Experiences with Asset Condition Assessment of Aged HV& EHV Solid Dielectric Circuits

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ABSTRACT

This paper reports on a data base of aged solid dielectric cable systems rated 69kV through 230kV aged 14 years to 44 years which has been subjected to diagnostic asset condition assessment tests. The paper outlines the test methodologies used for both on-line and off-line PD measurements and reports on the findings including PD occurrence rates for accessories and cable system in-service performance after testing.

INTRODUCTION

A combination of near power frequency AC Withstand and Partial Discharge (PD) testing has been the accepted practice for commissioning of High Voltage (HV) & Extra High Voltage (EHV) solid dielectric cable circuits since the late 1990'ties. Voltage levels and durations as well as and partial discharge test methodology employed for commissioning are largely agreed upon and described in various standards and technical documents including but not limited to IEC 60840, IEC 62067 and Cigre TB 728 and Cigre TB 841.

While experience with maintenance testing of medium voltage solid dielectric cable systems is quite strong and rooted in more than 20 years of test experience, experiences with condition assessment of aged HV & EHV cable systems is however less. In the past 5-7 years, asset condition assessment of older, aged HV & EHV circuits via electrical testing such as on-line PD and off-line PD at elevated voltage have become standard practice for some large transmission utilities in North America. In addition, for a subset of HV & EHV circuits additional electrical tests have such as LIRA, loss factor measurements including dielectric spectroscopy have been included in the measurement mix.

This paper reports on experiences gained condition assessment of older 69kV through 230kV solid dielectric circuits via off-line HVAC and Partial Discharge measurements. The circuits tested were aged 15 years with off-line PD testing at elevated voltage of solid dielectric cable circuits rated 69kV through 230kV rated solid dielectric circuits aged 14 years through 38 years at the time of testing. The paper outlines the test methodologies used for both on-line and off-line PD measurements and reports on the findings including PD occurrence rates for accessories and cable system in-service performance after testing.

BACKGROUND

In North America and the rest of the world, HV cable systems installed in the 1980'ties and later are approaching their end of mean-life (40 years). However, in-service cable failures remain rare and are largely confinded to accessories [3]. As such, in the past 5-7 years, north American utilities have experimented with spot on-line and off-line PD testing of older HV cable systems in order to provide for a data based asset condition assessment approach and with the intent to identify assessories at risk of failure and thus engage in preventive maintenance potentially resulting in life extension of the cable system.

As well, as well, during a test related outage, maintenance over sheath tests (jacket integrity tests), sheath voltage limiter tests and linkbox inspections would be performed. For joints installed in manholes (vaults) as often is the case in north America inspections of the mechanical support system would also be performed.

With respect to deciding for an on-line PD test or an off-line test often depends on the criticality of the circuit, of the in-service performance of similar circuits and the the operating environment of the circuit. For instance, for HV terminations located in coastal areas a tendency towards on-line PD spot tests has been seen in North America possibly followed by off-line testing at a later date. Wherewas for critical circuits or circuits containing joints, off-line testing would be considered with on-line PD measurement being omitted.

OFF-LINE TEST METHODOLOGY

Up until recently, little guidance was to be found in international standards or guides. However, with the recent publication of Cigre TB 841 some guidance exists with respect to off line PD testing for aged HV and EHV and EHV cable systems [2]. However, the test methodology appied to the group of circuits forming a basis for this paper is slightly different with test durations being reduced.

For PD testing, the test methodology applied is as recommended by [1]. Thus, for jointed circuits a distributed PD measurement with PD being acquired at all accessories at high voltage has been performed. For non-jointed circuits, a dual end partial discharge measurement has been performed.

At each measurement location, an sensitivity assessment was performed : For terminal PD measurements on short lengths of non-jointed cable systems, a known charge was injected similar to the methodology presented in IEC 60270. For distributed PD measurements where clamp-on High Frequency Current Transformers were placed around bonding cables at accessories a known signal (charge) was injected on the bonding lead and the response recorded. As well, though not recommeded in [2], prior to applying voltage a noise measurement would also be performed and recorded.

For most cross-bonded or directly grounded joints, clamp on HFCTs would be placed around the bonding leads. The HFCTs has a frequency response of approximately 300khz to 60MHz and has, in a shielded environment, a sensitivity down to 1pC of apparent charge. An example of an HFCT clamped around a bonding lead is given in Figure 1. In the case of 'through joints', i.e. no bonding leads are accessible, capacitive sensors were placed on the outside