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PART III

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SAXTON PLUTONIUM PROGRAM

Quarterly Progress Report
for the period ending March 31, 1965

by

N.R. NELSON
(Westinghouse Atomic Power Division)

1966

EURATOM/US Agreement for Cooperation

EURAEC Report No. 1368 prepared by the
Westinghouse Electric Corporation, Pittsburgh, Pa. - USA

AEC Contract No. AT(30-1)-3385

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Brussels, February 1966 - 48 pages - 11 figures - FB 60

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SUMMARY

The fuel design, mechanical, thermal and hydraulic is complete for all special types of fuel rods. Some difficulties were encountered in using Belleville type retaining springs to prevent movement of pellets.

A final measurements program was developed and analysis of specific configurations was completed. The initial critical experiments with the 5.7 % enriched UO_2 rods show close agreement between the predicted and measured number of fuel rods required for criticality.

The fuel fabrication is underway and close to completion.

A modified SELNI container design has been examined and found to be safe nuclearly for shipment of four Sacton 9 × 9 assemblies.

The preparation of the Safeguards analysis report is complete.

The licence has been received to run critical experiments with plutonium bearing fuel rods. Criticals have been with 5.7 % enriched pelletized UO_2 fuel rods.

CONTENTS

LIST OF FIGURES

SAX-100 Project Administration

N. R. Nelson

Progress review meetings were held at Westinghouse and at Numec by AEC personnel from the New York Operations Office and from Germantown Headquarters. As a result of these meetings, revised schedules were made based on Numec working six days a week with three shifts per day in critical path areas. While many technical difficulties were encountered, such as cracking of pellets during sintering and during centerless grinding, difficulties in developing satisfactory pre-production techniques for end plug welding and in keeping ahead of schedule in chemical analyses, Numec responded rapidly and effectively in solving these problems. At the end of this period, 182 pelletized fuel rods had been completed and were ready for shipment. The remainder of the 530 pelletized fuel rods are nearing completion and are scheduled for shipment by mid-April.

At Battelle Northwest Laboratory, difficulties were encountered in powder processing to particle density requirements,in Dynapak equipment breakdowns and in developing end plug welding techniques to increase the effective minimum wall thickness in the weld area. These problems are now well in hand and 84 vibratory compacted fuel rods have been completed. The remainder of the 160 vibratory compacted fuel rods are scheduled for completion by the end of April.

Manuscript received on December 10, 1965.

A license amendment has been received to permit carrying out of critical experiments at the Westinghouse Reactor Evaluation Center (WREC) with PuO_2-UO_2 fuel rods.

A license amendment has been received to install PuO_2-UO_2 fuel rods into enclosures at the Westinghouse APD Cheswick Plant.

The Safeguards Report has been written, reviewed and is being reproduced by Saxton. It is scheduled for delivery to the Commission by April 5th and most likely, for review by the ACRS in its May meeting.

A 3 x 3 sub-assembly including both pelletized and vibratory compacted fuel rods is being prepared for irradiation in Saxton Core I. It will be reinserted in Core II along with the main loading of PuO_2-UO_2 9 x 9 fuel assemblies.

Critical experiments have been run using the 5.7% enriched UO_2 fuel rods for Saxton Core II. Starting the week of April 5, critical experiments will be run using pelletized PuO_2-UO_2 fuel rods for Saxton Core II. During the program, two zone criticals using both UO_2 and PuO_2-UO_2 rods will be run with borated water. These experiments will be completed by mid-June. Fuel assemblies will be completed and ready for shipment to Saxton by mid-July.

SAX-210 Nuclear Fuel Design

F. L. Langford, W. L. Orr

The work under this task was completed during the previous quarter.

A topical report is in preparation.

SAX-220 Fuel Design - Mechanical, Thermal & Hydraulic

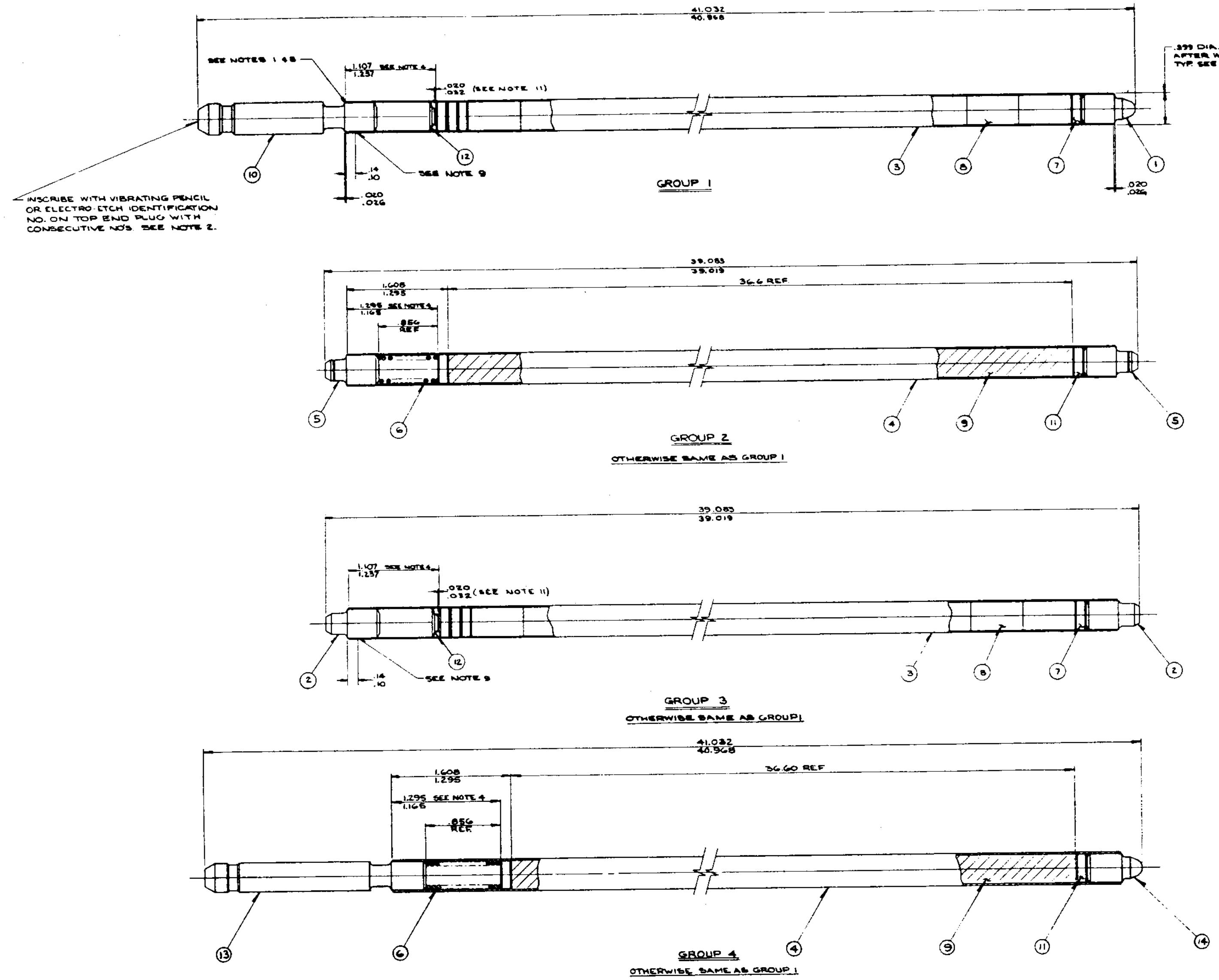
H. N. Andrews, N. J. Georges, E. A. Bassler,
E. Paxson, D. Frank

The objective of this sub-task is to develop mechanical, thermal and hydraulic specifications and design for the PuO_2-UO_2 rods and assemblies.

The decision was made in this period to include vibratory compacted and pelletized PuO_2-UO_2 fuel rods in a 3 x 3 sub-assembly and to substitute a flux wire thimble in place of the center fuel rod in the sub-assembly. The detail and assembly drawings for the 3 x 3 sub-assembly are being revised to incorporate the thimble. The fuel rods for this sub-assembly are shown in Figure 220.1.

The design of the removable plutonium fuel rods to be used in the vacant fuel rod locations in the 9 x 9 assemblies has been completed. These removable rods are shown in Figure 220.2. The non-removable rods for the 9 x 9 assemblies are shown in Figure 220.3.

Stress analysis of the fuel cladding for the plutonium rods has been completed. Since the rods have been designed with sufficient internal void volume to limit the end of life fission gas pressure to less than the reactor coolant pressure, the net pressure acting on the clad will induce no tensile stresses. The maximum tensile stress will be due solely to thermal stresses. The maximum value of these stresses calculated at the hot spot for both clad materials are as follows:



BILL OF MATERIAL						NO REQ			
NOTE	ITEM	TITLE	DRAWING & OR PT	MATERIAL SPECIFICATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1	END PLUG	674C887 IT.4			1	–	–	–
	2	END PLUG	674C886 IT.3			–	–	2	–
	3	TUBE	499B772 IT.6			1	–	1	–
	4	TUBE	674C863 IT.1			–	1	–	1
	5	END PLUG	674C886 IT.4			–	2	–	–
	6	SPRING	500B086 IT.6			–	1	–	1
	7	FILLER	498B981 IT.2			AS REQ	–	AS REQ	–
Y	8	PELLET STACK	500B071 [illegible]			1	–	1	–
X/Y	9	FUEL COLUMN				–	AS REQ	–	AS REQ
	10	END PLUG	674C887 IT.3			1	–	–	–
	11	FILLER	500B158 IT.2			–	AS REQ	–	AS REQ
	12	SPRING	500B157 IT.2			1	–	1	–
	13	END PLUG	674C887 IT.1			–	–	–	1
	14	END PLUG	674C887 IT.2			–	–	–	1

X - FUEL TO CONSIST OF URANIUM DIOXIDE AND PLUTONIUM DIOXIDE POWDER PREPARED FOR COMPACTION BY DYNAPAK OR EQUIV. PROCESS AND VIBRATORY COMPACTED PER WAPD APPROVED PROCEDURE TO A DENSITY OF 87.0 ± 1% OF THEORETICAL. ENRICHMENT OF UO_2 OXIDE COMPOSITION, PuO_2 CONTENT, PARTICLE DENSITY & SIZE FOR POWDER TO BE SPECIFIED ON P.O.

