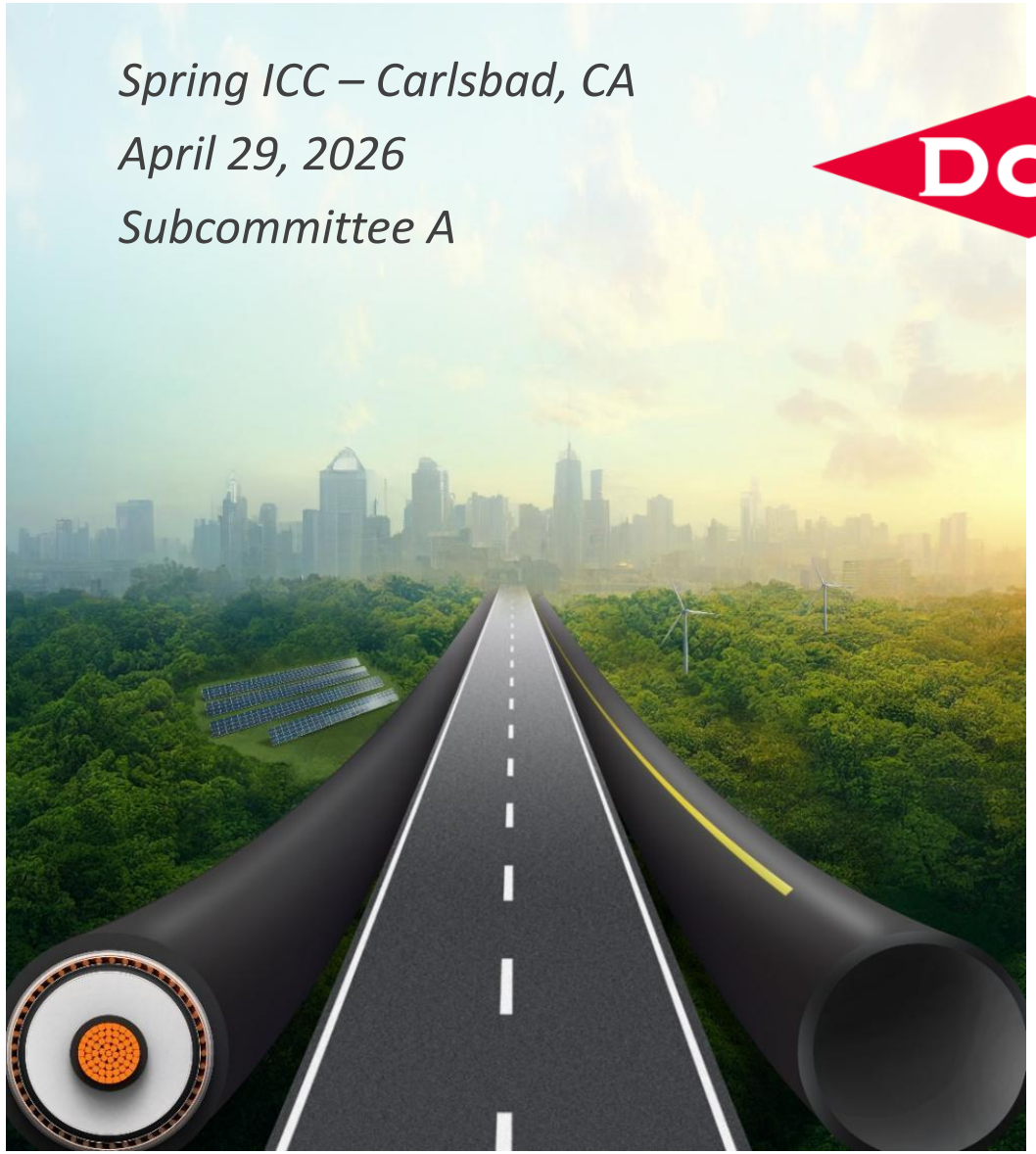


PROVEN CABLE PERFORMANCE ASSESSMENT AFTER 40 YEARS OF FIELD AGING

Paul Brigandi* — Dow Wire & Cable
Timothy Person — Dow Wire & Cable
Brent Richardson — Richardson Bros. Services
Stephen Wolbach — Alabama Power Company
Diana Ramirez-Wong — Georgia Tech, NEETRAC

*Application Technology Leader,
Wire & Cable, Dow
Email: pjbrigandi@dow.com

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PRESENTATION OVERVIEW

- Why 40 Years Matters
- Galleria Mall Field Study Overview
- Cables & Test Program
- 40-Year Electrical & Material Performance
- Key Findings & Implications



WHY A 40-YEAR FIELD EVALUATION OF MV CABLE SYSTEM?

