HOW TO PREDICT FIELD DUARABILITY IMPROVEMENTS FROM REDESIGN CREDIT NUMBERS

INTRODUCTION

DEFINITION : A REDESIGN CREDIT NUMBER assigned to a part which fails and is then redesigned or changed is a number between 0 and 1 which represents the fraction of such redesigned parts which would survive the number of hours at which the original part failed .

EXAMPLE : For example , if a certain part fails in X_o hours and is then redesigned with a REDESIGN CREDIT NUMBER of 0.8 , this tells us that .8 (i.e. , 80%) of such redesigned parts would survive the same X_o hours of service at which the original part had failed. In other words, we predict that the failure probability of the redesigned part for X_o hours of service is $1 - 0.8 = 0.2$.

IN GENERAL : A REDESIGN CREDIT NUMBER P assigned to a part which initially failed in X_0 hours (before redesign) is predicted to have a survival probability P for the same X_o hours of service after it is redesigned.

In determining the improved durability on a log-log plot of failures per machine versus hours of operation we assign the part in question the fraction $1 - p = q$ failures at X_o hours instead of the original 1 failure at X_o hours when the part was still underdesigned.

AN ACTUAL NUMERICAL EXAMPLE

RAW DATA :

MACHINE # 1	Redesign Credit Number	MACHINE # 2	Redesign Credit Number	MACHINE # 3	Redesign Credit Number
F_1 24 hrs.	.5	F_1 68 hrs.	.9	F_1 80 hrs.	.7
F_2 46 hrs.	.5	F_2 100 hrs.	.5	F_2 170 hrs.	.8
F_3 135 hrs.	.8	F_3 150 hrs.	.9	F_3 190 hrs.	.3
S 185 hrs. (Suspended)		F_4 225 hrs.	.8	S 250 hrs. (Suspended)	

NEW FAILURE TOTAL (AFTER REDESIGN) = 1.2	NEW FAILURE TOTAL (AFTER REDESIGN) = 0.9	NEW FAILURE TOTAL (AFTER REDESIGN) = 1.2
Instead of Original Failure Total of 3	Instead of Original Failure Total of 4	Instead of Original Failure Total of 3

TABLE I

BEFORE REDESIGN CREDITS

CUMULATIVE FAILURE TOTAL	HOURS TO FAILURE	NUMBER OF MACHINES WHICH HAVE RUN TO THE INDICATED HOURS	FAILURES PER MACHINE
1	24	3	.333
2	46	3	.667
3	68	3	1.000
4	80	3	1.333
5	100	3	1.667
6	135	3	2.000
7	150	3	2.333
8	170	3	2.667
6	190	2 (machine 2 & 3)	3.000
7	225	2 (machine 2 & 3)	3.500

Plotting HOURS TO FAILURE as ABSCISSA and FAILURES PER MACHINE as ORDINATE on LOG-LOG PAPER yields the LINE A in FIGURE 1, from which we obtain the following parameters :

b = 1.05   (Slope of Line A, i.e., WEIBULL SLOPE)

θ = 66 hours   (Characteristic Life at 1 Failure/Machine)

TABLE II

(AFTER REDESIGN CREDITS ARE COUNTED)

REDESIGN CREDIT ON FAILED PART	ORIGINAL FAILURE CUMULATIVE TOTAL	HOURS TO FAILURE	CUM. FAILURE TOTAL AFTER REDESIGN CREDITS	NUMBER OF MACHINES WHICH HAVE RUN THE INDICATED HRS.	REVISED FAILURES PER MACHINE (AFTER REDESIGN CREDIT)
.5	1	24	.5	3	.167
.5	2	46	1.0	3	.333
.9	3	68	1.1	3	.367
.7	4	80	1.4	3	.467
.5	5	100	1.9	3	.633
.8	6	135	2.1	3	.700
.9	7	150	2.2	3	.733
.8	8	170	2.4	3	.800
.3	6	190	1.9 = 1.2 + .7	2 (machine 2 &3)	0.950
.8	7	225	2.1 = 1.9 + .2	2 (machine 2 & 3)	1.050

NOTE : The CUMULATIVE TOTAL AFTER REDESIGN CREDITS (column 4) is simply a summation of quantities $(1 - p)$, where each p = Redesign Credit Number in Column 1. Now, plotting HOURS TO FAILURE as ABSCISSA and REVISED FAILURES PER MACHINE as ORDINATE on LOG-LOG PAPER yields the LINE B in FIGURE 1. From LINE B of FIGURE 1 we obtain the new parameters (after redesign). These are :

b = 0.80   (Predicted Weibull Slope after redesign)

