A NEW TESTING METHOD FOR LV UNDERGROUND CABLE INSULATION

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ABSTRACT

This paper presents the development of a new method for verifying the mechanical integrity of the insulation of low-voltage cables in order to ensure a quality installation and prevent potential arcing faults. The approach consists in injecting compressed air into the cable core and observing the subsequent pressure variations. The diagnosis of insulation failure (leak) is based on the reduction rate of the pressure of the air stored in the cable once the injection has been stopped. Conclusive results were demonstrated during a comprehensive laboratory validation program as well as on the distribution network. Prototypes developed based on this method were successfully tested on Hydro-Québec's underground distribution network. Following the conclusive results of the test, Hydro-Québec has decided to implement this technology in 2012.

KEYWORDS

Low voltage cables, Cable insulation verification, LV arcing fault

INTRODUCTION

The development of an arcing fault on low-voltage (LV) cables in an underground duct is likely to have harmful consequences. Gases generated by the degradation of materials near the fault (pyrolysis of insulating materials and/or electrolysis) may create violent explosions. The main cause of this phenomenon on Hydro-Québec's network is likely insulation failure (latent fault) which dates back to when the cables were installed.

Conventional protection systems (e.g. fuses, circuit breakers) are not capable of eliminating this type of fault, which is often intermittent. It develops quite randomly and may occur over a long period of time (even hours). Furthermore, dielectric tests are not effective for detecting insulation failure in a dry environment.

Several studies were conducted in the past on this phenomenon [1, 2]. In 2003, CEA Technology carried out a research program in view of developing a solution to quickly interrupt arcing faults [3]. Several universities and utilities, including Hydro-Québec, took part in the program. However, the study concluded that there is no effective way of preventing arcing faults at an affordable cost using an electrically-based approach.

A certain number of faults of this type occurred on Hydro-Québec's low-voltage distribution system as well as at other electrical utilities with the same type of installation. Though their frequency is very low, the consequences can be serious for public safety and for the installations.

Two examples of violent explosions created by an arcing fault on low-voltage cables are shown in Figures 1 and 2.

To deal with the situation, Hydro-Québec decided to develop a new method and device for verifying the mechanical integrity of the insulation of the low-voltage cables installed in ducts by pulling.

Fig. 1: Explosion in an underground vault

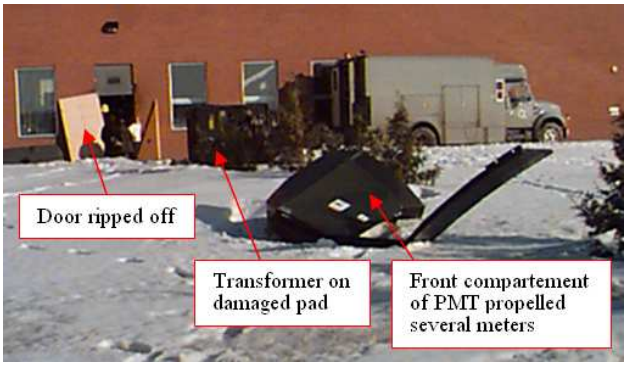

Fig. 2: Explosion in the connection cabinet of a pad-mounted transformer

The cables used in Hydro-Québec's low-voltage underground distribution network (240/120 V and 600/347 V) are made up of a core formed of aluminum or copper strands, and an insulating layer made of cross-linked polyethylene (Fig. 3). The cable/neutral assembly, consisting of two or three phase conductors (2 AWG to 1000 kcmil) with a copper neutral, is installed in the form of a twisted bundle in a PVC duct.

METHOD

The new method for verifying the insulation of LV cables consists in injecting compressed air into the cable core and of observing the changes in pressure after the injection is stopped. The detection of insulation failure (leak) is based on the reduction of the pressure of the air contained in the cable.

Numerous tests were conducted in the laboratory to develop a method based on this principle that is capable of meeting the performance requirements related to its implementation on Hydro-Québec's distribution network.

Several variants were assessed on the optimal way of injecting air into the cable and the effectiveness of