- For decades, ~40 years has been widely considered the expected service life for underground MV cable systems*
- Many 1st generation TR-XLPE installations are now at or beyond this design-life projection
- Utilities face critical decisions:
  - When is replacement needed?
  - Extend service?
  - Re-rate or re-purpose existing assets?
- The Galleria Mall system offers a rare opportunity to assess the current state near the end of expected service life

*Thue, W., Burnstein, B.; Electric Power Research Institute (EPRI), Distribution Cable Research Digest 2000, EPRI Publication BR-110693, Palo Alto, CA, USA, 2000. (Available to EPRI members only).

Why the Galleria Mall System Is a Rare Opportunity

- One of the earlier TR-XLPE installations on the Alabama Power system
- Installed in 1985, now past the historically expected ~40-year service life
- Half loops of TR-XLPE and EPR insulated cables with the same voltage class, loading, and environment
- Previously evaluated at 17 and 25 years, enabling a true long-term aging trend assessment

Study Scope

- Field-removed TR-XLPE and EPR cables after ~40 years of continuous service
- Identical operating and environmental exposure for both insulation systems
- Direct continuity with prior 17- and 25-year evaluations of the same system

Key Objectives

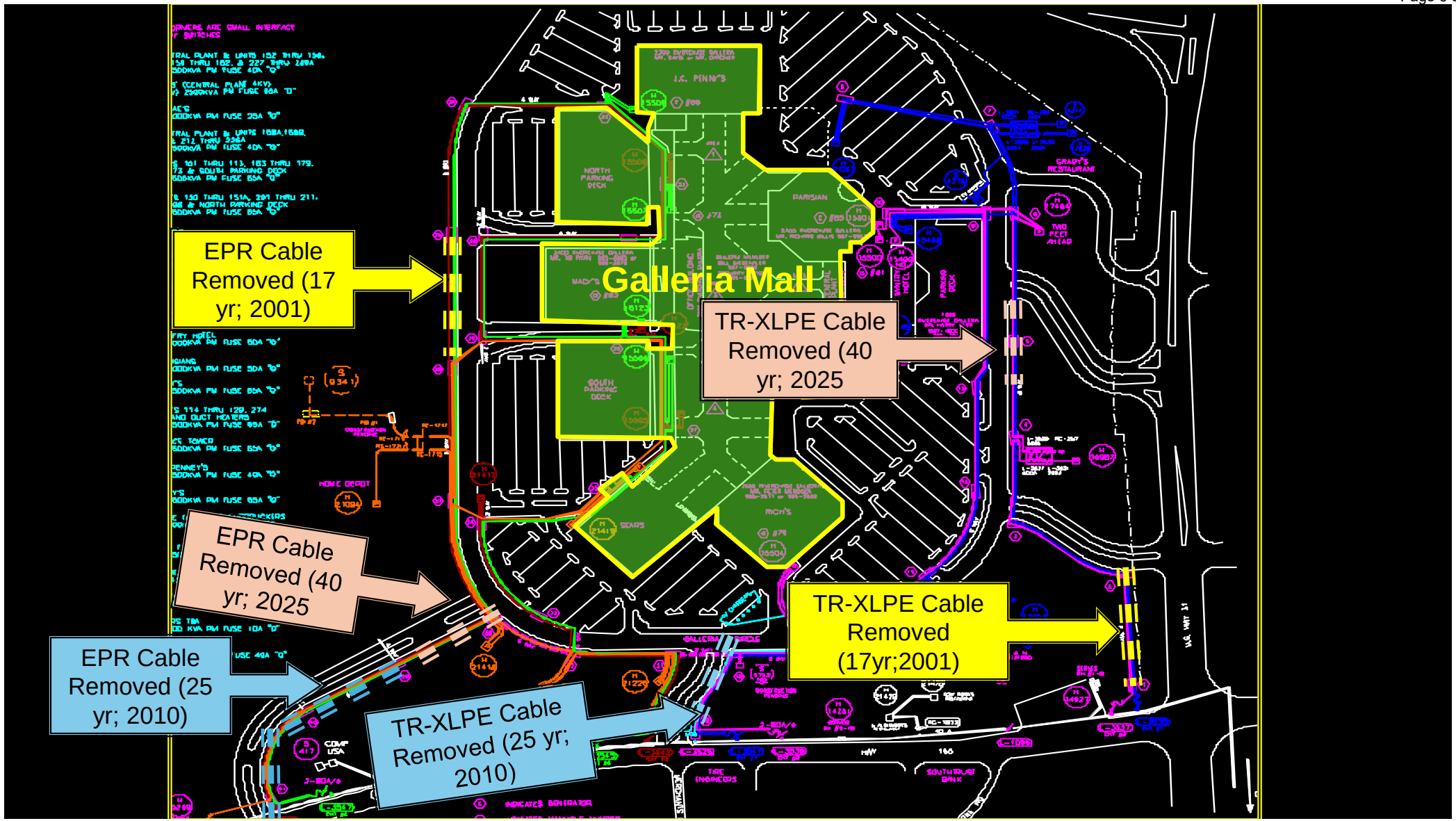
- Evaluate 40-year field performance of TR-XLPE and EPR cables
- Assess current health condition and continued fitness for service of the 40-year-old cable system
- Directly compare TR-XLPE vs. EPR performance after four decades
- Benchmark 40-year results against prior 17- and 25-year evaluations