θ = 209 hours (Predicted Chraracteristic Life at 1 Failure/Machine) (after redesign)

LOG - LOG PLOTS OF FAILURE PER MACHINE
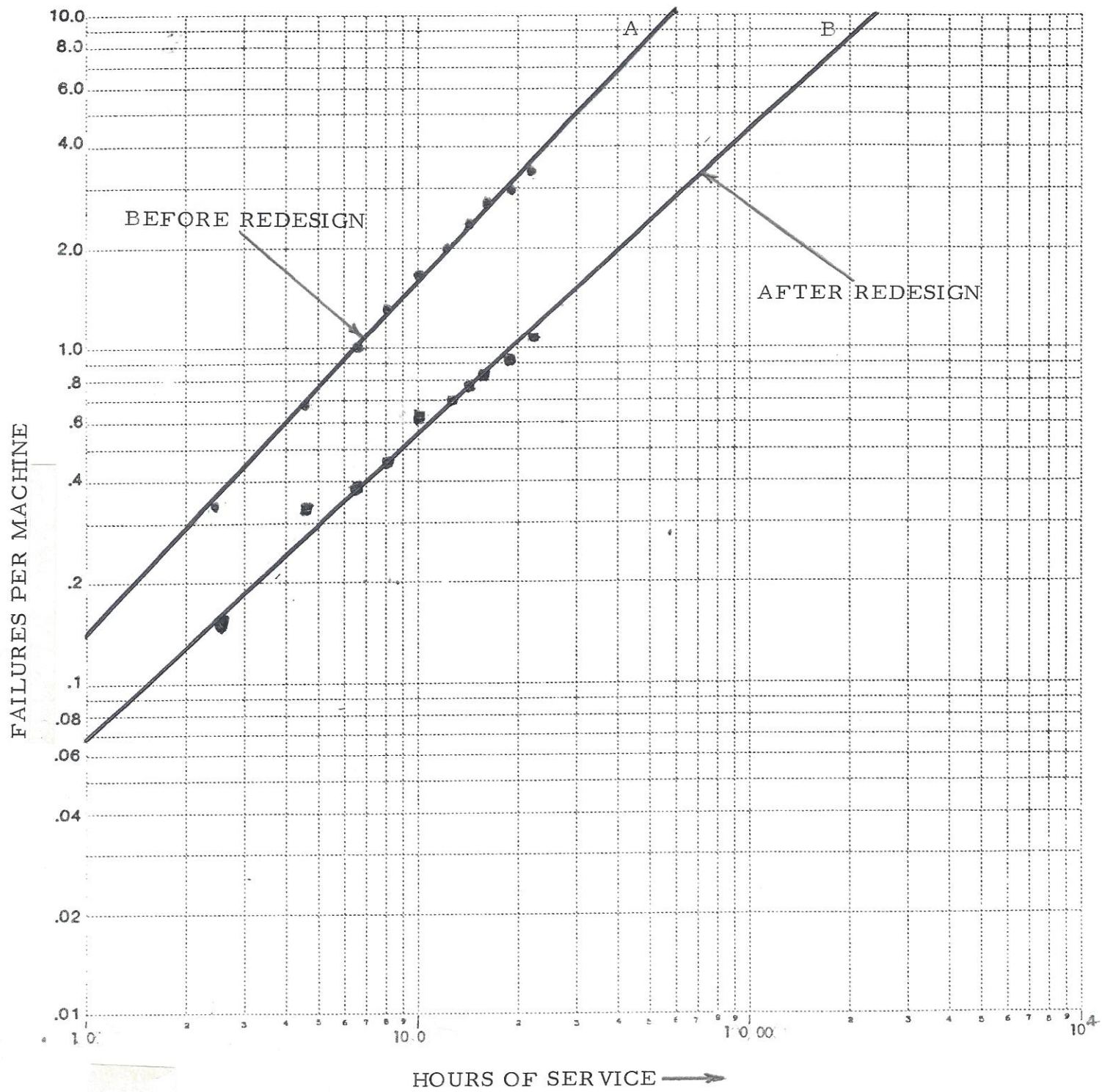   A: ORIGINAL DATA
    B: AFTER REDESIGN CREDITS ARE ASSIGNED

FIGURE 1

IMPROVEMENT CONCLUSION
FOR THE REDESIGN CREDIT NUMBER EXAMPLE

In the example we have herein discussed , we conclude that the REDESIGN increases the characteristic life from 66 hours to 209 hours for the same type of service on these machines. The Weibull Slope is not changed significantly by the redesign .