International Journal of Offshore and Polar Engineering
Vol. 5, No. 1, March 1995 (ISSN 1053-5381)


# Icing Rate Meter Estimation of Atmospheric Cable Icing

Pierre McComber
Ecole de Technologie Supérieure, Montréal, Canada

Jacques Druez*
Université du Québec à Chicoutimi, Chicoutimi, Canada

Jean Laflamme
Hydro-Québec, Montréal, Canada

## ABSTRACT

**In many Northern countries, the design and reliability of power transmission lines are closely related to atmospheric icing overloads. It is becoming increasingly important to develop a reliable instrument to warn of icing conditions before icing loads become sufficient to damage the power transmission network. One such instrument, the icing rate meter (IRM), was tested on an icing test site at Mt. Valin (altitude 902 m), Québec, Canada. In this paper measurements from 19 icing events during the 1991-92 winter are divided into 1-h periods of icing to provide the experimental icing rate data. The icing rates measured on 12.5-mm and 35-mm cables are then compared with the number of IRM signals per hour in relation to initial ice load, temperature, wind velocity and direction. From this analysis, a better calibration for the IRM instrument is suggested. The improvement of the IRM estimation is illustrated by making a comparison with measurements of the icing load estimation with the old and new calibrations for two complete icing events.**

## INTRODUCTION

Atmospheric icing is an important cause of damages to stuctures and power transmission lines in Northern Québec. Due to the topography, it is not possible for the power transmission lines to reach the Southern markets without going through mountains for substantial distances. In these mountains, clouds are frequently found above an altitude of 300m (984 ft); in-cloud icing occurs with increasing frequency above that altitude and is therefore a hazard for the transmission lines.

Measurements of atmospheric icing on power transmission lines have been made to study the frequency and severity of rime loads (Diem, 1956). Field measurements have been obtained by instrumenting experimental cables located in areas where icing is frequent (Govoni and Ackley, 1983; Smith and Barker, 1983; McComber and Govoni, 1985; Druez et al., 1988).

However, it is difficult to relate cable icing measurements to standard icing meteorological parameters (Yip and Mitten, 1991). Icing has never been systematically measured, as precipitation for example, by the meteorological services. Various instruments are being developed to provide better monitoring of icing conditions. One such instrument is the icing rate meter (IRM), which counts icing and de-icing cycles per unit time on a standard probe and can be used to estimate the icing rate on nearby cables. The calibration presently used (McComber et al., 1993b) was originally based on experiments conducted in a cold room (Tattleman, 1982).

The purpose of this study is to analyze icing data collected on a test site and correlate the accreted mass of ice with measured icing rate meter signals in order to provide a better calibration of the icing rate meter as an instrument to estimate cable icing and to contribute to the development of an improved icing model for power transmission line cables.

For this study, the icing loads are measured on two test cables set up on Mt. Valin at an altitude of 902 m (2959 ft), in the Laurentian mountains near Chicoutimi. This test facility consists of a 96.5-m (316.5 ft) cable span designed and built in collaboration with Hydro-Québec to investigate icing of power line cables. This installation provided the opportunity to gather cable icing data for complete winter seasons. At the Mt. Valin test site, as long as the temperature remains below 0°C, rime accretes and a significant portion stays on the line during the winter season until it melts in the spring.

## TYPES OF ATMOSPHERIC ICING AFFECTING STRUCTURES

Three basic kinds of ice are formed by accretion in the atmosphere: glaze, hard rime and soft rime. Glaze is transparent and has a density with respect to water of approximately 0.9. (The density of pure ice is 0.917.) Hard rime is white and sometimes opaque, depending on the quantity of air trapped inside the ice. Its density varies from 0.6 to 0.9. Soft rime is white and opaque. It is feathery or granular in appearance with a density below 0.6. The density will increase with increasing drop size, temperature, windspeed and liquid water content of the air.

Cloud or fog droplets have diameters smaller than 200$\mu$m. Cloud droplet sizes measured experimentally indicate that low-level clouds, which can affect a structure on a mountain summit, have droplet sizes in the 1-45 $\mu$m range. Consequently, exposure to supercooled clouds or fog will usually result in soft rime. On the Mt. Valin summit, in-cloud icing is frequent from December through March. However, freezing precipitations, which have droplets larger than 200$\mu$m, also occur and are most frequent in early winter. The higher liquid water content associated with the

*ISOPE Member.

Received January 14, 1994: revised manuscript received by the editors September 26, 1994. The original version (prior to the final revised manuscript) was presented at the Fourth International Offshore and Polar Engineering Conference (ISOPE-94), Osaka, Japan, April 10-15, 1994.
KEY WORDS: Atmospheric cable icing, icing rate, device.