Accelerated Life Test Fitting of Bi-Layer Insulations for HVDC Cable Accessories

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Introduction

- HVDC cable accessories (joints and terminations) are critical components for system reliability.
- Electro-thermal lifetime modelling for cable insulation is well established, but its applicability to cable–accessory interfaces has to be proved.
- Interface regions introduce higher variability, making lifetime assessment more challenging.
- The IPM–Arrhenius life model is adopted to assess the lifetime behaviour of XLPE/EPDM bi-layer interfaces.

Electro-thermal test conditions

- Bi-layer XLPE/EPDM configuration reproducing cable–accessory interfaces.
- XLPE side facing the high-voltage electrode, EPDM grounded.
- Failure times recorded for statistical lifetime analysis.
- Test duration: up to ~1–2 months.

Electric Field (kV/mm)	Temperatures (°C)		
	70	60	50
200	X	–	X
180	X	X	X
170	–	X	X
160	X	–	–

ALT test matrix showing electric field–temperature combinations;
X = test performed, – = not tested..

Statistical data analysis

- Failure times analysed assuming a 2-parameter Weibull distribution.
- Censored data treated using two schemes: single right-censoring (SRC) and censoring by measured quantity (CMQ).
- Median lifetime ($t_{50\%}$) used for robust lifetime estimation under high scatter.
- Electric field dependence at fixed temperatures modelled using the Inverse Power Model (IPM).

$$L(E,T) = L_H(T)(E/E_H)^{-n(T)}$$

- Life exponent n extracted from linear fitting in log–log scale.

T (°C)	n (SRC)	n (CMQ)
70	46.8	45.2
60	34.0	40.7
50	27.3	14.6

Reference: n= 10 (Cigré Technical Brochure 852)

Conclusions

- The applicability of the IPM–Arrhenius life model is extended from cable insulation to cable–accessory interfaces.
- Failure times show high scatter, but consistent trends emerge from Weibull-based percentiles.
- Life exponent values ($n \approx 15$–45) are significantly higher than the reference value (n = 10), indicating good electrical endurance.
- ALTs at $60\ ^\circ\mathrm{C}$ are currently not completed yet: further tests are ongoing.

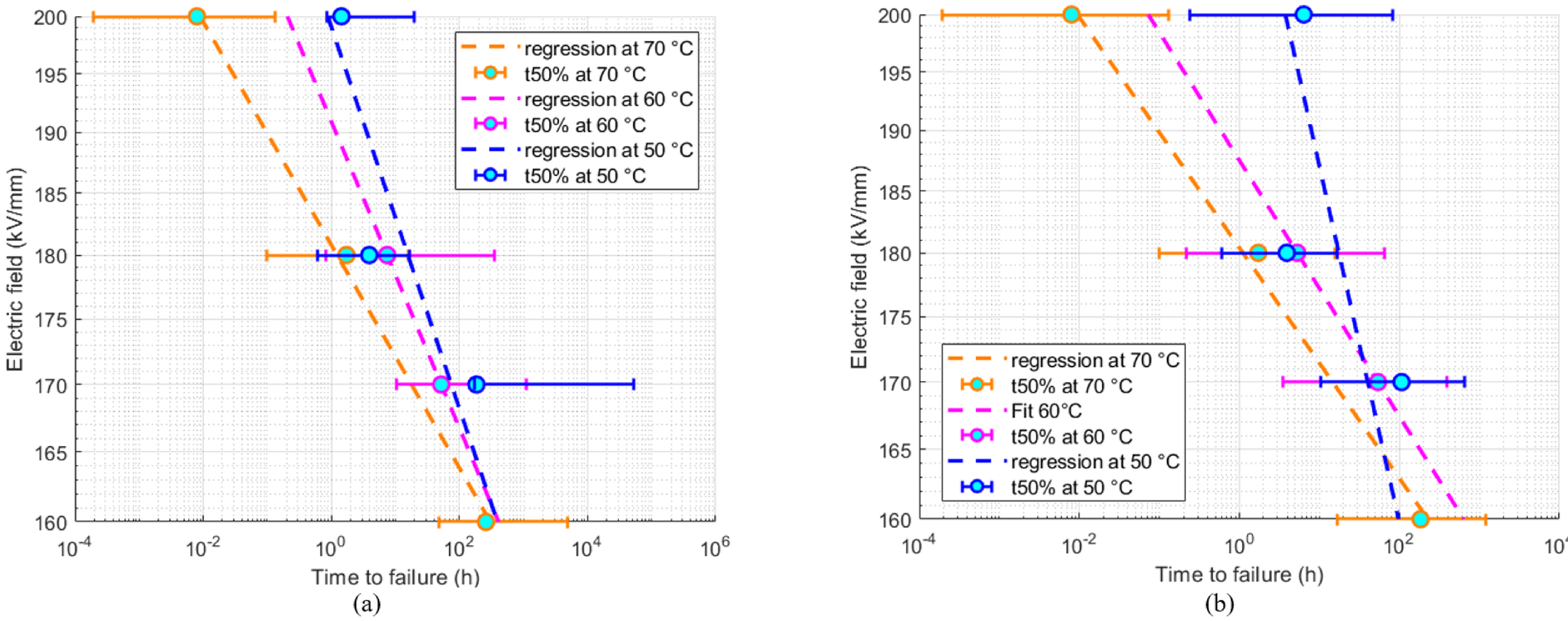

Fig. 1. Accelerated life test plot in log-log scale of $t_{50\%}$ at $70\ ^\circ\mathrm{C}$, $60\ ^\circ\mathrm{C}$ and $50\ ^\circ\mathrm{C}$ with 90% confidence bounds and a linear regression, obtained with: (a) the SRC scheme; (b) the CMQ scheme.

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