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FUEL PERFORMANCE COMPARISON OLD REACTORS -
MARCH 1960 THROUGH DECEMBER 1960

AUTHOR

Re Re Bloomstrand

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January 1961

J. R. Young, Special
Operations Analysis
Production Planning & Scheduling
MANUFACTURING SECTION

FUEL PERFORMANCE COMPARISON

OLD REACTORS • MARCH 1960 THROUGH DECEMBER 1960

Introduction

As you requested, in relation to evaluation of the block discharge mode of operation, data for comparison of fuel rupture performance of the old reactors have been assembled, and are transmitted herein. We have analyzed these data and the results are also transmitted in this report.

Summary and Conclusions

Based on analysis of rupture experience from March through December, 1960, adjusted for differences in power, temperature, exposure, and throughput, there are no significant differences in fuel rupture performance between the old reactors. This statement does not imply that there are no differences in economic performance between reactors. Differences of this nature cannot be judged solely from the data of this report.

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A second conclusion is that the block-discharge mode of operation does not, per se, affect the metal performance level. That is, if we write the rupture model as follows: Rupture Rate = $q P^{.3} T^{.8} M^{.5}$, where q is the measure of the metal performance level, q does not vary significantly between the reactors. P , T , and M are power, temperature and exposure.

Details

It was agreed to examine the fuel performance of the old reactors subsequent to the initiation of the first block at DR, which was charged late in February. Because rupture index data are calculated monthly, the study was begun with the March experience.

The following tables (Tables I and II) summarize the rupture index (ΔRI) and rupture history of the five old reactors over the subject time period. Rupture Index (ΔRI) is a measure of the rupture producing climate of a reactor and is calculated routinely on the IBM 7090.

TABLE I

Month	B		F		D		H		DR	
	ΔRI_N	ΔRI_E	ΔRI_N	ΔRI_E	ΔRI_N	ΔRI_E	ΔRI_N	ΔRI_E	ΔRI_N	ΔRI_E
Mar	1.57	0.041	3.82	0.082	2.33	0.050	1.39	0.091	0.23	0.092
Apr	2.48	0.051	3.38	0.086	2.73	0.052	1.79	0.089	0.74	0.200
May	3.53	0.035	2.99	0.063	2.76	0.092	1.97	0.100	6.02	0.136
Jun	3.00	0.078	3.11	0.123	2.32	0.064	0.69	0.071	.28	0.137
Jul	3.19	0.096	3.64	0.108	2.48	0.081	0.89	0.056	1.26	0.279
Aug	3.33	0.137	3.81	0.056	4.36	0.068	1.59	0.090	5.67	0.486
Sept	1.95	0.050	2.78	0.047	1.56	0.091	4.24	0.167	4.58	0.452
Oct	2.35	0.083	6.17	0.122	2.04	0.075	3.12	0.177	0.35	0.156
Nov	3.84	0.167	4.59	0.108	5.35	0.164	0.12	0.089	1.50	0.175
Dec	0.09	0.142	5.42	0.237	5.62	0.161	1.23	0.151	9.59	0.301

ΔRI_N = change in rupture index for I & E natural

ΔRI_E = change in rupture index for I & E enriched

TABLE II

Month	Number of Ruptures*	
	Natural (I & E)	Enriched (I & E)
Mar	F, B, D, DR, D, F, H (7)	DR (1)
Apr	F, F, (2)	DR (1)
May	D, H, F (3)	DR (1)
Jun	H, F, B (3)	D (1)
Jul	B, B, DR (3)	DR (1)
Aug	H (1)	(0)
Sept	D (1)	(0)
Oct	H (1)	H, F (2)
Nov	B, D, B, B, F (5)	(0)
Dec	F, B, H (3)	(0)

*Second failures in multiple failure lots and mechanical damage failures are excluded.

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As you know, we maintain control charts of the rupture experience to monitor changes in the metal performance level⁽¹⁾. These charts show the performance levels of all production type of elements - C, K, and O -- have improved during the time over which this study is being made. This means that intrinsic metal quality has been improving. This trend is readily seen in the above data. Therefore, objective conclusions about differences between the reactors, other than those resulting from shifting metal quality, must be inferred from data over identical time periods. The statistical precision of the analysis can be improved considerably by combining both enriched and natural experience, and thereby increase the total number of ruptures. This is done by normalizing using slug-by-slug rupture potential calculations (our standard practice).

The following data result when ARI values for enriched material are multiplied by a previously determined factor of 6.3 to normalize to the natural values. The data cover the span - March, 1960, through December, 1960.

TABLE III

Reactor	ARI _n	ARI _e *	ARI Total	Ruptures		
				R _n	R _e	R _t
B	29.33	6.19	35.52	8	0	8
D	36.71	6.69	43.40	5	1	6
F	35.55	5.66	41.21	8	1	9
H	17.72	6.83	24.55	6	1	7
DR	31.22	15.21	46.43	2	4	6
TOTALS	150.53	40.58	191.11	29	7	36

* Normalized to natural

Under the hypothesis that the q's were equal, though not necessarily constant, at each of the old reactors, the total number of ruptures incurred (36) could be distributed as follows:

TABLE IV

Reactor	Expected* Distribution of Ruptures	Observed Distribution of Ruptures
B	6.69	8
D	8.17	6
F	7.78	9
H	4.61	7
DR	8.75	6

* Expected number of ruptures is calculated by

$$\frac{(ARI)_1 (36)}{\sum_{i=1}^5 (ARI)_i}$$

(1) HW-65550, Bloomstrand, RR, "Use of Control Charts for Analysis of Plant Rupture Experience," 6/9/60, (Secret).

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By inspection, it can be seen that there is no significant difference between the two distributions; therefore, the hypothesis of identical metal performance level coefficients (q's) at each of the old reactors is accepted. A Chi-square test of the data confirms this conclusion.

These data tend also to substantiate the enrichment normalization factor of 6.3. From the data, if this factor is correct, one would expect $\frac{40.58}{101.11} (100) = 21.2\%$ of the total number of ruptures (36) to be incurred in enriched material; i.e. $(.212)(36)$ or 7.6. Seven were observed.

From the data of Table III, we note DR Reactor, on block-discharge, accumulated a much higher rupture index for enriched material than any of the older reactors. This factor is one of many that has bearing on assessment of overall economic performance differences between the reactors.

The existence of many such factors as pointed out here to prevent possible misinterpretation of the conclusion that block-discharge, per se, does not affect the metal performance level. This conclusion does not imply block-discharge as good method of fuel utilization as the variable goal method.

R. R. Bloomstrand

R. R. Bloomstrand
Process Analyst
RESEARCH & ENGINEERING SECTION

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