GALLERIA MALL



https://hooversun.com/news/what-s-next-for-the-riverchase-galleria/

- Constructed 1984–1985; opened 1986
- ~2 million ft² super-regional mall; largest in the Southeast at time of construction
- Located ~10 miles south of Birmingham, Alabama (Hoover)
- Major commercial facility with an electrical demand of approximately 20 MVA
- Supplied by four 200-A underground distribution loops at 34.5 kV


EPR Cable Removed (17 yr; 2001)
Galleria Mall
TR-XLPE Cable Removed (40 yr; 2025
EPR Cable Removed (40 yr; 2025
EPR Cable Removed (25 yr; 2010)
TR-XLPE Cable Removed (25 yr; 2010)
TR-XLPE Cable Removed (17yr;2001)

TEAM REMOVES CABLES FROM THE GALLERIA MALL LOOP



Similar 35 kV Cable Designs



Cable Component	TR-XLPE	EPR
Conductor	No. 1/0 Copper Conductor (strand fill*)	No. 1/0 Copper Conductor (strand fill*)
Conductor Shield	XLPE Semi-Conductive Conductor Shield	EPR Semi-Conductive Conductor Shield
Insulation	345 mils TR-XLPE Insulation	345 mils EPR Insulation
Insulation Shield	Strippable XLPE Insulation Shield	EPR Semi-Conductive Insulation Shield
Concentric Neutral	16 x #14 Copper Concentric Neutral	16 x #14 Copper Concentric Neutral
Jacket	80 mils Semi-Conductive PE Jacket	80 mils PE Insulating Jacket

***TR-XLPE Cable used a viscous fill material within and over the conductor strands with a semi-con tape layer over the filled conductor. EPR Cable used a soft rubber strand fill material.

