Comprehensive Transmission Cable Monitoring System

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ABSTRACT

Transmission cable systems asset management approaches have become increasingly needed for reliable system performance and to proactively manage and predict end of service life for individual components of the entire cable system. This paper details a comprehensive transmission cable monitoring system designed to meet the evolving needs of transmission cable systems and details the designs, and installation challenges of the system, as well as a review of our first years of operational experience.

This article is relevant for cable and accessories manufacturers, and utility professionals looking to install similar cable asset monitoring systems, as it outlines some options and learnings in the realm of transmission cable system design and installation.

KEYWORDS

Asset Health, Assets Management, Operational Workflow, Fault Annunciating, Self-Inspecting, Cable Monitoring System, Cable Termination, Partial Discharge, Service Life, Grounding, Sheath Currents, Monitoring Sensors, Distributer Temperature Sensors (DTS), Distributed Acoustic Sensors (DAS), IR Camera, Displacement Sensor, Local Vibration Sensor, High-Frequency Current Transformer (HFCT), Low-Frequency Current Transformer (LFCT), In-Vault Architecture, End-To-End Monitoring.

INTRODUCTION

Transmission cable systems assets management approaches have become increasingly needed with a globally booming renewable energy resources market, vehicle electrification, and other demands that shift what is expected from our transmission grid, especially as 70% of T&D lines are well into the second half of their lifespans by end of 2022.

The ability to assess cable system condition in near real-time and proactively repair or replace risky parts, prevent, or avoid catastrophic failures, or predict remaining life are moving to the top of power utility's priority list, and will help address the evolving demands placed on the transmission grid.

To leverage the latest technologies and advancements in Artificial Intelligence (AI), historically detailed and accurate data and databases are needed to make AI effective and meaningful. The first step in our real-time database creation has been the installation of required sensors, data acquisition units, and dedicated communications channels.

Con Edison's comprehensive cable monitoring program incorporates sensors and communications equipment in transmission vaults to monitor asset health parameters alongside operational parameters. The sensors include video and infrared cameras, distributed and local vibration sensors, partial discharge sensors, distributed and local temperature sensors, splice displacement sensors, and physical security alarms. The sensors provide automated information about cable parameters that can lead to faults, enable remote inspections of equipment, and enhance physical security on the feeder. Distributed vibration sensors notify company personnel about construction – such as excavation, piling, drilling, or blasting - along the feeder route, and heavy transportation traffic.

Including these features in the design of underground transmission lines will save on the monitored cable's operations and maintenance costs by reducing in-person inspections and providing data directly to the utility's information systems. The monitoring system will also enhance safety of employees and the public by reducing in-person inspections, identifying construction hazards, and identifying broken, bouncing, or misaligned underground vault covers, and give advanced warning on degradation to the cable insulation and grounding systems.

This system will allow Con Edison to manage its underground transmission assets proactively and more cost-effectively.

DESCRIPTION OF CABLE MONITORING SYSTEM (CMS)

The cable monitoring system design is unique and innovative as it combines two potentially separate operational workflows into a single integrated system. The Con Edison architecture, nicknamed "FAST" for "Fault Annunciating Self-Inspecting Transmission", combines asset health parameters typically associates with an asset's condition with external operational parameters related to that asset often used for periodic inspections. Combining these two data types expands the role of the monitoring system and broadens the possible return on investment for such a system and approach. Fault Annunciating is focused on asset-health and condition monitoring, and Self-Inspecting is focused on ongoing operational inspection requirements. While some cable monitoring systems have paired multiple sensor elements, we are not aware of any other system that has integrated this level of monitoring, sensors, and data acquisition to specifically combine asset-health and parameters with operational parameters on such a scale.

The FAST system captures information along the entirety of the underground HV cable circuit from substation to substation. The key parameters collected are Partial Discharge (PD), cable sheath currents, Distributed Temperature (DTS) and Distributed Acoustic (DAS) information, splice displacement, splice vibration, splice temperature, and is supported by three video streams.

Partial Discharge System (PDS)

Based on failure statistic, most vulnerable components of the underground transmission cable system are cable splices and terminations. These components must be monitored during commissioning tests to identify any assembly defects or establish reference data at time of