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PHYSICS CONSIDERATIONS OF OLD PILE EXPANSION STUDY

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PHYSICS CONSIDERATIONS OF OLD PILE EXPANSION STUDY

by

W. S. Nechodom

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PHYSICS CONSIDERATIONS OF OLD FLE EXPANSION STUDYINTRODUCTION

In view of the more-or-less eminent conversion of at least some of the older Hanford reactors to zirconium process tubes, it has been requested the feasibility and economics of increasing the process channel size by overboring be studied. This report is concerned with the feasibility from an operational physics standpoint of either (1) raising reactor power levels with present aluminum process tubes and redesigned fuel elements (2) raising reactor power levels with zirconium replacement tubes of current outside diameter, or (3) raising power levels with either zirconium or aluminum tubes of 200 mils greater outside diameter. This report is of a survey nature only, and the data contained herein should be considered in that light.

SUMMARY AND CONCLUSIONS

Because of the greater capacity of their safety systems it may be assumed that the power level of the C and E reactors either with or without overboring would not be limited from an operational physics viewpoint.

Power level increases at the 4 oldest piles would be limited insofar as production efficiency is decreased by the need for supplementary poison to satisfy the total control criteria. This effect is least pronounced in the overbored cases, and could probably be alleviated to some degree in all cases by limiting the reduction in slug size and accompanying increase in enrichment levels which are indicated for the highest power considered. However, it appears to be desirable to eliminate the total control problem at the 4 oldest reactors by expanding the Ball X safety systems and VML systems.

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that an equilibrium exists. The program, or manual operation (including the possibility of the manual operation with control of heating elements, etc.) does for all cases indicate that no manual attention will be required.

RESULTS

computed to the base case. strength - corrected values give an indication of the amount of control required were varied inversely to the indicated change in control strength. Thus the basis the various resistivity values (cold steam wet, cold steam dry, etc.) strength and control system strength. To place this variation on a meaningful computed results. This results in a variation in local control resistances for each case. Considerable variation was found in the program - heat, the cold steam wet resistances, temperature coefficients, and dry all cases studied, and the program was used to determine the proper condition. The equilibrium resistivity and flattening efficiency was held constant for appears to be fairly reasonable.

the program - computed cold to hot changes were correct. This assumption To obtain hot dry resistances for all cases it was necessary to assume that values of K_{eff} . In the base case to the program - computed values of K_{eff} . instances the value for each case were corrected by the ratio of the known occurs in the program calculation of the dry pile resistances. In these the known values for the base case. The most significant instances of this Some of the data obtained from the computer program did not correspond to

DISCUSSION

The "Giant" program which was used was instructed to design the fuel element in each case to fit the given conditions of pressure drop along the slug column, ΔT along the slug column, tube power, etc. As a result of these instructions the program designed relatively small, highly enriched fuel elements for the highest power cases (2950 MW) in both the zero and 200 mil overbored cases. Such slugs are not acceptable from a physics standpoint for the four oldest reactors because of the excessive wet-to-dry reactivity increase. The increase is less severe in the 200 mil overbored case, and would require less correction to slug dimensions. The problem does not exist at C and H piles where enlarged ^{safety} systems are present.

The cold, dry ^{effective} for each case was computed by the program, then corrected for Samarium poisoning. The value obtained for the base case was about ^{16.} ~~10~~ mk higher than the known value obtained from reactor data. The value for each case was accordingly reduced by the ratio of the known to the computed value for the base case. Results indicate that in the zero mil cases the cold, dry, pile reactivities are considerably higher than at present, with the increase attributable to the smaller slugs and higher enrichments designed by the program. While it would be possible to operate the reactor under the total control limitations imposed by this higher dry reactivity, the reactor operating efficiency would be reduced by the need for excessive supplementary total control to satisfy the Total Control Criterion. In the 200 mil overbored cases the cold dry reactivities are only a few milik higher than the base case, the maximum being the equivalent of 6 mk higher. Satisfying the Total Control Criteria would require the use of somewhat ~~more~~ ^{less} supplementary poison than at present.

Again the foregoing discussion applies only to the 4 oldest reactors and

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Preliminary analysis⁽¹⁾ indicates the desirability of eliminating the need for supplementary total control by expanding the Ball 3-X systems at the 4 oldest reactors, and since an outage for channel enlarging would furnish the outage time for such a project, it is recommended that these systems be enlarged to approximate the capacity of the C and H pile ball 3-X systems.

The data on which the foregoing discussion is based is summarized in Table I.

(1)

Report, Reactor Dept., "Increased Control Systems for the Hanford Production Reactors,"
by H. E. ... G. H. ... D. G. ...