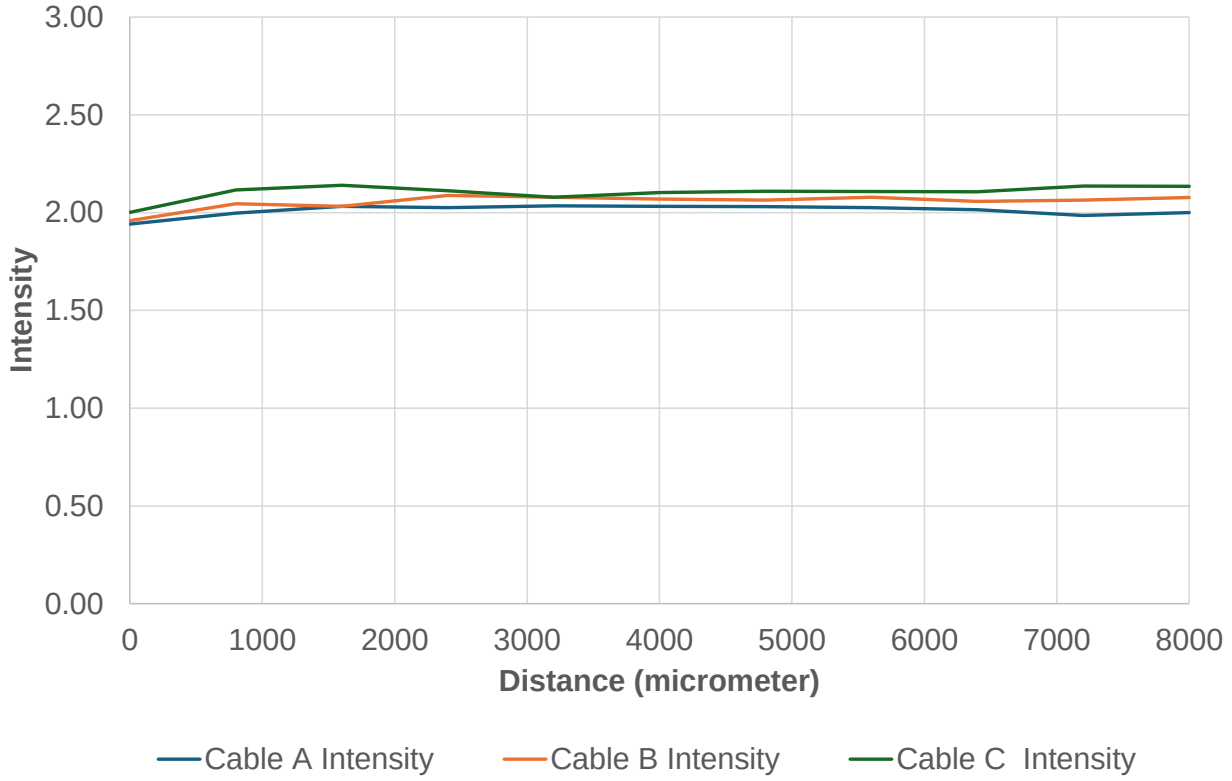
TEST PROGRAM

- TR-XLPE and EPR 35kV cables with 40 years of field service
- 300 circuit feet from each cable removed for stress testing was done by NEETRAC an independent 3rd party testing organization
  - HVTT (Ambient)
  - Impulse (90 °C)
  - DF 60Hz versus Temp
  - Treeing analysis
  - VLF tan δ
  - TR additive analysis
  - Moisture Analysis

Performed by NEETRAC

Performed by Dow

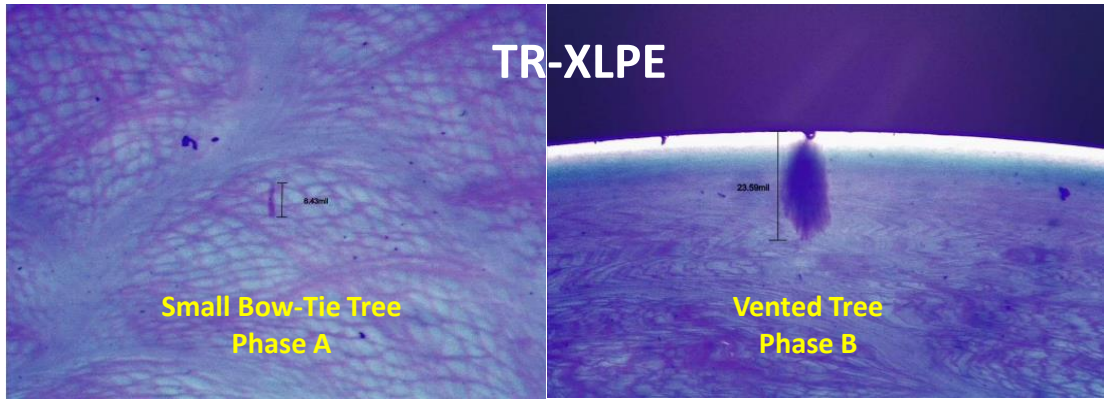
STABLE TREE RETARDANT ADDITIVE DISTRIBUTION IN TR-XLPE

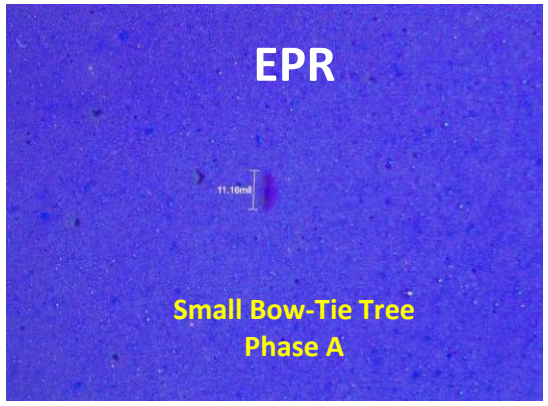


- Normalized absorbance of a peak assigned to the TR additive relative to one assigned to PE
- The spectra were collected in 11 evenly spaced steps (about every 800 µm) along each slice from the insulation shield to the conductor shield

WATER TREE ANALYSIS – ONLY SMALL NUMBER PRESENT AFTER 40 YRS

	TR-XLPE		EPR	
	Volume Analyzed: 0.6 in^3		Area Analyzed: 23.7 in^2	
Vented Trees	10-12 mils: 1	21-30 mils: 1	10-12 mils: 0	21-30 mils: 0
Bowtie Tress	6-10 mils: 3	11-20 mils: 1	6-10 mils: 1	11-20 mils: 1

