RELIABILITY ASSESSMENT OF JQC-3FC (T73) SPDT RELAY

PRESENTED BY –

LT CDR ARAVIND MANIKANDAN (25RE61D01)

KADIMI TARUN (25RE61R05)

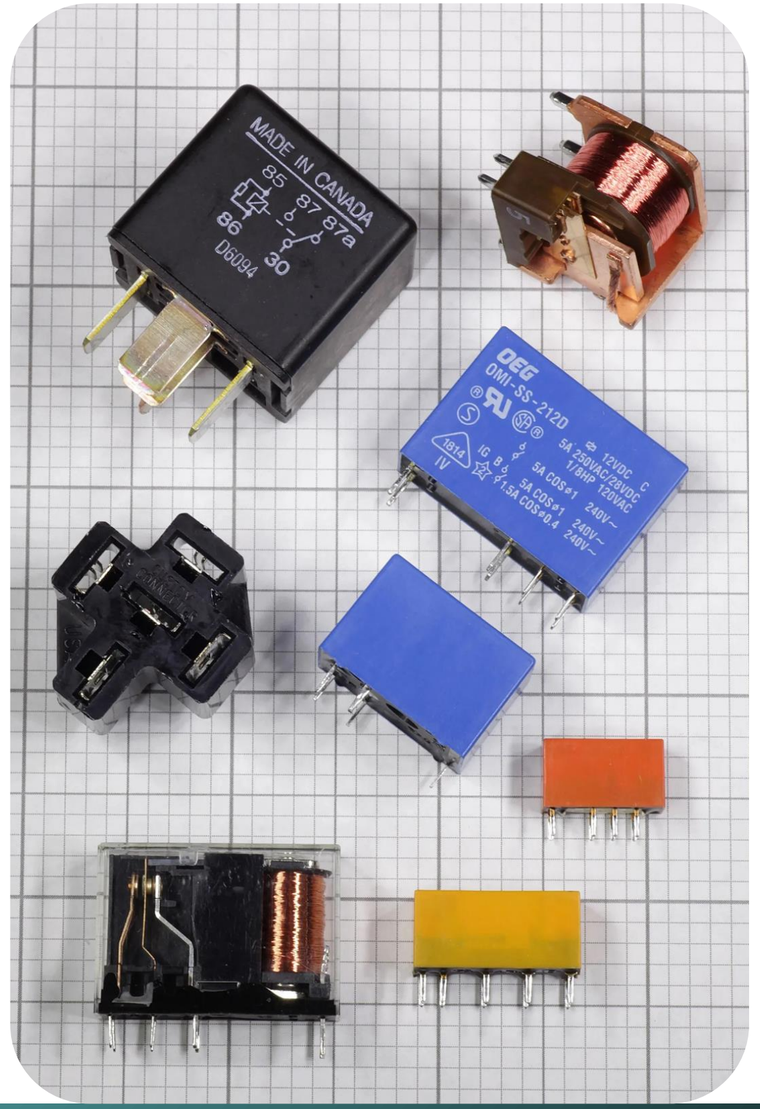
SUTAMA SARKAR (25RE61R07)

RELIABILITY TESTING LABORATORY

AUTUMN SEMESTER 2025-26

Scope

1. Introduction
2. Test Methodology
3. Data Modelling (Weibull + Arrhenius)
4. Results and Reliability Estimates
5. Inferences
6. Conclusions
7. Recommendations



Introduction

OBJECTIVE: Assess relay lifetime using elevated-temperature ie accelerated testing.

