DIELECTRIC LOSS CHARACTERIZATION OF HYDRO-QUEBEC MEDIUM VOLTAGE (MV) SUBMARINE CABLES - PHASE 1

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ABSTRACT

This paper presents the results of a study carried out in order to perform a condition assessment of seven MV submarine cables operated by Hydro-Québec Distribution (HQD). The assessment was based of the principle of dielectric loss characterization. Two methods were chosen: Time Domain Spectroscopy (TDS) and VLF Tan delta. Results show that combining the two methods provides a valuable source of information. The use of VLF Tan delta also allows for comparison with the extensive measurement database of tests performed on other equivalent cable systems.

KEYWORDS

Submarine Cables, Dielectric Loss, Very Low Frequency (VLF), Tan Delta, Time Domain Spectroscopy (TDS)

INTRODUCTION

Hydro-Québec Distribution (HQD) operates several MV submarine cable links in order to supply customers living on Île-d'Orléans, Île-aux-Grues and Isle-aux-Coudres islands along the St-Lawrence River. These links constitute critical assets in the HQD underground system, as they are the only source of power for the residents of these islands and they represent a significant capital investment. Furthermore some of these submarine cables are approaching or exceeding the typical “design life” of these types of cable systems, with ages ranging from 29 to 48 years.

Prior to 2007, none of these cable systems had been subjected to any kind of diagnostic testing. At this time a test program was initiated to obtain numeric re-interpretable data in order to assess the health of these cable systems. All the submarine cable systems in this study are protected against water ingress. Those insulated with XLPE and EPR are equipped with lead sheaths and are mechanically protected with steel wire armor screen. Paper cables are “pipe-type” design, so their protection is intrinsically provided by the steel pipes. However, most of them are simply laid on the river bed. Therefore they are subject to salt water tidal currents and they do not benefit from the protection of burial. Hence, one of the concerns for HQD relates to the possible occurrence of any insulation degradation that could be associated with local or global water ingress. Also, in order to allow for accurate planning of refurbishment or system upgrades, it is of interest to be able to monitor the evolution of the health (or condition) of the insulation with time.

In order to address these issues, a diagnostic testing program was initiated. The objective of this program was to measure and eventually monitor over time the global insulation condition of a set of selected submarine cables, using dielectric spectroscopy. For this purpose, dielectric loss was characterized, for a set of voltages up to operating voltage (U_0).

Phase 1 of this project consisted of performing an initial condition assessment for each cable. The plan for phase 2 will include the acquisition of trending information from subsequent measurements made at regular intervals (ex. 3 to 5 years). This paper presents the results for phase 1. A preliminary condition assessment will also be discussed.

SPECIAL ISSUES WITH SUBMARINE CABLES

Compared to those installed in traditional cable systems (URD, feeders, etc.), submarine cables present a number of special issues.

Length: In most cases, submarine cable segments are very long compared to those of traditional underground land cable systems. Instead of one to several hundreds of meters, submarine cables lengths tend to be in the range of one to few thousands meters.

Architecture: In addition to being characterized by much greater lengths, submarine cable systems have typically very few or zero joints.

Value: Installation costs of submarine cables are typically much higher than that of traditional land cable systems: generally at least several times more expensive on a per unit length basis.

Criticality: In addition to the cost, installation of submarine cables requires much longer times than land cables: the cable supply needs to be planned well in advance and the installation process is far more complex and takes longer time. Also, in many instances, utilities cannot afford to operate on more than one cable. Hence, reliability is a key issue since there is typically no backup. The criticality issue has a great impact on testing strategies: diagnostic techniques and procedures are expected to be selected in a way that minimizes the risk of failure on test.

Effort: Given the value and criticality of submarine circuits, submarine cable operators naturally tend to be more willing to invest in testing efforts in order to maximise the amount of information that could be obtained on the condition of the cable system while favouring the best achievable accuracy. Concerns would be leaning more on the “input” issue compared to land cable situations where the attention is more typically focused on the “throughput”.

DESCRIPTION OF SUBMARINE CABLES TESTED

The study presented in this paper covers 7 submarine cable circuits, each consisting of three-phase (3φ) medium voltage (MV) cables operated at 25 kV, including: