UHF PARTIAL DISCHARGE DIAGNOSIS OF PLUG-IN CABLE TERMINATIONS

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ABSTRACT

The experiences in on-line application of the ultrawide band partial discharge (PD) detection in high voltage plug-in cable terminations are presented. Issues of sensitivity of capacitive and inductive field couplers (sensors) are discussed. A series of comparative tests was done using an artificial defect to establish a link between peak voltage, as well as the energy of UHF pulses and the corresponding apparent charge, provided with a conventional IEC 60270 method. Examples of the UHF phase resolved PD measurements and measurements with a power detector are given. Experiences from a field testing are reported as well. The diagnostic system can be applied as a quality check on the just assembled terminations, as well as for the purposes of the condition assessment of insulation integrity after years in service.

KEYWORDS

Partial discharge (PD), UHF, on-line diagnostics, termination, sensors.

INTRODUCTION

A failure of a high voltage power cable causes a service interruption, costly location, repairs and loss of revenues. Utility experience shows that poor termination and jointing is a major cause of cable failure. This is due to the fact that, in contrast to the cable itself, these components have more complex structure, sometimes even with several dielectrics, and increased field gradients. But moreover they are assembled and installed under on-site conditions and thus exposed to the higher risk of defects and contaminations.

Modern plug-in cable connectors (terminations) for GIS and transformers are made from silicone rubber. The electrical life span of this high polymeric material normally exceeds 40 years, but only in absence of PD activity that inevitably causes material degradation. Several IEC standards, e.g. IEC 60840 [1], prescribe routine tests on the prefabricated components of HV cable accessories to be carried out by manufacturers. Unfortunately, there are no standards for testing a complete accessory yet. But an improper assembly done under on-site conditions can strongly affect the long-term performance of the completed accessory. Therefore, to make sure that the assembly was done immaculately, a quality check is often desired by utilities.

Another application field of the presented test technique is a condition monitoring of cable accessories in order to predict failures before they occur. Those accessories that are about to fail can then be replaced, thereby reducing the risk of cable system failures and improving the overall quality of power supply.

Partial discharge measurement is a well established criterion for the condition assessment and quality control of the high voltage electrical insulation. PD, originated from a microdefect, incepts periodically according to ac cycle of the operation voltage and gradually degrades and erodes the polymeric material, eventually leading to breakdown. To detect such a PD activity under conditions of on-site on-line testing, the ultrawide band PD (UHF PD) diagnosis principle can be deployed. This method is based on sensing the electromagnetic emissions from discharge sites in the insulation. The coupling sensors should be placed possibly close to the test object and effectively screened against outside interferences.

Although there are several well known off-line test techniques, which are successfully applied to diagnose long power cables including their accessories, they all need load flow re-dispatching and a separate voltage source to energize the cable line apart from the network. The on-line test approach overcomes these difficulties allowing sensitive measurement on the terminations, while the cable is in normal operation. This contribution discusses the experiences in on-line UHF PD diagnostics of high voltage cable terminations.

PRINCIPLE OF DIAGNOSTICS

The occurrence of partial discharges in electrical insulation is always associated with the emission of electromagnetic pulses. A typical PD pulse has a rise time of less than 1 ns and a pulse width of several ns, implying in frequency-domain a bandwidth of several GHz. The electromagnetic emissions propagate in all directions from the PD source. Different materials impose different attenuation rates to the travelling waves. In general, the attenuation of the PD pulses is a function of frequency [2]-[3]. The higher the frequency components will be attenuated rapidly when they travel along the cable. Therefore, detecting PD in the UHF band (300-3000 MHz) has the advantage of the distance selectivity of only several meters. This can be perfectly used for the diagnosis of the concentrated equipment such as transformers, GIS, machines and cable accessories. The distributed equipment, e.g. cables, can be effectively diagnosed in HF and VHF bands.

Fig. 1 demonstrates the principle of UHF diagnosis of the plug-in cable connectors. A portable metallic sleeve is clamped around the cable immediately behind the