Fifteen Years Damped AC On-site Testing and Diagnosis of Transmission Power Cables

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ABSTRACT

It is known that using factory routine tests (insulation coordination) the quality of a power cable as well as the accessories is fully tested at the manufacturer. Nevertheless the risk of accessories parts delivery and installation problems may influence the quality of a newly installed power cable circuit. The current IEC standards are manufacturers' standards and they do not provide adequate recommendations for after-lying testing and demonstration of above-mentioned problems. A breakdown may occur only in case of extremely serious defects during the after-laying test (very seldom). This means that in a no-breakdown situation the presence of defects in cable parts or in accessories cannot be excluded.

Therefore in contrast to the IEC standards the standards IEEE 400 and IEEE 400.4 recommend partial discharge monitored testing e.g. by continuous or damped AC voltages (DAC).

In case of continuous AC voltages due to the high level of EM disturbances occurring by on-site generation of resonant AC voltages (ACRT), the PD detection in accordance to IEC 60270 is not sensitive enough to be used for PD detection in cable insulation and in all types of cable accessories. In contrast to ACRT the use of DAC provides in addition to voltage withstand test also very sensitive and IEC 60270 conform PD detection of the complete cable circuit.

Based on the international experiences as collected in the last 15 years at different power grids this contribution focuses on the use of DAC for after-laying testing and diagnosis of all types of transmission power cables. In particular supported by practical examples different important aspect of testing new connections as well as condition assessment of service aged power cables will be mentioned in this paper.

KEYWORDS

Transmission power cables, on-site testing, after-laying testing, diagnostic testing, damped AC voltages, partial discharges, defect localization, dissipation factor, tan δ.

INTRODUCTION

Considering that reliable energy transport is fundamental for on- and off-shore infrastructures, the aspects of maintaining the quality control regulations for newly installed and service aged cable connections are of importance. As a result, important questions for Transmission Grid Operators (TSOs) about maintaining /updating internal procedures for a reliable network operation are:

1. How do you perform in a sensitive and non-destructive way the detection of poor workmanship defects of newly installed cable circuits?
2. How do you perform non-destructive diagnostics of cable circuits in service to determine the actual condition?

Following present IEC standards for power cables up to and above 150 kV voltage ratting [2,3] the testing after-installation protocols for power cables are limited to manufacturer's minimum recommendations and therefore do not cover the present needs the be preventive against possible failure risk during operation. As a result considering responsible operation and asset management of transmission power cables the following aspects are outside TSOs consideration:

After installation testing of newly installed cable systems to find:

1. Manufacturing related defects → due to high level of quality control less probable;
2. Accessories parts delivery problems → due to diversification in the supply chains more probable;
3. Installation related defects → due to diversification in the installation supply chains highly probable.

Maintenance and diagnostic testing of cable systems in operation to estimate:

1. Operational damages and over electrical and thermal stresses → cannot be neglected e.g. transients and over - voltages;
2. Assess aging processes → depends on many operational and local factors e.g. presence of installation defects, constrictions works;
3. The remaining life → goal of most asset managers to keep CAPEX and OPEX on an optimal level.

Unfortunately to define their quality testing procedures, still some of the traditional testing companies, contracting companies and also a number of TSO companies are referring to IEC procedures, which have been introduced 30 years ago by manufacturers only: IEC 60840 and IEC 62067 [2,3]. Both documents are only cable manufacturers' standards and therefore the majority of the content is discussing the factory testing aspects and only a half page of 62 pages total is proposing some basic tests for the after-installation test. No guidelines are provided regarding the maintenance of cable circuits and maintenance-/diagnostic testing. In particular the IEC 60840 and IEC 62067 standards recommend a Go/No-Go decision as a result of a breakdown by one of those tests:

- Soak test with Uo at 24 hours or
- After-laying test with 1.73 Uo or 2.0 Uo for cables with rated voltages up to 150 kV,
- After-laying test with 1.7 Uo, 1.4 Uo or lower for cables with rated voltages above 150 kV.