Y - GAS & VAPOR CONTENT OF FUEL TO BE LIMITED TO FOLLOWING:

GROUPS 1 & 3 — H_2O – 30 PPM
N_2 — 75 PPM
H_2 — 15 PPM
TOTAL GAS – .05 cc/gm (EXCLUSIVE OF H_2O)

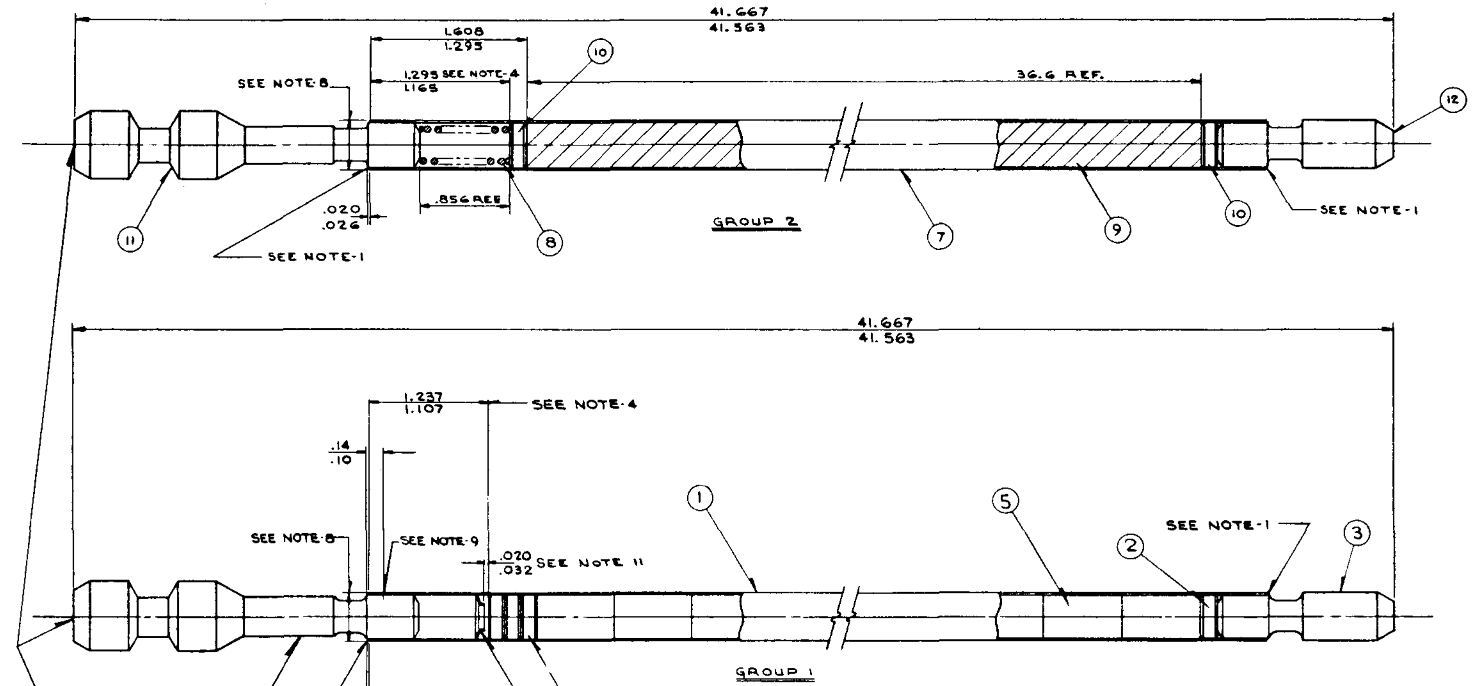
GROUP 2 & 4 — H_2O — 100 PPM
N_2 — 100 PPM
H_2 — 20 PPM (Si-H & C-H BOND)
TOTAL GAS – .06 cc/gm (EXCLUSIVE OF H_2O)

NOTES:

1. WELD PROCEDURE AND INSPECTION TO BE APPROVED BY WAPD
2. RECORD IDENT. NO, FUEL WT, & METAL WT.
3. MOISTURE CONTENT OF FUELS PRIOR TO WELDING TO BE AS SPECIFIED IN NOTE "Y". TUBE MUST BE DRY.
4. USE ONE FILLER AT BOTTOM OF FUEL TUBE AND ADD FILLERS TO TOP END AS NECESSARY (MIN OF ONE ADDITIONAL FILLER AT TOP END) TO OBTAIN THIS DIMENSION.
5. ROD ASSEMBLY MUST BE STRAIGHT WITHIN .010 PER FT. BETWEEN END PLUG WELDS WHEN LYING ON A FLAT SURFACE AND END PLUGS MUST BE CONCENTRIC WITHIN .003 WITH RESPECT TO END OF TUBE.
6. PRIOR TO ASS'Y., WIPE INSIDE & OUTSIDE SURFACES OF TUBE, SPACER, END PLUGS, & SPRING (USE ALCOHOL ONLY AS A SOLVENT) WITH SWABS TO REMOVE ALL FOREIGN MATTER. WIPE WITH DRY SWAB AFTER CLEANING.
7. ALL SURFACES IN WELD AREA TO HAVE SMOOTH TRANSITION. CAUTION! NO GRINDING OF TUBE WALL PERMITTED. ROLLING OF WELDS PERMITTED PROVIDED THE OPERATION DOES NOT EXTEND OVER THE UNSUPPORTED CLAD AREA. THE ROLLING PROCEDURE IS TO BE APPROVED BY WAPD ENGINEERING.
8. FUEL ROD ASS'YS TO BE CORROSION TESTED AFTER WELDING IN ACCORDANCE WITH WAPD APPROVED PROCEDURE. MAX TUBE & WELD DIA AFTER PICKLING TO BE .397.
9. PRICK PUNCH END PLUGS OF GROUPS 1 & 3 AT 3 EQUALLY SPACED LOCATIONS TO OBTAIN .001/.003 INTERFERENCE FIT WITH TUBE. CAUTION! REMOVE ALL SHARP EDGES IN RAISED METAL CAUSED BY PRICK PUNCHING SO AS NOT TO SCORE I.D. OF TUBE (TYP BOTH ENDS)
10. ~~[illegible]~~
11. THIS DIMENSION TO BE ESTABLISHED BY SPRING INSERTION TOOL & IS NOT AN INSPECTION REQUIREMENT.

Figure 220.1

3 x 3 Sub-Assembly Fuel Rods



BILL OF MATERIAL						NO. REQ.			
NOTE	ITEM	TITLE	DRAWING & GR. OR IT.	MATERIAL SPECIFICATION	EQUIVALENT SPECIFICATION	GR. 1	GR. 2	GR. 3	
	1	FUEL TUBE	499B772 IT.8			1	–		
	2	FILLER	495B981 IT.2			AS REQ	–		
	3	END PLUG	678C067 IT.1			1	–		
	4	END PLUG	678C067 IT.3			1	–		
Y	5	PELLET STACK	500B071 GR.2			1	–		
	6	SPRING	500B151 IT.2			1	–		
	7	TUBE	674C868 IT.1			–	1		
	8	SPRING	500B056 IT.1			–	1		
X/Y	9	FUEL COLUMN				–	AS REQ		
	10	FILLER	500B136 IT.2			–	AS REQ		
	11	END PLUG	678C067 IT.4			–	1		
	12	END PLUG	675C067 IT.2			–	1		

X FUEL COLUMN TO CONSIST OF A MIXTURE OF URANIUM DIOXIDE & PLUTONIUM DIOXIDE POWDER VIBRATORY COMPACTED IN ACCORDANCE WITH WAPD APPROVED PROCEDURE TO A DENSITY OF 87±1% OF THEORETICAL. POWDER TO BE PREPARED FOR COMPACTION BY DYNAPAK OR EQUIVALENT PROCESS. ENRICHMENT OF UO_2, OXIDE COMPOSITION, PuO_2 CONTENT, AND PARTICLE SIZE & DENSITY FOR POWDER TO BE SPECIFIED ON P.O.

