Electrical and I&C Components

Longer Term Operations

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NRC Public Meeting

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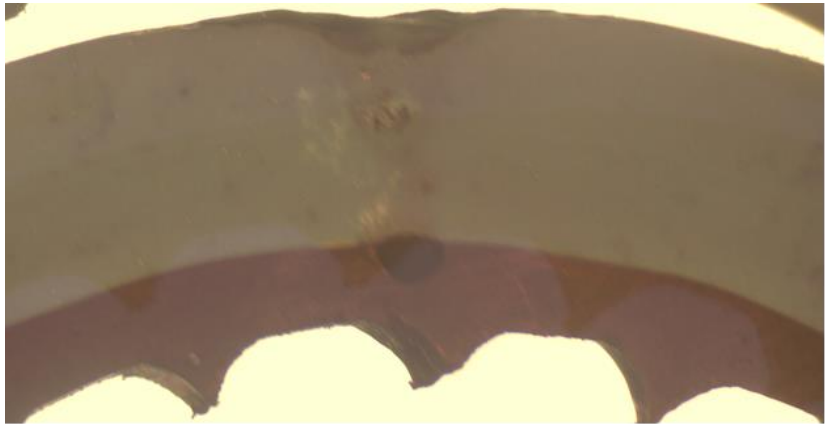
Cable Aging Management

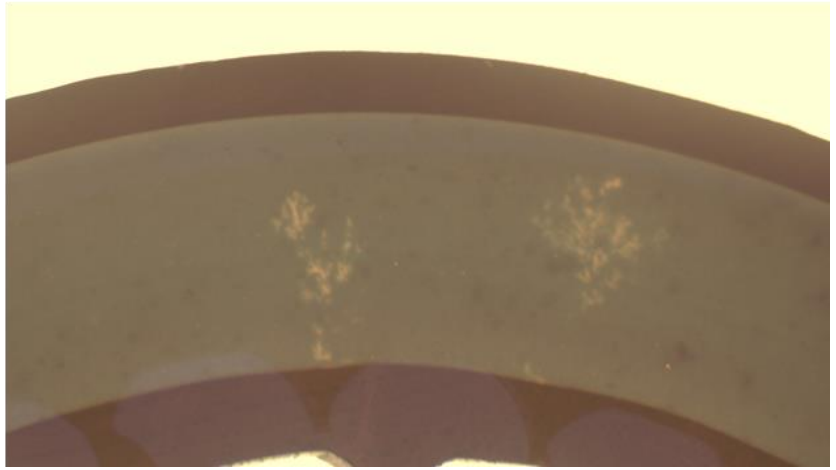
- Cable aging is most affected by operating environment: temperature, radiation exposure, and electrical stress (medium voltage cables only)
- Temperature and radiation levels in cable locations, except local adverse environments, would not lead to large amounts of cable replacement (slide 4)
- Thermal resiliency of the polymer (e.g., cross-linked polyethylene, ethylene propylene rubber, silicon rubber) will determine service life
- Cable aging management programs are designed to:
  - Identify, via periodic walkdowns, local adverse environments and cables adversely affected by those environments
  - Use of condition monitoring to identify if cable insulation is degraded, and to what level
  - Use the corrective action program (CAP) to determine the extent of degradation, required actions, and extent of condition
  - Mitigate, repair, or replace cables to maintain overall plant safety and reliability

Thermal degradation showing that cables age based on both the environment and by polymer type. The cracked cable jacket is chloroprene; the black cable jacket is chloro-sulfonated polyethylene.

Cables Aging Management

- Examples of EPRI research supporting aging management:
  - Developed guidance for cable aging management program implementation as required by GALL which have been used to identify adverse environments and cable degradation
  - Developed guidance to support periodic cable walkdowns to identify adverse local equipment environments
  - Development of condition monitoring tests to identify degraded insulation in the worst environments (covered by GALL XI.E1, E2, E3 (GALL-SLR for XI.E3 a, b, c), E4, E5, and E6)
- DOE LWRS program, EPRI, and NRC Research maintain a joint roadmap and meets regularly to discuss research
- EPRI has established a Cable Users Group to monitor industry operating experience
- EPRI will update aging management guidance, as required, based on new research results and operating experience