Stress Temperatures

403 K, 393 K, 363 K

Goal

Estimate lifetime
and reliability
at normal use condition

Relay Model

DL JQC-3FC (T73)
DC05V (5-pin, blue casing)
Mechanical life : 10 million cycles

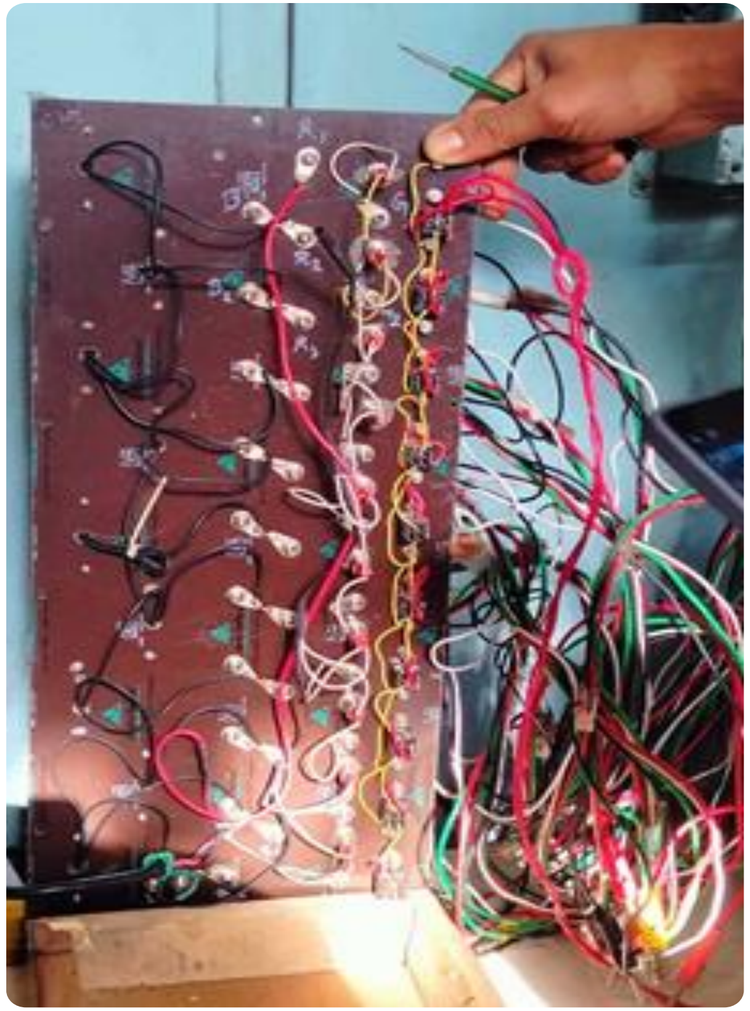
Load

1A resistive (10 bulbs), 5s ON / 10s OFF duty cycle

Introduction

Thermal Chamber

Preparation of Test Set Up



Relay Main Circuit Board

Test Methodology

01 Data collected at 3 temperatures until failure

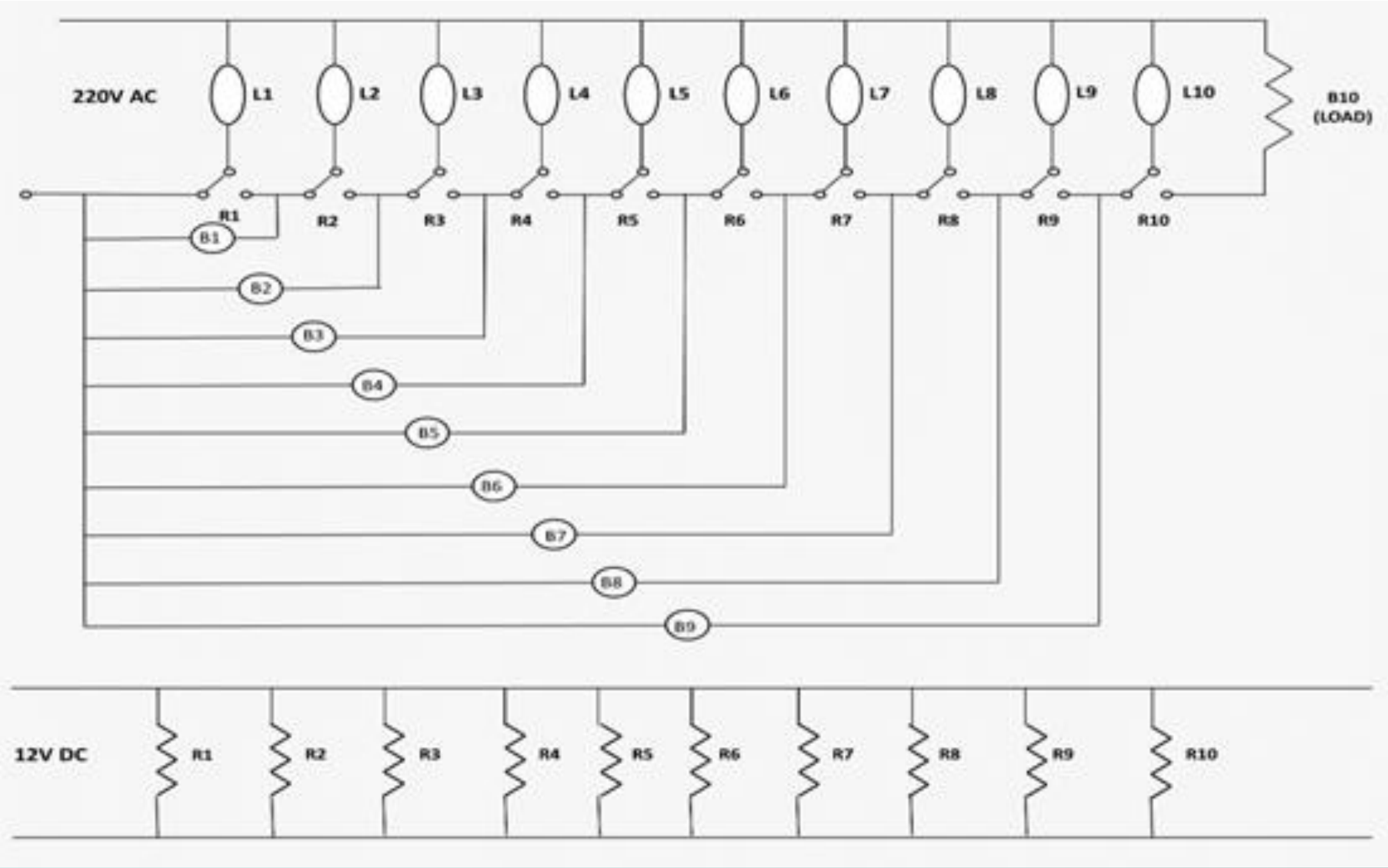
02 Probability Paper Plotting to determine best dstr fit

03 Common β applied using pooled estimation

04 Arrhenius model used: ln(θ) vs 1/T

05 Activation Energy (Ea) and Acceleration Factors (AF) computed

Circuit Diagram



R=Relay
B=Bulb
L=Indicators

Test Result

Test data at 403K

Relay No.	Failure times (cycles)
R2	2724
R9	3324
R6	3765
R5	4457
R10	5433
R1	6088
R3	6822
R4	7699
R8	8250
R7	8542

Test data at 393K

Relay No.	Failure times (cycles)
R2	3022
R10	3627
R4	4956
R7	5416
R3	6612
R1	7210
R5	8342
R8	9076
R6	10549
R9	11351