Y GAS & VAPOR CONTENT OF FUEL TO BE LIMITED TO FOLLOWING:

GROUP 1- H_2O - 30 PPM
N_2 - 75 PPM
H_2 - 15 PPM
TOTAL GAS - .05 scc/gm (EXCLUSIVE OF H_2O)

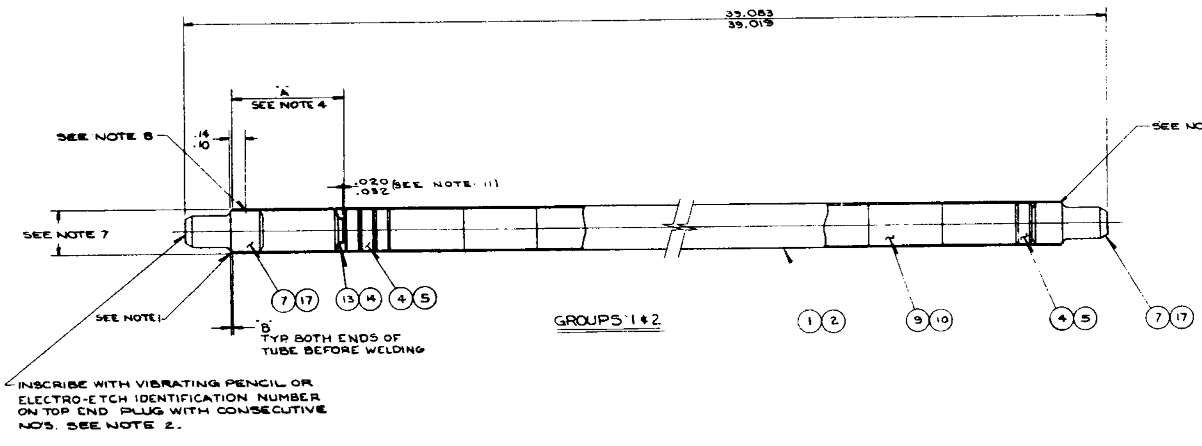
GROUP 2- H_2O - 100 PPM
N_2 - 100 PPM
H_2 - 20 PPM (Si-H & C-H BONDS)
TOTAL GAS - .06 scc/gm (EXCLUSIVE OF H_2O)

NOTES:

1- WELD PROCEDURE & INSPECTION TO BE APPROVED BY WAPD
2- RECORD IDENT. NO., FUEL WT., & METAL WT.
3- MOISTURE CONTENT OF FUELS PRIOR TO WELDING TO BE AS SPECIFIED IN NOTE "Y" TUBE MUST BE DRY.
4- USE ONE FILLER AT BOTTOM OF FUEL TUBE AND ADD FILLERS TO TOP END AS NECESSARY (MIN. OF ONE ADDITIONAL AT TOP END TO OBTAIN THIS DIMENSION.)
5- ROD ASS'Y MUST BE STRAIGHT WITHIN .010 PER FT. BETWEEN END PLUG WELDS WHEN LYING ON A SURFACE PLATE.
6- PRIOR TO ASS'Y, WIPE INSIDE & OUTSIDE SURFACES OF TUBE, SPACER, END PLUGS, & SPRING (USE ALCOHOL ONLY AS A SOLVENT) WITH SWABS TO REMOVE ALL FOREIGN MATTER. WIPE WITH DRY SWAB AFTER CLEANING.
7- END PLUGS TO BE CONCENTRIC WITH TUBE ENDS WITHIN .010 TOTAL AFTER WELDING.
8.- MAX. DIA. PERMITTED AFTER WELDING AS FOLLOWS: .399 DIA (BEFORE PICKLING) ALL SURFACES IN WELD AREA TO HAVE SMOOTH TRANSITION. CAUTION! NO GRINDING OF TUBE WALL PERMITTED ROLLING OF WELDS PERMITTED PROVIDED THE OPERATION DOES NOT EXTEND OVER THE UNSUPPORTED CLAD AREA. THE ROLLING PROCEDURE IS TO BE APPROVED BY WAPD ENGINEERING.
9.- PRICK PUNCH END PLUGS AT 3 EQUALLY SPACED LOCATIONS TO OBTAIN .001/.003 INTERFERENCE FIT WITH TUBE. CAUTION! REMOVE ALL SHARP EDGES IN RAISED METAL CAUSED BY PRICK PUNCHING SO AS NOT TO SCORE I.D. OF TUBE. (TYP. BOTH ENDS)
10.- FUEL ROD ASS'Y TO BE CORROSION TESTED AFTER WELDING IN ACCORDANCE WITH WAPD APPROVED PROCEDURE. MAX. TUBE & WELD DIA. AFTER PICKLING TO BE .397
11.- THIS DIMENSION TO BE ESTABLISHED BY SPRING INSERTION TOOL & IS NOT AN INSPECTION REQUIREMENT.

Figure 220.2

9 x 9 Assembly Removable Rods



BILL OF MATERIAL						NO. REQ.				
NOTE	ITEM	TITLE	DRAWING & GR. OR IT.	MATERIAL SPECIFICATION	[illegible]	GR. 1	GR. 2	GR. 3	GR. 4	GR. 5
	1	FUEL TUBE	4998772 IT. 4			1	—	1	—	
	2	FUEL TUBE	4998772 IT. 6			—	1	—	—	
	3	FUEL TUBE	674C863 IT. 1			—	—	—	1	
	4	FILLER	4988981 IT. 1			AS REQ	—	—	—	
	5	FILLER	4988981 IT. 2			—	AS REQ	—	—	
	6	END PLUG	674C886 IT. 2			—	—	2	—	
	7	END PLUG	674C886 IT. 3			—	2	—	—	
	8	END PLUG	674C886 IT. 1			—	—	—	2	
Y	9	PELLET STACK	500B071 GR. 2			1	—	—	—	
Y	10	PELLET STACK	500B071 GR. 3			—	1	—	—	
X/Y	11	FUEL COLUMN				—	—	AS REQ	AS REQ	
	12	~~SPRING~~	~~500B086 IT. 1~~			—	—	1		
	13	SPRING	500B157 IT. 1			1	—	—	—	
	14	SPRING	500B157 IT. 2			—	1	—	—	
	15	FILLER	500B158 IT. 1			—	—	AS REQ	—	
	16	FILLER	500B158 IT. 2			—	—	—	AS REQ	
	17	END PLUG	674C886 IT. 4			2	—	—	—	

'X' - FUEL COLUMN TO CONSIST OF A MIXTURE OF URANIUM DIOXIDE & PLUTONIUM DIOXIDE POWDER VIBRATORY COMPACTED IN ACCORDANCE WITH WAPD APPROVED PROCEDURE TO A DENSITY OF 87 ± 1% OF THEORETICAL. POWDER TO BE PREPARED FOR COMPACTION BY DYNAPAK OR EQUIVALENT PROCESS. ENRICHMENT OF UO_2, OXIDE COMPOSITION, PuO_2 CONTENT, AND PARTICLE SIZE & DENSITY FOR POWDER TO BE SPECIFIED ON P.O.

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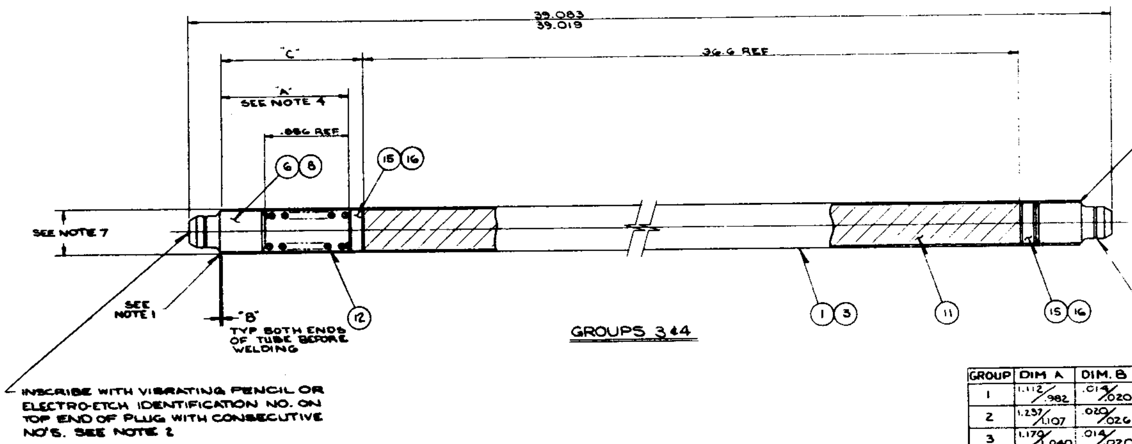
N_2 - 75 PPM
H_2 - 15 PPM
TOTAL GAS - .05 cc/gm (EXCLUSIVE OF H_2O)

GROUPS 3 & 4 — H_2O - 100 PPM
N_2 - 100 PPM
H_2 - 20 PPM (Si-H & C-H BONDS)
TOTAL GAS - .06 cc/gm (EXCLUSIVE OF H_2O)



GROUP	DIM A	DIM. B	DIM. C
1	1.112/.982	.014/.020	—
2	1.237/1.107	.020/.026	—
3	1.170/1.040	.014/.020	1.483/1.170
4	1.295/1.165	.020/.026	1.608/1.295

NOTES:

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3. MOISTURE CONTENT OF FUELS PRIOR TO WELDING TO BE AS SPECIFIED IN NOTE "Y" TUBE MUST BE DRY.
4. USE ONE FILLER AT BOTTOM OF FUEL TUBE AND ADD FILLERS TO TOP END AS NECESSARY (MIN. OF ONE ADDITIONAL AT TOP END TO OBTAIN THIS DIMENSION.
5. ROD ASS'Y MUST BE STRAIGHT WITHIN .010 PER FT. BETWEEN END PLUG WELDS WHEN LYING ON A SURFACE PLATE.
6. PRIOR TO ASS'Y, WIPE INSIDE & OUTSIDE SURFACES OF TUBE, SPACER, END PLUGS, & SPRING (USE ALCOHOL ONLY AS A SOLVENT) WITH SWABS TO REMOVE ALL FOREIGN MATTER. WIPE WITH DRY SWAB AFTER CLEANING.
7. MAX. DIA. PERMITTED AFTER WELDING AS FOLLOWS: GROUPS 1 & 3 - .395 DIA. GROUPS 2 & 4 - .399 DIA (BEFORE PICKLING) ALL SURFACES IN WELD AREA TO HAVE SMOOTH TRANSITION. CAUTION! NO GRINDING OF TUBE WALL PERMITTED ROLLING OF WELDS PERMITTED PROVIDED THE OPERATION DOES NOT EXTEND OVER THE UNSUPPORTED CLAD AREA. THE ROLLING PROCEDURE IS TO BE APPROVED BY W APD ENGINEERING.
8. PRICK PUNCH END PLUGS OF GROUPS 1 & 2 AT 3 EQUALLY SPACED LOCATIONS TO OBTAIN .001/.003 INTERFERENCE FIT WITH TUBE. CAUTION! REMOVE ALL SHARP EDGES IN RAISED METAL CAUSED BY PRICK PUNCHING SO AS NOT TO SCORE I.D. OF TUBE. (TYP. BOTH ENDS)
9. FUEL ROD ASS'YS (GRS. 2 & 4) TO BE CORROSION TESTED AFTER WELDING IN ACCORDANCE WITH W APD APPROVED PROCEDURE. MAX. TUBE & WELD DIA. AFTER PICKLING TO BE .397.
10. ~~[illegible]~~
11. THIS DIMENSION TO BE ESTABLISHED BY SPRING INSERTION TOOL & IS NOT AN INSPECTION REQUIREMENT.

