HYDRO-QUÉBEC EXPERIENCE WITH INFRARED IMAGING FOR THE MAINTENANCE OF THE UNDERGROUNS MEDIUM-VOLTAGE CABLE SYSTEM

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ABSTRACT

This article describes Hydro-Québec's experience with using infrared imaging for underground distribution system maintenance. The inspection technique is presented, followed by an explanation of the method used to conduct diagnostic tests on joints and terminations on energized MV underground cables, both on- and off-load. The various types of anomalies encountered are described and the ensuing maintenance interventions are outlined. Lastly, the results are presented, demonstrating the efficacy of this approach in improving system reliability.

KEYWORDS

Maintenance, infrared, thermal imaging, diagnostic, medium-voltage cable joints.

INTRODUCTION

Hydro-Québec Distribution has over 10,300 km of 12-kV and 25-kV medium-voltage underground cables. The system is almost entirely composed of duct-installed bare concentric neutral cable, with 28-kV XLPE or TR-XLPE insulation. Approximately 380,000 joints of different types, all rated 25kV, are installed in 32,000 manholes.

Because of the high voltage present on the distribution system, an arc is created when a fault occurs on equipment. The power and energy dissipated by this arc depend on the short circuit current at the point of fault. The consequences will vary in severity, depending on the arc power and energy and on the type of equipment. The main effects of a fault are as follows [1]:

- production of hot gases, flames, and dust potentially harmful to the health of the workers if inhaled in large quantities; this could also reduce visibility;
- rupture of the faulted equipment and violent projection of pieces of metal and other materials, hot gases, flame, smoke, etc., dangerous for the workers and possibly damaging to surrounding equipment;
- violent sound impact that can temporarily reduce or even permanently damage the workers' hearing;
- very intense flash containing ultraviolet rays that can blind the workers, damage their sight, and burn the skin;
- strong temperature elevation that can cause burns and breathing difficulties;
- risk of electrocution for any worker who comes in contact with the arc;
- pressure rises due to a rapid elevation of temperature.

Cable joints in manholes are considered as possible weak elements, causing around 70% of cable system failures in 2001 at Hydro-Québec Distribution. Considering the need to perform effective maintenance and to reduce the risk to workers of defective joints, a thermal imaging maintenance program has been in continuous development at Hydro-Québec since 2000.

TECHNIQUE

Thermal imaging with an infrared camera is a well-known technique for the maintenance of electrical equipment. Its application to medium-voltage equipment is not a trivial task, due to heat transfer through the insulation layers. The thermal imaging program is performed on energized joints and terminations accessible in manholes. More than 98% of the Hydro-Québec Distribution cable system is installed in conduit and manholes.

The inspection is a three-step process. First, a survey is performed from outside the manhole. The main objective is to ensure safe entry into the manhole. Second, after the worker has entered the manhole, the current load is measured on each specific accessory. Finally, the current values are input into a dedicated diagnostic software program developed at IREQ (Institut de recherche d'Hydro-Québec). A vehicle has been specially equipped for infrared imaging inspections, including compartments for the equipment and a computer to run the software.

To perform the first step from outside the manhole, the infrared camera is placed in a protective housing with a remote-controlled pan and tilt, all mounted on a pole. Figure 1 shows the arrangement. Images are sent to the worker sitting in the vehicle.

Figure 1. Left: housing with pan and tilt; right: pole placed into manhole

In this first step, the operator looks at the infrared spectrum and the visible spectrum for anomalies. If there is any object with a temperature exceeding 130 degrees Celsius or an abnormal heat pattern (see Method section), the inspection is halted and manhole entry is prohibited until the abnormal accessory has been de-energized and replaced. Otherwise, the worker is allowed to enter the manhole to measure the current load. The load is measured with a clip-on ammeter, and the values are used in the diagnostic.