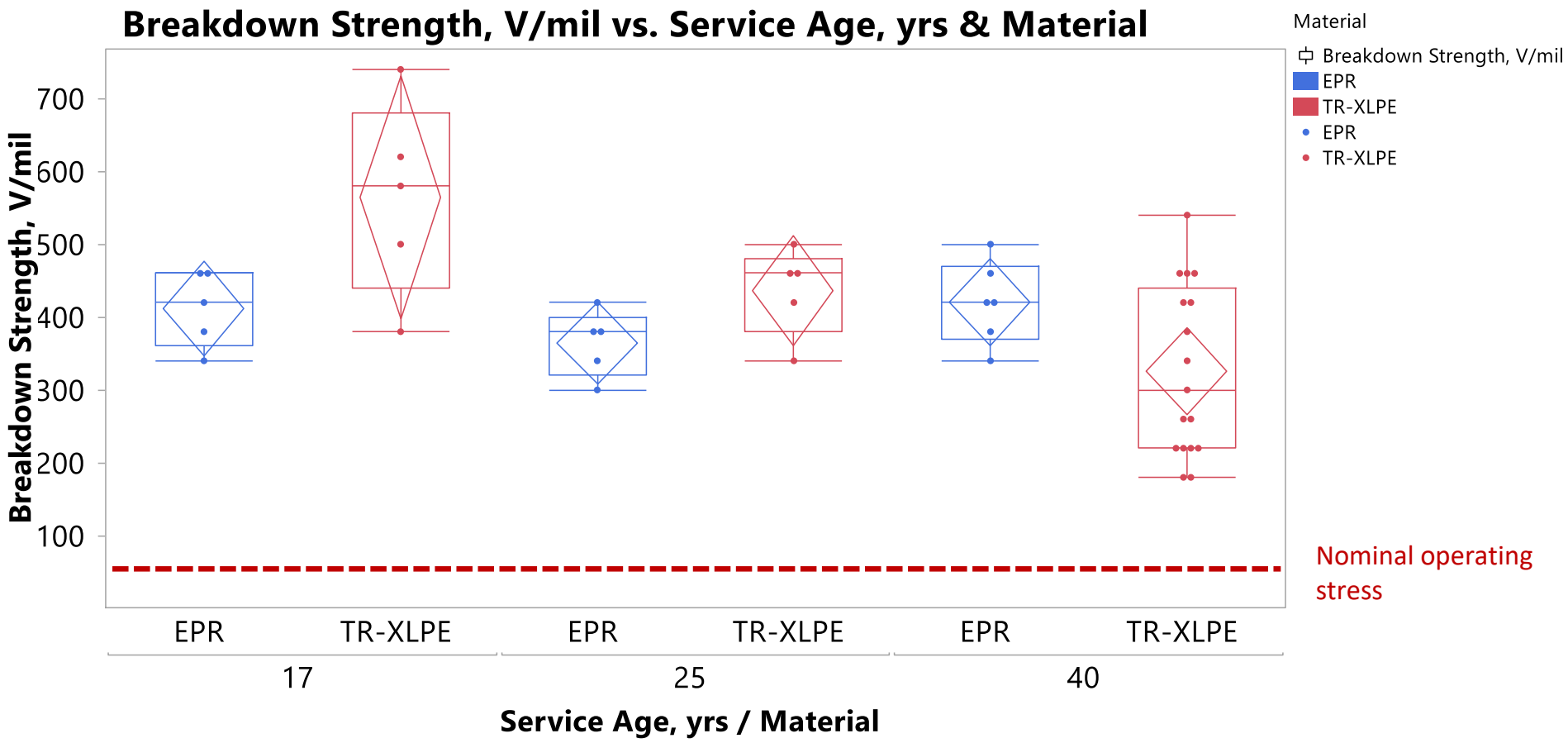




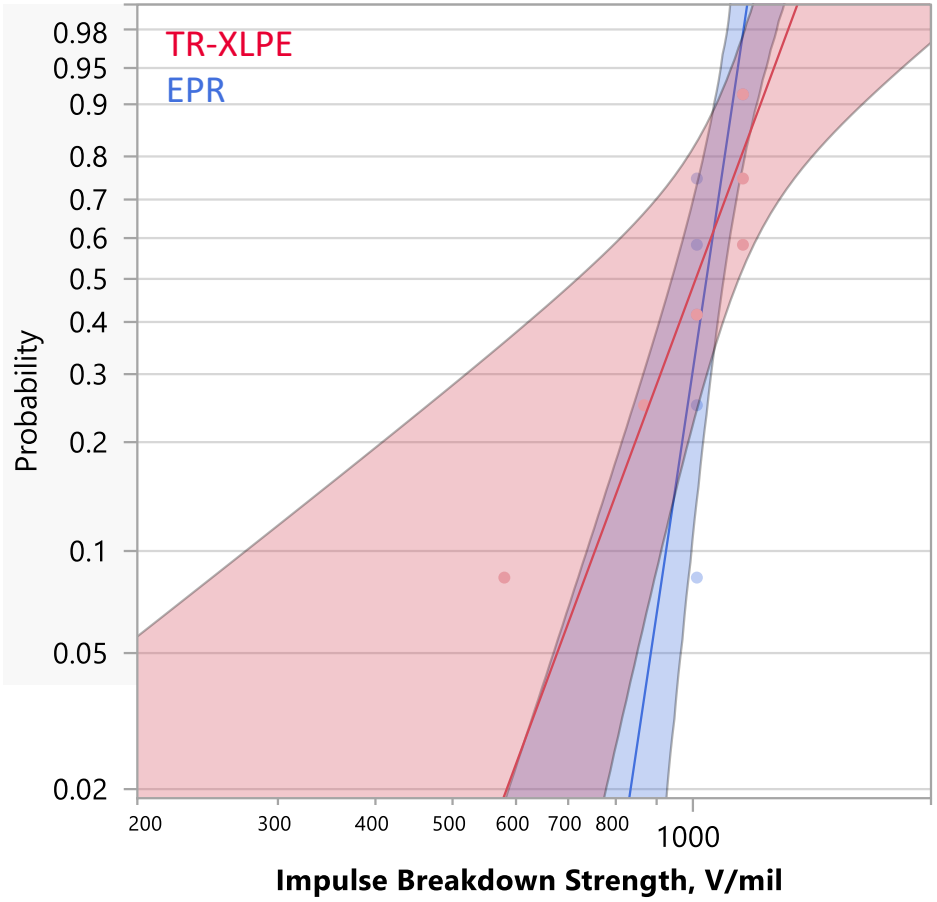
- No indication that water treeing became any more severe even as the cables reached the end of the projected life
- Maintained breakdown strength characteristics several times greater than the nominal stress level