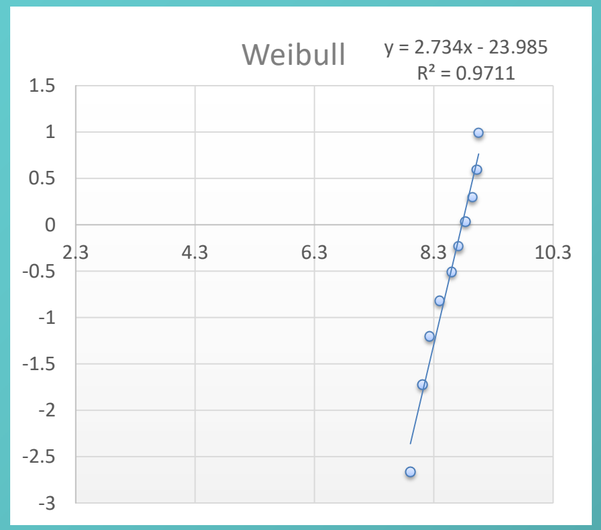
Test data at 363K

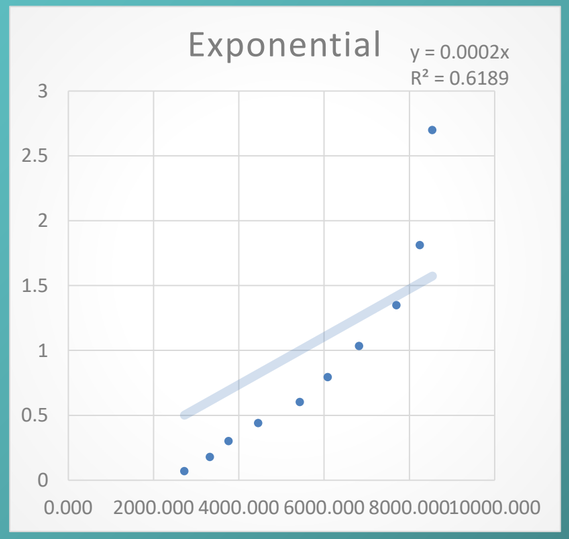
Relay No.	Failure times (cycles)
R1	5568
R9	7123
R4	8476
R6	9920
R8	11042
R3	12457
R2	13843
R7	15321
R5	16455
R10	17863

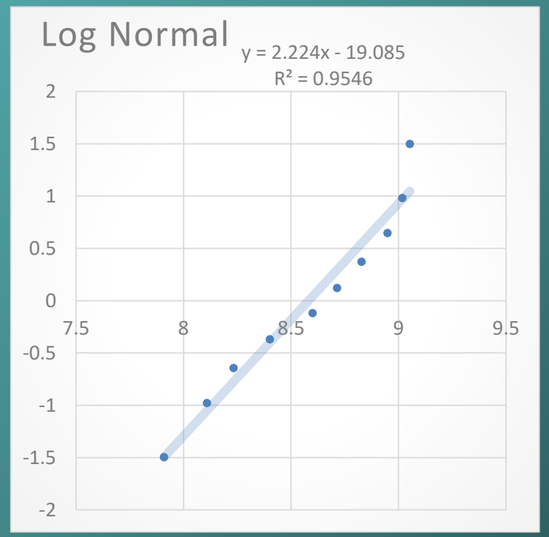
All failures are observed in short circuit mode

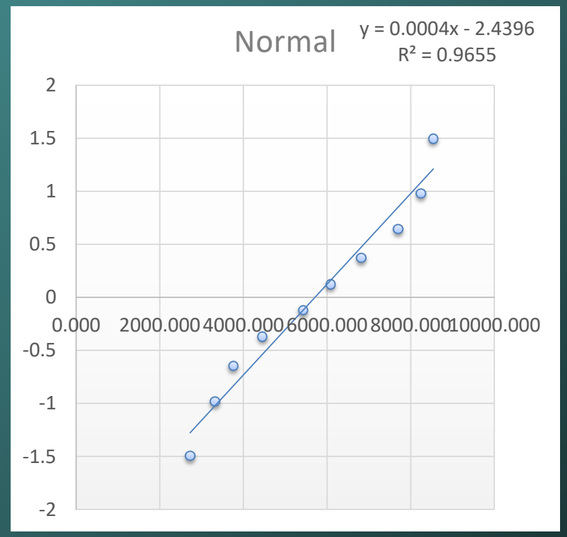
Distribution Fitting of the Failure Times using Least Square Estimation (LSE) Method

