CABLE TECHNOLOGY LABORATORIES, INC.

NEW BRUNSWICK, NJ

CTL AGING

OF MEDIUM VOLTAGE CABLES

by

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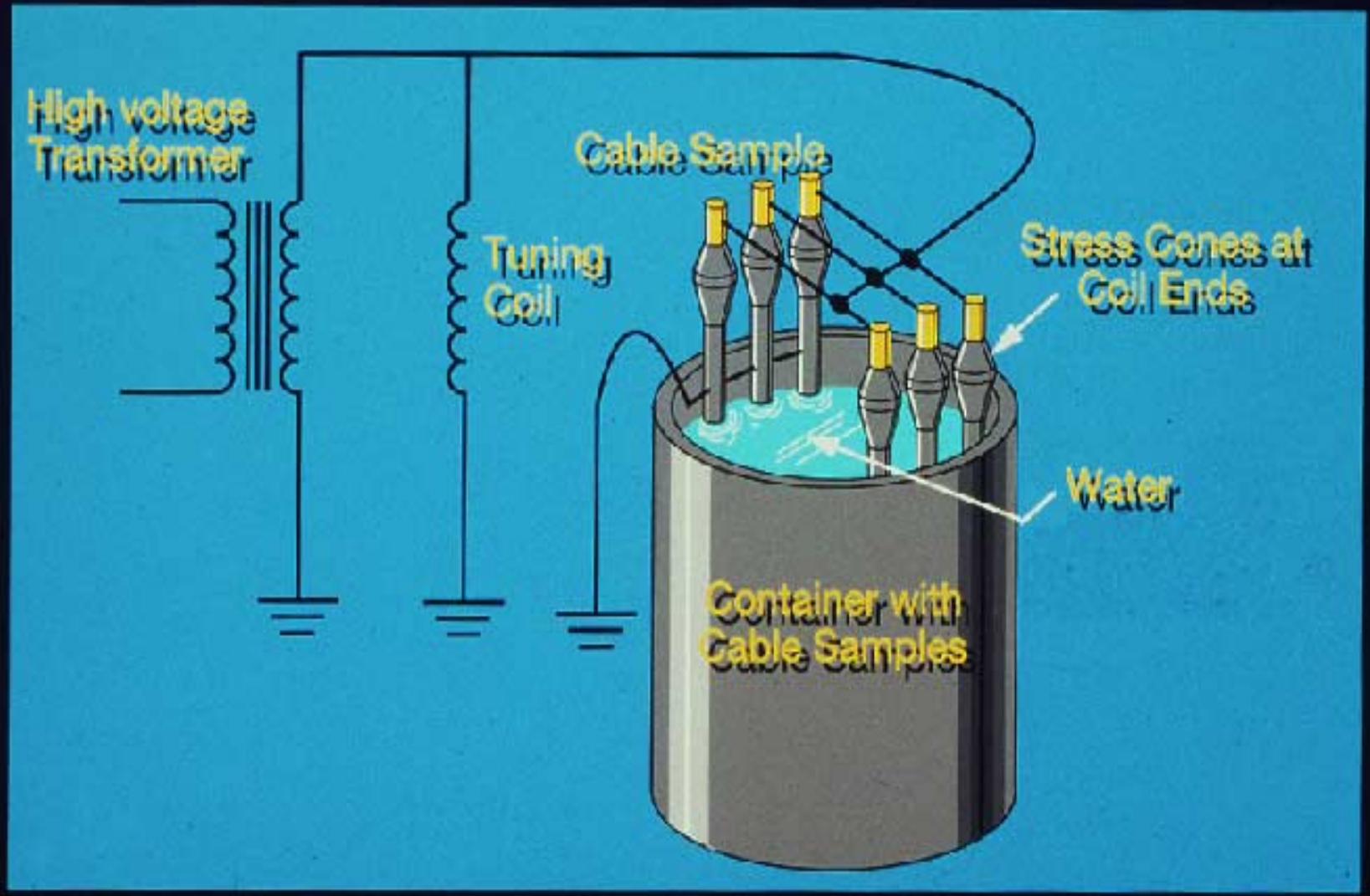
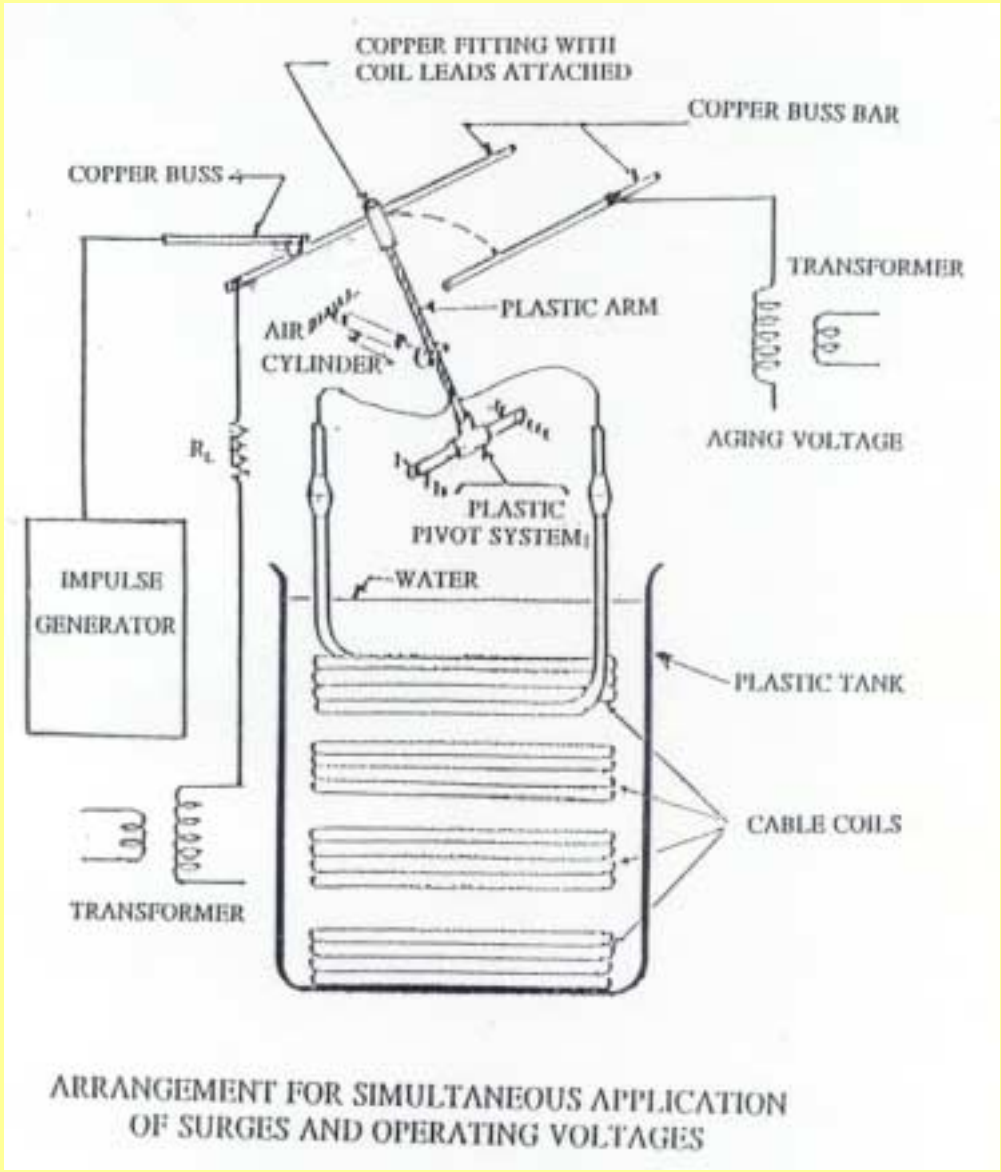
Cable Accelerated Aging Test Set-Up