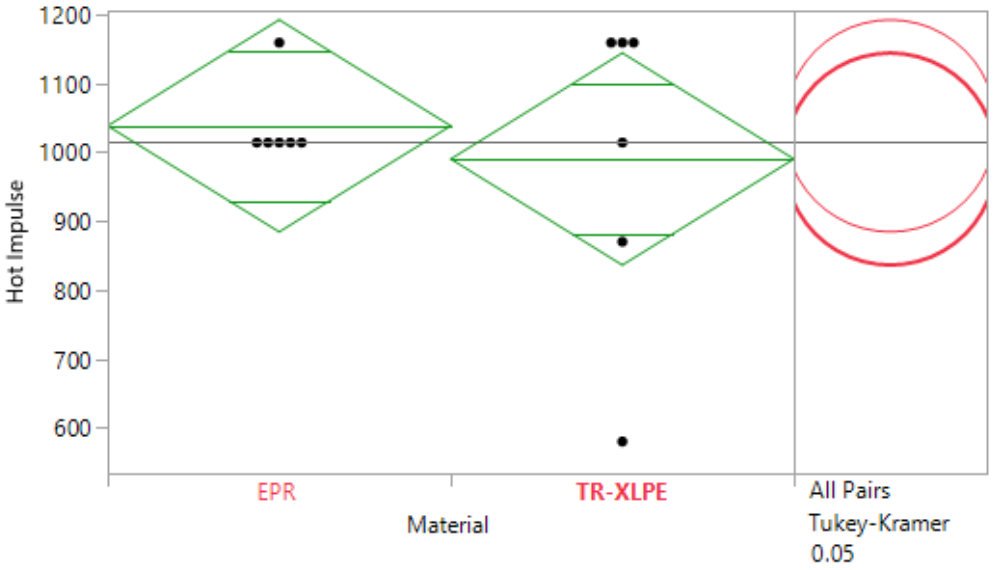
Pelissou, S., et al, "A Review of Possible Methods for Defining Tree Retardant Crosslinked Polyethylene (TRXLPE)", IEEE Electrical Insulation Magazine, v.24, n.5 (2008).