LSE of Failures Observed at 403K

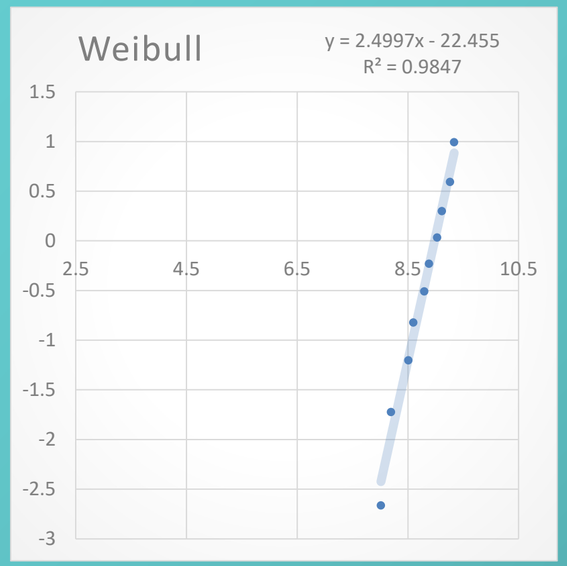


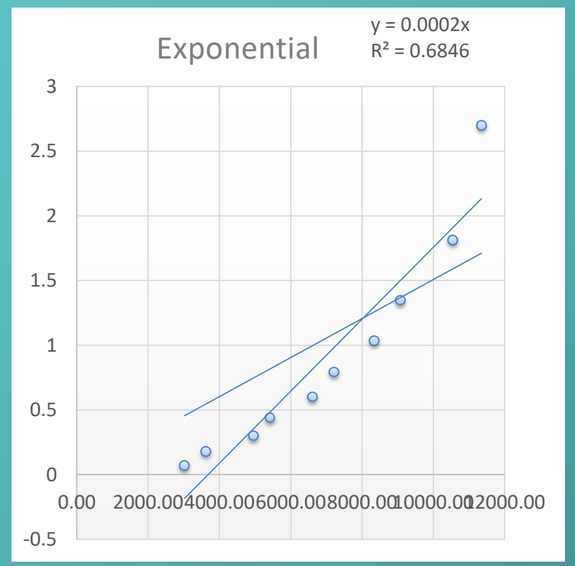


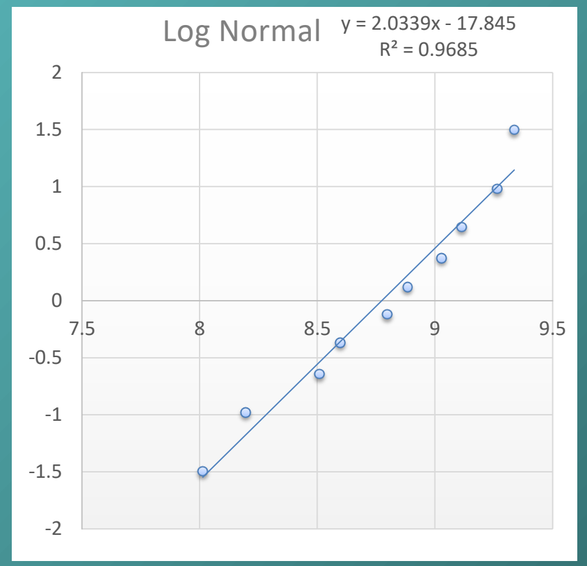


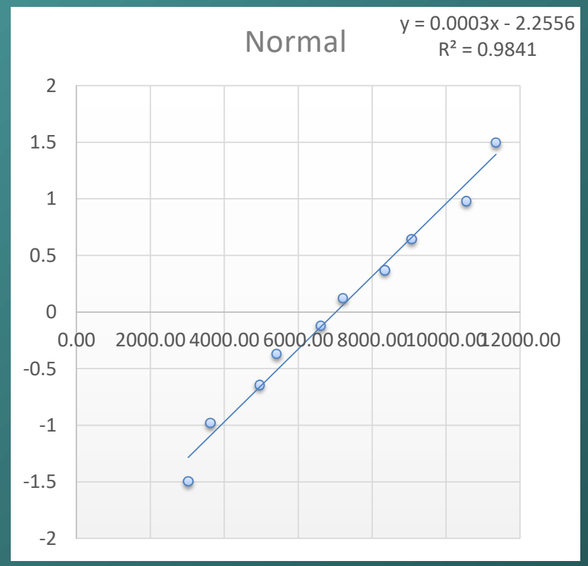


LSE of Failures Observed at 393K

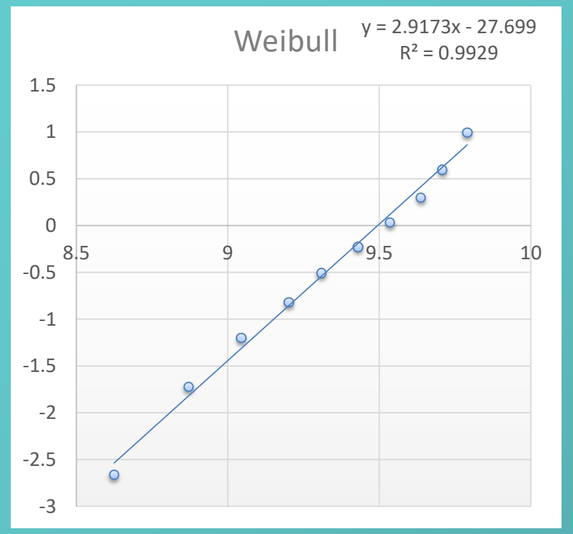


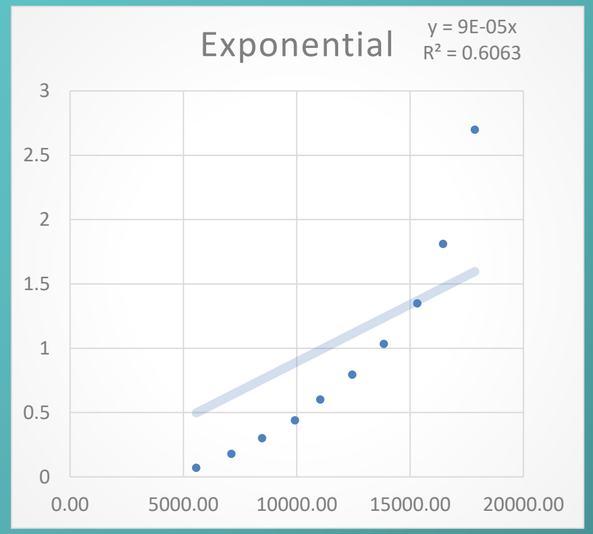


