# Integrating Diagnostic and Factory Tests to Maximize Reliability of New Critical Power Cable Systems

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## *ABSTRACT*

*One of the more important challenges in power cable testing is finding an optimal balance between diagnostic technologies to be deployed and achieving the highest effectiveness possible for the particular case under consideration. Therefore, this paper discusses methods and experiences with diagnostic testing to support the asset management of new critical Medium Voltage (MV) power cable systems from the factory to commissioning to service. The discussion is based on a case study that is a bay crossing in the USA. It corresponds to a new power cable system that is considered de facto critical mainly because of its restricted accessibility once in service as well as economic impact. The case study illustrates the deployment of diagnostic technologies from the factory to commissioning to maximize reliability, avoid unexpected problems as well as minimizing risks and costs.*

## *KEYWORDS*

VLF, Diagnostic Testing, Asset Management, Condition Based Maintenance, Critical Infrastructure

## INTRODUCTION

Utilities all over the world, and especially in North America, are facing a significant future challenge to maintain and renew their ageing assets [1]. Utility assets (like most equipment) degrade over time and eventually reach the point at which their performance is lowered sufficiently that they can no longer perform their intended functions. Equipment populations with assets that are far enough into this process produce service failures [2].

Effective asset management strategies require the availability of appropriate information on the performance of the assets themselves. In essence, the extra information comes from an effective diagnostic program whose results enable the utility to undertake “smart maintenance” in that only those assets that will likely impact the reliability in the near future receive some form of remediation.

To address this need for underground cable systems, voltage sources were developed during the last two decades that utilize AC frequencies in the range of 0.02-300 Hz [3][5]. The possibility of augmenting the withstand capability with diagnostics such as dielectric loss and partial discharge further increases the usefulness.

Guidance on use and interpretation of cable diagnostic technologies has focused primarily on single diagnostics for single phaseconventional land distribution cable systems. The need for the use of coupled diagnostics on critical cable systems, where the risk profile is quite different to conventional distribution cable systems, is not currently addressed in the literature. In this context, critical cable systems may be considered as those associated with

- long length subsea / river crossings,
- power plants, and
- life safety systems.

These applications are considered critical because their risk of failure profile and related consequences are significantly different to traditional distribution applications and require a number of extensions to the standard diagnostic testing paradigm.

Therefore, the work reported here discusses methods and experiences with diagnostic testing and corresponding analyses to support the asset management of new critical Medium Voltage (MV) power cable systems from the factory to commissioning to service.

Asa noted before the issues apply to a wide range of applications, however in this paper how these are addressed is discussed in a case study based on a subsea bay crossing to an island in the southern US. Specifically, the case study corresponds to a new power cable system that is considered *de facto* critical because its restricted accessibility once in operation. Additionally, the cable system delivers electrical power to a high-profile tourist area with high impact on the local economy.

The case study is used to illustrate the deployment of diagnostic technologies from the factory to commissioning to maximize reliability, avoid unexpected problems, and minimize risks and costs. Special attention is given to the approach that was designed to address the installation of joints required to complete the system span using a myriad of complimentary diagnostic technologies.

Other approaches, complementary to diagnostics, that are briefly discussed are: (1) cable system technology selection, (2) cable quality assurance, (3) verification of cable integrity after transportation, and (4) future performance assessment.

Important lessons learned from each of the items above are presented and discussed in the paper. The work that is reported here can be used as guidance by utility engineers to maintain reliable operation of their important new cable critical cable assets and it constitutes the main contribution of the paper.

## CRITICAL POWER CABLE SYSTEM

The definition of a critical MV power cable system could change from utility to utility; specific cases may require unique parameters to define whether the system is critical or not. However, there are categories that apply to each case to be able to establish the system criticality, they are as follows:

- **Impact to the end customer:** This category includes power cable systems that support critical infrastructure (e.g. hospitals, airports, governmental agencies, high profile customers, dense commercial/industrial/tourist areas, etc.). It is also important to consider that this category also carries the highest impact on the utility's