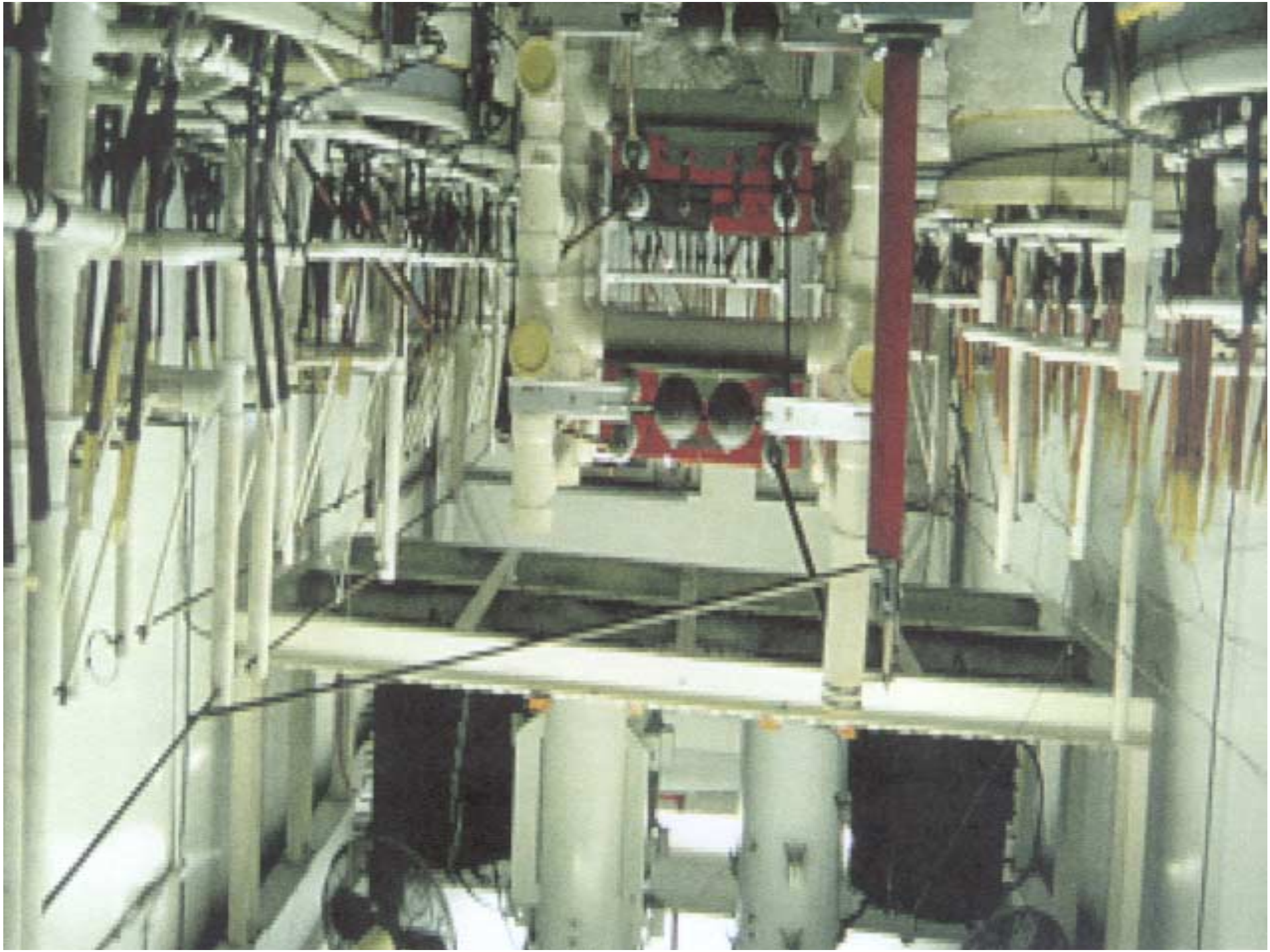


CABLE AGING METHOD

Cable Rating	15 kV
Temperature	30 ± 5°C
Water	Outside - Inside
Aging Voltage	2.5 V_o
Transients	1.2 x 40 :s.
Transient Application	3 x 120 kV/week
Aging Coils	210 ft.
Individual Samples	35 ft.



ARRANGEMENT FOR SIMULTANEOUS APPLICATION
OF SURGES AND OPERATING VOLTAGES



AGING EVALUATION

- Coils Removed at Pre-determined Intervals
- Each Coil Divided into 6-35 Foot Long Samples
- AC and Impulse Breakdown Tests at Ambient Temperature
- Characterization Tests:
  - Treeing Analysis
  - Shields Volume Resistivities
  - Insulation Shield Strippability
  - Insulation Moisture Content

15 KV CABLE CONSTRUCTIONS

Conductor	1/0 (19w), Al.
Conductor Shield	15 mils S.C. XLPE
Insulation	175 mils XLPE or TR-XLPE or EP
Insulation Shield	30 mils S.C. XLPE
Concentric Neutral	16 x #14, Cu
Jacket	None

15 KV CABLE AGING TEST MATRIX

Aging Voltage – kV		**15**	
Aging Conditions	Aging (Months)	Breakdown Tests	
		AC	Impulse
Unaged	0		
A) 30°C Water Outside	24		
	48		
B) 30°C Water Outside & Inside	18		
	42		
C) 30°C Outside & Inside with Voltage Transients*	18		
	36		

* 120 kV Standard Impulse Voltages (1.2–1.4 x 40–50 μs.)

AC VOLTAGE BREAKDOWN STRESS

15 kV Cables Aged at 30°C
(all conditions)

Insulation	Unaged	Aged 48 Months	
	V/mil	V/mil	% of Unaged
XLPE	1300	290-380	22-29
TR-XLPE	800	860	107
EP	930	320-360	35-38

IMPULSE VOLTAGE BREAKDOWN STRESS

15 kV Cables Aged at 30°C (all conditions)

Insulation	Unaged	Aged 48 Months	
	V/mil	V/mil	% of Unaged
XLPE	3280	1260-1610	38-49
TR-XLPE	3020	1640	54
EP	1650	920-1070	56-65

More Recent Project

Field and Laboratory Accelerated Aging of EP and TR-XLPE Distribution Cables

Project Cables

- 5 Commercial EP's
- 1 Commercial TR-XLPE
- 15KV - 175 Mil - 4/0 Cu
- Concentric Neutral
- Unjacketed

