International Journal of Offshore and Polar Engineering
Vol. 2, No. 3, September 1992 (ISSN 1053-5381)

Ice Accretion on Energized Line Insulators

M. Farzaneh* and J. Kiernicki
Department of Applied Sciences, Université du Québec à Chicoutimi
Québec, Canada

J.-F. Drapeau
Institut de recherche d'Hydro-Québec, Québec, Canada

ABSTRACT

A laboratory study of ice accretion from supercooled droplets on energized insulators was investigated. Wet ice, which is associated with the highest probability of flashover, was produced at temperatures of -12°C and -7°C with water droplets of 50 and 80 μm and liquid water contents of 4.4 and 6.8 g.m-3. Wind velocity and the conductivity of freezing water played important roles in the uniformity and roughness of ice accreted, respectively. It was also found that the mean power fed to the insulators by conduction current and corona discharges was about 40% of heat power liberated by the freezing process during wet ice accretion.

INTRODUCTION

One of the serious problems with power transmission by overhead lines in Northern countries and cold regions is atmospheric ice accretion due to freezing rain, in-cloud riming and wet snow combined with wind. The excessive accumulation of ice leads to mechanical damages, especially to the conductors and towers. This is a well-known problem for transmission line designers.

Another problem with atmospheric ice accretion on power lines is the flashover phenomena occurring on insulators. Unlike the mechanical aspect mentioned above, the importance of problems caused by flashover phenomena on ice-covered insulators was not sufficiently considered in the past. Wet ice accretion and melting ice considerably change the dielectric properties of insulators and favour the occurrence of flashover, thus the interruption of customer supplies. Due to the nature of these phenomena, failures by ice accretion often take a relatively long time to repair and cause considerable economic losses. The degree of loss in the dielectric properties of insulators depends essentially on the type and amount of ice accreted. To the best of our knowledge the systematic efforts to establish a relation between the type of ice and minimum flashover voltage of ice-covered insulators were undertaken by Phan and Matsuo (1983). These authors examined the minimum flashover voltage, V_{MF}, of a short string of insulators covered by soft rime, glaze and wet-grown ice deposits. They concluded that the most dangerous type of ice buildup is this wet-grown ice deposits having a density of 0.87 $g{\cdot}cm^{-3}$. The authors improperly called this hard rime because of its milky appearance. In fact the lowest flashover voltage of insulators was obtained with this particular type of ice. Regarding the effects of voltage polarity, it was shown that the amount of ice accreted on an energized insulator string under similar atmospheric conditions was approximately the same for alternating, positive and negative applied voltages even though the minimum flashover voltage, V_{MF}, under dc- was significantly lower than dc+ and ac (Farzaneh and Laforte, 1991). Furthermore the V_{MF} of insulators employed under direct or alternating voltages depends on the thickness of ice accretion. The results of a previous study (Farzaneh, 1991) showed that the V_{MF} of a short insulator string, employed under positive and negative voltages, decreases with increasing values of ice thickness, ε, up to 2 cm, accreted on a monitoring cylinder of 3.8 cm rotated at 1 R.P.M. For ice thicknesses larger than 2 cm, V_{MF} was approximately constant. It was also found that when applying voltage during wet ice formation on insulators, discharges always exist during accretion. The flashover obtained in this case was always lower than that obtained when H.V. was shut off during ice accretion (Phan and Matsuo, 1983).

Considering the above, it would be of interest for insulator manufacturers and electrical companies to determine the flashover performance of insulators to be used in cold regions under controlled atmospheric conditions. These conditions should be those causing the highest probability of flashover.

Although the relationship between meteorological conditions and the type of ice accretion was established either by observation (e.g., Kuroiwa, 1965) or by an analytical method (e.g., Makkonen, 1981), the application of these results to an intricately shaped object is not evident. With line insulators, in addition to their intricate shape, the heating effect of the leakage current and also the heat transfer by ionic wind (Teisseyre and Farzaneh, 1990) make the application of the above-mentioned results more difficult. Consequently, this paper will first try to study the influence of different atmospheric parameters on the rate and type of ice accretion on an energized insulator string, in a cold room, and will then suggest the most appropriate conditions at which the insulators should be tested.

EXPERIMENTAL CONDITIONS AND PROCEDURES

Cold Room

Atmospheric ice was accreted on an energized insulator string in a 4.8 m x 2.8 m x 3.5 m cold room where a minimum temperature of -35°C could be obtained (Fig. 1).

* ISOPE Member.
Received March 30, 1992: revised manuscript received by the editors June 6, 1992. The original version (prior to the final revised manuscript) was presented at The Second International Offshore and Polar Engineering Conference (ISOPE-92), San Francisco, USA, June 14-19, 1992.
KEY WORDS: Ice accretion, iced insulators, flashover.