Laboratory investigation of a service aged HV cable termination

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ABSTRACT

In this paper, some issues of diagnostic tests (PD, tan delta, voltage withstand) of HV cable lines are presented. This case-study emphasizes the role of detection of local degradations besides the general condition assessment of the insulation. The partial discharge tests (DAC offline method) detected the weak points of the cable line, which were the porcelain outdoor terminations. Considering the results of PD tests, the porcelain outdoor terminations were replaced and diagnostic test were executed before taking the line into operation. Finally, the steps, results and experiences of the laboratory examination of deteriorated outdoor porcelain termination are presented and discussed.

KEYWORDS

high voltage cable termination, partial discharge, damped AC, field testing, weak spot analysis, voltage withstand test, laboratory test

INTRODUCTION

Almost all utilities operate extensive cable networks therefore the reliable power supplying requires the proper condition of the cable lines. From the point of view of reliability, the weakest points of these lines are the cable accessories such as terminations and joints and the failure of these components can result in serious consequences [1]. Moreover, the new stresses e.g. repetitive pulses generated by inverters can also reduce the reliability of the cable accessories [2, 3]. Therefore, the regular or on-line diagnosis of these components have become more and more important [4-7].

The cable accessories are very complex components moreover, they are assembled on-site and in many cases the environmental and weather conditions are not satisfying for the perfect assembly. Hence, the commissioning test of cable lines is one of the most important issues nowadays [8,9].

The most common condition monitoring techniques for cable accessories are based on partial discharge (PD) measurement because these methods are feasible to locate the sources of PDs. Several partial discharge measurement techniques have been developed to diagnose high voltage cable lines and accessories, as well.

In this paper, a case-study of a high voltage cable termination diagnostic is introduced.

Three 64/110 kV cable lines were operating from 1977 to supply an industrial customer. During almost entire lifetime they were operating reliably without any outages. Considering their age (more than 30 years) and the customer's demand of stable and reliable supplying, the utility company decided to investigate the condition of insulation of each line. For condition monitoring, damped ac technique were used and the result of the measurement showed occurrence of partial discharge in one end terminations of cable line. The terminations were replaced and the measurements after the replacement verified the substitution: the partial discharges disappeared. One of the terminations was dismounted and investigated in laboratory.

DIAGNOSTIC TEST ON A XLPE CABLE LINE

The applied diagnostic tests have been carried out with damped ac offline method on all three cable lines. In addition, withstand tests were carried out on each line by 50 damped ac voltage cycles.

As part of diagnostic tests both partial discharges and dielectric loss measurement up to $1.7V_0$ were executed. The measurements were carried out in summer of 2014.

Two lines of them have passed on the tests however, on the third one intensive partial discharge (PD) activity was detected.

Measurement results

The 2806 m long 64/110 kV HV cable line was mounted with porcelain insulated outdoor termination on the near end while on the far end GIS indoor sealing terminations were used. The investigated cable line consists of 4 straight joints and 2 grounded joints in each phases.

The results of the tests can be seen in Table 1.

	L1	L2	L3
GroundNoise [pC]	77	81	80
PDIV [kV RMS]	51.3	70.4	62.8
PDEV [kV RMS]	45.7	64.5	57.6
PDmax [pC] (PDIV)	84	187	1539
PDlevel [pC] (PDIV)	47	92	304
PDmax [pC] (Uo)	1583	157	1539
PDlevel [pC] (Uo)	1011	73	304
PDmax [pC] (1.7*Uo)	13346	27810	35785
PDlevel [pC] (1.7*Uo)	9229	8049	13277
PDmax [pC] (2*Uo)	-	-	-
PDlevel [pC] (2*Uo)	-	-	-
Capacitance [uF]	0.511	0.510	0.508
Frequency [Hz]	74.24	74.32	74.44
Diel. Losses	0.1 %	0.1 %	0.1 %

Table 1.

Since the background noise was relatively low the PD measurement was sensitive enough. The PD evaluation was carried out simultaneously by the usage of conventional PD detection according to the IEC 60270 standard and by the evaluation of time domain reflection that is used for determining the location of partial discharges.

Fig. 1-3. show the phase resolved partial discharge diagrams of single and multiple periods of sine wave at V_0 and $1{,}7V_0$ on different phases according to the IEC 60270 standard.