Effective on-site testing and non-destructive diagnosis of new installed and service aged (E) HV power cables up to 230 kV

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ABSTRACT

This contribution presents modern on-site testing and diagnosis of power cables up to 230 kV which is based on the use of damped AC (DAC) and which consists of voltage testing, partial discharge detection and dissipation factor measurements. Since the last 14 years the application of DAC voltage energizing is getting more and more worldwide acceptance.

INTRODUCTION

It is known, that an insulation failure of a power cable can occur as a result of the normal operational voltage or during a transient voltage due to lightning or switching surges. Most failures occur as a result of localized electrical stresses that are higher than the dielectric strength of the dielectric materials in the area of the localized stress or if the bulk dielectric material degrades to the point where it cannot withstand the applied voltage. To find this defect (result of poor installation or heavy service conditions) prior to a failure, on-site tests are applied to assess the quality and cable system integrity as well as the availability and reliability of the cable circuit.
Modern on-site testing and diagnosis of power cables up to 230 kV consists of voltage testing, partial discharge detection and dissipation factor measurements. Since the last 14 years the application of damped AC (DAC) energizing is getting more and more worldwide attention.
In relation to the applied damped ac testing procedures, the IEEE 400.4: Guide for Field-Testing of Shielded Power Cable Systems Rated 5 kV and above with Damped Alternating Current Voltage (Damped ac), document is in the balloting process. This guide includes practical considerations, based on user experience during the last 14 years in relation to several IEC standards. Examples of such considerations include the number of damped ac excitations applied during testing and the minimum recommended test voltage level. Regarding the DAC voltage withstand test user feedback has confirmed the following test parameters:
1. Maximum damped ac test voltage levels:
a. For HV cables (36-150 kV) up to 1.73 – 2.0 U_0
b. For EHV cables (150-230 kV) up to 1.4 – 1.7 U_0

2. Number of damped ac excitations at maximum applied damped ac voltage withstand level: 50. In Europe some of the users are also following the 1 hour test duration.

An international survey showed that in the majority of cases where DAC has been applied, voltage withstand tests have been combined with advanced diagnostic measurements (e.g., partial discharge and dielectric loss). It can be seen from Figure 1 that monitored DAC testing is used not only for diagnosis of service-aged cable circuits (almost 90 % of users), but also for after-laying testing of new cable circuits (67 % of users).
In this paper, the use of damped sinusoidal ac voltages (damped ac) for monitored testing of power cables will be discussed based on general considerations and practical examples

ON-SITE GENERATION OF DAC VOLTAGES

Damped ac testing can be used as a simple withstand test or in combination with partial discharge (PD) and dissipation factor (DF) measurements for new installed and service-aged cables. The use of damped ac voltages for testing power cables is in compliance with relevant IEC, IEEE, and Cigre international standards and guidelines.
To generate damped ac voltages with durations of a few tens of cycles of ac voltage at frequencies up to a few hundreds of Hz, a test system has been developed. This method is used to energize and to test on-site power cables with sinusoidal ac frequencies. The system consists of a digitally controlled high voltage power supply to energize capacitive load of power cables with large capacitance (e.g., 10 µF), figure 1.

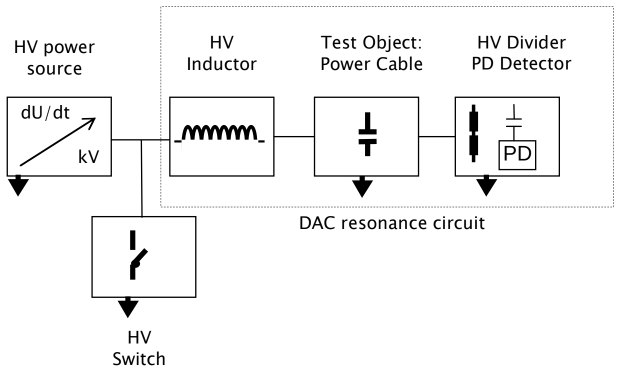

Fig. 1: Schematic Diagram of Damped ac (DAC) Systems for On-site Testing and PD Detection of Transmission Power Cables

With this method, the cable under test is energized during a time $t_{charge}=U_{max}\ C_{cable}/I_{load}$ with continuously increasing voltage, see Figure 2. During this phase the test object is stressed with an increasing uni-polar voltage. The