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By Authority of RM-61en2-28-94 CG-4K-2By J. J. Sawley 3-4-94Verified By DK-Hanson 3-17-94

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R Nilson

April 19, 1961

R. E. Trumble, Representative C-Overbore Task Force
 Process and Reactor Development Subsection
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40-TUBE OVERBORE FACILITY LOCATION - C REACTOR

INTRODUCTION

Possible locations of the projected 40-tube overbore facility at the C Reactor are discussed from the standpoint of obtaining conversion ratio data applicable to a full-reactor overbore program.

SUMMARY

Several alternative locations and approaches appear possible, they are listed below; first, in the order in which they would furnish best conversion ratio data:

- I. A. Overbore a block of about 44 channels in the flat zone, and charge the appropriate mixture of .947 enriched and natural uranium columns which would represent the full-scale reactor loading. Each column would be suitably shortened to obtain reasonable tube powers.
- B. A somewhat more conservative approach to (A) above. The block would initially be loaded with natural uranium columns, and include a few "pioneering" E columns to test the feasibility of allowing specific powers to exceed 110 power units/ft.

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- II. Overbore 36 channels in the top three lattice units and change the appropriate mixture of .947 enriched and natural uranium columns. Only columns in the third lattice unit possibly need be shortened to maintain reasonable tube powers.

If the alternatives were re-listed in the order of probability of successfully completing the conversion ratio test they would be reversed; maximum specific powers in alternative II would be no higher than these already reached in the current overbore testing program. Specific powers predicted for .947 enriched columns in the flat zone of alternative I could reach as high as about 130 kw/ft. On the other hand, much more straightforward and definitive conversion data would be obtained from alternative IA than from Alternative II.

RECOMMENDATIONS

From the standpoint of obtaining best possible conversion data combined with somewhat conservative approach it is recommended that alternative IB be pursued. Roughly estimated accuracy of conversion ratio test results might be:

Alternative IA	$\pm 2-3\%$
Alternative IB (No E-metal)	$\pm 3-4\%$
Alternative II	$\pm 4-6\%$

DISCUSSION

Data obtained from current overbore fuel loadings indicate the feasibility of operating at maximum specific powers as high as about 105 kw/ft of column. These powers have been demonstrated in short-column loadings in the flat zone of the C reactor¹.

The specific power of .947 enriched fuel relative to natural uranium fuel has been calculated by W. A. Blyckert for both overbore and non-overbore geometry and for both green and exposed loads. The results are summarized in Table I, which also includes an experimental value to demonstrate the apparent accuracy of the calculational technique.

TABLE I

SPECIFIC POWER OF .947 ENRICHED VS. NATURAL URANIUM FUEL

	Calculated Relative Specific Power <u>Green</u>	800 Exposure <u>800 Exposure</u>	Observed <u>Value Ripe</u>
Present C geometry	1.225	1.185	1.161
Overbored geometry	1.185	1.136	- -

¹Personal communication with M. A. Clinton April 6, 1961.

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It appears that the maximum specific power in the .947 enriched overbored geometry would be about 125 kw/ft under current operating conditions in the flat zone at C reactor. The calculated maximum stress at this power is about 112,000 psi as opposed to 95,000 psi at 105 kw/ft.

Alternative IA

A block of about 44 channels in the flat zone containing about a 30/70 mixture of E metal and natural uranium would permit a "buffer" region two lattices wide surrounding a test block of six channels. The buffer region is very desirable because of the difference in lattice characteristics between the overbored and standard lattices. Multi-group flux spectrum calculations indicate this, while the flux spectrum near the boundary between two different regions represents the normal spectrum of neither region, the spectrum changes rapidly with distance from the boundary, and at a distance of about two lattice units is essentially stabilized. This is demonstrated by the calculated flux spectrum near the core-reflector boundary of the K reactor² and the NPR³. Since the flux spectrum will vary across the block, and since the test columns must be short-charged to control tube powers, a tube power traverse across the block will be somewhat depressed in the center (the amount of depression has not been calculated, but should be minor).

Conversion ratio measurements obtained from this block loading would have to be corrected for:

- a) the short-column configuration, a relatively minor effect.
- b) the excessively high graphite and neutron temperatures within the boundaries of the block. Specific powers in this block loading will average between 60 and 65 percent higher than the specific powers in either the current C pile loading or the full-scale overbored C pile loading, while the pile power level and gas atmosphere must be almost wholly determined by the requirements of the remainder of the reactor. To a first approximation, the maximum graphite temperatures which would be attained within the boundaries of the block might increase from about 580 C to as high as $(580 - 60) 1.65 + 60 \approx 900$ C. This difference in graphite (and neutron) temperature would result in a higher than normal buildup of the higher plutonium isotopes which would have to be corrected by theoretical means to establish a "normal" pile conversion ratio. The effect on total plutonium buildup would be smaller and more easily corrected.

Major engineering considerations associated with this approach are:

- a) the high (130 kw/ft) specific power and associated rupture potential.
- b) the high estimated graphite temperatures and their effect on pile life, operating limits, and graphite thermocouple lifetime.

² HW-68518, "KW Wet Critical Loading Three Group Flux," D. E. Simpson, February 15, 1961.

³ HW-60364, "Two-Group NPR Flux Distributions," G. W. Allen, September 21, 1959.

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Alternative IB

This alternative is essentially the same as (A) above, except that the block would be initially loaded with natural uranium plus a few .947 enriched columns to explore these higher specific powers. If the exploration is successful, the discussion of IA applies. If it is unsuccessful, then the added problem of extrapolating conversion ratios from overbored natural uranium to a mixture of natural uranium and .947 enrichment will exist.

Alternative IIB

A block of overbored channels three lattices high by twelve wide in the top three rows of the pile containing the proper ratio of E-metal to natural uranium could also be used to obtain conversion ratio information.

Interpretation of conversion ratio test results from this type of loading would be considerably more difficult than in (I).

- a) placement of the test block in the buckled region of the reactor will result in non-representative fast-neutron losses which will reduce the magnitude of the epithermal capture term in the Pu-buildup equation.
- b) placement of a test block of only three lattice widths, between the pile reflector on one side and the present enrichment ring on the other side will cause the flux spectrum and therefore the conversion ratio within the block to be strongly affected by both of these boundaries.

Calculational techniques for evaluating the effects in a) and b) are at best only in the formative stages.

The engineering problems encountered in alternative I would essentially all be alleviated by utilizing this fringe location. Graphite temperatures and specific powers within the block should be no higher than normal central zone values. This alternative, however, does introduce the problem of increases in reactor shield temperatures. If it is assumed that shield temperatures are proportional to fringetube power, then maximum top shield temperatures should increase from about 85 C to about 130 C. While this temperature is above presently recommended limits, Smalley feels that it would be permissible for at least the six months required to irradiate a conversion ratio test, after which a shield protection blanket loading could be substituted.

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