BREAKDOWN STRENGTH WELL ABOVE OPERATING STRESS AFTER 40 YRS

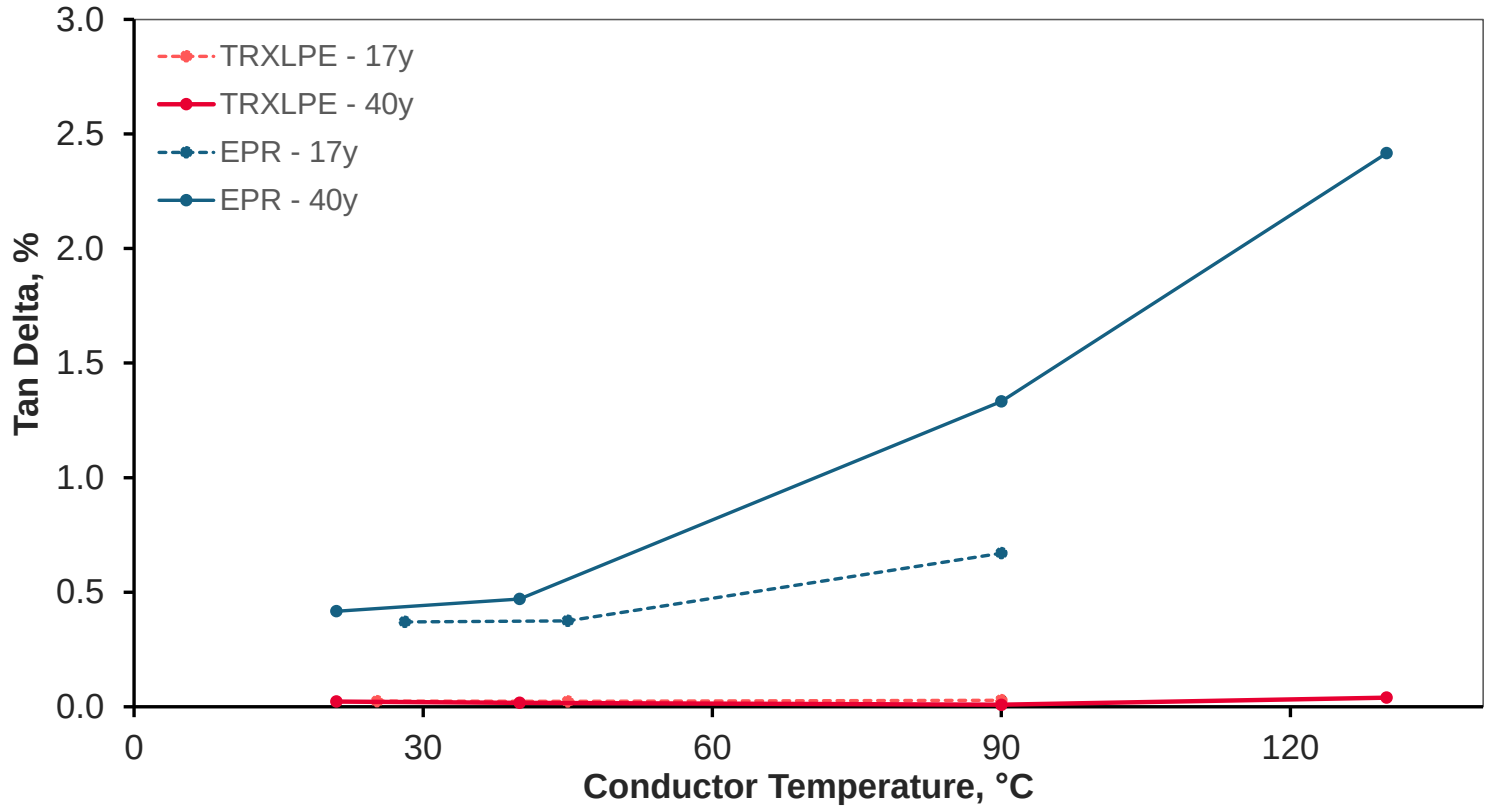


Hot Impulse Breakdown at Elevated Temp After 40 Yrs





DISSIPATION FACTOR OF TR-XLPE REMAINS WELL BELOW 0.5%



Dielectric losses in TR-XLPE remain minimal with temperature and age

VLF Tan Δ (CDFI) – Cable Diagnostic Assessment

- CDFI-based VLF tan δ evaluation (0.1 Hz)
- Test stress levels: 0.5, 1.0, 1.5U_o
- Action guidance informed by multi-diagnostic data
- Asset decision support (replace / monitor / no action)

Insulation Material	Phase	VLF tan δ at 0.5 U_o	VLF tan δ at 1.0 U_o	VLF tan δ at 1.5 U_o	Std. Dev. @ 1.0 U_o	Tip-Up (TU)
TR-XLPE	A	0.2355	0.2116	0.1953	0.0037	**–0.04**
	B	0.3655	0.3400	0.3268	0.0000	**–0.03**
	C	0.4989	0.4716	0.4526	0.0037	**–0.05**
EPR	A	7.0200	7.1000	7.1979	0.0000	**0.18**
	B	7.8672	7.9884	8.1226	0.0037	**0.26**
	C	8.0300	8.1400	8.2600	0.0000	**0.23**

"Tip-Up" is the change in tan δ at 1.5Uo compared to 0.5Uo.

CDFI Action Guidance:

- ✅ TR-XLPE: No action required — low tan δ, negative tip-up possible
- ✅ EPR: No action required — higher tan δ, positive tip-up expected

KEY TAKEAWAYS — 40 YEARS OF PROVEN FIELD PERFORMANCE

Material Insights – 1st-gen TR-XLPE:

- Maintains low dielectric losses
- Uniform additive distribution
- Comparative water-treeing behavior

1985 vintage **EPR**:

- Moderate increase dielectric losses with age
- Similar breakdown strength
- Comparative water-treeing behavior

Field Aging Behavior after 40-years in service

- Diagnostic indicators show slow, stable aging
- Retention of breakdown strength several times higher than operating stress.

