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INCENTIVES FOR USING POISON SPLINES
AT C PILE

INTRODUCTION

The benefits of the poison spline system as developed and partially tested by the Facilities Engineering Operation^{1,2,3} are considered over a two year period. The full pile operational charge-discharge installation at the end of that time could make the poison spline system a marginal operation. This document lists the production gains that are possible, how these gains compare with the cost of the poison spline system, and how this system compares with other available supplementary reactivity control systems.

SUMMARY

Total production at C Pile can be increased by about 2.5 per cent through reduction of start-up losses, increased flattening efficiency, and reduction of minimum down time by using a poison spline supplementary reactivity control system. Total costs are estimated to be about 15 per cent of the value of the estimated production gain if the system were used for two years. Of the three systems for supplementary reactivity control that were considered, it appears that the greatest gains are available through the poison spline system, and this system is the only one which would not require downtime for installation.

1. HW-43926, Interim Report, "Production Test 105-618-A, Poison Spline Flexible Control System", P. B. McCarthy.
2. Poison splines have been used at D Pile since November, 1956 for equilibrium flattening.
3. Each spline is used only once - the splines are cut up as they are removed and stored in casks until they can be disposed of permanently.

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DISCUSSION

The ability to add or remove poison material during operation in addition to the horizontal control rod system, provides additional reactivity transient control under non-equilibrium conditions and additional control over the power distribution under equilibrium conditions. The additional transient control permits a reduction in non-equilibrium production losses, and the additional power distribution control allows increases in equilibrium production. Removal of poison during an outage to shorten the minimum down time is also possible if poison can be added later during operation.

The main advantage of the poison spline system of supplementary reactivity control over other systems (PCCF, poison column displacement) is that any tube in the pile may be used if provided with a relatively inexpensive cap,* and the tubes that are used are not taken out of service for irradiation of natural uranium. The regions where production gains are possible may be broken down as follows:

1. Elimination of production losses due to temporary poison start-ups.
2. Elimination of production losses due to reduced level start-ups (start-ups when reactivity rather than temperature is the limiting factor).
3. Production gains from flexible flattening (flattening changes may be made during operation).
4. Production gains due to reduction of minimum down time.
5. Production gains due to an increase in the number of tubes charged with uranium.

Complete elimination of the losses in items 1 and 2 can be accomplished at C Pile if thirty tubes, in the region where temporary poison columns are normally charged, are fitted with the special front caps. Approximately forty additional caps, distributed more or less evenly throughout the rest of the reactor central zone would be sufficient for equilibrium flattening adjustments and could be used to prevent tube power distribution cycling. The minimum down time may be reduced approximately one hour for every forty to fifty inhours of poison that are removed during an outage whenever this is advantageous; this gain is somewhat contingent upon the amount of reactivity invested in splines during the preceding equilibrium operation. Certain production gains are presently made by using poison columns to flatten the neutron flux distribution. This is done at the expense of taking tubes out of plutonium production service. On the average, about tubes at the C Reactor are used for poison columns, and the spline system will allow these tubes to be used for plutonium production. The present poison tubes normally produce a useful product, and the value of this product must be subtracted from the value of the production gained due to returning these tubes to plutonium production. This was estimated to be worth \$200/year.

The estimated production gains per year from each of the five items mentioned above are listed below. The gains are based on the assumptions listed on page 5 and are converted to dollars assuming

Item 1	\$ 18,000
Item 2	\$ 15,000
Item 3	\$ 58,000
Item 4	\$ 17,000
Item 5	\$ 4,000

\$112,000 or about 2.5% of present total production.

* Rearrangement of the cap distribution to compensate for radical loading changes, etc., would not be difficult.

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DISCUSSION (Continued)

The total value of the possible production gains for a two year period would then be \$224,000.

The approximate cost of the poison spline supplemental reactivity control system is estimated below:

INITIAL INVESTMENTS

1 spline remover	\$3,500
3 small storage casks @ \$500/cask	1,500
1 large storage cask	1,500
70 special caps @ \$30/cap	2,100
TOTAL	\$8,600

Operating Expenses

600 splines/year @ \$10/spline \$6,000/year

1080 manhours/year @ \$6/manhour \$6,500 year

The total cost for a two year period would then be \$33,600. Some additional manpower will be necessary for spline burial but this will be more than offset by the elimination of the manpower now necessary for charging and discharging temporary and permanent poison.

COMPARISON OF AVAILABLE SUPPLEMENTARY REACTIVITY CONTROL SYSTEMS

The poison spline supplementary reactivity control system is one of three systems that can be available in the near future.

The poison column control facility has been evaluated for C Pile for a one year period and was found to be unattractive economically⁵ under present loading conditions. This can be extended to a two year period, which is now considered the time until full pile operational charge-discharge equipment will be installed at C Pile; on a two year basis the PCCF installation still appears economically unattractive. The fact that some money has been spent for PCCF equipment may bring the economics near the marginal region, provided that no extra downtime is required for installation.

The poison column displacement system has not been thoroughly evaluated, but its value would be almost entirely for improving equilibrium control. The fact that fixed poison tube positions having a minimum poison column value of about seven inhours are required is a distinct disadvantage when only about 100 inhours of reactivity are available for poison; the value for reducing minimum downtime would be much less than that for poison splines. One advantage of the poison column displacement system over poison splines, however, is in the ability to extend scram recovery time (approximately 2 - 3 minutes at C Pile with 100 inhours of flattening). The poison spline development program is considerably ahead of the displacement cylinder program with regard to demonstrating operation and mechanical feasibility.

5. HW-46347, An Economic Evaluation of the Poison Column Control Facility for the C Reactor, F. C. Franklin.

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Operational Physics Operation
Research and Engineering
IRRADIATION PROCESSING DEPARTMENT

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ASSUMPTIONS

1. Assumed plant average value of an MWD
 2. Temporary poison start-up losses⁶ 300 MWD/start-up
 3. Reduced level start-up losses⁷ 100 MWD/start-up
 4. Temporary poison start-ups per year⁷ 0
 5. Reduced level start-ups per year⁷ 0
 6. Days of equilibrium operation per year⁷ 200
 7. Average equilibrium power level⁸ 1450 MW
 8. Per cent increase in equilibrium power level due to ability to vary local reactivity strengths during operation⁹ 0
 9. Start-ups per year where reduction of minimum down time is feasible⁷ 0
 10. Average central zone tube production 200 MWD/year
 11. Average amount of reactivity carried as flattening⁷ 100 inhours
 12. Average effective reactivity value per spline¹⁰ 8 inhours
 13. Estimated number of splines needed per year 600 0
 14. Spline insertion rate¹¹ 0 10/hour
 15. Spline withdrawal rate¹¹ 2/hour
 16. Number of men required for spline insertion and withdrawal operation¹¹ 3
 17. Assumed cost of one manhour \$6
 18. Average number of tubes needed for 100 inhours of flattening by present poison tube method⁷
 19. One atom of product from poison irradiation (mint) is equal in value to one atom of plutonium.
 20. Production rate of product from one full tube of poison (Mint)¹² .02314 gm/MWD/AT
6. HW-45043, "Outage Time Economy", A. P. Vinther.
 7. Estimates based on past two years operation corrected for known present and future changes in operation methods.
 8. Based on 920 KW for the average of the ten highest powered tubes and 1575 effective central tubes.
 9. HW-45706, "Supplemental Reactivity Control", G. F. Owsley.
 10. 305 Pile Tests
 11. Personal Communication, P. B. McCarthy Facilities Engineering Operation
 12. Personal Communication, W. C. Albert, Production Operation

END

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