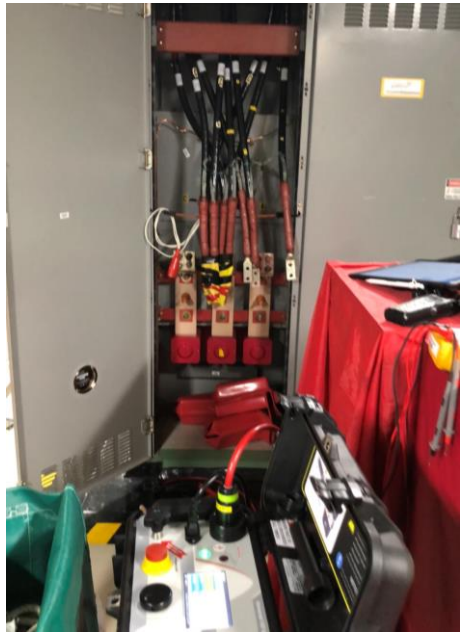
Water tree degradation of medium voltage cable insulation

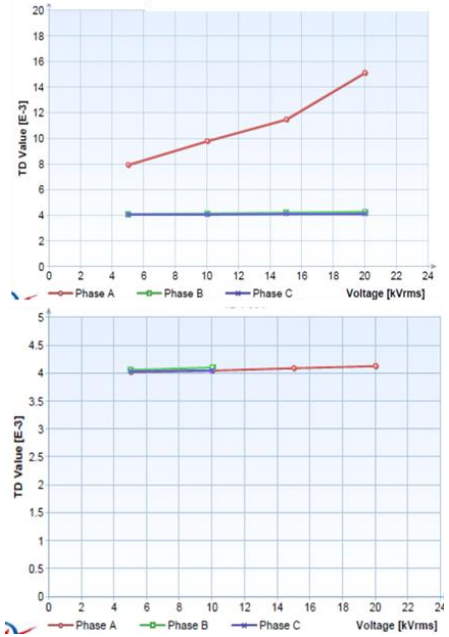
Highlights of EPRI Research on Cable Aging Management

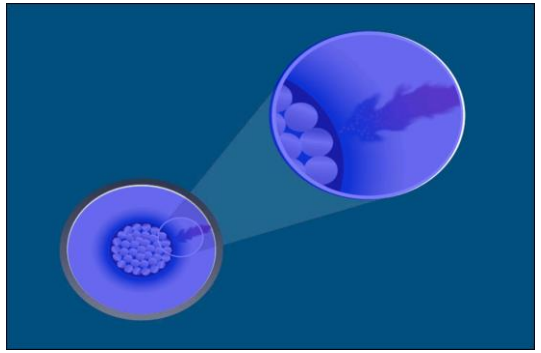
Topic	Title
Cable Aging Management Program Implementation	Low-Voltage and Instrumentation and Control Cable Aging Management Guide, Revision 1
	Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants, Revision 1
	Cable Polymer Material Handbook—Instrument Cable
	Cable Polymer Material Handbook—Low Voltage Power and Control Cable
	Cable Polymer Material Handbook—Instrument Cable
Failure Mechanism Research	Plant Engineering: Medium-Voltage Cable Failure Mechanism, Update 7: Evaluation of Main Factors Causing Formation of Large Water Trees in Service-Aged, Pink and Brown Ethylene Propylene Rubber–Insulated Medium-Voltage Cables
	Plant Engineering: Medium-Voltage Cable Failure Mechanism Research, Update 6
	Plant Engineering: Medium-Voltage Cable Failure Mechanism Research, Update 5
	MV Cable Accessory Research: 35-kV Termination Investigation. EPRI, Palo Alto, CA: 2019.
	Lead-Free Rubber Cable Materials: Technical Evaluation
	Results of Radiation and Temperature Monitors: Research for Installed Cables at U.S. Nuclear Power Plants in Support of Long-Term Operations
Condition Monitoring	Effects of 0.1 Hertz Withstand Testing on Medium-Voltage Cable Insulation
	Evaluation and Insights from Nuclear Power Plant Tan Delta Testing and Data Analysis – Update
	Medium-Voltage Motor and Cable, Very-Low-Frequency (VLF) Tan Delta Testing from the Cable Termination
	Field Guide for Very Low Frequency Tan Delta Testing of Medium-Voltage Motors and Cables from the Cable Terminations
Mitigation and Replacement Strategies	Wireless Technologies as a Replacement for Degraded Cable Systems
	MV Cable Fault Location Troubleshooting Guide
	Results of Cable Rejuvenation of Severely Degraded Black Ethylene Propylene Rubber Medium-Voltage Cables

Aging Management Activities

Inspection / Monitoring → Analysis / Evaluation → Mitigation / Modernization → Repair / Replacement







The Path Forward – Enhancements and Optimization

Enhanced Inspections

- Advanced Visual Data
- Monitoring technologies
- Advanced Nondestructive Evaluations

Data Management

- Electronic Database
- Data Visualization
- Digital Twin

Data Utilization

- Risk Informed
- Predictive Analysis

Trending Across the Industry

- Increased Communication between Utilities, Regulators, and Research