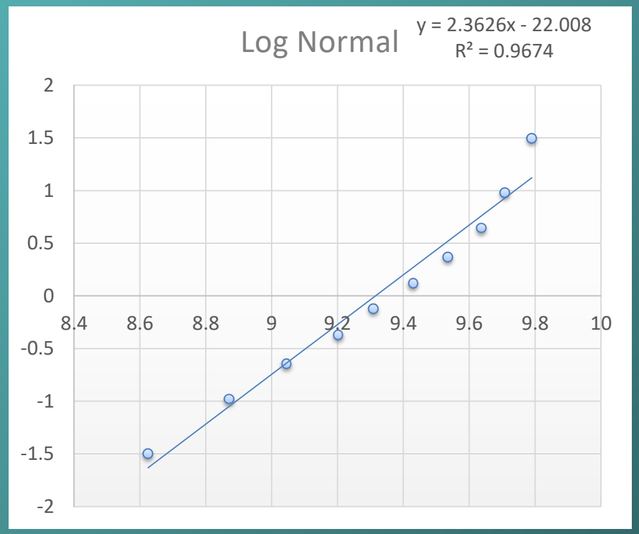


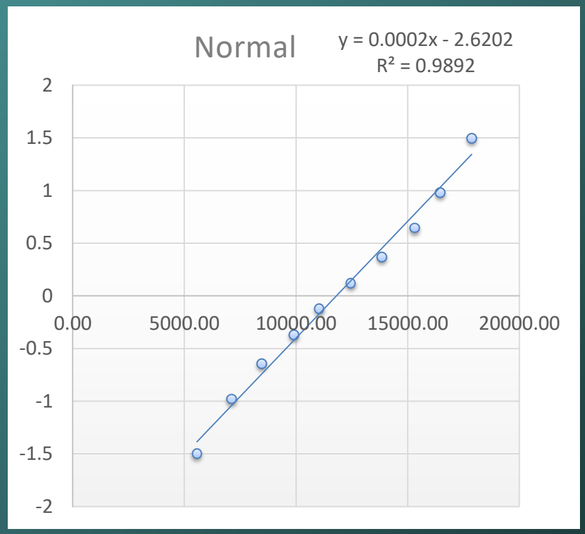


LSE of Failures Observed at 363K







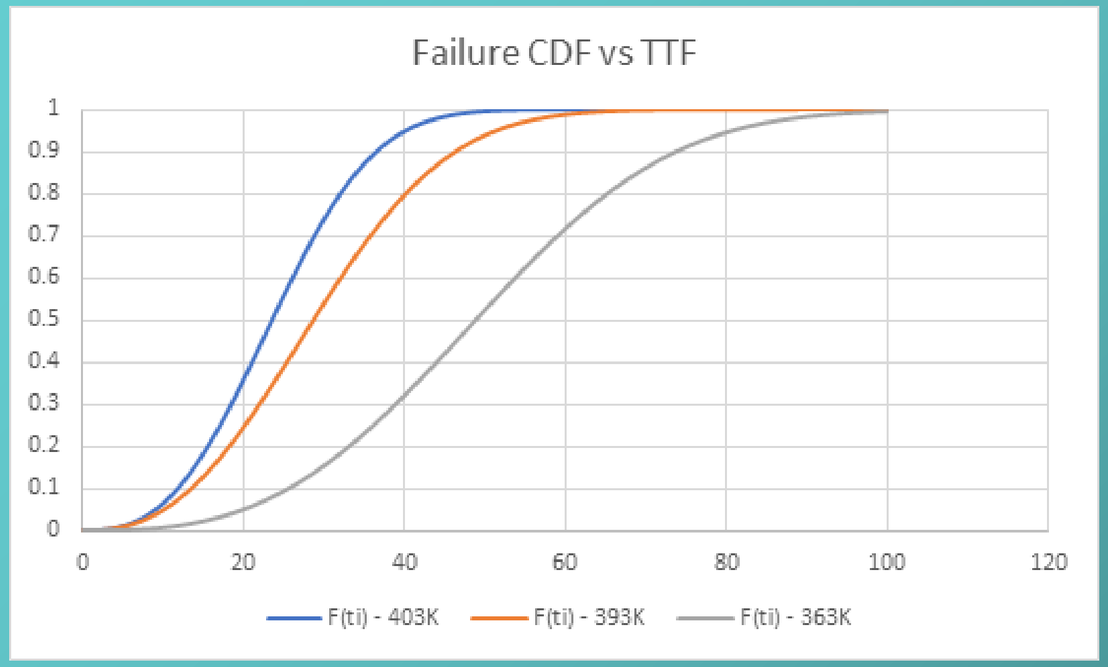


It can be observed from the above figures that the coefficient of correlation is higher and closest to 1 for Weibull distribution

