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AEC RESEARCH AND DEVELOPMENT REPORT

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FINAL REPORT ON PRODUCTION TEST NO. 105-245-P

EFFECTIVENESS OF CADMIUM COATED SPLINES

COPY 1 OF 1, 37

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EFFECTIVENESS OF CADMIUM COATED SPLINES

Cadmium coated splines have been developed to supplement the regular control rod systems under emergency shutdown conditions from higher power levels.

In addition, the process control group of the P Division asked that probable spline requirements for safe operation at various power levels be estimated, and the details included in this report.

The results of the test indicated a reactivity value of 10.5 ± 1.0 ih for a single spline, and 19.0 ± 1.0 ih for two splines in tube 1674-B under the loading conditions of 4-27-49, the date of the test. The temperature rise of the cooling water for this tube under these conditions was found to be 37.2°C . for 275 kW operation.

An estimate of spline requirements is given below. These estimates are more general in application if the time of insertion is given as "Hours in excess of maximum down time for normal start up".

<u>Power, MH</u>	<u>300</u>	<u>325</u>	<u>350</u>
Total lh to be made up by splines	17	35	50
Total lh plus safety factors	60	90	120
Total No. of splined tubes*	4	6	8
Total time of loading. 1st step (4 splines (2 tubes @ 29 hrs.		25 hrs.	22 hrs.
2nd step " @ 39 hrs.		31 hrs.	27 hrs.
3rd step " --		41 hrs.	33 hrs.
4th step " --		--	43 hrs.

The pile behavior data from which the estimates were made, were for an "average" Eamford pile, and the estimates were then made conservative enough to be safe for any of the present piles.

* Although the spline test indicated 19 ih for 1674-E, in practice, tube choice limitations, shadowing, etc. would make 15 ih a more realistic average value.

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Details

Tube 1674-B was selected for the test. It was the required 2 lattice units away from any "T" columns, although there are "B" columns in tubes 1474-B and 1775-B. It was up for discharge on the following shutdown, and is low enough in the pile to minimize tube replacement difficulties.

Normal start-up preparations were made following the shutdown of 4-27-49, except that the outlet water from cross-header 15 $\frac{1}{2}$ was valved to the relief riser. An indication was obtained with all of the rods out and the rising period noted on the #2 Beckman only. The P. C. was found to be inoperative, and the galvanometer not connected. When the period was sufficiently well established, the VSR's were lowered, and after shutting off the inlet water to 15 $\frac{1}{2}$ cross-header, tube 1674-B was opened, and a cadmium spline inserted between the ribs. Water was returned to 15 $\frac{1}{2}$ cross-header, the VSR's withdrawn and the rising period noted on the #2 Beckman and the #1 Galvanometer. When the activity reached 1.5 cm. on the Galvanometer, the VSR's were lowered and after throttling 15 $\frac{1}{2}$ cross-header again a second spline was inserted into tube 1674-B along the side of the tube above the ribs. When the inlet water had been returned to normal, the VSR's were withdrawn and the rising period again noted on #2 Beckman and the Galvanometer. The activity reached 6 cm. on #1 Galvanometer this time before the VSR's were lowered. The splines were then removed and the valving on cross-header 15 $\frac{1}{2}$ returned to normal, both front and rear. The unit was started up in the normal fashion, the rising period being measured with "A" in the all out position.

Analysis of Data

To evaluate the splines, the periods taken without splines were compared to determine the xenon decay during the time of the test and the indicated corrections were applied to the periods observed with the splines inserted. A tabular summary of the data is given below.

<u>Time</u>	<u>Condition</u>	<u>Period</u>	<u>Period of Value (1h)</u>	<u>Interpolated "No Spline" 1h</u>	<u>Net</u>
(P.M. of 4-27)					
4:10	No spline, all rods out	172 sec.	17.7	17.7	0
4:15	" " " " "	168 "	18.0	18.0	0
5:10 ⁶	1 spline, " " "	90 "	29.9	40.4	10.5
6:12	2 splines, " " "	52 "	44.6	63.6	19.0
7:48	No spline, A in, rest out	78 "	33.4 + 63.6	97.0	0

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To estimate the spline requirements for safe operation at higher power levels, an emergency is assumed wherein the pile must be shut down, and without access to the rear face, be held through loss of water, and complete xenon decay. The total to be held under such circumstances at 275 MW is itemized below.

Decay of xenon	500 ih	VSR's	1700 ih
Loss of water	850 ih	Available HSR	<u>270 ih</u>
Graphite heating	<u>440 ih</u>		1970 ih
	1790 ih	Reduction due to shadowing	<u>150 ih</u>
			1820 ih

Note

The values given in this table differ from those given in similar summaries in Document HW-9028, "Pile Control", 2-23-48, and HW-9413, "Control System for H Pile", 4-6-48; at that time the equilibrium xenon for 275 MW operation was about 530 ih. Increased flattening in the piles since then had reduced the equilibrium value to about 500 ih. The graphite heating effect as entered in the above table is the gain in reactivity experienced in heating the graphite from the 275 MW equilibrium temperature to an estimated maximum of 660° C. At the time of the previous report the effective graphite temperature was about 200° C. and the graphite heating effect was given as 500 ih. At the present time the effective temperature at 275 MW is more nearly 250° C., and thus the reactivity gain in heating the graphite to 660° C. is only 440 ih. The available horizontal rod strength has also changed. At the time of the previous report, an excess of 50 ih was usually held in the control rod at equilibrium, leaving 350 ih available. At the present time, a more realistic figure could be 80 ih, and the total strength has decreased to an apparent 350 ih, leaving 270 ih available in the horizontal rod system.

If it is desired to operate the present piles at higher power levels without sacrificing any of the present safety factor, some provision must be made to supplement the present horizontal and vertical safety rod systems, since operation at higher power level results in more reactivity held in xenon, and less in the regular flattening of the pile. For an average pile this change in flattening over 275 MW operation would be about 17 ih for 300 MW, 35 ih for 325 MW, and 50 ih for 350 MW.

The amount of additional safety factor to be allowed in estimating spline requirements is arbitrary, and in this case was made quite liberal. The schedule of spline insertion times included in the table are based on the rate of xenon decay following a shutdown from equilibrium operation. It was found that this gave conservative estimates when applied to non-equilibrium

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shutdowns if the time of insertion was specified in "hours in excess of the maximum down time for a normal start-up". For example, if the shutdown is made from equilibrium operation, the maximum down time might be 21 hours. Twenty hours after this time (41 hours after shutdown) the xenon will have decayed to about 90 ih. On the other hand, if the shutdown was made at the time of turnaround, the maximum down time might be only 4 hours, and twenty hours thereafter (24 hours after shutdown), the xenon will have decayed to 140 ih.

Since pile conditions vary so greatly from one area to another and with time, no expression for the variation of maximum down time with shutdown conditions, will be given here, but rather the maximum down time furnished by the Pile Physics Group for each particular area and shut-down should be used.

ABC:bb

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