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Dielectric Loss Characterization of Hydro-Québec Medium Voltage (MV) Submarine Cables - Phase 1

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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 St Lawrence River. These links constitute critical assets in the HQD underground system, as they represent the only source of power for the inhabitants of these islands, and significant capital replacement value. 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.

Until 2007, none of these cable systems had ever been subjected to any diagnostic testing. At this time a test program was initiated to obtain numeric re-interpretable data to assess the health of these cable systems. All the submarine cable systems in this study are protected against water ingress with lead sheath and mechanically protected with steel wire armor screen. However, most of them are simply laid on the river bed ; 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 degradation of the insulation that could be associated with any local or global ingress of water. Also, in order to allow an accurate planning of refurbishment or upgrading projects, the need has been identified to make it possible to monitor the evolution of the health (or condition) of the insulation with time.

In order to address these issues, a diagnostic test program was started, the objectives being to measure and eventually monitor in time the global condition of the insulation of a set of selected submarine cables, using dielectric spectroscopy. For this purpose, dielectric losses were characterized, for a set of voltages up to operating voltage (U_o), using Time Domain Spectroscopy (TDS) (Jicable 2007 B.6.3) and VLF Tan delta performed at various frequencies (0.1Hz and 0.02Hz). Seven submarine cable 25kV three phase circuits were selected for this study:

- 3 XLPE based insulation cables (1973, to mid 1980s);
- 1 EPR based insulation cable (1997)
- 3 paper based insulation cables (1962, to 1981)

Phase 1 of this project consisted of performing an initial condition assessment for each cable (Figure 1 shows data for paper cables). The plan for phase 2 will consist of acquiring trend data by performing subsequent measurements at regular intervals (ex. 3 to 5 years).

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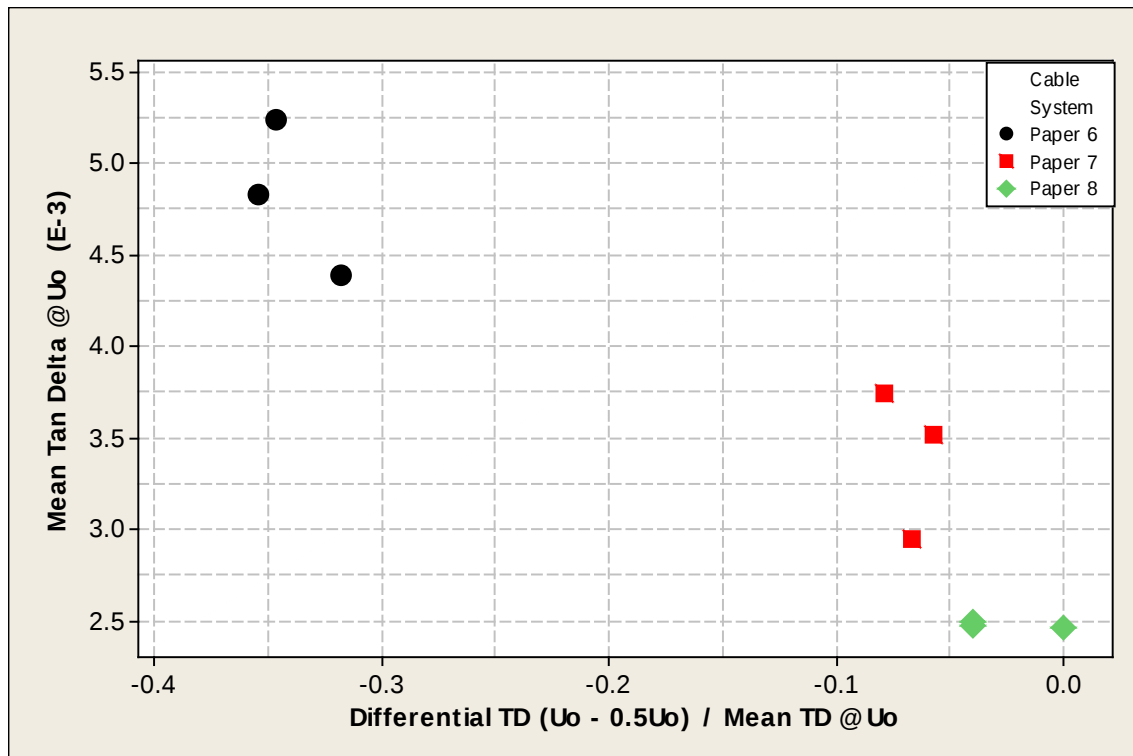


Figure 1: Differential and Mean Tan Delta data for paper insulated submarine cable systems

This paper presents the results for phase 1. A first preliminary condition assessment will be discussed, based on observations regarding:

- VLF Tan delta values in terms of diagnostic features such as time stability, voltage dependence (tip-up) and absolute Tan delta values;
- Shape of dielectric loss spectrum vs. frequency;
- Comparison between different phases within same circuits or between similar circuits.

Finally, the advantages of combining TDS and VLF loss data for performing a better condition assessment of cable insulation will be discussed. The discussion will also address the particular issues associated with the assessment of submarine cables.

Key words: Submarine cables; TDS; VLF, Dielectric spectroscopy