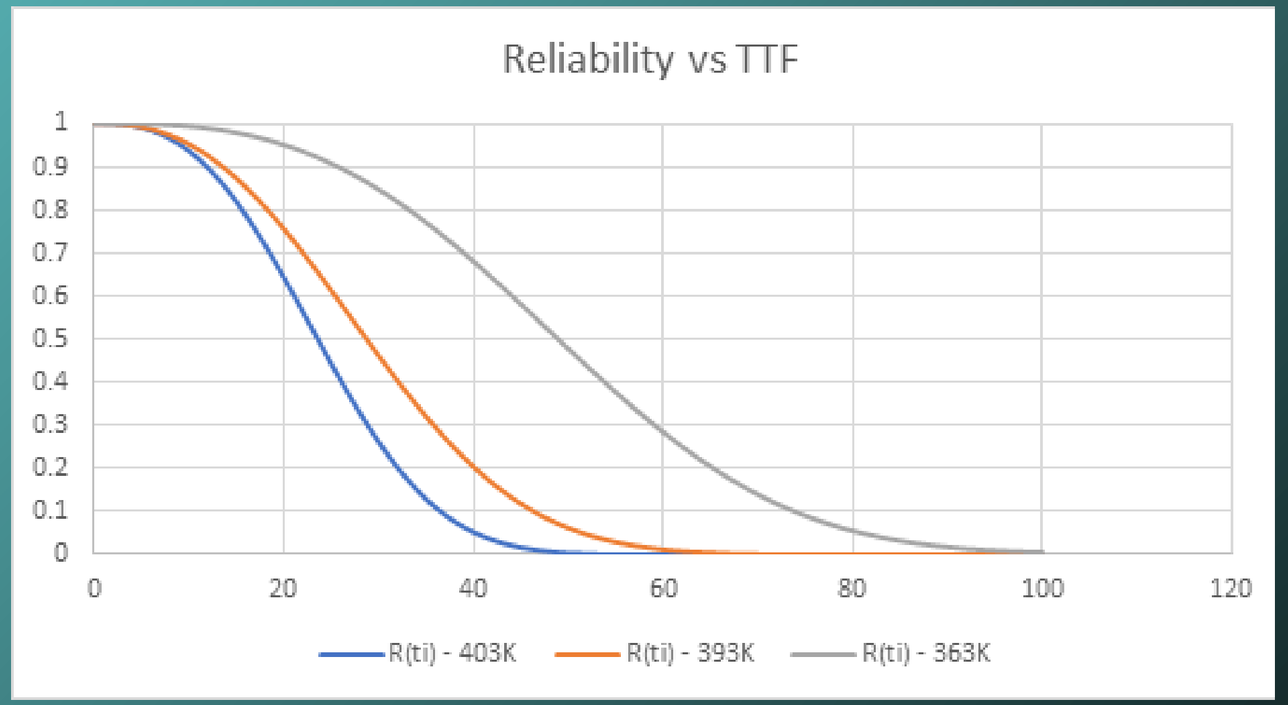
Weibull Distribution Parameters for Failures at different Temperatures

Shape and Scale Parameter for Test Temperatures

Temperature (in K)	Shape Parameter	Scale Parameter (in cycles)
403	2.734	6456.61379
393	2.499	7967.11698
363	2.917	13289.6164



Failure CDF Plot vs TTF(hrs) at different Test Temperatures



Reliability Plot vs TTF(hrs) at different Test Temperatures

Determination of Acceleration Factor Graphically.

Averaging of Shape Parameter.

β(average) = (β 403K + β 393K + β 363K)/3 = 2.717

Revised Scale Parameter is calculated using Maximum Likelihood Equation

$$\hat{\theta} = \left(\frac{1}{n} \sum_{i=1}^{n} t_i^{\beta} \right)^{1/\beta}$$

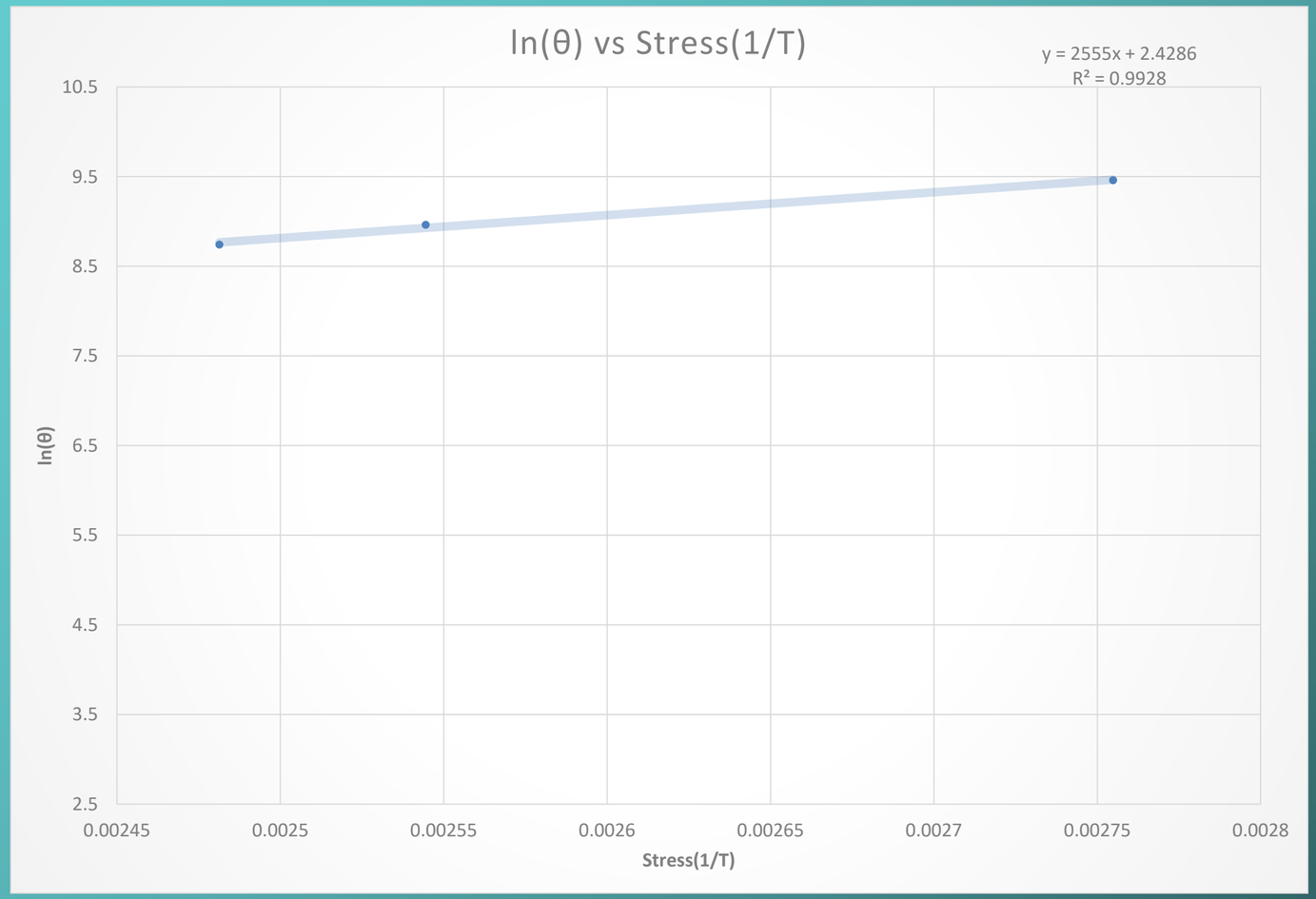
The MTTF values are calculated using formula

