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SOME NPR PRODUCTION VARIABLES

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D. E. Simpson
Reactor Design Analysis Unit

January 20, 1961

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◎ SOME NPR PRODUCTION VARIABLES ◎

In connection with current updating of the NPR testimony, calculations of NPR production parameters have been made for a variety of assumed operating conditions. All cases assume operation at full design power of 4000 MW. Initial and final enrichments and plutonium production per MWD of exposure have been calculated for a nominal 22 lb/ft. metallic uranium fuel element at exposures of 1000, 1400, and 2000 MWD/T; 23 lb/ft. fuel element at 1000 MWD/T; 24 lb/ft. element at 1000 and 2000 MWD/T; a UO₂ fuel element of about 12.9 lb/ft. at 2000 and 3000 MWD/T; and a 22 lb/ft. uranium fuel element at 1400 MWD/T with the Zr-2 process tube replaced with a stainless steel tube of 170 mil thickness. The fuel element geometry in all cases is a tube-in-tube.

The initial NPR fuel element has been well established as a 22 lb/ft. tube-in-tube with initial enrichment of 0.947 weight percent U-235. Reactivity adjustments are to be made by changing an appropriate number of natural uranium fuel elements in the reactor loading. In this study, the average production parameters were calculated by finding the fraction of the loading which is natural uranium, r , according to the relationship

$$r = \frac{k_{0.947} - 1.012}{k_{0.947} - k_{nat}}$$

and averaging each parameter

$$\bar{x} = r x_{nat} + (1 - r) x_{0.947}$$

In the above

k = k_{eff} for full pile loading

x = value for any parameter in full pile loading at the enrichment indicated by the subscript

$\bar{x}$ = average value of any parameter

All calculations for this review were made with R. O. Gumprecht's MOFDA fuel design code for the IBM-7090. The dimensions of the basic 22 lb/ft. fuel element were Gumprecht's current best values. For all other cases, the ratio of inner tube volume to outer tube volume was held the same as in the 22 lb/ft. case and the dimensions were adjusted by the program to obtain a balance of water temperatures in the three flow channels.

The results of the calculations are summarized in the following table.

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NPR PRODUCTION PARAMETERS

<u>Fuel</u>	<u>Exposure (MWD/T)</u>	<u>Initial Enrich.</u>	<u>Final Enrich.</u>	<u>gm-Pu MWD</u>	<u>Fuel Dimensions (in.)</u>			
					<u>Outer Tube</u>		<u>Inner Tube</u>	
					<u>OD</u>	<u>ID</u>	<u>OD</u>	<u>ID</u>
22 #/ft.	1400	.930	.778	.858	2.354	1.808	1.173	0.489
22 #/ft.	1000	.928	.816	.902	2.354	1.808	1.173	0.489
22 #/ft.	2000	.939	.736	.799	2.354	1.808	1.173	0.489
23 #/ft.	1000	.937	.824	.916	2.367	1.796	1.187	.474
24 #/ft.	1000	.954	.841	.926	2.378	1.783	1.200	.454
24 #/ft.	2000	.969	.766	.823	2.375	1.779	1.199	.444
UO ₂ -12.9 #/ft.	2000	1.017	.776	.693	2.473	1.907	1.257	.576
UO ₂ -12.9 #/ft.	3000	1.048	.711	.619	2.473	1.907	1.256	.575
22 #/ft. with s/s proc. tube	1400	2.579	2.403	.653	2.345	1.797	1.163	.461
22 #/ft. (.947 enrich.)	1400	.947	.795	.852	$\frac{r}{.075}$			
	1000	.947	.834	.895	.080			
	2000	.947	.743	.797	.035			
22 #/ft. (natural U)	1400	.715	.574	.927				
	1000	.715	.608	.986				
	2000	.715	.529	.853				