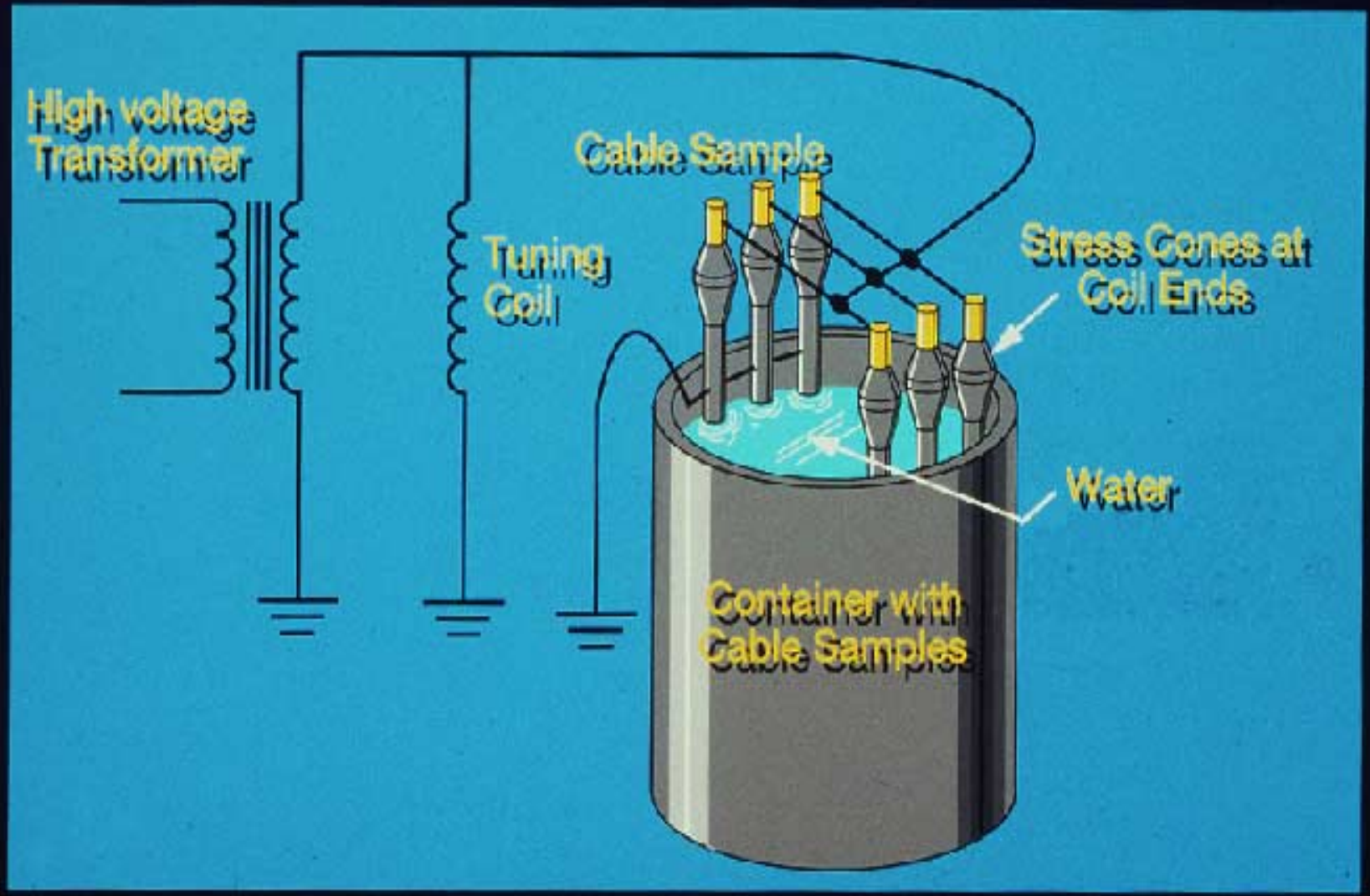
Project Goals

- Age Several EP Cables in Field and Laboratory
- Age TR-XLPE as a Control
- Monitor Field Operational Parameters
- Adjust Laboratory to Field Parameters
- Compare Field Aging to Laboratory Aging
- Develop an EP Aging Model

