

**COBHAM**

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8 July 2009

The most important thing we build is trust



**ERA TECHNOLOGY  
ANTENNA AND  
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## Life Prediction of Cables and Cable Materials

- 
- **Identify accelerating factor (s)**
    - Temperature
    - Electrical stress
    - Multi factor
      - Mechanical stress/humidity/electrical stress
  - **Define end of life property**
    - Mechanical properties
    - Time to failure
    - Electrical breakdown strength
    - Conventional and accelerated creep rupture
  - **Age specimens at different times and conditions**
  - **Measure changes in properties**
  - **Select model to predict lifetime**
    - Arrhenius
    - Inverse Power Law
    - Electrokinetic Ageing
    - Williams Landel Ferry

# Life Prediction of NBR/PVC Cable Sheathing



- **Instrumentation and power cables**
- **Temperature as the accelerating factor**
- **Oven aged tensile specimens at different temperatures**
- **Periodically measured change in tensile strength and elongation at break**
- **Extrapolated results to 50 % change in properties at each T**
- **Use Arrhenius to determine life time**

$$\ln (K) = E_{\text{act}} /RT+ \ln A$$

$E_{\text{act}}$  is the activation energy

R is the Gas Constant

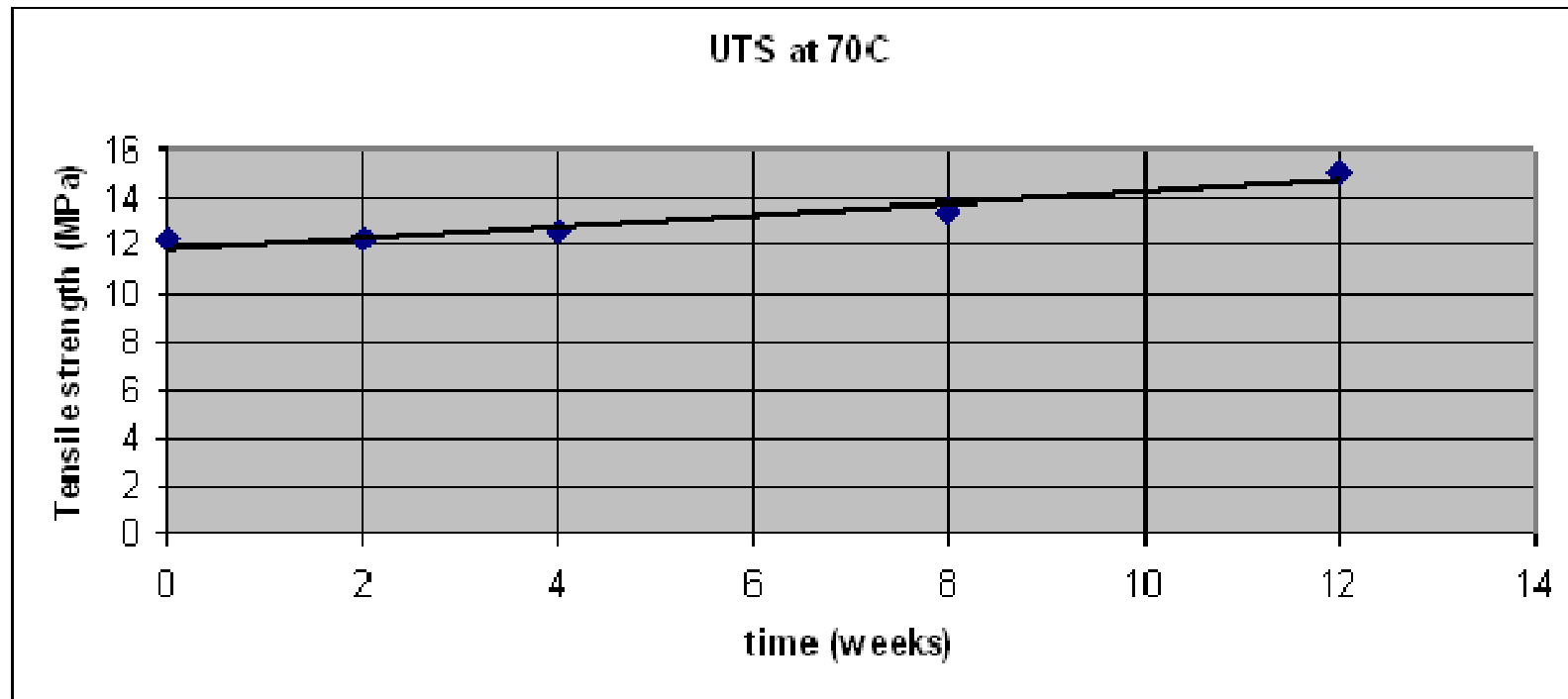
T is absolute temperature

A is a constant

# Life Prediction of NBR/PVC Cable Sheathing



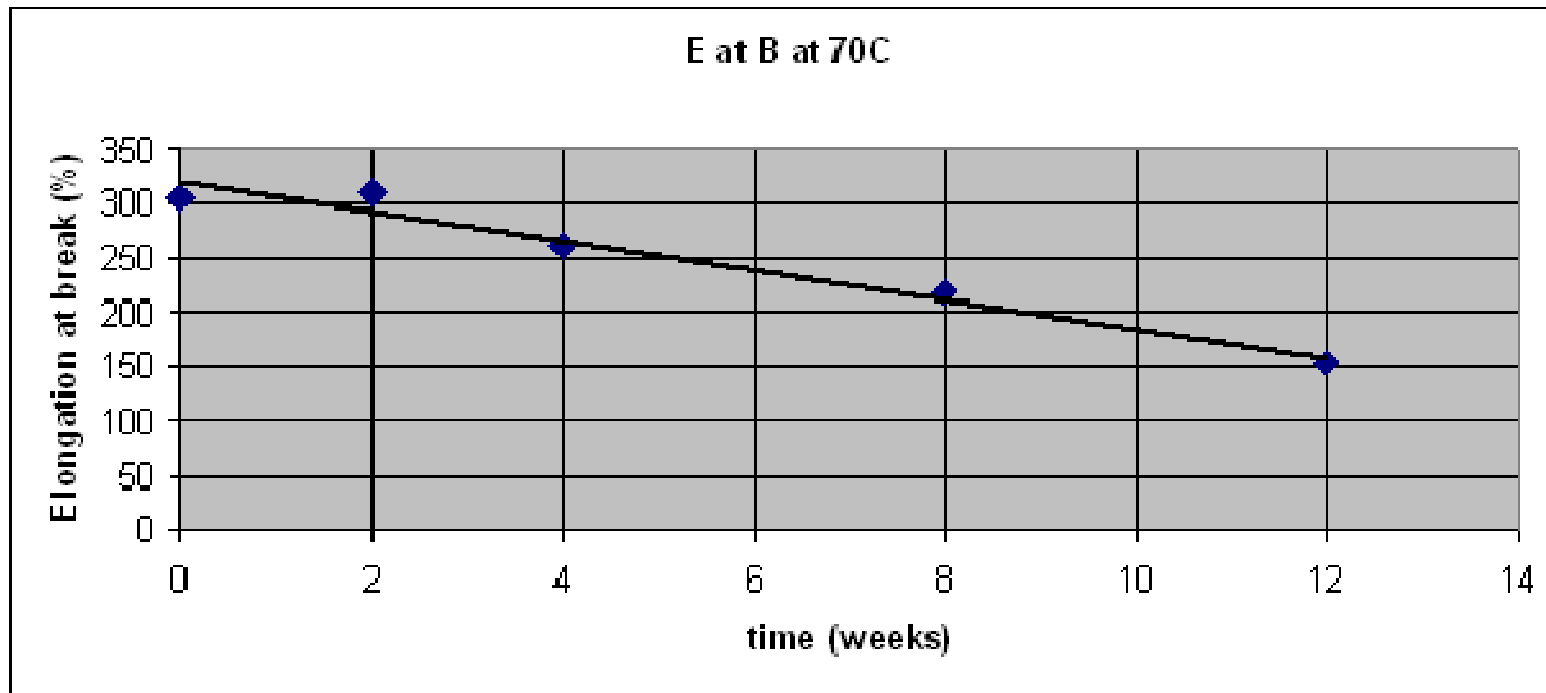
- **Tensile strength of power cable sheath**



# Life Prediction of NBR/PVC Cable Sheathing



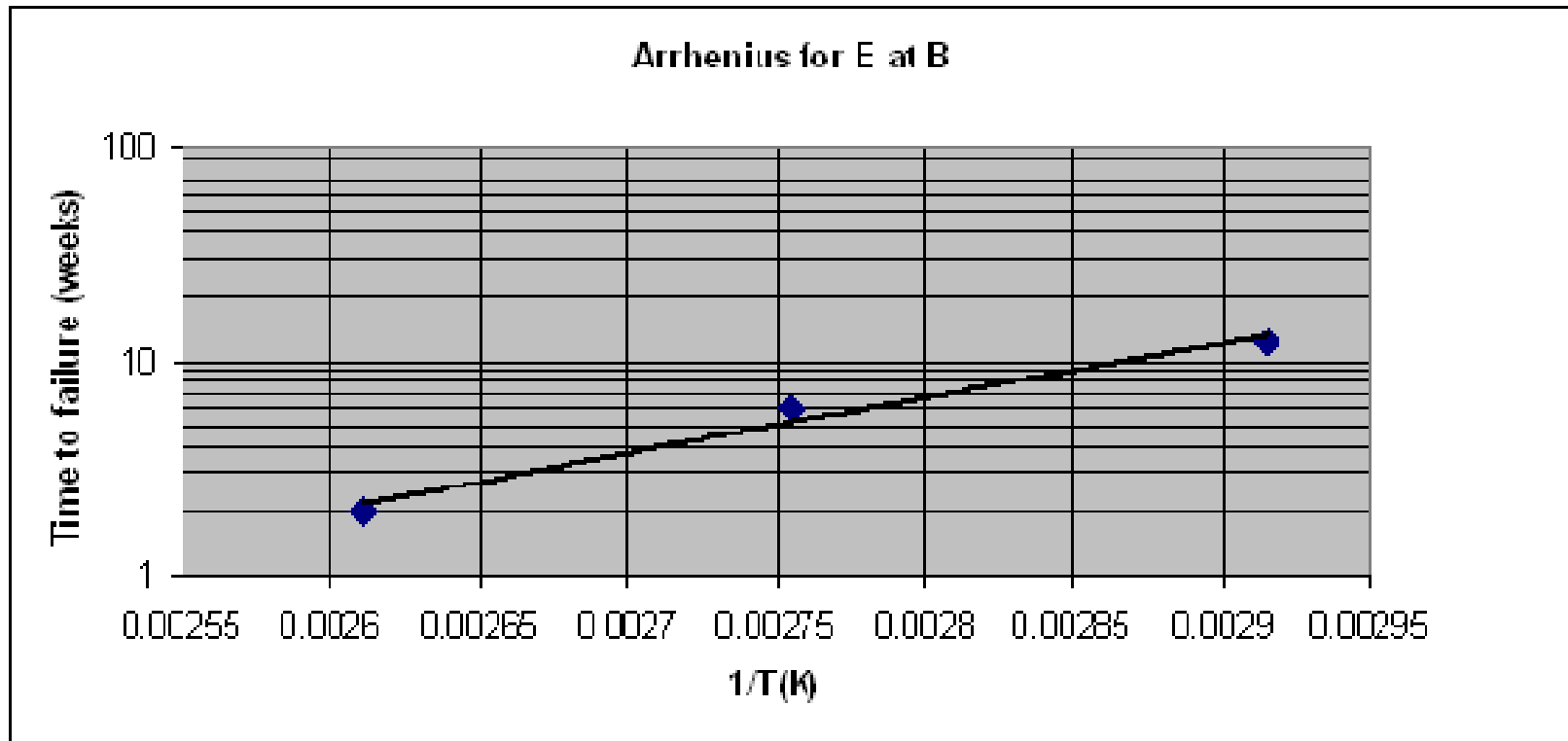
- **Elongation at break of power cable sheath**



