A STUDY ON THE EFFECT OF PERFORMING VLF WITHSTAND TESTS ON FIELD AGED DEGRADED JOINTS

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ABSTRACT

In this study, VLF withstand tests were performed on MV joints with various levels of degradation. Joint samples were identified in the field as those showing abnormal heat patterns during infrared imaging examination. A total of 30 aged joints were removed from service and tested in laboratory. The resulting effect of VLF withstand on their condition was evaluated by comparing the surface temperature rise and dielectric loss after vs. before performing the VLF withstand test. In addition, VLF diagnostic features relating to the condition of the joint were investigated and are discussed in terms of their applicability to cable systems according to the length.

KEYWORDS

Diagnostic, Joint, VLF withstand, Dielectric loss, VLF Tan Delta, Time Domain Spectroscopy (TDS), Infrared Thermography (IT)

INTRODUCTION

Hydro-Québec Distribution (HQD) system includes over 10,300 km of 12 kV and 25 kV medium voltage underground cables. It is almost entirely composed of duct-installed bare concentric neutral cables, with 28 kV XLPE or TR-XLPE insulation. The present architecture includes around 32,000 manholes into which are installed a total of ~380,000 joints of different types, all rated 25 kV.

Maintenance practices at HQD include manhole inspections aimed to detect defects or anomalies on any joint or cable. Energized components are examined with an infrared thermography (IT) imaging system [1] and afterwards, are checked for partial discharge (PD) presence. In addition to those inspections and subsequent maintenance actions, up to April 2011, withstand tests were performed on every new cable circuit or following a repair.

The method that was used for withstand testing was a direct current (DC) test according to IEEE 400 1991™ [2]. In the near future, HQD considers introducing very low frequency (VLF) withstand testing for maintenance as described in IEEE 400.2™ [3]. Accordingly, for 25 kV systems, testing would be performed with VLF sine 0.1 Hz at 23 kV_{rms} for 30 minutes.

The anticipation of such a change in withstand testing methods brought to the fore several interrogations about how aged cables and joints will behave under test and after return to service. One of the main concerns is related to joints showing thermal anomalies (“Hot Spots” (HS)) under IT examination. Such anomalies are known to be associated to local degradation in the bulk of the joint’s insulation.

Therefore, an experimental project has been undertaken at IREQ (Hydro-Québec Research Institute) in order to investigate the effect of performing VLF withstand testing on the properties of the insulation of joints with various levels of initial degradation. The aged joint samples (some showing HS) were taken out of service and recovered individually, with a special care taken to keep approx. 1 m of cable on each side, in order to allow performing proper HV testing in the lab. Right after being prepared for testing, all joint samples were stored immersed in water until ~24-48 h prior to the testing time. Keeping the joint body in the water was done in order to preserve the worst possible condition of the insulation. Two types of joints being known for having the highest failure rates at HQD, were investigated: type A is a disconnectable straight splice with taps design and type B is a pre-molded straight splice design. All samples have been operated for 20 to 30 years in service.

The influence of performing VLF withstand tests on joints was evaluated by monitoring the variations of their dielectric properties after vs. before the execution of a withstand test, using several diagnostic features (mainly dielectric loss and surface temperature pattern evaluations).

Another objective of this study was to investigate the VLF loss diagnostic features according to type and severity of joint degradation. A particular attention was given to the possible application of such diagnostic features to various scenarios of cable systems. The concern is to see how diagnostic outcomes would show-up for a whole circuit, according to the length, assuming the presence of one of the most degraded joints of this study.

EVALUATION PROTOCOL

The test protocol used for this investigation is shown in Figure 1. It is based on the principle of performing a “pre-characterization” prior to the VLF withstand, followed by a “post-characterization, aiming to evaluate the differences of monitored features “after” vs. “before” the execution of the VLF withstand test. The monitored features are the surface temperature characteristics, measured through an infrared (IR) thermography examination protocol, and the dielectric loss measured with Time Domain Spectroscopy (TDS) [4].

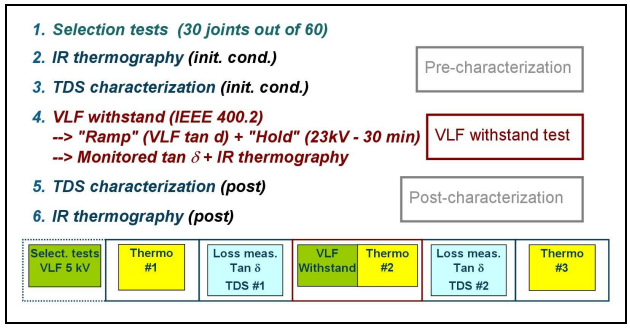

Figure 1: Test protocol for joint condition evaluation