Figure 220.3

9 x 9 Assembly Fixed Rods

Clad Type	Thermal Stress at Outer Surface
Stainless Steel	7780 psi tensile
Zircaloy-4	2380 psi tensile

Some problems with the fuel retaining springs have been encountered during manufacture of the pelletized plutonium fuel rods. The springs, which are in the form of Belleville springs, have a slight interference fit with the fuel tube and were designed to prevent movement of the fuel under inertial loads of less than 6 g's. Upon inspection after the final closure weld on the first two lots of fuel rods, a large percentage of the springs were found to have been overloaded and yielded to the point where they were free to move within the rods and no longer functioned as designed.

One problem was traced to the welding process where the chill blocks used to clamp the rods during welding were supplying sufficient radial load through the tube wall to compress and deform the springs. This problem was rectified by reworking the chill blocks to apply the clamping load at a distance from the springs. A more recent problem has arisen where the springs are being yielded somewhat but not enough to loosen them or prevent them from performing as designed. This latter problem, which appears to be a result of some relative expansion between the fuel and fuel tube, is currently under study.

Shipping requirements for the pelletized plutonium fuel rods and fuel assemblies have been revised as a result of the spring problem. Originally it had been planned to ship all of the fuel rods and fuel assemblies in the horizontal position. However, because some of the pellets could become loose in the fuel rods with the yielded springs, shipment of fuel rods to and from the critical facilities prior to loading into fuel assemblies will be done with the rods in an inclined position and in shock cushioned cradles. This is being done to minimize any separation of pellets in the fuel rods.

It is also planned to ship those fuel assemblies which contain any of the rods with yielded springs in the inclined or vertical position for the same reason. The design of the shipping containers is proceeding under shop order SAX-330.

SAX-230 Fuel Design - Materials

R. J. Allio, A. Biancheria

The work under this task leading to a set of materials specifications was completed during the previous quarter. A topical report will be prepared on this subject.

SAX-250 Planning and Analysis of Critical Experiments

F. L. Langford, W. L. Orr, R. H. Chastain,
H. I. Sternberg, L. Bindler, P. Deramaix

A. Introduction and Summary

1. Introduction

The objective of this task is to plan, design, and analyze the critical experiments that are being carried out at the Westinghouse Reactor Evaluation Center (WREC) to verify the nuclear design of the unirradiated fuel before it is installed in the Saxton reactor.

A program of experiments expected to last approximately 2-1/2 months is now is progress. The same fuel rods to be used in the subsequent irradiation test are to be used in these experiments.

2. Summary

The following statements briefly summarize the work performed under this task during the quarter:

a. The preliminary measurements program described in the previous quarterly/1 was revised and a final measurements program was developed.

b. The analyses of the specific configurations included in the final measurements program was completed. Predictions were made as to the number of fuel rods and the boron concentration requirements for each configuration. At the close of the quarter, a critical configuration was established using the conventional Saxton UO_2 fuel (5.69 a/o U-235). Preliminary results indicate comparatively good agreement between the analysis and experiment (critical rods; analysis = 356 rods, experiment = 346)

c. An analytical comparison was made of the kinetic characteristics of a critical configuration composed of UO_2 fuel with that of a mixed-oxide (PuO_2-UO_2) critical for an assumed moderator-fill accident. This study shows that in spite of the shorter neutron lifetime and small β_{eff}, a transient in the PuO_2-UO_2 critical results in a lower fuel temperature for the same reactivity addition than that in a core containing UO_2. This result is due to the larger Doppler coefficient in the plutonium fuel. The effect of a variation in the size of the Doppler coefficient on the maximum fuel temperature reached in a transient was also investigated.

d. A study was made of the reactivity vs period characteristics for cores composed of two different fuels. The method to be used in interpreting reactivity measurements in the critical experiment correctly accounts for spatial neutron importance.

B. Final Measurements Program

Table 250.1 contains a description of the planned experiments and their sequence. As shown in Table 250.1, the conventional Saxton UO_2 fuel will be available in advance of the mixed-oxide (PuO_2-UO_2) fuel. A series of preliminary experiments is now in progress using these UO_2 fuel rods. Included in Table 250.1 are the predicted reactivity requirements for the various configurations as to number of fuel rods and boron content. For cores containing the mixed-oxide fuel an allowance for a possible discrepancy between analysis and experiment based on a calculation of Hanford criticals was included. No allowance was included for the cores containing UO_2 alone. The allowance included for each configuration is listed in Table 250.1 together with the fuel rod and boron content requirements. (The effect of the 1/4" aluminum spacer plate in the longitudinal plane in the experiment was neglected in the analysis).

Preliminary results from the first UO_2 critical configurations indicate the analysis and experiment are in good agreement. The analyses predicts 356 fuel rods are required for criticality in a square core at a 0.56-inch pitch. A total or 346 rods was required in the experiment for a full water height, just critical configuration.

Table 250.1

Measurements Program Outline

Configuration Number	General Description	Number of Regions	Fuel Type	Core Geometry	Lattice	Measurements	Remarks - Predicted Requirements
A(1)	UO_2, One-Region, Clean Core Experiments	One	UO_2	Square	0.56	Criticality	A series of square cores at different water heights until all available conventional Saxton UO_2 fuel rods are installed
A(2)		One	UO_2	Square	0.792	Criticality & Buckling	Remove every other rod in A(1) to form a critical configuration in a loose lattice
A(3)		One	UO_2	Square	0.56	Type A*	Predicted critical rods = 356 at full water height (calculated k_{eff} = 1.0)
A(4)		One	UO_2	Square	0.56	Reactivity, Power, Flux	Special experiments including: Slot experiments - 1-5 slots in center; Control rod experiments - 1-5 rods; 3 x 3 experiment using PuO_2-UO_2 rods
1(a)	One-Region, Clean Core Experiments	One	PuO_2-UO_2	Square	0.56	Criticality	A series of square cores at different water heights until all available PuO_2-UO_2 rods are installed. H/Pu = Saxton design, hot.
1(b)		One	PuO_2-UO_2	Square	0.792	Criticality & Buckling	Remove every other rod in 1(a) to form a critical configuration in a loose lattice
1(c)		One	PuO_2-UO_2	Square	0.56	Type A	Predicted critical rods = 355 at full water height (calculated k_{eff} = 1.025)
1(d)		One	PuO_2-UO_2	Square	0.56	Reactivity, Power, Flux	Special experiments including: Slot experiments - 1-5 slots in center; Control rod experiments - 1-5 rods; 3 x 3 experiment using UO_2 rods
1(e)		One	PuO_2-UO_2	Square	0.56	Criticality, $d\rho/dT$	Moderator temperature coefficient
2(a)	Two-Region, Clean Core Experiments	Two	PuO_2-UO_2 Inside, UO_2 Outside	Square	0.56	Criticality, $d\rho/dT$	Using the heated water from 1(e) obtain a hot critical. While cooling, obtain $d\rho/dT$
2(b)		Two	As Above	Square	0.56	Type A	Dump hot water. Obtain cold critical. The predicted clean core critical configuration is 144 PuO_2-UO_2 rods in the center of the core (12 x 12) with 217 UO_2 rods installed on the outside forming a 19 x 19 rod array. (Calculated $k_{eff} \approx 1.025$)
2(c)		Two	As Above	Square	0.56	Reactivity, Power, Flux	Special experiments at region boundaries: Slot experiments; Control rod experiments
3(a)	Two-Region, Borated-Core Experiments	Two	PuO_2-UO_2	Square	0.56	Type A	Borate water. Use all PuO_2-UO_2 rods except those needed for power measurements. For a core containing 400 PuO_2-UO_2 rods, a boron concentration of 150 ppm is predicted. (Calculated k_{eff} = 1.025)
4(a)	Two-Region, Borated-Core Experiments	Two	PuO_2-UO_2 Inside, UO_2 Outside	Square	0.56	Fuel Substitution Experiment	Remove PuO_2-UO_2 rods and add UO_2 rods. Obtain critical at same boron as 3(a)
4(b)		Two	As Above	Square	0.56	Type A	Increase boron content. Add PuO_2-UO_2 rods and UO_2 rods until critical. For a configuration consisting of 361 PuO_2-UO_2 rods (19 x 19) in the center of the core with 368 UO_2 rods installed on the outside forming a 27 x 27 rod array, a boron concentration of 1525 ppm is predicted (calculated k_{eff} = 1.016)
4(c)		Two	As Above	Square	0.56	Reactivity, Power, Flux	Slot experiment on boundary
5(a)	Two-Region, Inverted Core	Two	UO_2 Inside, PuO_2-UO_2 Outside	Square	0.56	Type	Load inverted core at $\approx$ the boron content of 4(b) above
5(b)		Two	As Above	Square	0.56	Critical Rods	Dilute to $\approx$ boron content of 3(a)
5(c)		Two	As Above	Square	0.56	Type A	Dump water. Clean core critical
6	One-Region Clean Core	One	PuO_2-UO_2	Square	0.60	Type A	Predicted critical rods = 260 (calculated k_{eff} = 1.025

*Type A Measurements Include:

1. Number of rods required for full water height critical
2. Critical buckling and savings from fuel rod scan and foil measurements
3. β/ℓ measurement

If the reactivity for the mixed-oxide (PuO_2-UO_2) cores is significantly different from that expected it will be necessary to modify some of the experiments listed in Table 250.1. For example, if the reactivity is higher than expected, a boron content of more than 150 ppm will be required for configuration 3 (a), the single-region, borated-core experiments. However, if the reactivity is less than expected, it may not be possible to conduct these experiments with the limited number of fuel rods available. Thus, changes in the experiments will be made as required by the experimental results.