$$\mathrm{MTTF} = \theta \, \Gamma\left(1 + \frac{1}{\beta}\right)$$

Revised Parameter Values for Test Temperatures

Temperature (in K)	Shape Parameter	Scale Parameter (in hrs)	Mean Time to Failure (in hrs)
403	2.717	6260.16	5568
393		7817.70	6954
363		12824.19	12824

Arhenius Plotting of ln (θ) vs Stress (1/T)



ln(θ) = ln A + B/T

ln A = 2.4286

A = 11.34

B = Ea/R = 2555

Activation Energy =

Ea = 2555 x 8.617 x 10^-5 = 0.22016 eV

Acceleration Factors (AFs)

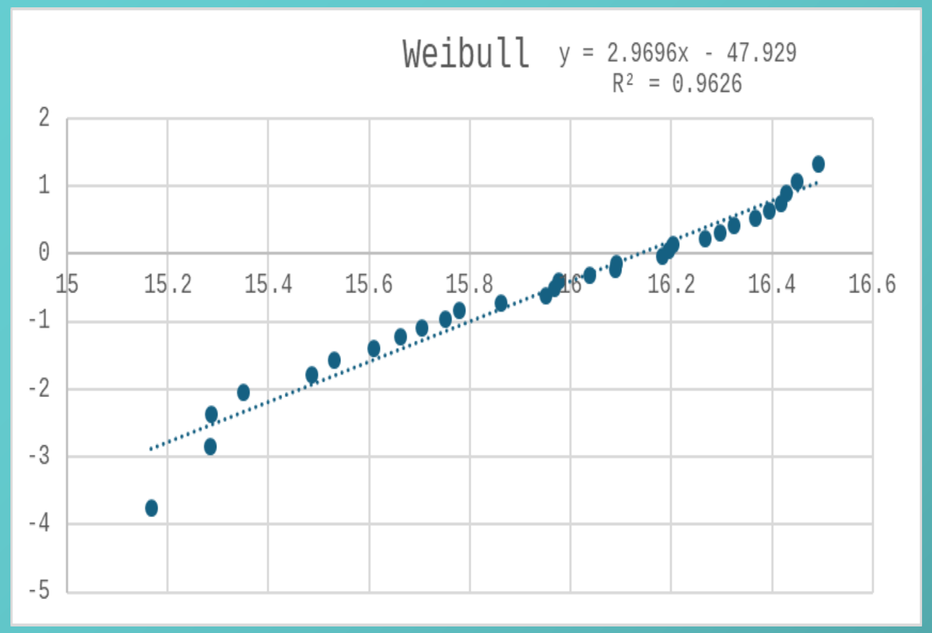
AFs are calculated as below and the normal use life of Relays observed in above three experiments are as below

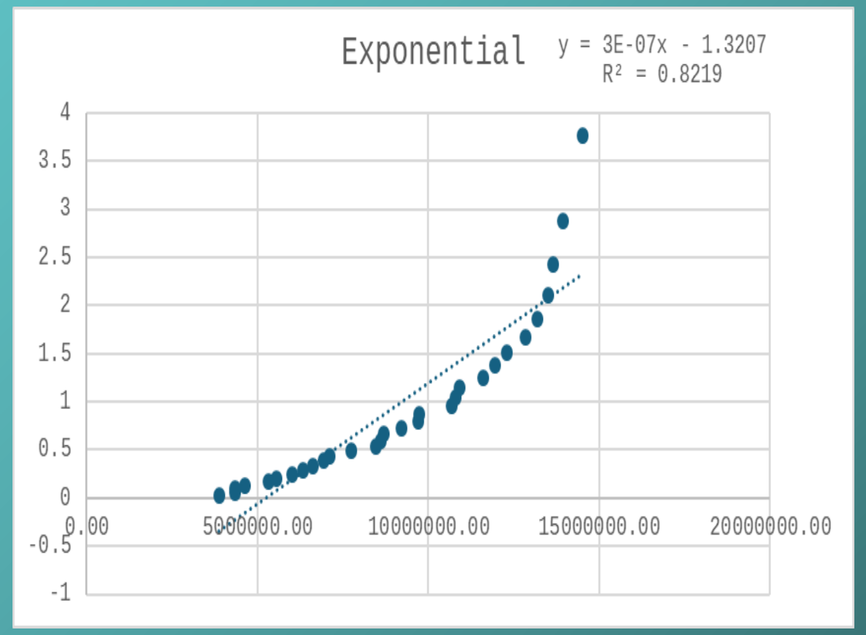
$AF_{t \rightarrow u} = \theta(use)/\theta(test)$