Reliability Confirmed

- 1985 vintage TR-XLPE and EPR exceed life expectancy of 40 years
- No immediate reliability concerns identified

Looking Forward for TR-XLPE

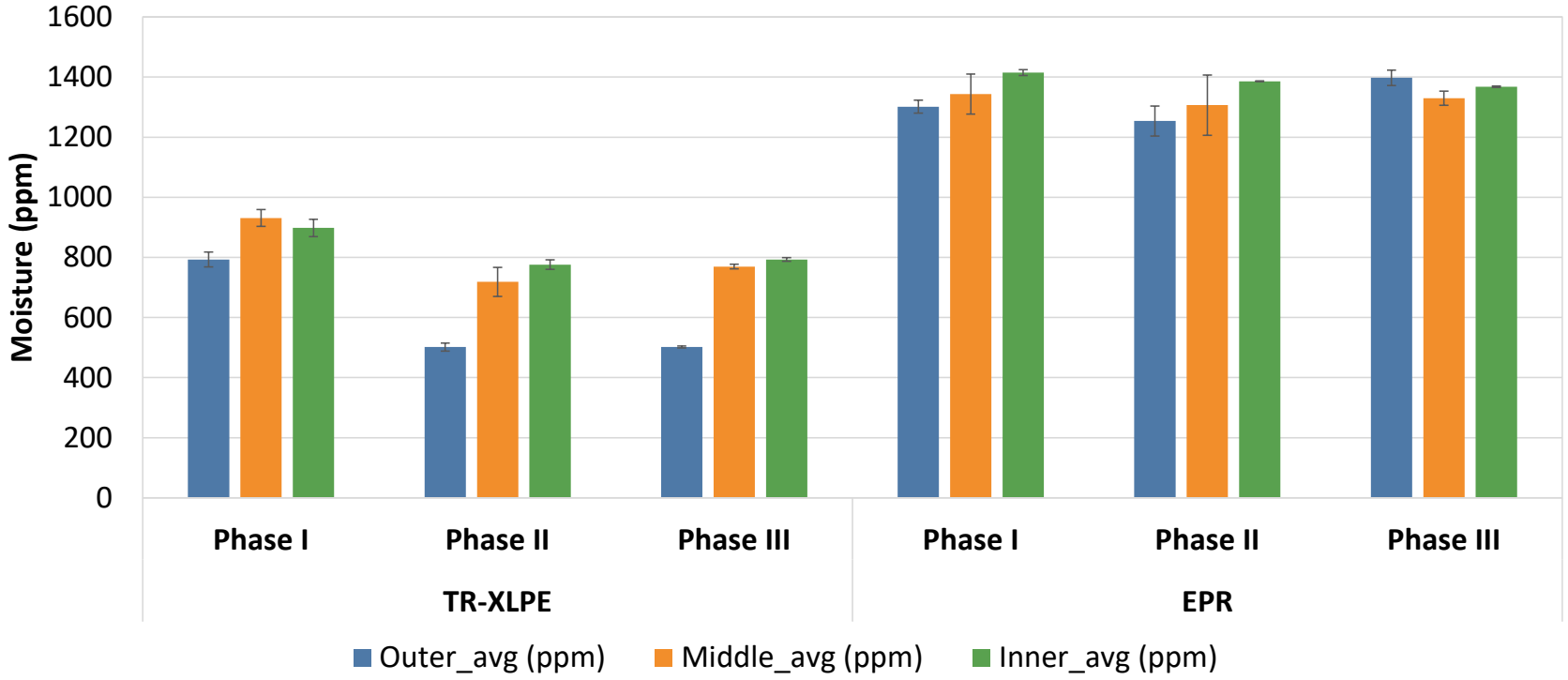
- Modern TR-XLPE (Gen-3) delivers significantly improved aging performance
- Enables higher-stress and wet-design MV/HV applications

Thank you!

PAUL BRIGANDI - BIO

Dr. Paul Brigandi is the Application Technology Leader for Dow Packaging & Specialty Plastics Wire & Cable business in North America based in Collegeville, PA. Paul has experience across the cable industry in power transmission and distribution as well as telecommunication markets focused on research and development of new material solutions. His technical expertise includes formulation and processing of polyolefins, elastomers, and polymer composites. Paul is active in several industry organizations including serving on the IWCS symposium committee, Insulated Conductors Committee, Communications Cable and Connectivity Association, and Fiber Broadband Association technical committees. Paul earned a Ph.D. in Polymer Science and Engineering from Lehigh University and a B.S. in Chemical Engineering from the University of Delaware. He is also an active Adjunct Professor at Lehigh University in the Material Science & Engineering department.

MOISTURE ANALYSIS FOR TRXLPE AND EPR INSULATION



Moisture levels remain well controlled in TR-XLPE across outer-to-inner insulation