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A Laboratory Simulation of Wet Icing Buildup on H.V. Insulators

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ABSTRACT

The objective of the present study is to propose a practical laboratory method to simulate wet atmospheric ice accretion on H.V. insulators. The relatively high liquid water fraction contained in such deposits is the principal cause of insulator flashover. The method developed is based on first accumulating a low-density soft rime on energized insulators and then heating the produced deposits in an air temperature above 0°C. During the warmup, meltwater formed at the accretion surface is absorbed by the soft rime ice to produce a liquid water fraction simulating that formed in natural wet snow. This approach makes it possible to determine the performance of insulators under wet-snow-like conditions with relatively simple, low-cost equipment.

INTRODUCTION

Over the last few years, several electrical power failures due to ice and wet snow accretion occurred on Hydro-Québec overhead power lines (Drapeau, 1991; Hydro-Québec, 1995). These power outages were due in part to the occurrence of flashovers on ice- and snow-covered insulators. In order to gain a consistent understanding of the roles of ice and snow in insulator flashover, a research program was established at the University of Québec in Chicoutimi, in collaboration with Hydro-Québec. The first stage of the research work involved ice accumulation on insulators. A part of the study, concerning the determination of atmospheric conditions favouring the accretion of the most severe type of ice, i.e., the type of ice associated with the highest probability of flashover, was reported in previous papers (Farzaneh et al., 1995; Farzaneh and Drapeau, 1995).

The second stage of the research, which is the subject of the present paper, deals with a practical laboratory simulation of wet icing on H.V. insulators. The best example of such accretion is wet snow. This form of atmospheric wet icing is said to form when snowflakes 1 to 5 mm in diameter coalesce partially before touching the ground if they come into contact with a positive temperature up to +4°C. Depending on weather conditions, wet snow deposits may contain a fraction of liquid water up to 50% of their total weight (Mitsuru et al., 1990).

The problems caused for outdoor insulation by wet atmospheric accretions such as wet snow are, first, the bridging of insulator sheds, causing a notable reduction in leakage distance, and second, the presence of liquid fraction in the deposits. This causes a relatively high conductivity path between the high voltage and grounded sides of insulators. The combination of the two causes a drastic drop in the leakage resistance of insulators, resulting in a significant increase in leakage current. In turn, the heating effect of the leakage current causes ice crystals to melt and provokes the deposits to fall off or melt completely in several places along the insulator or insulator string. Because of the low resistivity of the remaining deposits, the voltage drop along the airgaps caused by the melting or falling of deposits will be very high. Under such conditions, local arcs along the air gaps will occur and more ice crystals will melt. Such conditions could bring the insulators to the occurrence of a flashover arc (Farzaneh et al., 1995; Farzaneh et al., 1996).

In order to simulate wet snow accretion on H.V. insulators in the laboratory, two approaches may be considered:

- The first approach purports to use a system for generating snowflakes to be injected into the air flow that strikes the insulators. This approach requires complex and costly equipment (Mitsuru et al., 1990). Moreover, such a system produces small quantities of snow flakes and would be difficult to adapt to the cold room designed for insulator flashover tests.
- The second approach consists of examining the possibility of obtaining wet ice accretion with the same device used to produce other types of atmospheric ice from supercooled droplets (Farzaneh and Drapeau, 1995).

The principal objective of the present study is to examine the practicality of the second approach and to identify a procedure by which the environmental conditions for obtaining ice accretion producing bridging of insulators can be created. The approach retained consists of forming low-density rime from supercooled droplets. The ice buildup is then heated in air above 0°C to be partially melted. The study also calls for identifying the main characteristics of such wet ice deposits grown on insulators.

EXPERIMENTAL RESULTS

Facilities and Procedure

Ice was accreted on a short string of 5 porcelain insulator units from supercooled droplets in a cold room 4.8 m × 2.8 m × 3.5 m (Fig. 1). The air temperature in the cold room was controlled by a proportional integral and differential system (PID), with an accuracy of ±0.2°C.

Tap water, with a conductivity of about 80 μS.cm^{-1} at 20°C, was used to spray the insulators, which were placed vertically in the center of the cold room. The spray system consisted of 4 air-atomizing nozzles mounted on a vertical support parallel to the axis of the insulator string, at a distance of 180 cm. In order to improve the uniformity of icing on the surface of the insulators, the nozzles oscillated along a vertical axis (Fig. 1).

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KEY WORDS: Atmospheric wet icing, H.V. insulators, flashover.