Close and Return

DEVELOPMENT OF DIAGNOSTIC PROCEDURES FOR XLPE CABLES WITH WATER TREES

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ABSTRACT

This paper describes the results obtained and work in progress for a research project to develop condition assessment techniques for water treeing in medium voltage XLPE cables. The research was initiated after Ergon Energy experienced failures of 22kV XLPE insulated cables and management sought data and expertise that would allow them to manage a problem that had the potential to cause serious disruptions to the network. The research was carried out in close collaboration with Ergon Energy and with a strong focus to achieve a practical outcome suited to the special requirements of the Authority. It involved long term laboratory ageing experiments, application of dielectric response measuring techniques, field test on suspect cables as well as modelling of the dielectric responses and correlation of the results with the laboratory and field measurements.

KEYWORDS

Water tree, Australia, Forensic Analysis, Non Destructive Diagnostics, Accelerated Ageing, Electric Field Modelling, Field Testing.

INTRODUCTION

Ergon Energy is a power authority responsible for power supply to Queensland except for the more heavily populated south east corner surrounding the capital city of Brisbane. Queensland is a large state in the northern half of eastern Australia and outside its south east corner has a number of smaller but reasonably large cities separated by large sparsely populated regions. This favours the use of equipment that was light, suitable for air transport and could provide results in a short testing period.

Water trees had not been discovered in Australian cables until recent repeated failures of 22 kV cables in North Queensland were attributed to the presence of water trees. Subsequent investigations suggested that the conditions leading to water tree development occurred in a significant proportion of existing cables. There was therefore a requirement to establish procedures for managing degrading cable networks to maintain high reliability whilst at the same time keeping down costs. The first step was to carry out a comprehensive literature search on experience and research on water trees was carried out and documented. This provided the basis for formulation of a program to obtain data and develop techniques that could be used by Ergon in development of their asset management programme. In this paper the programme of research undertaken is described. The primary focus of the research is to develop a better understanding of water treeing and develop techniques that are of practical use to Ergon Energy.

DESCRIPTION OF THE PROJECT

The project originally envisaged four areas of investigation as follows:

- **Ageing experiments**
  In development of these tests the procedures described in IEEE Standard 1407 were used. Accelerated ageing was carried with current circulating in the cables and a voltage of $3U_0$ in water baths of "distilled" water with controlled impurities and held at a temperature of 50°C. The "time to failure" test option with regular non destructive diagnostic measurements was used.
- **Dielectric response measurements**
  The diagnostic measurements included time and frequency domain tests. These were carried out at regular intervals in order to observe the progressive deterioration of the insulation.
- **Computer modelling**
  The aim of this work was to postulate a model of the conduction as well as the polarisation effects of the insulation together with bow tie and vented water trees of differing densities, distributions and electrical characters. Using this model polarisation and depolarisation current (PDC) would be obtained and compared with data from the field and the laboratory. In this way macroscopic characteristics can be examined for their effect on the PDC. There is also an interest in short testing times to facilitate field testing and these models would assist in obtaining a better understanding of time domain testing.
- **Forensic Analysis**
  Analysis of failed samples and model development requires knowledge of the water tree structure in the cables being studied. To this end a technique to allow slicing of the cable insulation and recording the 3D nature of water treed sample has been developed and is described below. Also knowledge of chemical nature of the water tree sites is valuable input for these studies and these will be carried out as required.
- **Field Tests**
  This provides valuable data on response of field cables and the effect of terminations and joints. Comparison of laboratory results with field data will also enable evaluation of the results from the laboratory tests.

PROJECT IMPLEMENTATION

Close attention was paid to the IEEE Guide to meet the aim