EXPERIENCE WITH PD MEASUREMENTS AND COMMISSIONING TESTS

Edwin PULTRUM, KEMA, (Netherlands), hvl@kema.com
Hans-Erik KEIZER, KEMA, (Netherlands), hvl@kema.com

ABSTRACT

The commissioning of new HV cable systems is commonly performed by means of an AC voltage test. The experience has shown that a proper combination of test voltage and duration can indeed detect incipient failures. The combination of such an on-site test with partial discharge measurements is relatively new. This partial discharge measurement may give additional information about accessories installed in the circuit. This paper describes the development, advantages and limitations of on-site PD measurements.

KEYWORDS

TAI, commissioning test, partial discharge, PD, on-site, HV

INTRODUCTION

To check the correct installation of a cable circuit a commissioning test is to be performed. These on-site tests or tests after installation (TAI) on HV cables were originally performed with DC voltage and later on with oscillating wave voltages. Nowadays DC is recognised as being ineffective and even more being harmful for XLPE cable systems and oscillating wave voltages have become obsolete for HV cables. The alternative, series resonant testing, is now widely accepted. This is reflected in today's standards and requirements.

A series resonant circuit is made up of a reactor in series with the cable to be tested. This series connection of a capacitor and reactor is usually energised by means of a step-up transformer. In the early days of this type of testing on polymeric HV cables there was a clear preference for variable frequency test systems [1,2]. With a fixed inductance the frequency is tuned to achieve resonance. At resonance, the energy swings back and forth between the cable (electric energy, ½CU2) and the reactor (magnetic energy, ½LI2). Only the losses have to be supplied by the exciter transformer (and frequency converter), such as dielectric losses in the cable, the magnetic losses in the reactor and also e.g. the losses associated with corona. The ratio between the reactive power in this resonant circuit and the losses determines the increase in voltage on the cable as compared to the voltage applied by the exciter transformer. In practice this ratio varies between 100 and 200.

When testing with a sufficient voltage level and duration, e.g. 1,7 U0, 1h for 132-150 kV cable systems, this voltage test as such can do the job of discriminating between circuits without and with a defect, without overstressing the cable. Nevertheless, recent years have shown that there is an interest in combining partial discharge (PD) measurements with this on-site AC voltage test. For MV cable circuits, both extruded and paper insulated, on-site PD measurements are performed for more than a decade. It must be mentioned here that these measurements on MV cables serve a diagnostic purpose, rather than being applied as a commissioning test. But the effectiveness of PD measurements as a diagnostic tool for MV cables, together with a.o. the desire to have even more confidence in the absence of defects in a newly installed cable circuit, triggered requests for this kind of measurements in combination with a regular voltage withstand test.

In this paper the development of the present PD measurement system in use with KEMA's series resonant test set will be discussed. Also the experience with this system will be put forward. Since on-site partial discharge measurement is definitely not a straightforward kind of measurement, the limitations of these on-site measurements are discussed.

DEVELOPMENT

General

Several aspects have been investigated during the development of the present system for on-site PD measurements on HV cable systems: detection, sensor, calibration and processing of data. These investigations were based on the condition that it has to be able to measure on cable circuits not equipped with (integrated) PD sensors. This means that signal pick-up has to take place at one end of the cable. Furthermore, the system has to cope with disturbance pulses produced by the frequency converter that drives the resonance.

Detector and sensor

Unfortunately the traditional PD detectors have only limited use on-site as a consequence of the higher disturbance levels. A quite common solution for on-site PD measurements appeared to be a good means to overcome the problem of disturbance: the use of a spectrum analyzer as a detector. Selecting a proper frequency band results in the optimal S/N ratio. The frequency range where to look for such a low-noise band is largely determined by the condition of single-ended measurement. PD pulses attenuate while propagating through the cable. This attenuation is highly frequency dependant. Based on VLF diagnostic measurements on MV XLPE cable circuits, it has been experienced that small PD pulses propagating through 3 km of cable can still be distinguished from noise. A compromise between sufficient flexibility in choosing a proper frequency band and the ability to detect with sufficient sensitivity PD pulses originating from the far end, resulted in a frequency range up to 5 MHz.

The first sensor we used for the on-site measurements is the traditional laboratory sensor: a coupling capacitor and quadrupole, see figure 1. This enabled us to realise a basic system in a short time. The drawback of this solution became clear during field measurements. The coupling capacitor is to be placed preferably close to the termination.