Q. **System Protection**

Explain how Hydro protects its transmission lines and its distribution lines from lightning and switching surges. Include in the response whether Hydro has a practice of installing metal oxide varistor (MOV) arresters on its pole-mounted distribution transformers.

A. Hydro transmission and distribution lines are protected from lightning surges by the use of lightning rods on each transmission structure. For wood pole lines, the lightning rod is connected to a solid steel wire which runs down the length of the pole and is connected to a counterpoise system at the base of the structure to dissipate the energy. For steel structures, the lightning rod is physically connected to the steel lattice structure and the structure is connected to the counterpoise system by means of a solid steel jumper at the base of the structure. All hardware on the structures is also connected to either the steel wire or structural lattice to protect it from lightning strikes.

With the exception of transmission lines TL206 (Bay d'Espoir to Sunnyside) and TL233 (Buchans to Bottom Brook), the existing Hydro owned transmission lines on the Island Interconnected System do not have continuous overhead ground wire along their entire length for lightning protection. TL233 was equipped with overhead ground wire along its entire length when constructed due to the known incidence of lightning along its route. TL206 was retrofitted with lightning arresters on each phase at each tower along its entire length due to operational experience with numerous lightning strikes resulting in the loss of both TL206 and its parallel circuit TL202. For new transmission line construction at the 230 kV voltage level Hydro considers the addition of overhead ground wire (OHGW) with integrated

fibre optic cable prudent for both lightning protection and high speed communication between stations.

All terminal stations are protected from lightning strikes by the installation of 1.6 km of OHGW on each transmission line entering the terminal station. As well, lightning arresters are used on both the high and low voltage windings of power transformers.

In Hydro distribution, MOV lightning arresters are required for applications of capacitor banks and submarine cables. Lightning arresters are also installed on distribution transformers in areas of high isokeraunic levels (i.e., areas which have a high incident rate of lightning strikes). Lightning arresters are also employed on the substation ends of overhead distribution lines in areas of high isokeraunic levels.

With respect to switching surges, Hydro employs surge arresters on its 230 kV and 66 kV switched shunt capacitor banks for transient over voltages associated with capacitor bank switching.

For transmission lines, surge arresters for line switching surge protection were not applied in the original system design. At the 230 kV transmission level the original circuit breakers were air blast type circuit breakers. At the 138 kV level, both air blast and bulk oil circuit breakers were employed and at the 66 kV level, bulk oil circuit breakers were employed. Hydro's transmission lines consist of relatively small diameter conductors and, subsequently, at the transmission line lengths, the capacitive line currents are not excessive. For example, Hydro's longest 230 kV transmission line on the Island has a capacitive current of approximately 61 A and its longest 138 kV line has a capacitive current of approximately 42 A. By comparison, Table 3A of ANSI Standard C37.06-1987 Table 3A lists the preferred

Capacitive Current Switching Ratings for general purpose circuit breakers at 160 A for 242 kV class circuit breakers and 63 to 80 A for 145 kV class circuit breakers.

There have been a limited number of detailed engineering studies for Hydro's Island Interconnected System with respect to transient over voltages. Results from the studies indicate transient over voltage factors of 2.04 for the 230 kV system, 1.4 on the 138 kV system, and 1.5 to 1.9 on the 66 kV system. By comparison, Hydro's transmission lines are designed according to the CSA Overhead Systems standard (CSA C 22.3), which utilizes transient over voltage factors of 2.75 at 230 kV, 3.0 at 138 kV, and 4.0 at 69 kV and below to ensure adequate air gap clearances on structures for all transients.

Using the three phase short circuit level as the measure of system strength, the 230 kV transmission system on the Island is relatively weak. As an example, the maximum 230 kV three phase short circuit level is approximately 20 kA. By comparison, the smallest standard offer from circuit breaker manufacturers in the 245 kV class has a symmetrical interrupting rating of 31.5 kA.

Operating experience of the Island Interconnected System has not revealed equipment issues related to significant switching surge over voltages to date.

Hydro is aware that Gas Insulated Switchgear (GIS) switching operations can result in significant very fast front transient over voltages. It is noted that the 230 kV GIS at Cat Arm is equipped with surge arresters on the 230 kV bus at the Cat Arm Terminal Station. Further, with the replacement of original air blast circuit breakers with gas insulated (SF_6) circuit breakers, Hydro will be installing surge arresters on 230 kV line terminations in SF_6 circuit breaker stations where determined necessary.