# Life Prediction of NBR/PVC Cable Sheathing



- Arrhenius diagram for power cable sheath E@B

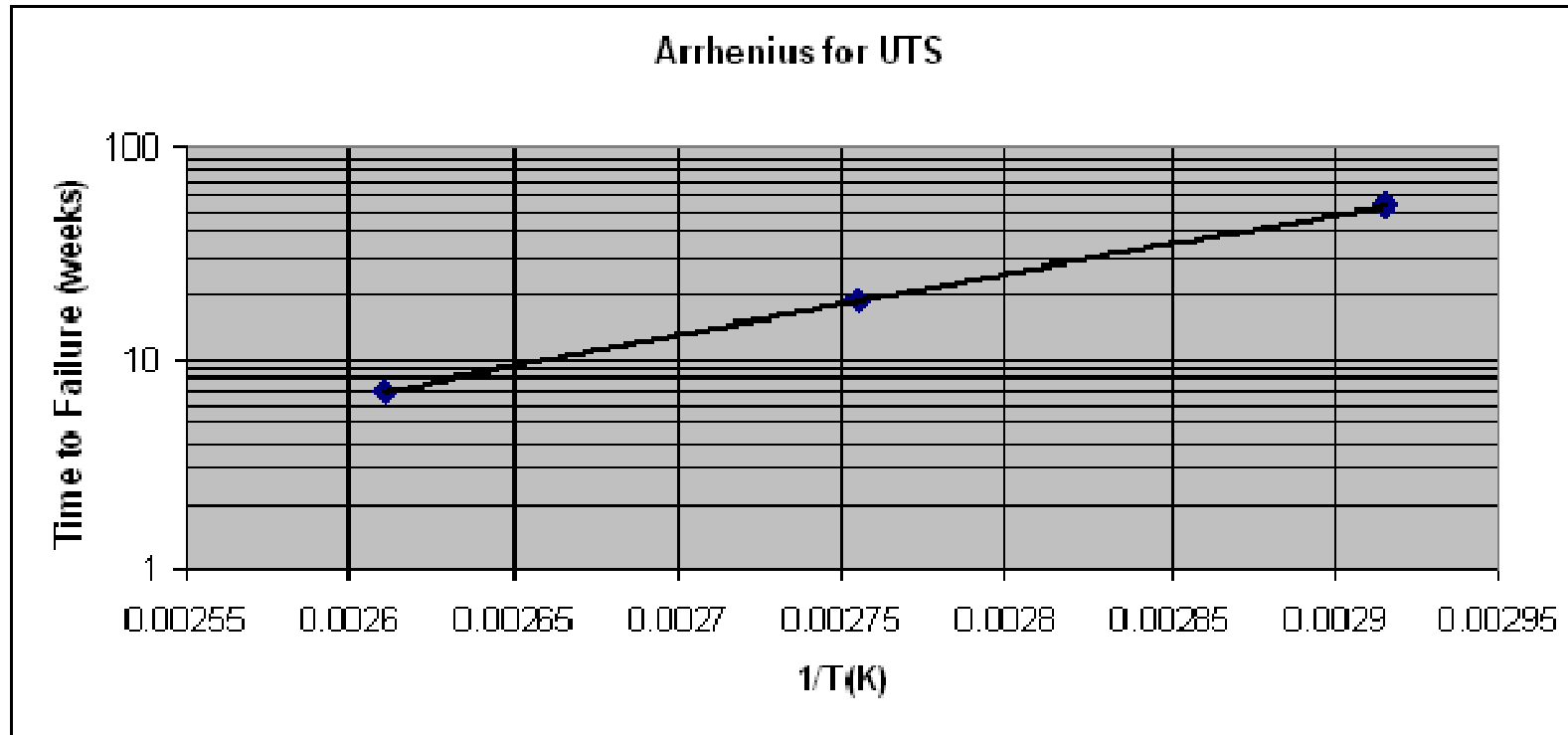


Predicts life expectancy of 3 years at 25°C

# Life Prediction of NBR/PVC Cable Sheathing



- Arrhenius diagram for power cable sheath tensile strength

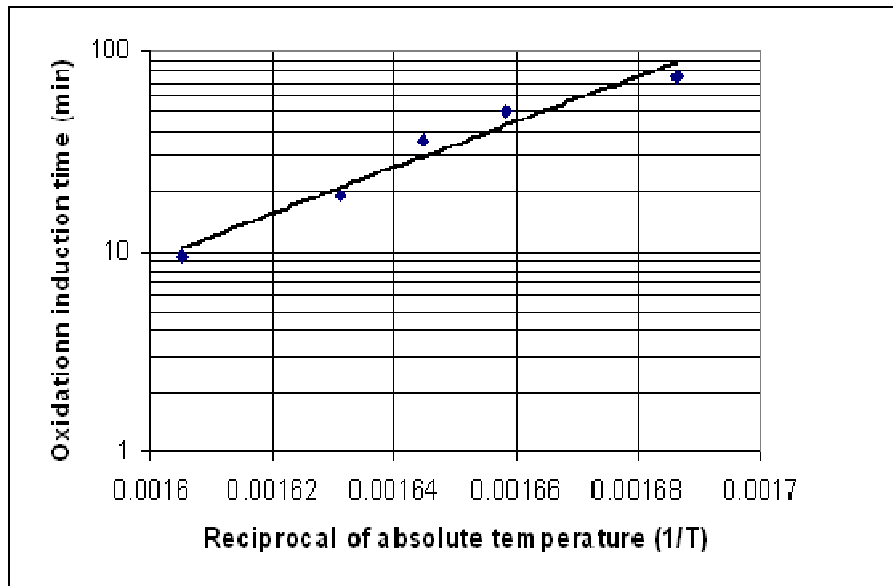


Predicts life expectancy of 19 years at 25°C

# A Word of Caution

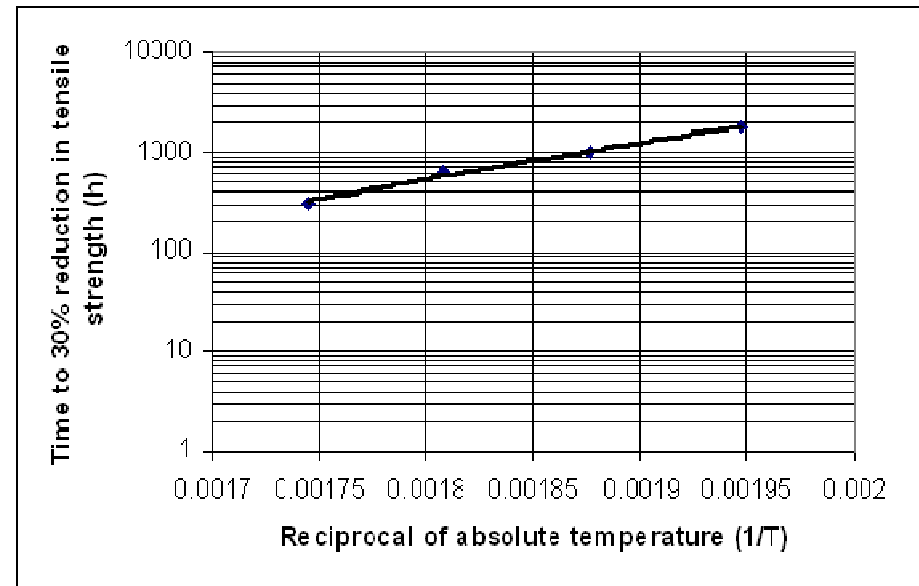


- Life prediction by OIT



Predicts life of 10,000 years at 150°C

- Life prediction by 30% change in UTS



Predicts 7 year life at 150°C

# Life Prediction of Cable sheath to Metronet Specification

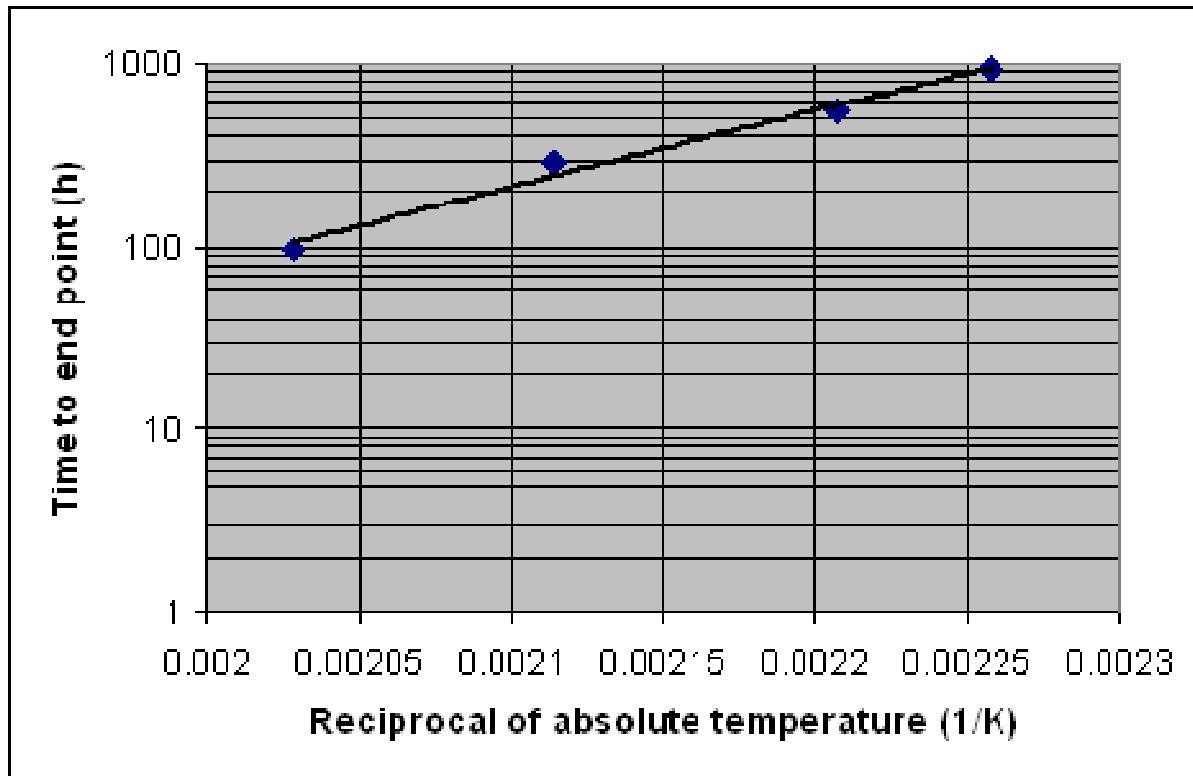


- 
- **Test Method to BS EN 50305**
  - **Weighted samples aged at different times & temperatures**
  - **At each sampling point bent under load both ways around mandrel**
  - **AC withstand test in saline water**
  - **Repeated at each temperature until sample fails AC test**
  - **Results plotted on an Arrhenius diagram**
  - **Best line of fit from Arrhenius used to define T for 20 000h life**

# Life Prediction of Cable sheath to Metronet Specification



- Arrhenius diagram



Predicts T for life of 20 000h of 115°C

- 
- **2000 mm<sup>2</sup> Milliken Conductor**
  - **XLPE insulation 22 mm radial thickness**
  - **Design stress at conductor 7.8 kV/mm**
  - **Electrical stress as the accelerating factor**
  - **Veneered to reduce sample size and test voltages**
  - **Veneers checked to ensure properties unaltered**
  - **Measured time to TTF on 8 specimens at each voltage**
  - **Ageing stresses ranged from 31 kV/mm to 40.5 kV/mm**
  - **Weibull/Weibayes with unfailed samples treated as suspensions**
  - **Used Inverse Power Law Model to predict life**