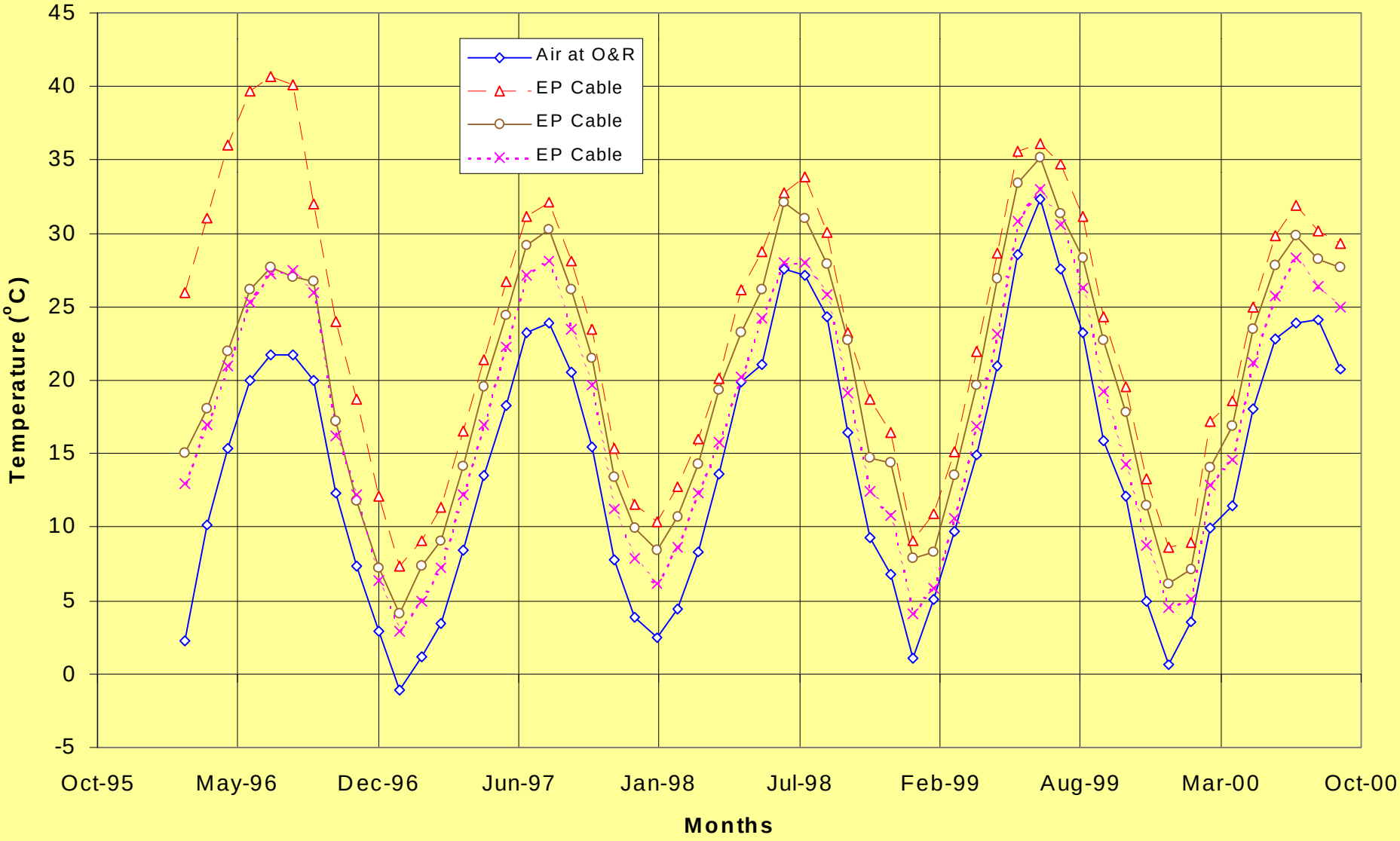
Three Test Sites

- 13.2/7.62 kV Mid-Circuit
- 34.5/19.9 kV URD Development
- 34.5/19.9 kV Laboratory - CTL

Cable Accelerated Aging Test Set-Up



Laboratory Cable Shield Average Monthly Temp. & Ambient Temp. at O&R



Evaluation Tests

- A.C. Breakdown
- Impulse Breakdown
- Cable Characterization

Shield Resistivity	Moisture Content of Insulation
Partial Discharge	Dissipation Factor
Shield Strippability	Water Tree Analysis

