

THE IMPACT OF TRANSMISSION CABLE SYSTEM CONSTRUCTION AND DESIGN ON COMMISSIONING TEST OPTIONS AND RESULTS

Benjamin LANZ, IMCORP, Manchester, Connecticut, (USA), ben.lanz@imcorpotech.com

Bernard DHUICQ, Silec Cable, Montereau, (France), bernard.dhuicq@sileccable.com

Steffen ZIEGLER, IMCORP, Manchester, Connecticut, (USA), steffen.ziegler@imcorpotech.com

ABSTRACT

To achieve on-site partial discharge (PD) test measurements, which are comparable with factory PD tests, a thorough understanding of how high voltage (HV) and extra high voltage (EHV) cable system design will impact PD test measurements is necessary. Experience indicates that simple modifications early in the design process can greatly simplify the commissioning test process and support a cable test protocol that can provide performance assurance comparable to that provided by manufacturing quality control standards. Test results will be presented that will demonstrate what is achievable on a well designed cable system using an effective and efficient PD commissioning test technique.

KEYWORDS

High Voltage; Extra High Voltage; Cable System Design; Partial Discharge Test; Factory Test Standards; Sensitivity Assessment; Calibration

INTRODUCTION

This paper provides cable system owners with insight into the impact of transmission cable system construction and design on commissioning test options and results. To put the design considerations in context of the industry's experience and need for more effective method to commission HV and EHV cable systems, this paper provides a brief historical review, a discussion of standardized test requirements, an overview of common PD test methods, a review of three case studies, and finally a discussion of design modifications that can greatly simplify the commissioning test process. The final goal of the paper is to present a combination of design considerations and robust PD test specification requirements that can enable test results to readily be compared with factory test standards and provide a credible reliability assurance.

Brief Historical Overview

By many accounts [1-5], well designed and carefully built HV and EHV solid dielectric cable systems rated up to 550kV have been extremely reliable. Since the 1960s, one of the critical methods of assuring dielectric reliability in these cable systems has been a power frequency partial discharge (PD) test performed at a voltage greater than the operating stress. This PD test is used throughout the design and type testing process, and is used routinely on every reel of cable and prefabricated cable accessory prior to being shipped from the factory (See Table 1).

While the factory PD testing standards for cables and accessories have evolved since the 1960s, field test methods have been slow to catch up. Compared to the exacting requirements of the factory quality control tests,

many of the early HV and EHV solid dielectric cable systems were energized with little or no additional electrical testing prior to energization. Thus, the authors believe the very high reliability achieved with these systems is not likely a function of the effectiveness of the commissioning test but rather a statement of the quality and diligence associated with the insulation products, shipping and handling, and installation workmanship.

Need for Effective Commissioning Tests

According to CIGRE Working Group B1.22 [6] there is a growing concern about installation workmanship of extruded high voltage cable systems. There are several market forces contributing to the reliability concerns including a general increasing trend in the volume of HV and EHV cable system projects, compressing project timelines, and a shortage of highly qualified technicians. One positive step to meet this market demand is the development of accessories which are easier to install. While the ease of accessory installation can accelerate technician training, compress a project's timeline and reduce costs, the construction of the accessory cannot compensate for poor cable preparation skills. In addition to working group B1.22, CIGRE has constituted Working Group B1.28 which has been tasked with the objective of documenting the technical feasibility and preparing recommendations for standardizing on-site PD tests. The authors' experience indicates that many cable system owners share the concern and interest acknowledged by these CIGRE work groups, and have expressed a need to specify a more meaningful commissioning test.

PD FACTORY TEST STANDARDS

To understand the impact of cable system construction and design on commissioning test options and results, it is necessary to review the basis of PD test standards and how they are used to determine the accuracy, validity, and comparability of PD tests. Standards writing organizations such as IEEE, IEC, ICEA and others have developed requirements for PD tests and pass/fail criteria on the basis of the following four generalized parameters:

1. Noise mitigation/sensitivity assessment
2. Apparent charge magnitude calibration
3. Voltage source frequency
4. PD test voltage level

Table 1 lists factory PD test requirements stipulated by some international standard organizations.