APPLICATION OF A COMBINED TECHNICAL APPROACH FOR MV CABLE AGING MANAGEMENT AT SOUTH TEXAS PROJECT NUCLEAR OPERATING COMPANY (STPNOC)

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ABSTRACT

Since 2012 the South Texas Project Nuclear Operating Company has adopted a more comprehensive technical approach for MV cable aging management than the sole VLF (0.1Hz) tan δ test commonly used by other operators. The core methodology relies on the combination of off-line PD monitored 60 Hz withstand testing, advanced off-line 60 Hz diagnostic PD testing, frequency domain dielectric spectroscopy and VLF tan δ testing. This approach provides significant benefits to minimize the risk of 'false positive' and 'false negative' diagnostic testing results, improves reliability, improves the allocation of funds for maintenance, addresses anomalous diagnostics results, and enhances project planning. This paper discusses the technical, regulatory, economic and risk management rationales for adopting this combined technical approach.

KEYWORDS

Cable Aging Management, Nuclear Power Plant, Medium Voltage, Partial Discharge, Frequency Domain Dielectric Spectroscopy, VLF Tan δ, Condition Assessment.

INTRODUCTION

In Europe and North America, most Nuclear Power Plants (NPPs) are reaching the end of their initial licensed period and entering periods of extended operation. In the US, plants can obtain 20-year extensions to their original operating licence from the Nuclear Regulatory Commission (NRC). Through the reactor licence renewal process the operators must demonstrate that the plant's systems and equipment will continue to operate in a safe and reliable manner through the period of extended operations (PEO). Electrical cables have been identified as essential components to the operation of the plants, especially cables related to safety systems or systems critical to operation. The Generic Aging Lessons Learned (GALL) Report, NUREG-1801, Sections XI.E1 and XI.E3 provide guidance to licence renewal applicants to develop a program for the aging management of non-environmentally qualified cables. As one of the most recent plants to start commercial operation in the US, in 1988 for Unit 1, the South Texas Project Nuclear Operating Company (STPNOC) license renewal process is subjected to the latest revision of the GALL report [1], which includes more comprehensive guidelines to manage aging cables than earlier versions. The cable aging management program (CAMP) developed by the operator needs to address the main aging mechanisms affecting medium voltage (MV) cables through periodic inspection and testing.

For MV cables, long term exposure to wet environments was identified as a leading cause of degradation [2][3]. To address this issue very low frequency (VLF), variable voltage dielectric loss (tan δ) measurements at 0.1Hz have been broadly implemented across the nuclear industry, relying on test methods and assessment criteria guidance from the Electric Power Research Institute [4] and IEEE 400.2-2013 [5]. While VLF tan δ has been successful in identifying moisture ingress related cable system degradation (e.g., water-trees, wet splices), it has no inherent ability to discriminate between local versus global degradation, and it is not known for its sensitivity to localized, latent defects and degradation causing partial discharge (PD) activity.

As part of its license renewal strategy and long-term objectives, STPNOC must abide by strict regulatory guidelines, operate with a very low risk tolerance to reliability and safety events, and optimize asset investments. To achieve this, STPNOC has committed to a comprehensive test methodology combined with risk mitigation strategies, as will be discussed in this paper.

The recommended core tests to achieve these goals include a combination of the following acceptance criteria based test techniques:

1. Off-line PD monitored 60Hz withstand (ACMWS)
2. Off-line 60Hz diagnostic partial discharge (ACPD)
3. Frequency domain dielectric spectroscopy (FDDS), including VLF tan δ

Investigative tests such as time domain reflectometry (TDR), frequency domain reflectometry (FDR) and DC metallic shield resistance are also deployed on a case-specific basis for engineering information or anomaly investigation. In a previous paper [6], the authors discussed the technical benefits, methodology and acceptance guidelines applicable utilizing the core techniques noted above, along with general statistics to illustrate how their combination leads to improved defect sensitivity and condition assessment for cable systems. The intent of the present paper is to focus on the technical, regulatory, economic, and risk management rationales for adopting this comprehensive test program at the STPNOC nuclear site. This discussion is supported by test and case study data collected since 2013.

METHODOLOGY SUMMARY

Offline PD Monitored AC Withstand Testing

The intention of off-line PD monitored 60Hz withstand (ACMWS) testing is to identify gross point defects in the cable system (including accessories as well as the cable dielectric itself), and then provide a confident global pass/fail assessment regarding fitness for service. Partial discharge (PD) is monitored to sensitively detect latent,