C. Supporting Analysis

The analysis carried out during the quarter was divided into two parts. The first part was concerned with determining the criticality requirements for the specified experimental configurations. Also, it was desired to select the most efficient methods for carrying out the post critical comparison of analysis with experiment. The second part was concerned with a further study of the kinetic characteristics of a critical configuration containing plutonium. A comparison of UO_2 and PuO_2-UO_2 criticals was made for transient conditions and the reactivity vs period characteristics of cores containing two different fuel types was studied.

1. Criticality Requirements

The analytic results obtained during the quarter were used with those reported previously to establish the criticality requirements for the various configurations listed in Table 250.1. The methods used are described in the following paragraphs.

a. Single Region Cores

The LEOPARD[2] - PDQ-3[3] sequence was used to determine k_{eff} as a function of boron content in the moderator for a single region square core composed of 400 mixed-oxide (PuO_2-UO_2) fuel rods in a 0.56-inch lattice. The calculated k_{eff} from PDQ-3, shown in Figure 250.1, was then used with the two-group constants from LEOPARD to determine the variation in reflector savings with boron content. Figure 250.2 summarizes the results. A two-group formula using the calculated reflector savings was used to determine the number of fuel rods required for a specified k_{eff}. Figure 250.1 also shows the number of fuel rods required for criticality for two assumed values of k_{eff}. Table 250.2 summarizes the information contained in Figures 250.1 and 250.2.

The same type of analysis (LEOPARD - PDQ-3) was carried out for a square, clean-core containing UO_2 fuel rods at a 0.56-inch pitch. These results are also included in Table 250.2.

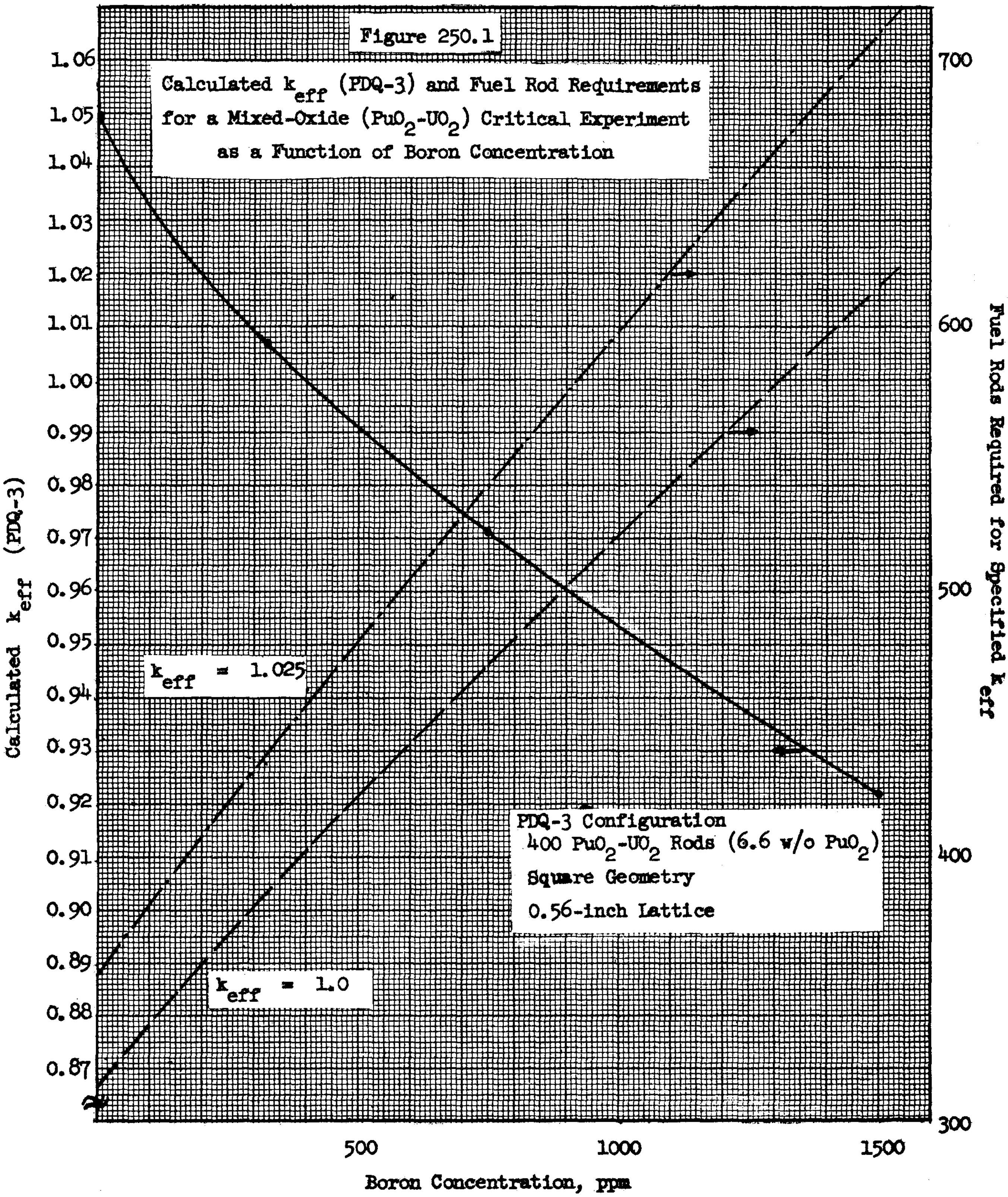


Figure 250.1
Calculated k_{eff} (PDQ-3) and Fuel Rod Requirements for a Mixed-Oxide (PuO_2-UO_2) Critical Experiment as a Function of Boron Concentration
k_{eff} = 1.025
k_{eff} = 1.0
PDQ-3 Configuration
400 PuO_2-UO_2 Rods (6.6 w/o PuO_2)
Square Geometry
0.56-inch Lattice
Calculated k_{eff} (PDQ-3)
1.06
1.05
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.87
Fuel Rods Required for Specified k_{eff}
700
600
500
400
300
500
1000
1500
Boron Concentration, ppm

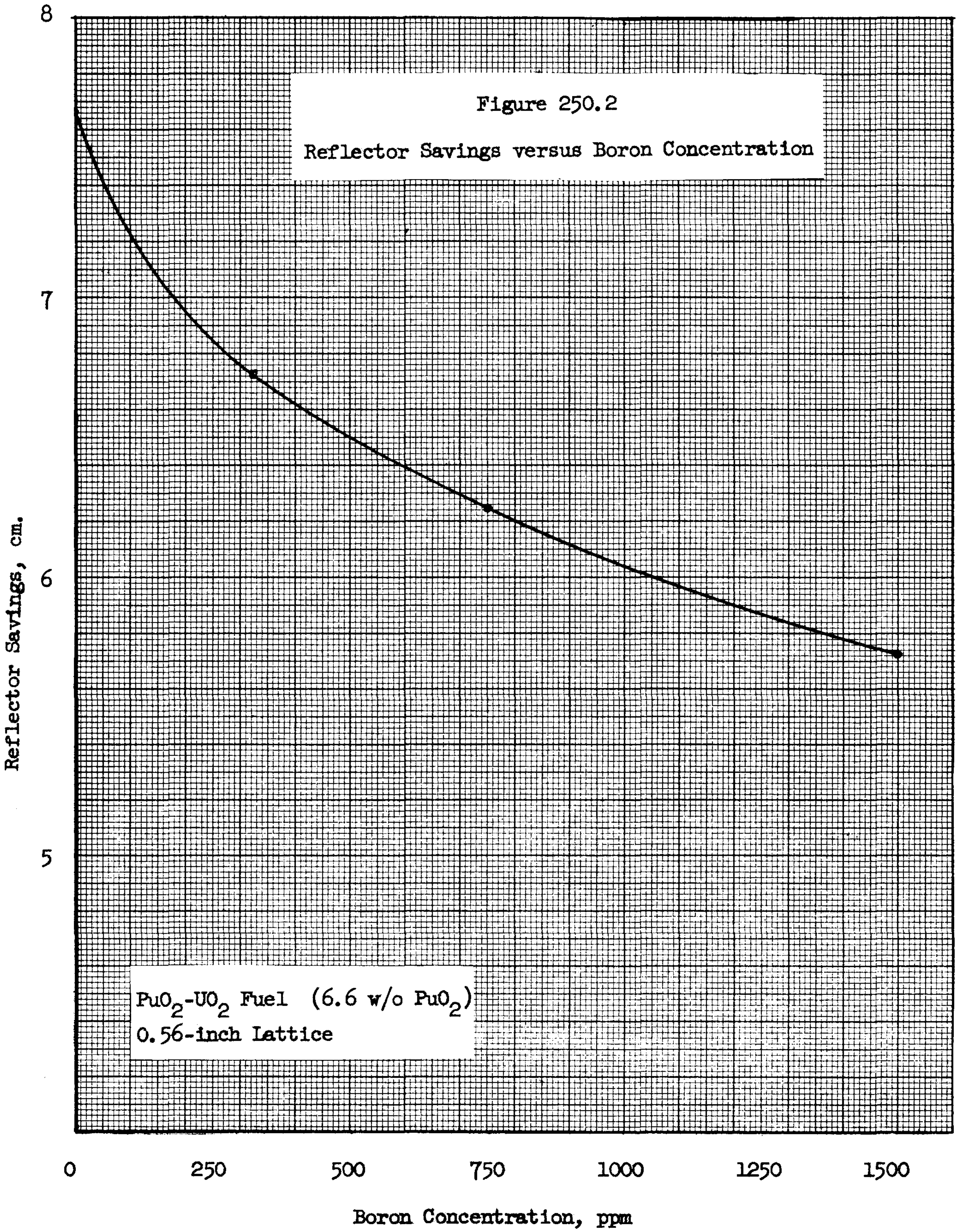


Figure 250.2
Reflector Savings versus Boron Concentration
PuO2-UO2 Fuel (6.6 w/o PuO2)
0.56-inch Lattice
8
7
6
5
Reflector Savings, cm.
0
250
500
750
1000
1250
1500
Boron Concentration, ppm

