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**COMPARISON OF THE VALUE OF FOUR "CORNER" RODS
THE POISON SPLINE SYSTEM FOR THE "K" REACTORS**

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October 27, 1958

K POTENTIAL GAINS FROM "CORNER" RODS AND/OR SPLINES

INTRODUCTION

The feasibility of adding four "corner" rods to the K Reactor's 20-rod HCR system is being investigated. It is necessary to compare the costs and production gains of this method for gaining additional reactivity and heat distribution control with other supplementary control systems. This document presents the results of an investigation of the production gains that could be made by adding four rods to the KE Reactor HCR system.

The value of increased production and ease of control from this addition to the HCR system is compared with the value of a poison spline supplementary control system.

SUMMARY

The addition of four "corner" rods to the HCR control system would provide the easiest method, from an operating standpoint, for increasing production through increased reactivity and heat distribution control. Unrestricted use of poison splines alone, however, would provide a larger production gain. The proposed rod locations are now used for the near-side chambers of the octant system; since the octant system is a safety item, it is assumed any rod project would need to consider their replacement. Additional horizontal control rods are not necessarily competitive with splines; the two together may be desirable for optimum operation. In any event, the development of the spline system for the K piles is proceeding. Incidentally, the graphite contraction and/or attack-distortion problem at the K piles could pose some very special problems for a project involving the graphite stack.

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DISCUSSION

All values given herein are estimates made by the KE Reactor physicist except for the data presented in Table I which is based on the KE Reactor operating history. Table I shows the start-up history for the KE Reactor from the initial start-up on 4-17-55 until 9-30-58.

TABLE I

KE START-UP HISTORY - 4-17-55 THROUGH 9-30-58

<u>Year</u>	<u>Number of Temporary Poison Start-ups</u>	<u>Number of Non-Temporary Poison Start-ups</u>	<u>Average Number of Poison Columns per "P" Start-up</u>
1955	5	17	8.60
1956	8	31	16.75
1957	9	41	17.33
1958 (9 mos. only)	10	17	20.00
1959 (Est.)	18	18	20.00

Note: One HCR is the equivalent of three poison columns or twelve poison splines.

Planned future operation will cause the number of temporary poison start-ups to increase, and it is anticipated that, without some additional control, approximately one-half of all future start-ups will be of the temporary poison type. (See Table I.) It is estimated that, with the installation of four "corner" rods to the HCR system, approximately 75% of these temporary poison start-ups would become non-temporary poison start-ups. In addition, the power level for non-temporary poison start-ups made at the minimum downtime could be increased from about 1200 MW to about 2000 MW, and the probability of shutting down because of temperature distribution problems at turnaround would be greatly reduced. Considering all factors, a production gain of about 800-1000 MWD per start-up could be made.

With poison splines, all temporary poison start-ups and the associated poison discharge outages could be eliminated; start-ups at the minimum down time could be made to about 2200 MW. A production gain of about 1000-1200 MWD per start-up could be realized.

Control of the graphite and tube outlet-water temperatures at equilibrium would be enhanced by either system. The poison spline system would be the more flexible and diversified, but the rods would provide the smoothest control. Therefore, the poison spline system would allow the greatest increase in equilibrium power level and also provide the better control for heat cycles.

Table II shows a comparison of estimated production gains for the two systems for start-up and equilibrium conditions.

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TABLE II

COMPARISON OF ESTIMATED PRODUCTION GAINS

	<u>Four "Corner" Rods</u>	<u>Poison Splines</u>
Start-up production gains per year	32,000 MWD	40,000 MWD
Equilibrium production gains per year		
1. Improved flattening	4,000 MWD /	24,000 MWD
2. Elimination of shutdowns caused by heat cycles @ 2,000 MWD/outage*	<u>6,000 MWD</u>	<u>10,000 MWD</u>
Total	42,000 MWD	74,000 MWD

The addition of four "Corner" rods to the HCR system would cause essentially no additional problems for reactor operation; the poison spline system has several drawbacks.

The largest problem with the poison spline system concerns manpower burn-out. Also, the introduction of a spline into a tube presents the possibility of a Panellit scram. Installation and operating costs will be different for the two systems. The time required to get these systems in operation must also be considered. These problems cannot be evaluated by the authors.

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*It is assumed that unscheduled outage time is one-half as valuable as scheduled outage time. Elimination of losses due to shutdowns at turnaround on start-up are included under start-up production gains. The assumption of about five outages/year caused by the inability to control cycles is somewhat arbitrary and speculative; many other things could affect this such as the proposed displacement columns. The important thing is the estimated relative effectiveness of the additional HCR's and the splines.

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