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COMPARING OBSERVED RUPTURE RATES OF I AND E FUEL ELEMENTS WITH PREDICTED RATES

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J. L. JAECH

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1. RR Bloomstrand

2. JL Jaech

December 5, 1958

R. R. Bloomstrand
1704-D BUILDING
100-D AREA

COMPARING OBSERVED RUPTURE RATES OF I AND E FUEL
ELEMENTS WITH PREDICTED RATES

The data you submitted consisted of pertinent side rupture data for I and E fuel elements, both natural and enriched. The effects due to differences in reactor operating conditions had been accounted for. The abscissa values against which rupture rates were plotted were called theoretical operating days (X).

The data are summarized below. The ΔX intervals are fairly large, a condition necessitated for this analysis by the relatively small number of ruptures that have occurred. The notation is consistent with that in general use.

TABLE I

X	C-I & E ²			K-I & E ²			C-I & E			K-I & E		
	N	L	F	N	L	F	N	L	F	N	L	F
0-30	1108	321	2	1221	78	2						
30-60	785	66	1	1141	236	2	999	110	1	4179	683	1
60-80	718	336	1	903	438	2	888	281	1	3495	889	2
80-100	381	348	3	463	375	1	606	447	0	2604	1319	1
100-110	30	29	1									

Associated with each of these fuel element types was an expected rupture rate curve. This analysis was performed primarily in order to determine the adequacy of these existing theoretical curves, which had been derived using rupture data for solid

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fuel elements. Since we are interested in determining this for the curve as a whole rather than for any given operating days value, the parameters associated with the curve were considered as opposed to making comparisons between observed and theoretical rupture rates at different operating days.

The model used for the theoretical curve is of the form:

$$F(X) = 1 - \exp - \left(\frac{X^a}{b} \right).$$

the parameter a has an assumed value of 5, while the b parameter differs for the four cases. Theoretical values (or better, predicted values) are given below, based on the predicted curves which you sketched.

TABLE II (Predicted $\ln b$ values)

C - I & E ²	26.05
K - I & E ²	26.57
C - I & E	27.32
K - I & E	27.87

In testing the adequacy of these curves, a check was first made on the assumed value of 5 for the a parameter. The data for each case were fitted by plotting the logarithm of instantaneous rupture rate as a function of the logarithm of time which should be a straight line under this model. It appears that the two lowest exposure ruptures for the C-I and E² regressions at least one of the K-I and E² ruptures may be anomalous. This is not inconsistent with the rupture model as recently revised. (1) If these three ruptures are eliminated, the following estimates for the a parameter were found.

TABLE III (Estimated a values)

C - I & E ²	6.2
K - I & E ²	2.4
C - I & E	2.3
K - I & E	2.6

The over-all weighted average is 3.9 with a standard deviation of 0.8. Thus, there is not sufficient evidence to conclude that the assumed value of $a = 5$ does not hold.

Using $a = 5$ then for each case, the following estimates of the parameter $\ln b$ were found, together with estimated standard deviations. Comparisons with predicted values are also shown.

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TABLE IV

<u>Case</u>	<u>Observed $\ln b$</u>	<u>σ</u>	<u>expected $\ln b$</u>	<u>(0-e)</u>
C-I&E ²	26.89	0.49	26.05	0.84
K-I&E ²	27.37	0.75	26.57	0.80
C-I&E	27.80	1.00	27.32	0.48
K-I&E	29.38	0.82	27.87	1.51

Note that the tendency is for the observed $\ln b$ values to be somewhat higher than expected, which means the rupture rate is somewhat lower. However, the discrepancy is not significant, i.e., it may well be due to chance. (Keep in mind that inclusion of the 3 ruptures eliminated would have narrowed rather than widened this gap.) A combined estimate gives

$(0-e) = .91$, with a corresponding standard deviation of 0.59.

Thus, the ± 2 standard deviation limits would be

$(0-e) = .91 \pm 1.18$.

This corresponds to a ratio of b values (and hence, a ratio of rupture rates in the region of interest) of 2.5, with limits of .76 to 8.1.

Conclusion

Solid rupture data experienced to date for I and E fuel elements give rupture rate curves which do not differ significantly from those predicted on the basis of solid fuel elements experience.

J. L. Jaech
J. L. Jaech

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