EXPERIENCES OF DIAGNOSIS OF HV CABLES BY DAMPED AC TECHNIQUE

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ABSTRACT

The results discussed in the paper are based on the measurements carried out using HV damped AC equipment for more than one year. Numerous measurements were executed and evaluated mostly in Central-European countries. The experiences and issues of the measurements are described by the help of some case-studies and the first steps of building the new knowledge base have been introduced by the authors.

KEYWORDS

High voltage cables, partial discharges, damped AC, field testing, knowledge base

INTRODUCTION

The transmission cable lines play important role in energy distribution while most of these HV cables have been in operation for 30-40 years. The only way of the safe future operation is the satisfactory knowledge of the condition of these cable lines, therefore the reliable diagnosis of these cables is a key question.

The damped AC technique as a diagnostic tool for medium voltage cables was introduced more than ten years ago and it has become a popular diagnostic method owing to its beneficial features: the measurement provides many diagnostic parameters e.g. PD inception an extinction voltages, PD location and loss factor and this method is applicable on mass insulated and extruded cables, as well. Obviously, many experiences have been collected about the application and the evaluation of measurement results on medium voltage cables.

Recently, high voltage damped AC measuring equipment has been introduced and it inherits the advantageous properties of the medium voltage one. Obviously, this is a relatively new technique, therefore less experience has been cumulated until now. Beside the less experience the knowledge base for interpretation of the results is based on measurements carried out in Western-Europe. However, the older cables and accessories used in Central Europe differ from the Western European ones, therefore the evaluation rules have to be adopted accordingly. The building of the knowledge base for correct measurement evaluation has to be based on numerous filed measurements.

TESTING METHODS FOR HIGH VOLTAGE CABLE LINES

To assure the reliability of cable systems it is of utmost importance to find and perform proper diagnostic measurements. These have to be carried out during the complete life cycle of the cable system: at the manufacturer as quality control, after installation and during operation as condition assessment.

Diagnostic measurements can be divided basically into two groups.

The goal of go-no go type measurements is to detect and to remove defective parts. For this purpose usually voltages above the nominal voltage is used for a specific interval.

The other group of measurements is intended to indicate the level of deterioration processes. Some of them reveal the overall condition of the insulation while others pinpoint local failures. For these measurements low voltage or moderately elevated voltage is used. A basic property of the diagnostic measurements should be that they do not damage or deteriorate the cable system.

The DC test is an easy-to-use method, with low power need and therefore performable by cheap and light instrumentation. The measurement is carried out at 1.5 to 3.5 times of the nominal voltage and is a go-no go type test based on the occurrence of breakdown or not. Nevertheless, several weaknesses of the method resulted in its abandonment at several utilities. The field distributions are different to those at AC operating voltage. The high voltages cause accordingly high fields, which may be above space charge injection level. The insulation is susceptible to space charge accumulation especially when DC field is applied to aged and/or wet cables. Partial discharges can also be measured, but their activity at DC voltage is low to detect harmful defects, which can do at AC voltage. Several laboratory experiments have shown the gravest disadvantage of the method: the lack of sensitivity for even serious damages at reasonable voltage levels.

While DC test of the core insulation turned out to be problematic, the DC integrity test of the jacket is carried out worldwide. Moderate voltage is applied for a few minutes between the shield and ground to check the integrity of the jacket of the cable. The integrity of the jacket is of paramount importance in avoiding moisture ingress and corrosion.

AC tests have in common, that they have high power needs. Field conditions are similar to real life and partial discharge and tan δ measurement are possible. However, if the measurement is carried out at different frequencies, the implementation of the results can be questionable.The easiest way to carry out AC test is system voltage test with phase-to-ground or phase-to-phase voltage. No external source is needed, but it takes a long time. And if the cable system fails and breakdown occurs, the high power transients can cause damages in the system. AC test at power frequency and elevated voltage would be ideal, but the price and weight of the transformer needed is beyond acceptable level. The solution for the problem is resonant testing, which is only limited by the capacitance of the cable, correspondingly to its length. Usually a minimum frequency of 25 Hz is chosen, which allows reasonably long cables to be examined. Usually, 2.5 times