Dielectric diagnosis of extruded cable insulation by very low frequency and spectroscopic techniques - A few case studies

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ABSTRACT

This paper presents few case studies of condition assessment of extruded cables using very low frequency and spectroscopic techniques. Distribution cables rated 22 kV which were submerged under water were assessed using VLF technique in addition to other techniques like insulation resistance and dc voltage withstand test. Few case studies of using low frequency partial discharge measurements for localisation of incipient faults are also presented and discussed. Studies indicate very low frequency tan δ and partial discharge techniques are promising tools for condition assessment of long length cables.

KEYWORDS

Dielectric diagnosis; very low frequency tan δ, Water logged cables, VLF PD.

INTRODUCTION

Electric transmission and distribution network comprises of large number of power cables which are quite expensive and form significant portion of the network. More importantly they are vital components for reliable delivery of electric power. However, the reliability of power distribution depend to a large extent on the healthy condition of the extruded cable insulation. Power cables with extruded insulation like EPR, PVC, XLPE are largely used in distribution & transmission network and these cables undergo different stresses during their service life period leading to insulation degradation and deterioration and hence forced outages. Forced outages are of serious concern and are not economical. In order to check healthiness of a cable system, it is important to perform diagnostic tests on in service cables. Though several diagnostic test methods like measurement of Insulation resistance, Polarization index, Dissipation factor, Loss angle and capacitance, VLF testing exist, there are certain merits and demerits in each technique and no technique can give the complete information about the healthiness of the cable. Applying effective technologies and remedial measures can reduce costs and improve the performance of cable systems. Lot of research efforts and activities are directed towards better understanding of degradation phenomena and finding suitable techniques for insulation diagnosis and remaining life estimation techniques. This paper presents and discusses few case studies of condition assessment of extruded cables using very low frequency and spectroscopic techniques.

Evaluation techniques

Techniques used in the present study include Insulation resistance, very low frequency tan δ, capacitance, PD measurements and dielectric spectroscopy.

VLF testing

Measurement of tan δ & capacitance or partial discharge of long length cables at power frequency by conventional bridge methods require large and expensive test sources for energizing the cable. Therefore measurements using either VLF test sources or resonant transformers are preferred. The main advantage of VLF testing is that lower rating test source is required for onsite testing. The power requirement at 0.1Hz is 500 times less compared to 50Hz.

The VLF tests at frequency 0.1, 0.05, 0.02, or 0.01Hz produce the same dielectric stress as at power frequency without deteriorating the cable due to harmful effects of DC polarization. Long length of cables can be charged using test sources operating at lower frequencies thus enhancing the range of the equipment. The VLF tests are conducted at voltages 1.5 to 3 times Uo. Special VLF source can charge cables up to 50 μF. VLF AC test equipment can be extremely useful for locating cable faults, thereby reducing fault location.

Dielectric spectroscopy (Dielectric response in frequency domain)

Dielectric spectroscopy measurement technique is essentially a dissipation factor measurement performed at multiple frequencies ranging from a few milli Hz to kHz. In principle, dielectric spectroscopy may be used to detect dipole orientation effects, and thereby detect increase in the polar molecules due to ageing, moisture absorption, contamination and incomplete curing. Changes in permittivity in the frequency domain may also reflect space charge polarization or partial discharges that can occur in composite insulation having internal voids. The plot of ε'' versus frequency may be used to evaluate increased losses due to change in carrier movement, polarization effects and partial discharges.

CASE STUDIES

A few case studies of condition assessment of extruded cables using very low frequency and dielectric spectroscopy techniques are discussed in the succeeding sections.

Case study 1

Insulation diagnosis was carried out on 11kV, 3 x 400 mm^2 XLPE cable which was in service in one of the steel industry that had failed abruptly. From the failed cable a section of healthy part approximately 18 metres long was cut and diagnostic tests were conducted on individual phases separately. The measured insulation resistance