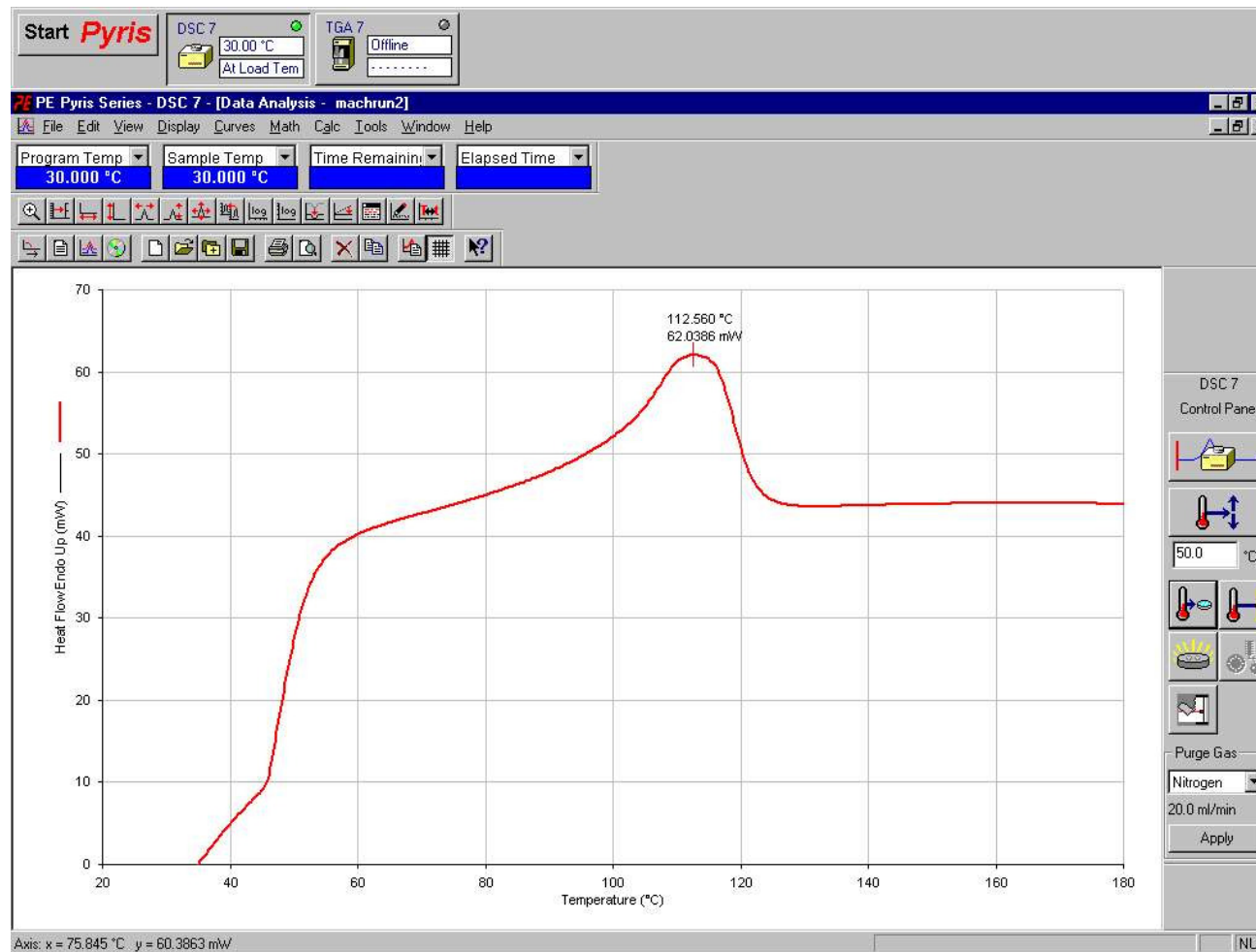
- **Veneers from XLPE insulation**
- **Those with thickness of 210  $\mu\text{m}$  selected for test**



- **Thermal history DSC run 1**



- **Thermal history DSC run 2**



- TTF Data 1**

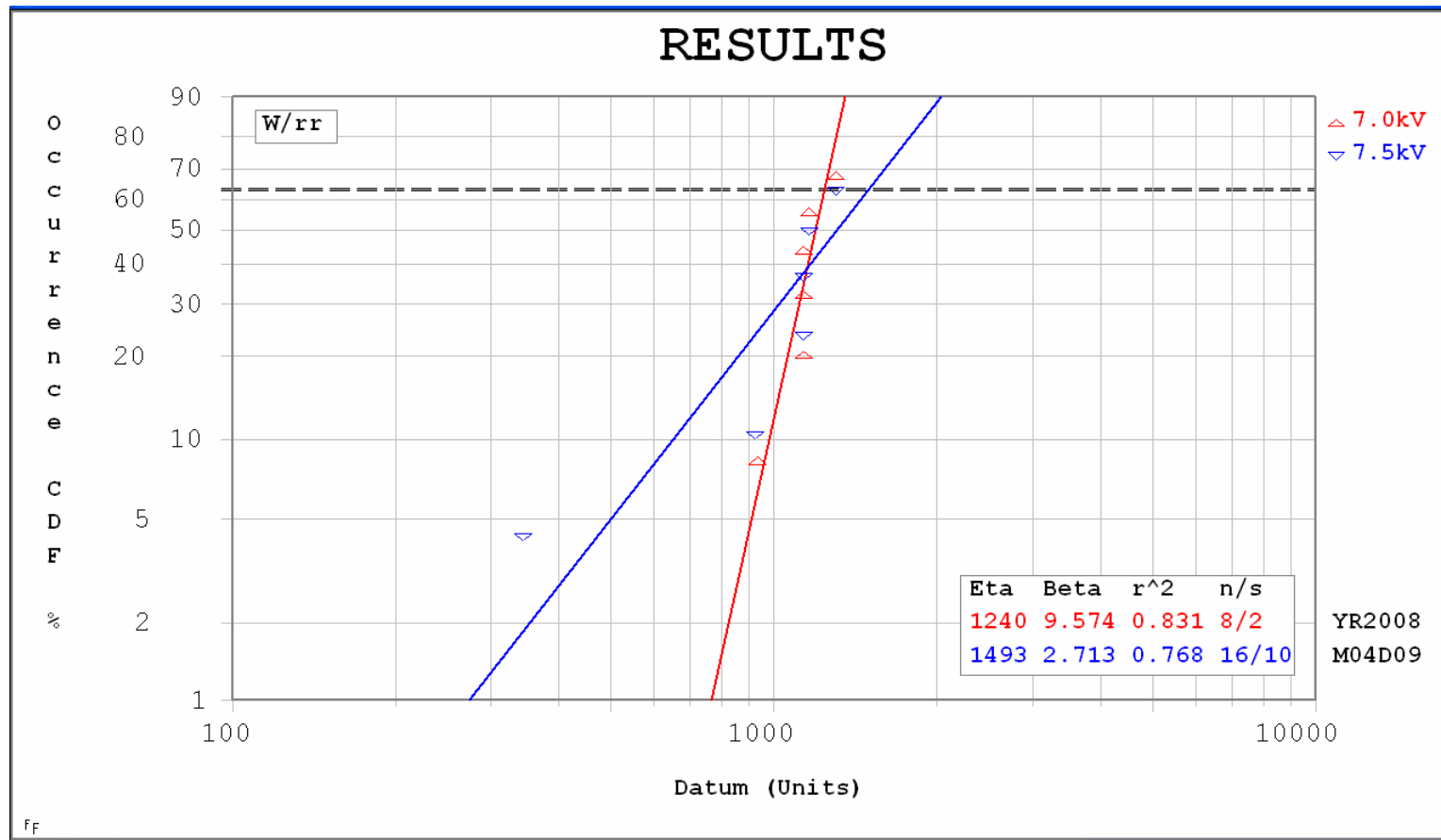
Specimen number	Test Voltage (kV)				
	6.5	6.7	7.0	7.5	8.0
1	>1539	>1539	932	344	344
2	>1539	>1539	1133	922	344
3	>1539	>1539	1133	1133	344
4	>1539	>1539	1133	1133	344
5	>1539	>1539	1160	1160	344
6	>1539	>1539	1301	1301	344
7	>1539	>1539	>1539	>1539	344
8	>1539	>1539	>1539	>1539	344