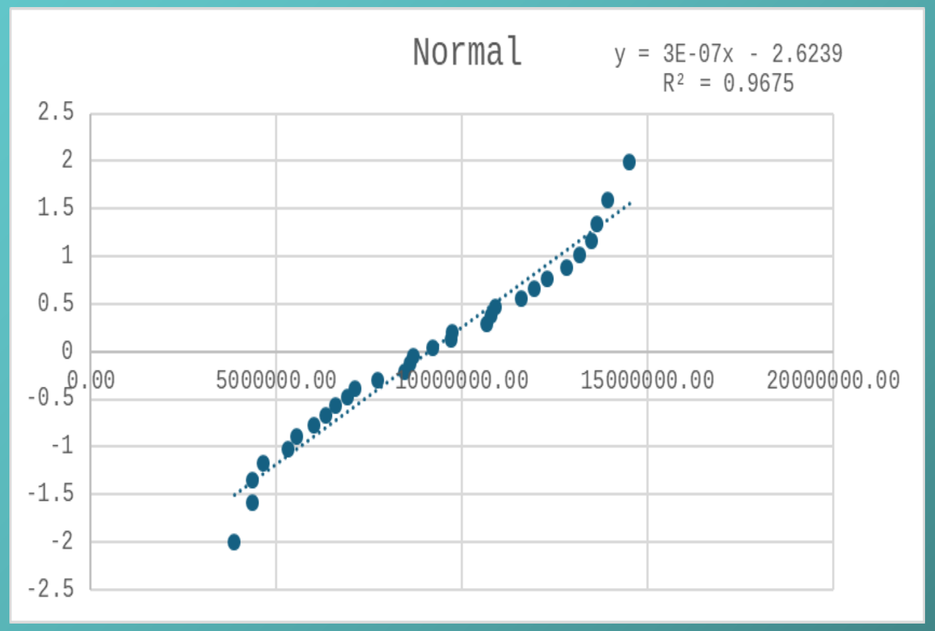
$AF_{403\text{-}298} = 10^7 /6260 = 1597.44$

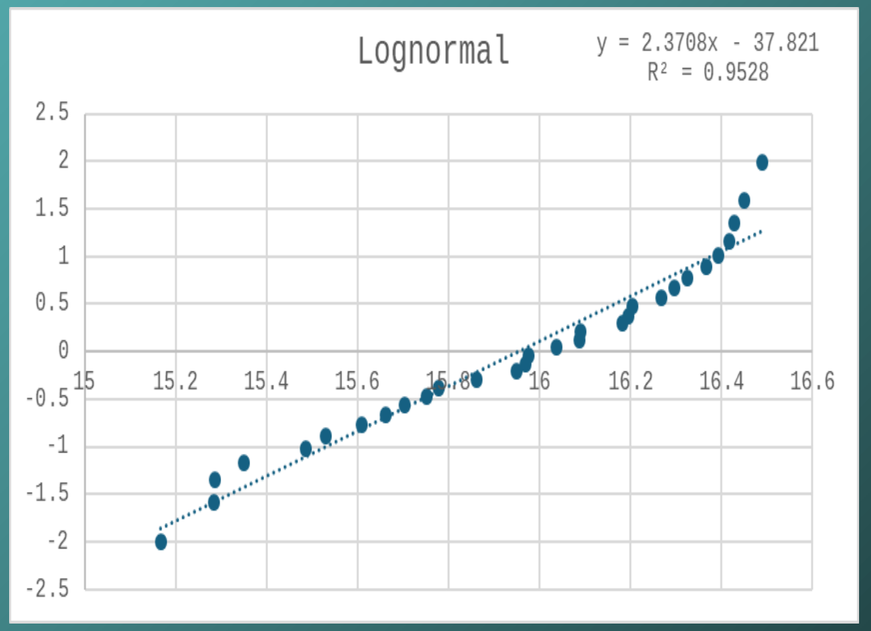
$AF_{393\text{-}298} = 10^7 /7818 = 1279.09$

$AF_{363\text{-}298} = 10^7/12824 = 779.79$





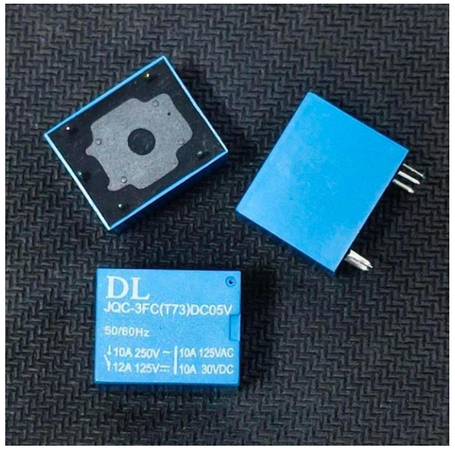




LSE Fitting of Cumulative Failure data

The cumulative failure data fits Normal Distribution the best

Inferences



- Overall Failure pattern follows the Normal distribution best
- Arrhenius modelling fits strongly with ln(θ) vs 1/T.
- The mean life of relays as observed from Normal Distribution (of complete failure data) is 8746333 cycles.

Conclusion

- Relay life decreases rapidly with temperature and switching rate
- Estimated mean life under normal use condition is 8746333 cycles vis-à-vis OEM established life of 10 million cycles
- Failures were dominated by contact wear out
- Relay endurance is strongly influenced by temperature, load and cycle rate

Recommendation

- Matching switching cycle to real-world conditions
- Improving chamber calibration and uniform airflow
- Usage of wider temperature spacing with larger samples

THANK YOU