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Case 84-200-1
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TABLE I

OLD FLE EXPANSION STUDY - PHYSICS PARAMETERS

Case Description	Fuel Element CD	Fuel Element ID	Fuel Element Uranium wt/ft.	Seed Enrichment U ²³⁵
1. Base Case. C II N fuel	1.445	.310	10.0 #/ft	.714
2. 0 overbore Al. tube, 200 psi ΔP	1.444	.349	9.31	.731
3. " " " 400 psi ΔP	1.478	.297	10.18	.720
4. " " " 200 psi ΔP	1.434	.367	9.02	.734
5. " " " 400 psi ΔP	1.470	.311	9.96	.721
6. " " " 200 psi ΔP	1.407	.409	8.30	.741
7. " " " 400 psi ΔP	1.448	.347	9.39	.723
8. 0 overbore Zr tube 200 psi ΔP	1.487	.364	9.91	.717
9. " " " 400 psi ΔP	1.522	.309	10.86	.708
10. " " " 200 psi ΔP	1.460	.405	9.18	.722
11. " " " 400 psi ΔP	1.500	.343	10.28	.709
12. 0 Mil overbore Al. tube 200 psi ΔP	1.706	.339	14.05	.729
13. " " " " 400 psi ΔP	1.739	.285	14.96	.732
14. " " " " 200 psi ΔP	1.695	.322	13.76	.727
15. " " " " 400 psi ΔP	1.729	.298	14.74	.729
16. " " " " 200 psi ΔP	1.670	.391	13.00	.725
17. " " " " 400 psi ΔP	1.709	.331	14.13	.725
18. 200 Mil overbore Al. tube 300 psi ΔP	1.664	.321	13.34	.734
19. " " " " 300 psi ΔP	1.641	.357	12.69	.732

Hot Operating Reactivity = 23 mk in all cases

Tube Dimensions, ID:

0 Overbore Aluminum = 1.609"
 0 " Zirconium = 1.659"
 200 Mil overbore Aluminum = 1.809"
 " " " Zirconium = 1.859"

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TABLE I

OLD FLE EXPANSION STUDY - PHYSICS PARAMETERS

Fuel Element ID	Fuel Element ID	Fuel Element Uranium wt./ft.	Fuel Element Enrichment U-235	At 800 MW/T 23.0 B.O. In P.W.	Full Power Level
445	.310	10.0 #/ft	.714 ⁴	812	1550 MW
444	.349	9.31	.731	821	660
478	.297	10.18	.720	813	660
434	.367	9.02	.734	825	660
470	.311	9.96	.721	813	674
407	.409	8.30	.741	833	649
448	.347	9.39	.723	817	660
487	.364	9.91	.717	817	670
522	.309	10.86	.708	806	691
460	.405	9.18	.722	825	660
500	.343	10.28	.709	810	683
706	.339	14.05	.729	804	721
739	.255	14.96	.732	798	734
695	.322	13.76	.727	805	717
729	.298	14.74	.729	797	730
670	.391	13.50	.725	809	712
709	.331	14.13	.725	799	722
654	.321	13.34	.734	805	712
641	.357	12.69	.732	808	704

cases

Aluminum = 1.609"
 Zirconium = 1.659"
 S-bore Aluminum = 1.809"
 Zirconium = 1.859"

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TABLE I (CONT'D)

Cold Clean Dry Reactivity Normalized and Corrected For Rod Strength		Cold Clean Wet Reactivity Normalized and Corrected For Rod Strength		Normalized Cold Wet to Dry Reactivity Change	Calculated Hot Wet to Dry Reactivity Change	
1.)	+ 44		+ 19 mk	$\frac{0.775}{0.775} + 25 \text{ mk. } 3411$	+ 15 mk 12.8	Prei with
2.)	60		25	0825 (35) 40303	20	(Exc)
3.)	54		27	00 27 2902	15	(wit)
4.)	62	} 58.5 } 17	23	005 39 9139	26	(con
5.)	55		26	0645 29 3168	21	(in
6.)	64		17	101 47 5022	49	(duc
7.)	56		22	0605 34 3912	43	(cri
8.)	59	} 51.5 (58)	25	34	25	(sup
9.)	52		27	25 - 2	19	
10.)	61		20	41	48	
11.)	53		24	29	42	
12.)	47		31	16	7	
13.)	44		34	10	4	(Sl1
14.)	49	} 46.5 } 47	30	19 - 3	13	(sta
15.)	44		31	13	10	(con
16.)	50		26	24 2	37	(the
17.)	46		29	17	32	(res
18.)	49	} 50	29	20	14	(mor
19.)	50		25	25 - 3	36	(the
					14.8	(cr:
						(mer

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TABLE I (CONT'D)

activity corrected length	Normalized Cold Wet to Dry Reactivity Change	Calculated Hot Wet to Dry Reactivity Change	Total Control Position	Speed of Control Position
	$\frac{0.775}{34.11} + 25 \text{ mk } 34.11$	+ 15 mk 12.6	Presently just meet criterion with occasional supp. poison	OK
08.25 35	10303	20	(Exceed criterion	OK
06.27	2702	15	(without supplemental	OK
08.39	1139	26	(control, resulting	OK
06.45 29	3148	21	(in <u>considerable</u> pro-	OK
10.47	5023	49	(duction loss in meeting	Unsatisfactory
06.534	3012	43	(criterion by use of	Unsatisfactory
			(supplementary poison	
34		25	(	OK
25 - 2		19	(	OK
41		48	(	Unsatisfactory
29		42	(	Unsatisfactory
16		7	(	OK
10		4	(Slightly worse from	OK
19 - 3		13	(standpoint of total	OK
13		10	(control criterion	OK
24 2		37	(than base case (1),	Possibly marginal
17		32	(resulting in slightly	" "
			(more production loss	
20		14	(than present in meeting	OK
25 - 3		36	(criterion with supple-	Possibly marginal
			(mental poison	

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