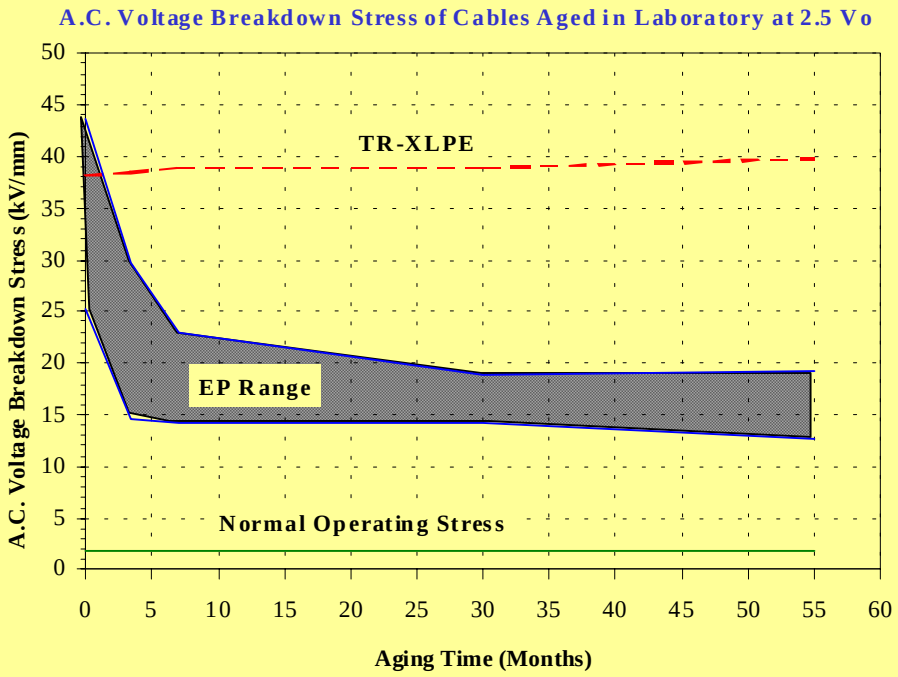
Moisture Content of Insulation

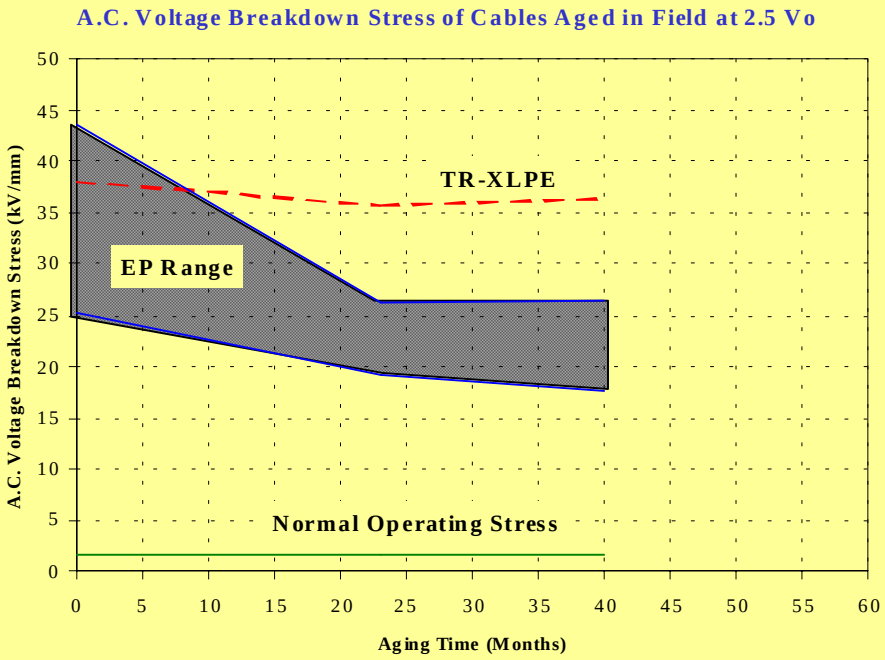
Close to Insulation Shield

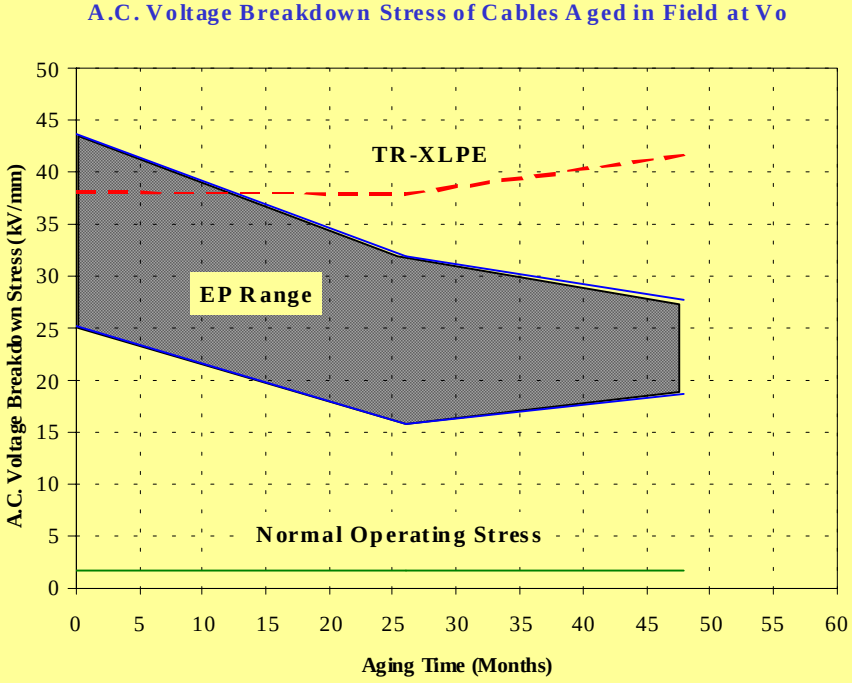
Cable Identification	Moisture Content (%)			
	New Cable	Aged in Laboratory 55 Months at 2.5 V_o	Aged in Field 40 Months at 2.5 V_o	Aged in Field 48 Months at 1.0 V_o
EP	0.09	0.15	0.13	0.13
EP	0.13	0.71	0.30	0.44
TR-XLPE	0.04	0.58	0.25	0.41
EP	0.06	0.14	0.11	0.14
EP	0.11	0.13	0.12	0.15
EP	0.10	0.17	0.16	0.20