- **TTF data 2**

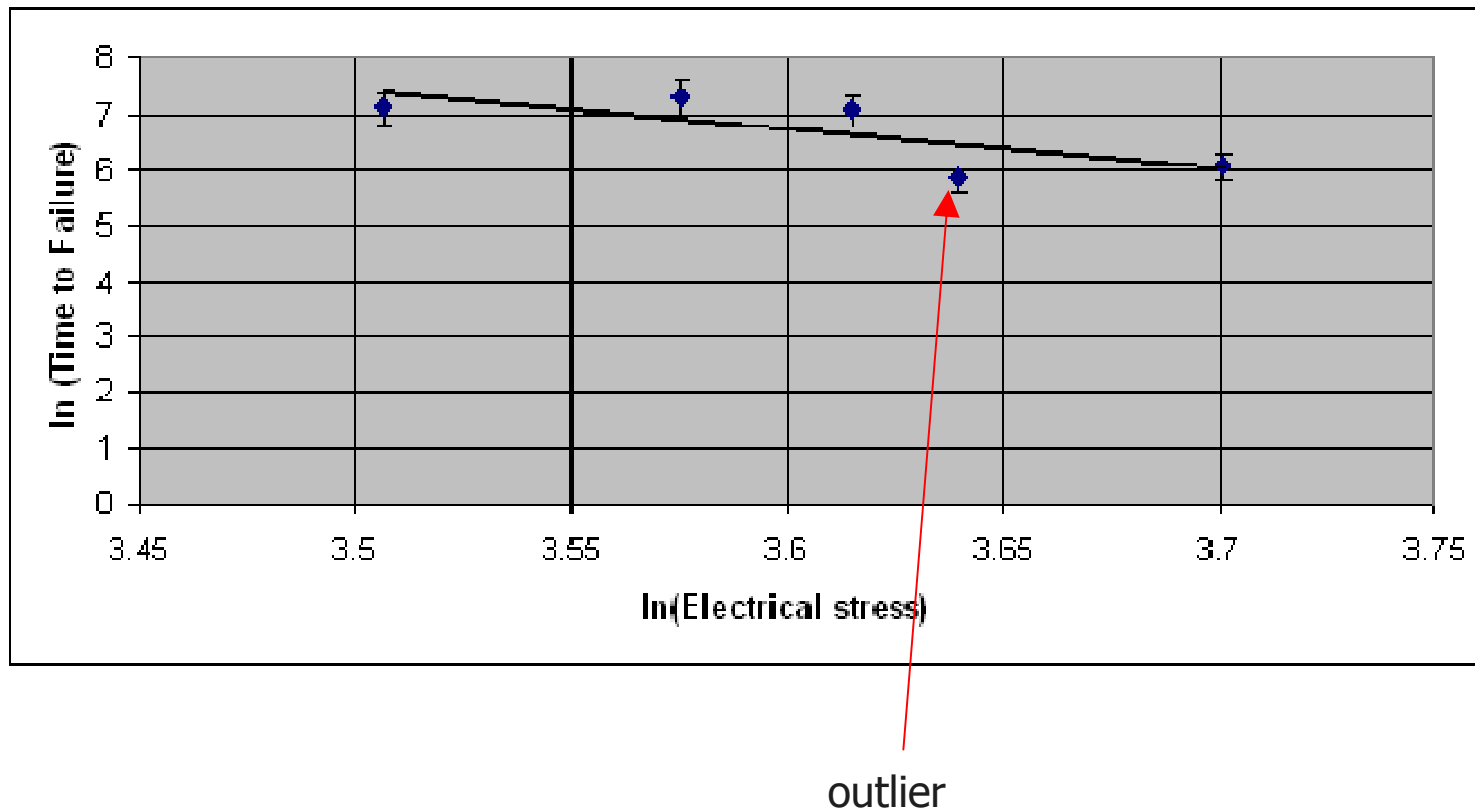
<b>Specimen number</b>	<b>7.8 kV</b>	<b>8.5kV</b>
1	930	430
2	>955	430
3	>955	430
4	>955	430
5	>955	430
6	>955	430
7	>955	430

