

Electrical and I&C Components

Longer Term Operations

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NRC Public Meeting

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Cable Aging Management

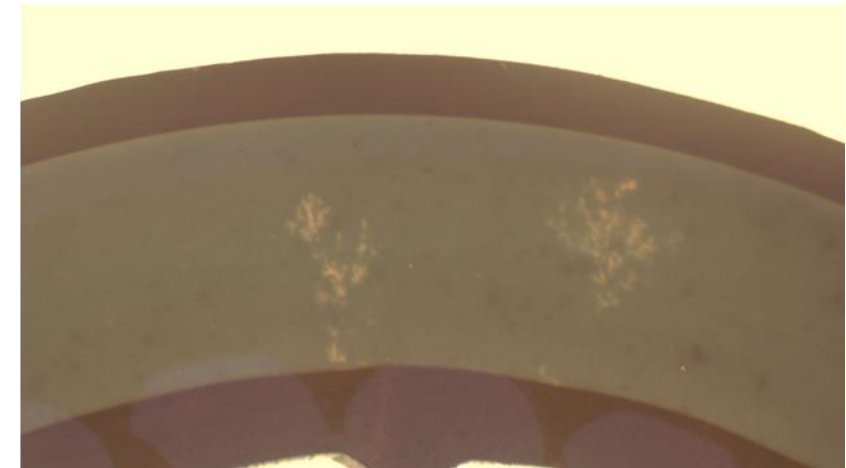
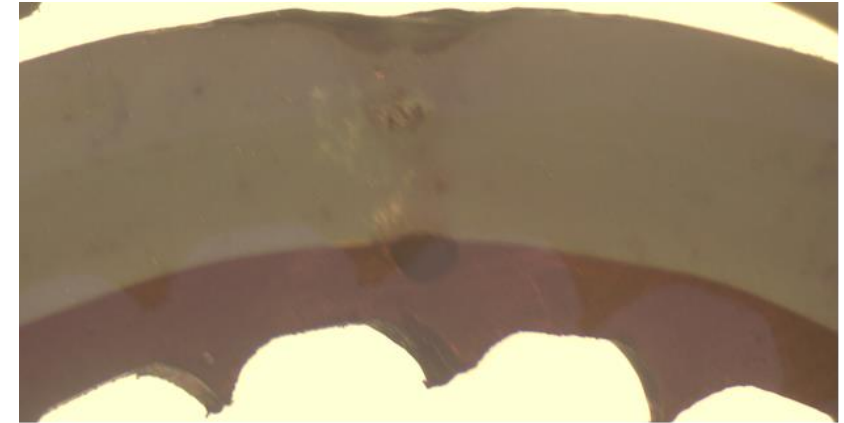
- Cable aging is most affected by operating environment: temperature, radiation exposure, and electrical stress (medium voltage cables only)
- Temperature and radiation levels in cable locations, except local adverse environments, would not lead to large amounts of cable replacement (slide 4)
- Thermal 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

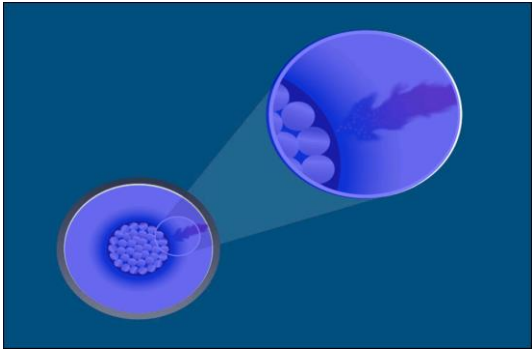
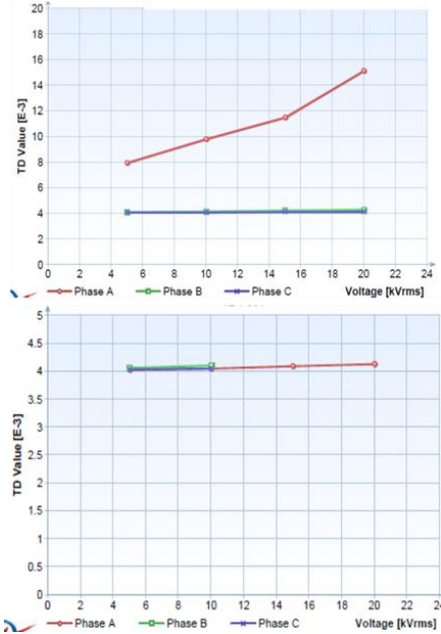
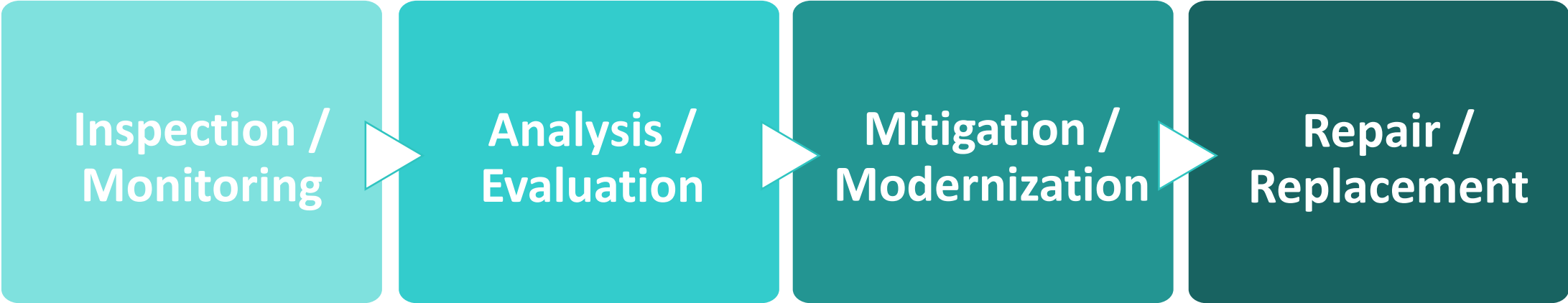