Dissipation Factor

	100 Tan δ at 20 kV			
Cable Identification	**New Cable**	**Aged in Lab. 55 Months at 2.5 Vo**	**Aged in Field 40 Months at 2.5 Vo**	**Aged in Field 48 Months at 1.0 Vo**
EP	**0.15**	**0.14**	**0.14**	**0.15**
EP	**1.70**	**3.60**	**2.45**	**3.17**
TR-XLPE	**0.04**	**0.06**	**0.04**	**0.04**
EP	**0.16**	**0.17**	**0.14**	**0.20**
EP	**0.15**	**0.15**	**0.15**	**0.16**
EP	**0.36**	**0.39**	**0.33**	**0.42**







AC Breakdown Strength

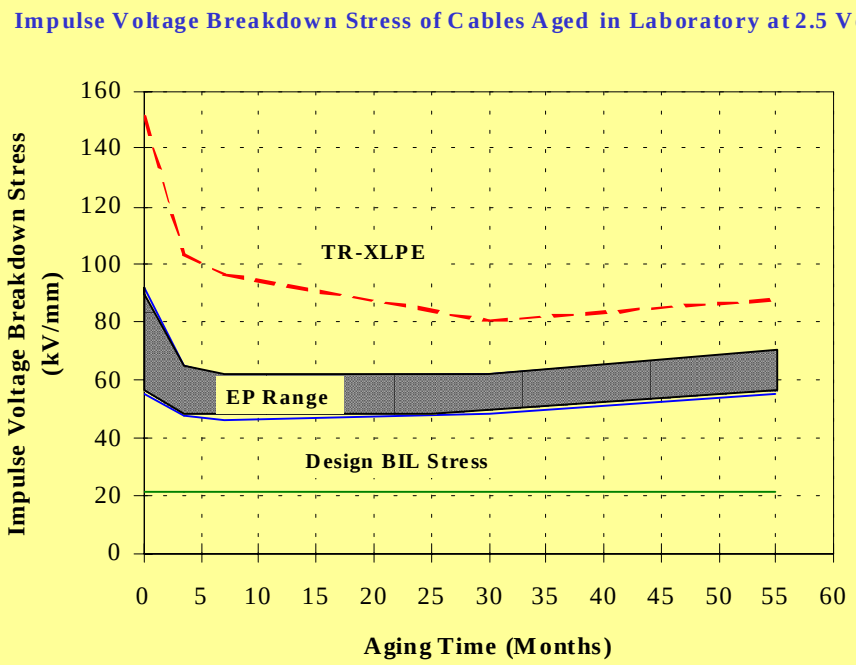
Cables Aged in the Laboratory

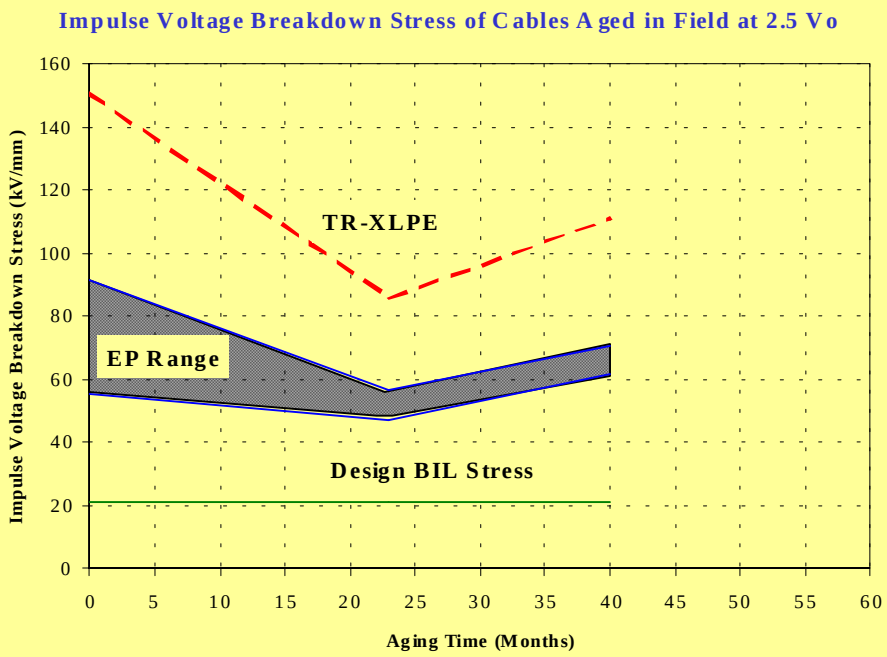
vs.