7.8kV data analysed by Weibayes

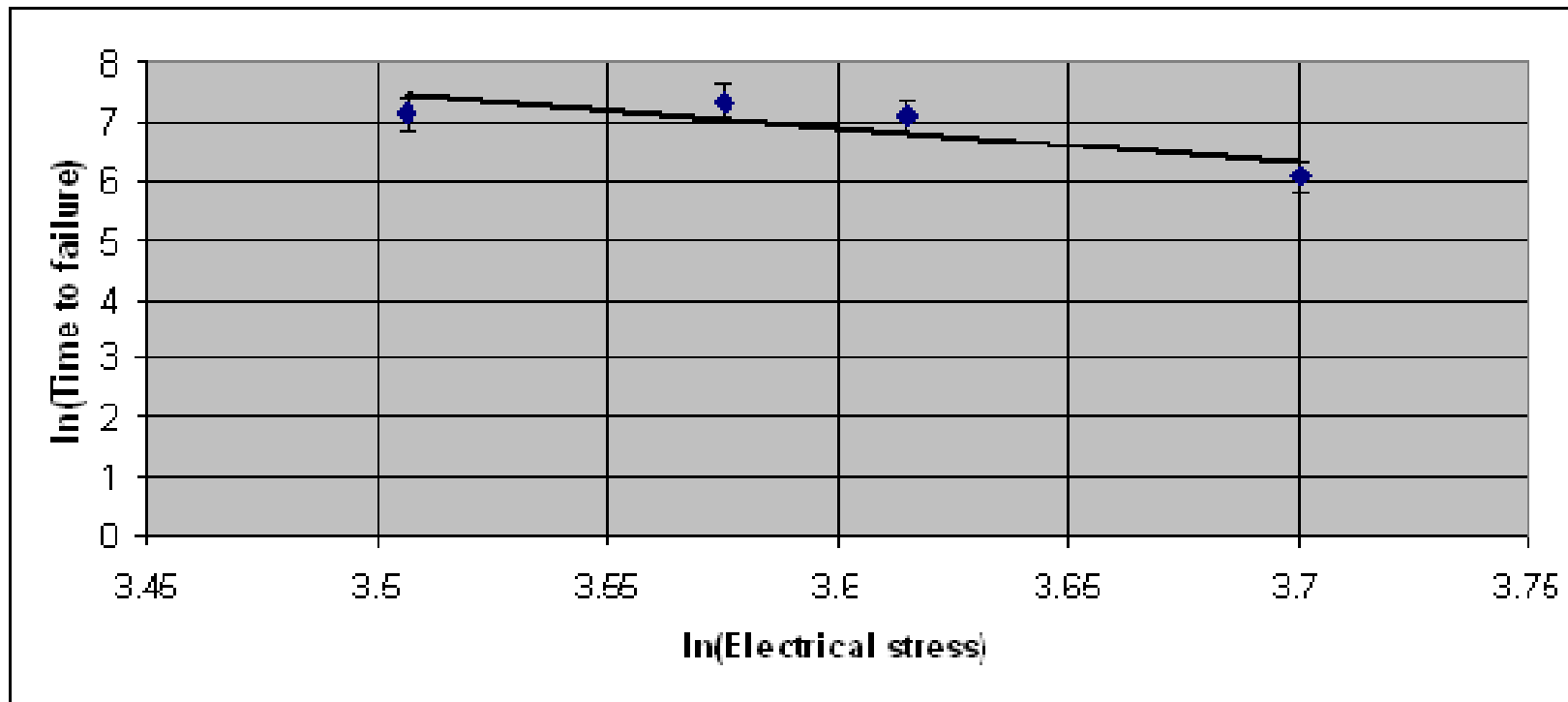
- Weibull Plots at 7.0 kV & 7.5 kV



- **IPL Plot for all test voltages**

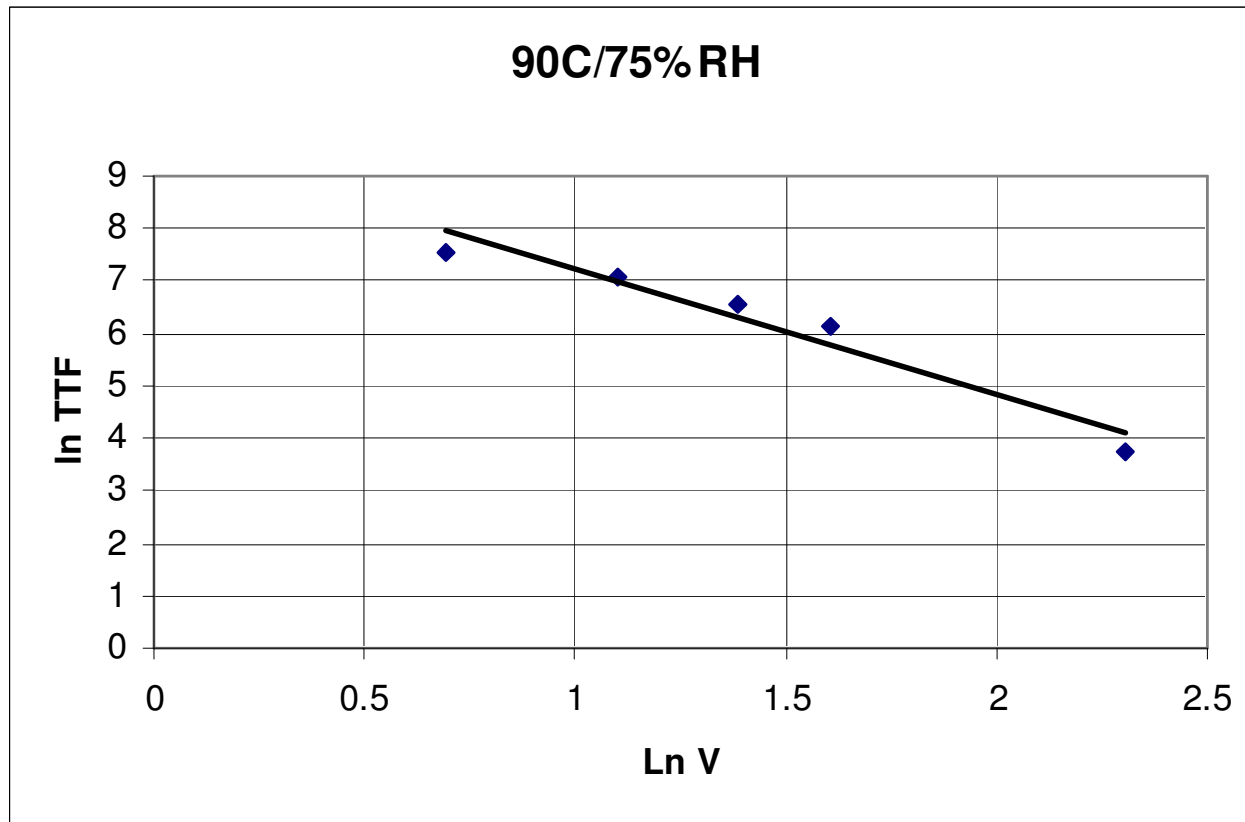


- **Revised IPL plot**



IPL extrapolation predicts life of 773 years at 7.8kV

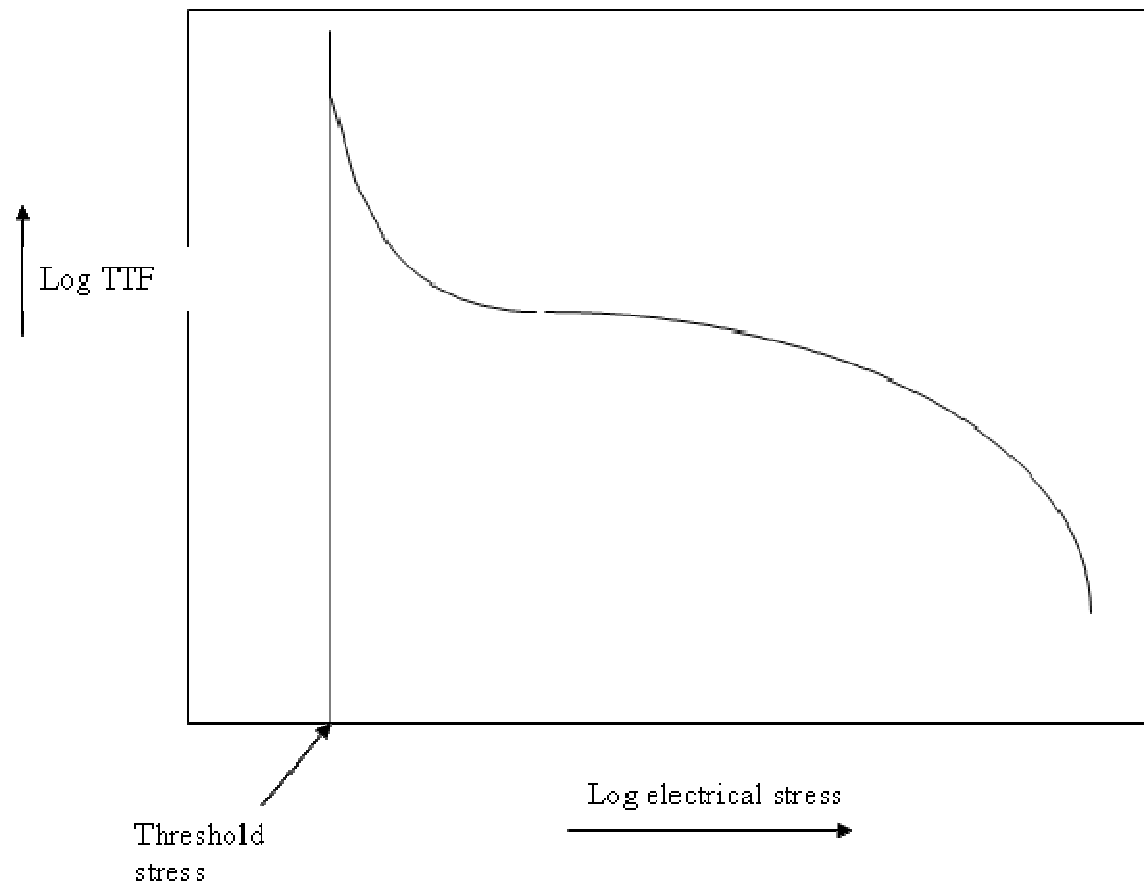
- **Non-linear AC ageing Data**



Suggests use of an alternative model

## Life Prediction of Railway Cables

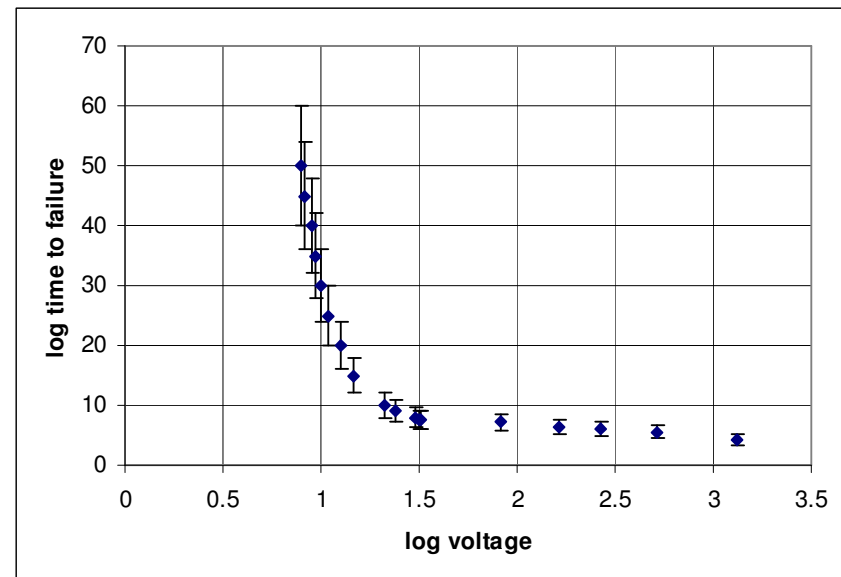
- **Alternative Ageing models**
- **Electrokinetic Ageing Model (Lewis)**
- **In(TTF) vs In(E) plot sigmoidal**



# Life Prediction of Railway Cables

## Investigation of EKE model

- Calculations to convert AC data to DC
- Curve fitting to generate predictive model
- Predicts threshold field at 2.25kV
- Test programme to check validity
- Life predictions using IPL & EKE models



- **Test Set up**



**Any Questions?**