Table 250.2

Calculated Reactivity, Buckling, Reflector Savings, and Fuel Rod Requirements for Single-Region Cores

Core	Boron Content (ppm)	PDQ-3 k_{eff}	LEOPARD B_M^2, cm^{-2}	Reflector Savings, cm	Number of rods for k_{eff} = 1.0	Number of rods for k_{eff} = 1.025
400 PuO_2-UO_2 rods in a square array	0	1.04960	0.012914	7.662	312	355
	325	1.00688	0.012372	6.723	386	435
	750	0.97139	0.011322	6.249	472	539
	1500	0.92204	0.009876	5.738	615	711
324 UO_2 rods in a square array	0	0.98953	0.013522	6.929	356	-

b. Two-Region Cores

The criticality requirements for the clean, two-region cores were determined using both one and two-dimensional calculations. The two methods were compared with respect to the calculated reactivity and computer time requirements. Table 250.3 summarizes the comparison for both one-region and two-region calculations. The calculated values of k_{eff} are in good agreement and the difference in computer time is sufficiently small that it is not a factor in the selection of the most desirable method of analysis. Consequently PDQ will be used as the basic analytic method in the post-critical comparison of analysis with experiment.

To simulate the Saxton design as closely as possible with the available fuel rods, all rods except those required for power measurements will be used in the borated, two-region cores. In the analysis a configuration consisting of 361 mixed oxide (PuO_2-UO_2) fuel rods in the inner region (19 x 19) with 368 UO_2 fuel rods in the outer region (forming a core 27 x 27) was assumed. The LEOPARD - PDQ-3 results for three variations in boron content are shown in Figure 250.3. An allowance for a possible discrepancy between analysis and experiment for the two-region core was included by weighting the k_{eff} allowance for each region (1.025 for PuO_2-UO_2, 1.0 for UO_2) by the neutron production for the region as determined in the PDQ-3 calculations containing 1750 ppm boron. For criticality (calculated k_{eff} = 1.016) a boron content of 1525 ppm is required.

Table 250.3

Comparison of Reactivity and Computer Time Requirements for Two Methods of Analysis

Geometry (Code)	One-Region Core			Two-Region Core		
	Radial (AIM-5)	Radial (X-Y, PDQ)	SQ (PDQ)	Radial (AIM-5)	Radial (X-Y, PDQ)	SQ (PDQ-3)
k_{eff}	1.026525	1.030828	1.025576	1.023077	1.025550	1.026433
PuO_2-UO_2 Area, cm^2	706.1	706.1	706.1	277.2	277.2	277.2
No. PuO_2-UO_2 rods	349	349	349	137	137	137
UO_2 Area, cm^2	-	-	-	461.3	461.3	461.3
No. UO_2 rods	-	-	-	228	228	228
Computer Time, min.	0.48	0.96	-	0.48	0.78	0.78

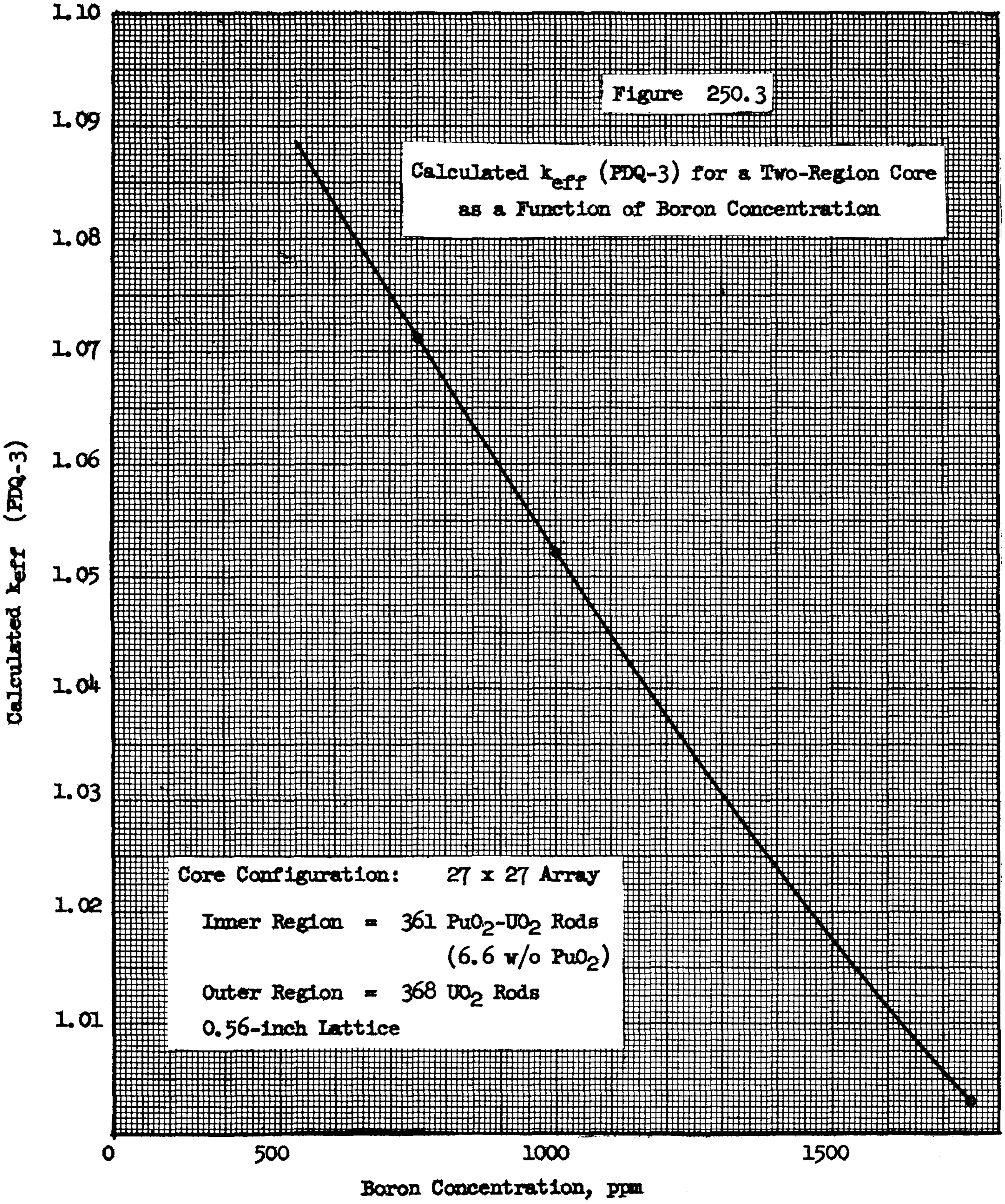


Figure 250.3
Calculated k_{eff} (PDQ-3) for a Two-Region Core
as a Function of Boron Concentration
Core Configuration: 27 x 27 Array
Inner Region = 361 PuO_2-UO_2 Rods
(6.6 w/o PuO_2)
Outer Region = 368 UO_2 Rods
0.56-inch Lattice
1.10
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
Calculated k_{eff} (PDQ-3)
0
500
1000
1500
Boron Concentration, ppm

c. Kinetic Studies

(1) Transient Analysis

In the last quarterly report, the results of a kinetics study of a single-region, 0.60-inch lattice, mixed oxide (PuO_2-UO_2) critical experiment were reported. In this study it was shown that the Doppler coefficient was the most important factor in terminating a transient produced by an increase in reactivity from an assumed moderator fill accident. Additional calculations have been made to determine the effect on the transient for an error in the size of the Doppler coefficient. A WIT-5[4] calculation was repeated for 0.8 and 1.2 times the variable Doppler coefficient used in the previous study. Other input parameters were unchanged. The results of the two calculations are shown in Figure 250.4. The difference in k_{eff} is small with both transients ending at about the same time. The smaller Doppler coefficient does not result in a significant change in the maximum fuel temperature reached in the transient.

To compare the kinetic response of a critical configuration composed of the mixed oxide fuel (PuO_2-UO_2) to one containing UO_2 alone, a duplicate kinetics study to that previously reported was carried out for a single-region, 0.60-inch lattice, UO_2 critical