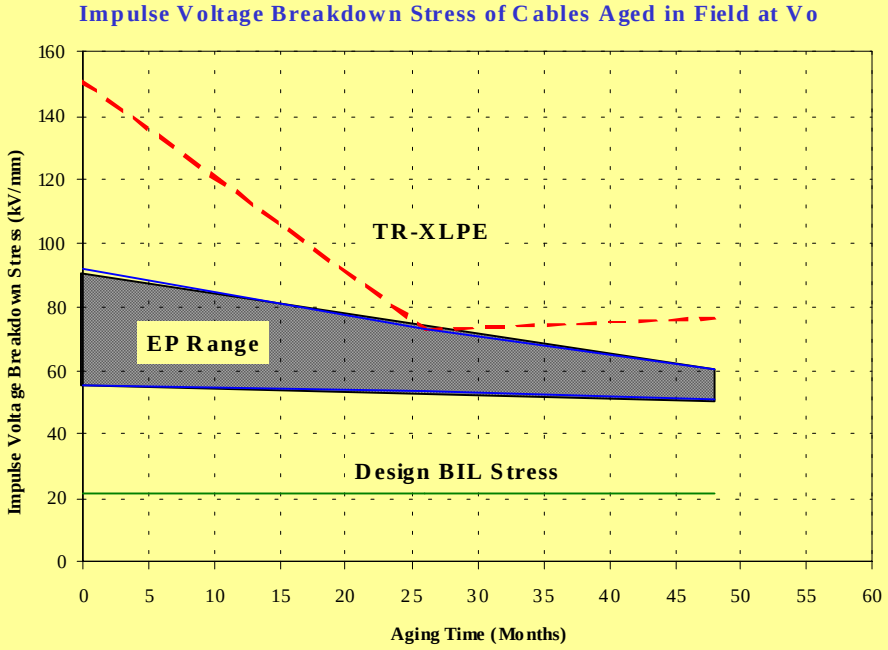
Cables Aged in the Field

A.C. Breakdown Voltage Retention

	55 Months in Lab. @ 2.5 Vo	40 Months in Field @ 2.5 Vo	48 Months in Field @ 1.0 Vo
EP	**76 - 37%**	**100 - 49%**	**78 - 57%**
TR-XLPE	**100%**	**96%**	**100%**







Impulse Breakdown Strength

Cables Aged in the Laboratory

vs.

Cables Aged in the Field

Impulse Breakdown Voltage Retention

	55 Months in Lab. @ 2.5 Vo	40 Months in Field @ 2.5 Vo	48 Months in Field @ 1.0 Vo
EP	**100 - 69%**	**100 - 73%**	**100 - 66%**
TR-XLPE	**58%**	**74%**	**51%**

STRIPPING STRENGTH AND VOLUME RESISTIVITY

Cables had none or negligible change in:

- Bond strength
- Resistivity of insulation shield
- Resistivity of conductor shield

Conclusions

- Aging medium voltage cables in the laboratory surrounded by 30°C water reproduces field aging of URD cables.
- Laboratory aging in 30°C water results in faster degradation than in the field, because the cables are surrounded continuously by water.

Conclusions (cont.)

- One EP and the TR-XLPE show excellent retainage of ac voltage strength. One EP cable also shows excellent retainage of impulse strength.
- All tested cables indicate negligible changes in stripping strength, shield volume resistivity and partial discharge.

REFERENCES

- IEEE Standard 1407-1998, “IEEE Trial-Use Guide for Accelerated Aging Tests for Medium-Voltage Extruded Electric Power Cables Using Water-Filled Tanks.
- EPRI TR-108405-V1 - Project 2713-03, August 1997, “Aging Study of Distribution Cables at Ambient Temperature with Surges”.
- Katz, C., Seman, G.W., Bernstein, B.S., “Low Temperature Aging of XLPE and EP Insulated Cables with Voltage Transients”, IEEE Trans. on Power Delivery, Vol. PWRD-10, No.1, pp 34-42, January 1995.
- Katz, C., Fryszczyn, B., Regan, A.M., Banker, W.A., Bernstein, B.S., “Field Monitoring of Parameters and Testing of EP and TR-XLPE Distribution Cables”, IEEE Trans. on Power Delivery, Vol. PWRD-14, No. 2, pp 679-684, July 1999.