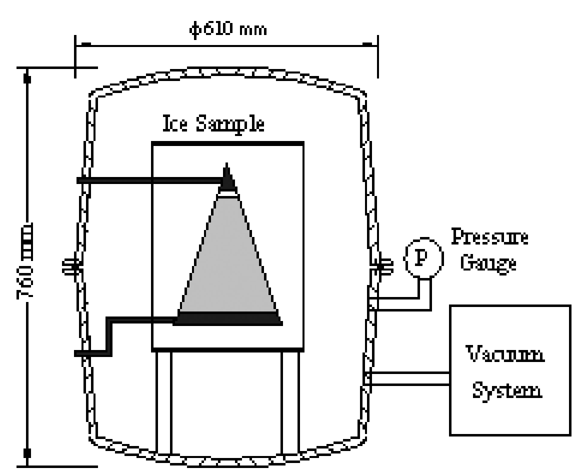

Fig. 1 Schematic diagram of evacuated chamber

*ISOPE Member.

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