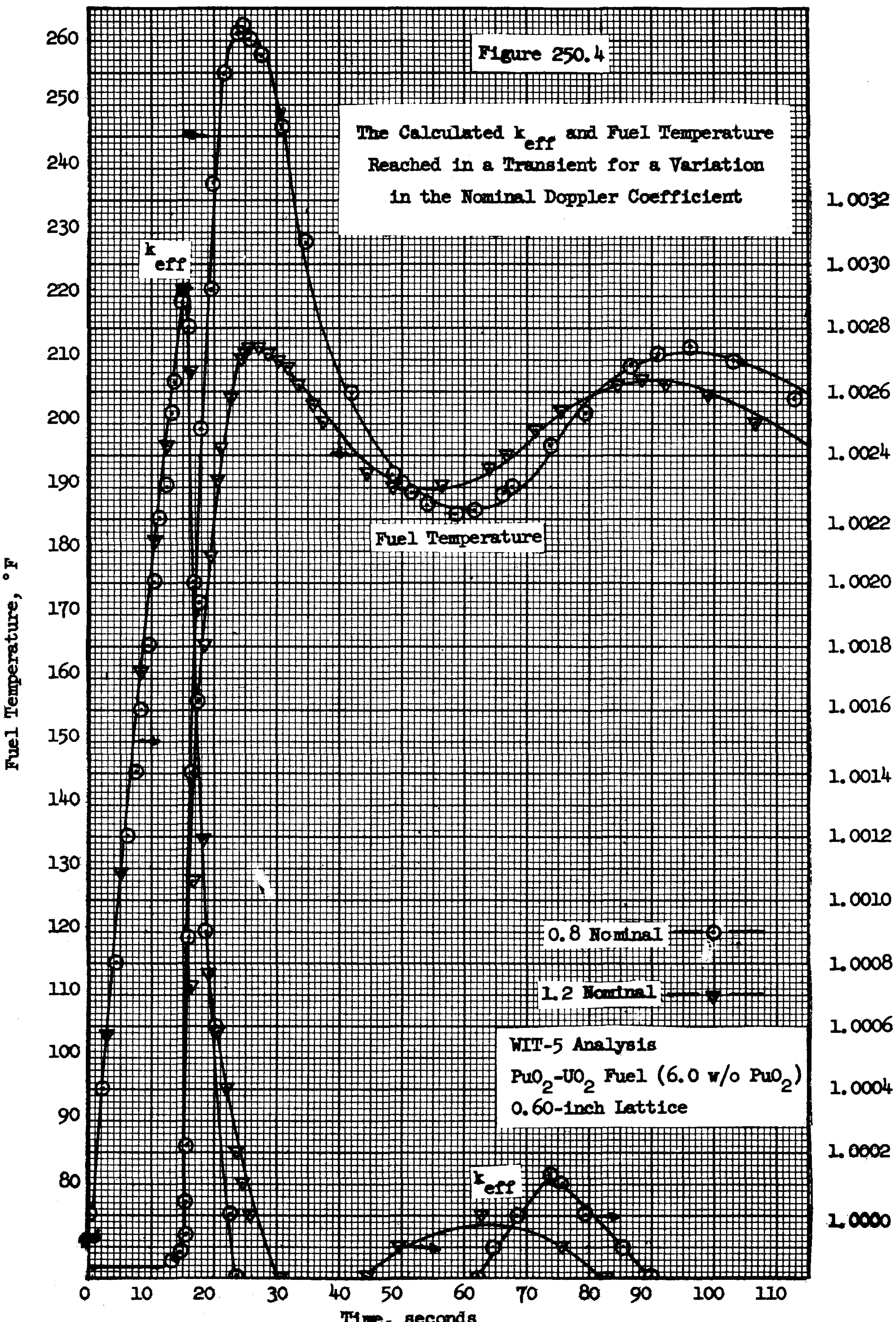


Figure 250.4
The Calculated k_{eff} and Fuel Temperature Reached in a Transient for a Variation in the Nominal Doppler Coefficient
k_{eff}
Fuel Temperature
0.8 Nominal
1.2 Nominal
WIT-5 Analysis
PuO_2-UO_2 Fuel (6.0 w/o PuO_2)
0.60-inch Lattice
Fuel Temperature, °F
Calculated k_{eff}
Time, seconds

experiment. The Doppler and moderator coefficients were calculated using the LEOPARD code. The code was run for variations in fuel pellet and effective resonance temperatures between 68°F and 500°F with a constant moderator and clad temperature of 68°F. The resulting values of k_{eff} were used to calculate the Doppler coefficients shown in Figure 250.5 and used in WIT-5. The moderator temperature coefficient was calculated using the LEOPARD code by varying the moderator temperature from 68°F to 212°F at a constant fuel temperature of 205°F and a constant clad temperature of 140°F. Figure 250.5 summarizes the results. The moderator temperature coefficient at 95°F ($-9.5 \times 10^{-5}/°F$) was used in WIT-5.

The prompt neutron lifetime (18.35 micro-seconds) and β_{eff}(0.008) were determined from LEOPARD. β_{eff} was determined by weighting the neutron production from each fissionable isotope by its delayed neutron characteristics.

All other input parameters to WIT-5 were the same as those used in the analysis of the mixed oxide (PuO_2-UO_2) critical. The results of the two calculations are compared in Figure 250.6. Figure 250.6 shows that for the same reactivity addition the maximum fuel temperature

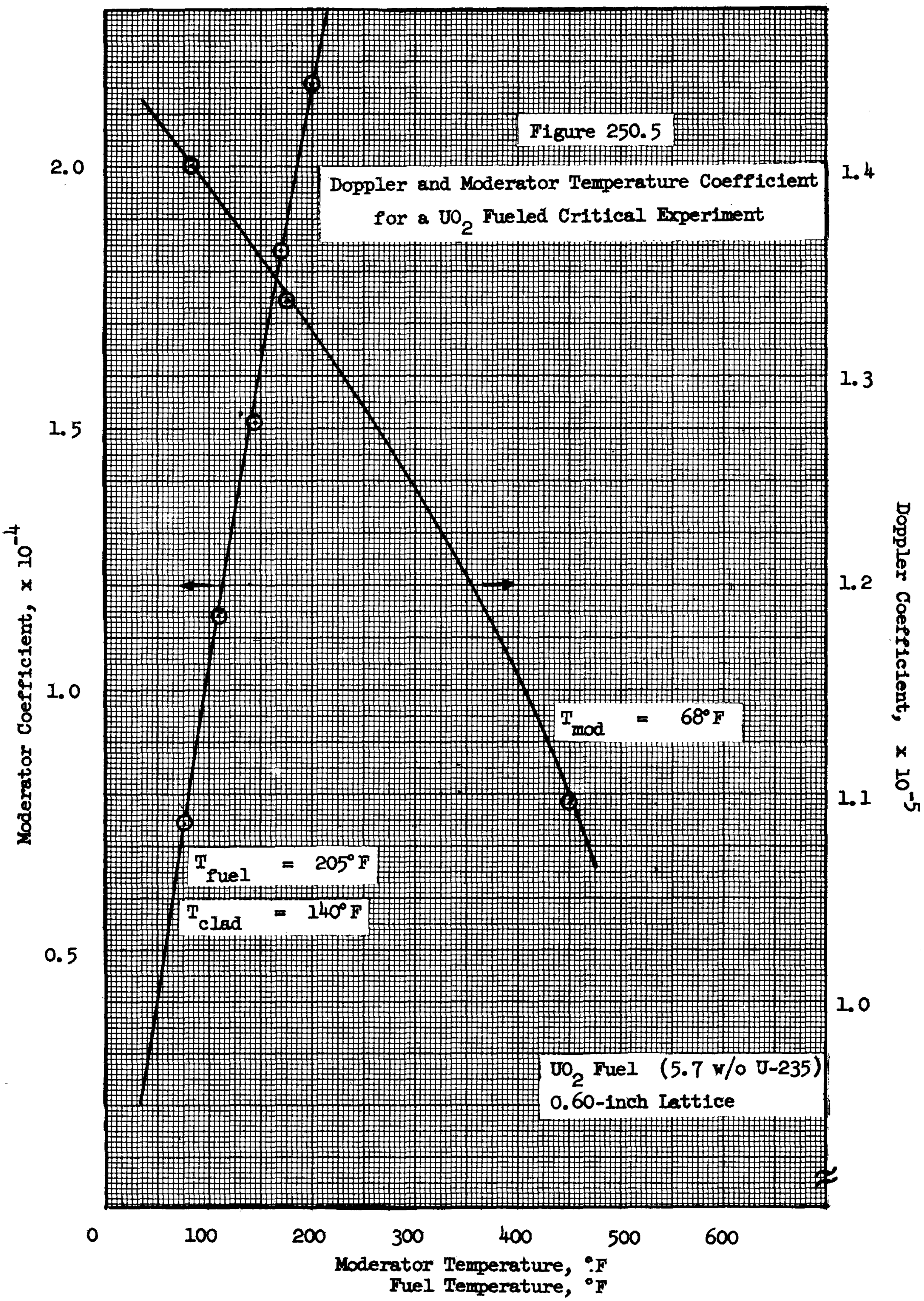


Figure 250.5
Doppler and Moderator Temperature Coefficient
for a UO2 Fueled Critical Experiment
2.0
1.5
1.0
0.5
1.4
1.3
1.2
1.1
1.0
Moderator Coefficient, x 10-4
Doppler Coefficient, x 10-5
T mod = 68°F
T fuel = 205°F
T clad = 140°F
UO2 Fuel (5.7 w/o U-235)
0.60-inch Lattice
0
100
200
300
400
500
600
Moderator Temperature, °F
Fuel Temperature, °F