Water tree degradation of medium voltage cable insulation

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
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



The Path Forward – Enhancements and Optimization

Enhanced Inspections

- Advanced Visual Data
- Monitoring technologies
- Advanced Nondestructive Evaluations

Data Management

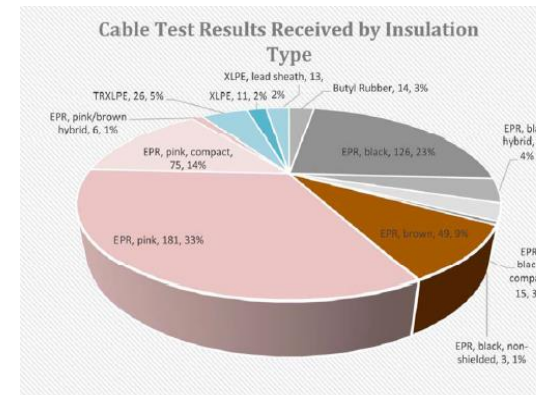
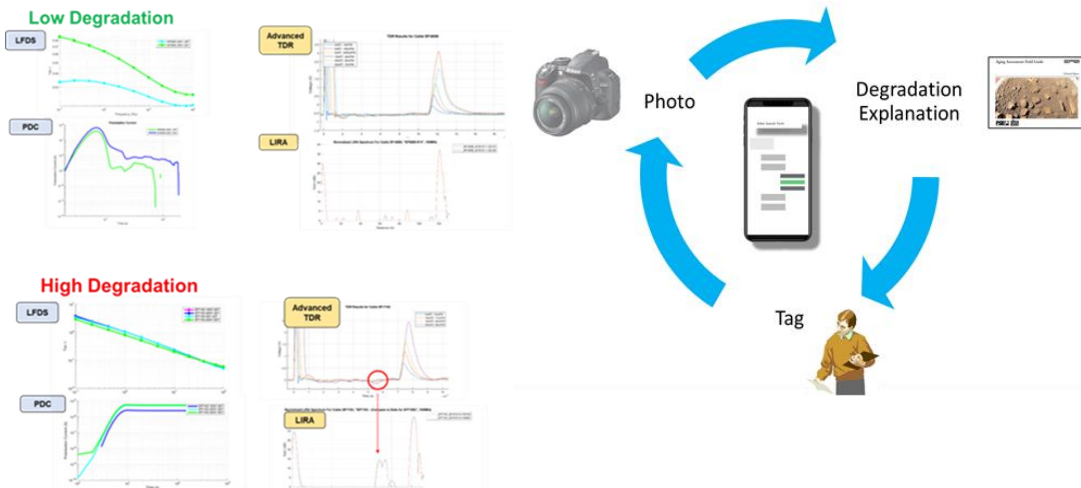
- Electronic Database
- Data Visualization
- Digital Twin

Data Utilization

- Risk Informed
- Predictive Analysis

Trending Across the Industry

- Increased Communication between Utilities, Regulators, and Research



		2012	2013	2014	2015	2016	2017	2018	2019	2020			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Submergence	Swim Lane												
	Org												
		Tan Delta Data Collection and Evaluation of Wet MV Cable											
		< MC 1025262 June 2012											
		< MC Tan Delta Insights-Update (3002005321) 9/29/15											
		EPR MV Cable Submergence Qualification (for Modern EPR with low susceptibility to submergence degradation)											
		Kerite EPR Submergence Qualification											
		< MC-1st Break-down Test 9/14											
		< MC-MV Kerite HTK Submergence 2yr-Update (3002005320) [11/12/15]											
		< MC-Final Report (3002010618) (12/20/17)											
	Pink EPR Submergence Qualification 100%												
	MC-Begin Aging (12/11/15)												
	MC-1st year Aging Complete (5/30/17)												
	MC-Final Report (3002013176) (July 2018)												
	LV Cable Susceptibility to Wet Aging Research												
	Pilot for Single-Conductor Cables												
	< MC-9/13												
	Follow-up for Multi-Conductor Cables												
	< MC-Begin Aging (3/15/15)												
	< MC-LV Wet Susceptibility Rpt (3002007991) (7/12/2016)												
	NRC/Sandia MV Cable Submergence Research												
	Phase 1												
	< MC-Submerged MV Cable Systems Report (SAND2015-1794)												
	Evaluation of EPR Tan Delta Criteria												
	Phase 2												
	ORNL/UMN Submerged Cable Research 40%												
	MC-Complete initial testing of XLPE cables												
	MT-Parr Oxid Study of PE & EPR												
	< MT-Accel XLPE Cable Aging												
	MT-Accel EPR Cable Aging												

A blue-tinted photograph of four people, two men and two women, standing together. They are wearing white lab coats or polo shirts with the EPRRI logo. One woman is wearing a white hard hat. They appear to be in a professional setting, possibly a laboratory or office, and are looking towards the camera with slight smiles. The background is a solid blue color.

Together...Shaping the Future of Electricity