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Roy Nilson

July 7, 1961

MISCELLANEOUS Pu²⁴⁰ CONCENTRATION DATA FOR THE C PILE OVERBORE STUDY

The following data were gathered on May 1, 1961, to support the statement that Pu²⁴⁰ concentration in overbored fuel would be no greater than that in present fuel geometries.

I. Pu²⁴⁰ Concentrations in Base and Overbored Cases:

DATA FROM FLEX I PROGRAM
 800 MWD/T EXPOSURE

Fuel	Base Case		Assumed % Power Gen.	r	Westcott T _n (°K)
	% ²⁴⁰	% ²⁴⁰ + ²⁴¹			
CIIN	6.7	7.5	76%	.065	585
CIIE	5.5	6.0	24%	.077	599
Pile Average	6.5	7.2			
<u>Overbore Case</u>					
CVIN	6.7	7.7	56%	.117	624
CVIE	5.6	6.5	44%	.136	653
Pile Average	6.2	7.2			

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It may be noted that the calculated neutron temperatures in the overbored fuel are higher than in the current fuel size. Such an increase, by itself, would lead to an increase in Pu^{240} concentration due to the increase in the absorption cross section of Pu^{239} with neutron temperature caused by a Pu^{239} resonance peak lying just above the thermal energy region. In this case, however, the neutron temperature increase is accompanied by a large increase in the epithermal ratio r ; the increase in r causes a much larger increase in the absorption cross section of Pu^{240} than in the absorption cross section of Pu^{239} . This causes more of the Pu^{240} which is formed to be further transmuted to Pu^{241} . The result is that while the pile-average Pu^{240} concentration is lower in the overbored fuel, the total of Pu^{240} and Pu^{241} is approximately the same or slightly higher.

II. Values for Pu^{240} Concentration at 800 MWD/T; Data from Sources as Stated.

	<u>12-2T Batch Test</u>	<u>Acct. Table Value</u>	<u>E-N Test Results</u>	<u>Flex I Program Values</u>	<u>Assumed Best Value</u>
OIIN	6.8%	7.2%	- -	6.9%	6.8%
OIII	- -	5.5%	(5.7%)	5.3	5.5%
CIIN	- -	7.0%	- -	6.7%	6.6%
CIII	- -	5.3%	- -	5.5%	5.3%
CVIN	- -	- -	- -	6.7%	6.6%
CVII	- -	- -	- -	5.6%	5.4%
KIIN	6.8%	6.8%	- -	6.8%	6.8%
KIII	- -	5.2%	- -	5.4%	5.2%

The differences between Pu^{240} concentrations predicted by the Flex I program and by the Accountability program are probably caused by a) differences in assumed graphite temperatures used in the programs, and b) differences in the assumed heats of fission assumed at some of the reactors. Where experimental data are available the "best" values are normalized to these results. In the case of E metal, Accountability table values were arbitrarily chosen as "best" because of the lack of experimental data with the exception of the E-N test. These latter data are not truly representative of normal E metal since the E metal was irradiated in a harder spectrum (higher neutron temperatures and Westcott r) caused by the inclusion of the lithium-aluminum slugs in the loading. A higher Pu^{240} concentration would be expected.

III. Probable Plant-Average Pu^{240} Concentration for the Last Six Months of 1960.

The plant fuel discharges and average discharge exposures are tabulated on a monthly basis. The plant is divided into the six older reactors and the K Reactors. Total through-puts and weighted average exposures are calculated. The average Pu^{240} concentrations are computed using Accountability table values, and the old pile natural uranium value is adjusted for the difference between Accountability table and "best" value in II above.

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Natural U

E Metal

	<u>Old</u>		<u>K</u>		<u>Old</u>		<u>K</u>	
	<u>Exp.</u>	<u>Tons</u>	<u>Exp.</u>	<u>Tons</u>	<u>Exp.</u>	<u>Tons</u>	<u>Exp.</u>	<u>Tons</u>
July	659	226	691	217	778	33	762	52
Aug.	686	170	684	259	788	31	690	35
Sept.	687	361	706	177	842	48	720	38
Oct.	693	301	679	219	796	33	744	42
Nov.	709	179	700	239	849	36	641	39
Dec.	693	279	642	192	852	55	678	34
Total	684	1516	684	1303	823	236	710	240
% 240	5.96%		6.02%		5.6%		4.7%	
% 240	6.0				5.2%			
% 240			5.9%					

IV. Average Pile Parameters - C Reactor

	<u>Tg(°C)</u>	<u>Max. Power (kw/ft)</u>
CIIN	425 ± 50	75
CIIE	465 ± 50	87
PIP CASE (95,000 Flow)		
CVIN	((425 ± 50))	71
CVIE		81
PIP EXPANSION (115,000 Flow)		
CVIN	()	86
CVIE	()	98

CIIN and CIE values are estimated current values. CVIN and CVIE PIP case values are estimated assuming a total power level, with the gas annulus and gas composition adjusted to yield the same graphite temperature. The PIP-expansion values assume specific power increases proportional to the bulk flow increase; graphite temperatures have not yet been calculated for these conditions.

V. Pu²⁴⁰ Concentration vs. Graphite Temperature in the Overbored Fuel Geometry.

The Flex I program was used to calculate values of Pu²⁴⁰ concentration as a function of graphite temperature and exposure. Results were plotted in Figures 1 through 7. These values are not normalized to the "best" values chosen in II above.

WS Nechodom

Reactor Physics
Process and Reactor Development Subsection

WA Blyckert

Reactor Physics
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4 Pu-240 and Pu-241

FIGURE 2
Pu-240 and Pu-241
VS
MD/I, GOAL
Wt. %
E-METAL
WATER

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FIGURE 3
C OVERBORE
Pu-239 BUILDUP VS GRAPHITE
—— NATURAL U
- - - E-METAL

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8/17/94

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