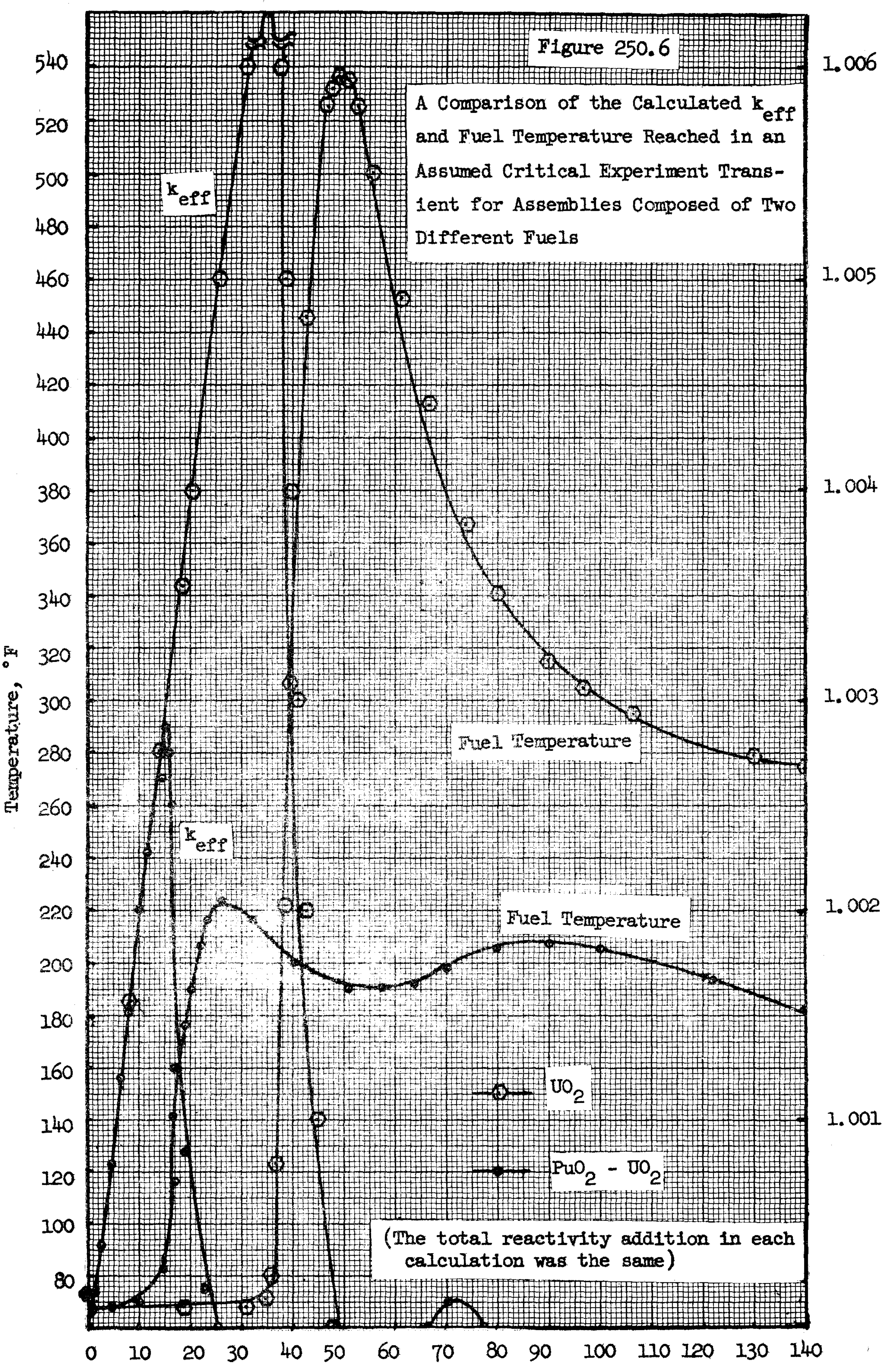


Figure 250.6
A Comparison of the Calculated k_{eff} and Fuel Temperature Reached in an Assumed Critical Experiment Transient for Assemblies Composed of Two Different Fuels
k_{eff}
k_{eff}
Fuel Temperature
Fuel Temperature
UO_2
$PuO_2 - UO_2$
(The total reactivity addition in each calculation was the same)
Temperature, °F
Calculated k_{eff}
Time, seconds
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
1.006
1.005
1.004
1.003
1.002
1.001
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

and installed system reactivity reach higher values in the UO_2 critical than in the mixed oxide (PuO_2-UO_2) critical. This result is attributed to the larger Doppler coefficient in the core containing plutonium. The study shows that in the comparison of transients terminated by an inherent shutdown mechanism such as the Doppler effect, the magnitude of the shutdown mechanism is significant whereas differences in prompt neutron lifetime and β_{eff} are not.

(2) Reactivity Period Characteristics

To determine the reactivity of the critical experiment from period measurements, it is necessary to determine β_{eff}, the effective fraction of delayed neutrons. For single-region cores β_{eff} was determined from LEOPARD calculations by means of the following two equations:

$$\overline{\beta} = \frac{\Sigma_j \, \Sigma_i \, \beta_{ij} \cdot \nu\Sigma_{f_j} \phi}{\Sigma_j \, \nu\Sigma_{f_j} \, \phi}$$

$$\beta_{eff} = I \cdot \overline{\beta}$$

where

β_i = the delayed neutron fraction for each group i, 6 delayed groups were used.

j = number of fissional isotopes.

I = an importance factor to account for difference in worth of the delayed and prompt neutrons.

The importance factor is the ratio of the calculated LEOPARD multiplication factor using the delayed neutron spectrum to that determined using the prompt neutron spectrum. The prompt neutron lifetime is also obtained from LEOPARD.

The kinetic parameters for the single-region cores are summarized in the following list. Comparable reactivity vs period curves are shown in Figure 250.7.

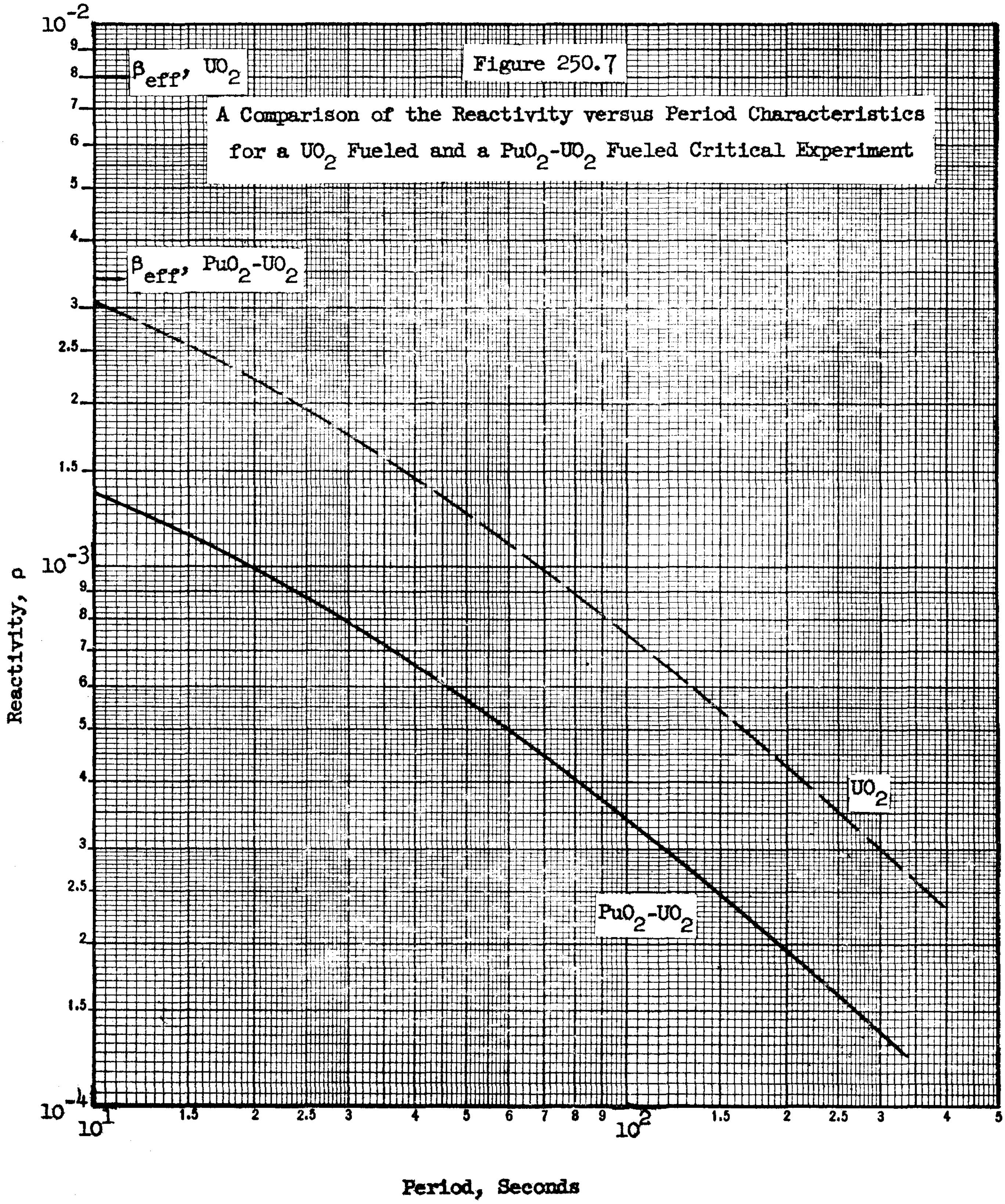
Kinetic Parameter*	UO_2 Fuel	PuO_2-UO_2 Fuel
β	0.00696	0.00293
I	1.144	1.155
β_{eff}	0.00796	0.00338
ℓ, microseconds	14.49	8.15

*500 ppm boron

The kinetic characteristics for the two-region cores composed of different types of fuel distributed spatially were computed by the following procedure. Group constants for each region were determined using LEOPARD for both the prompt and delayed spectra. Then, two AIM-5 one-dimensional calculations were used to determine β_{eff}. The first AIM-5 calculation was made using two energy groups with prompt-spectrum,

Figure 250.7

A Comparison of the Reactivity versus Period Characteristics for a UO_2 Fueled and a PuO_2-UO_2 Fueled Critical Experiment



fast-group constants obtained from LEOPARD. A buckling search was included to adjust the calculated k_{eff} to 1.0. The resulting transverse buckling was then used in the second AIM-5 calculation in three energy groups. The three energy groups consisted of a prompt spectrum fast group, a delayed spectrum fast group, and a thermal group. (The fraction of neutrons produced in the second group is the region β). The calculated k_{eff} for this second AIM-5 is $1 + \beta_{eff}$. Since this method includes the spatial importance in the calculation of β_{eff}, it will be used in the interpretation of period measurements in the critical experiments.

Figure 250.8 compares the reactivity vs period characteristics of a two-region core assumed to consist of 361 PuO_2-UO_2 fuel rods in an inner region (19 x 19) with 368 UO_2 rods in the outer region. The calculations were repeated for the same geometry but with the fuel positions reversed, the UO_2 in the inner region and the PuO_2-UO_2 in the outer region. The following list compares the calculated β_{eff} for each core. Also included are the values of β for each region.

β_{eff}	
Core 1 (PuO_2-UO_2 inside)	Core 2 (UO_2 inside)
0.00406	0.00623

β , PuO_2-UO_2 = 0.00294

β , UO_2 = 0.00698

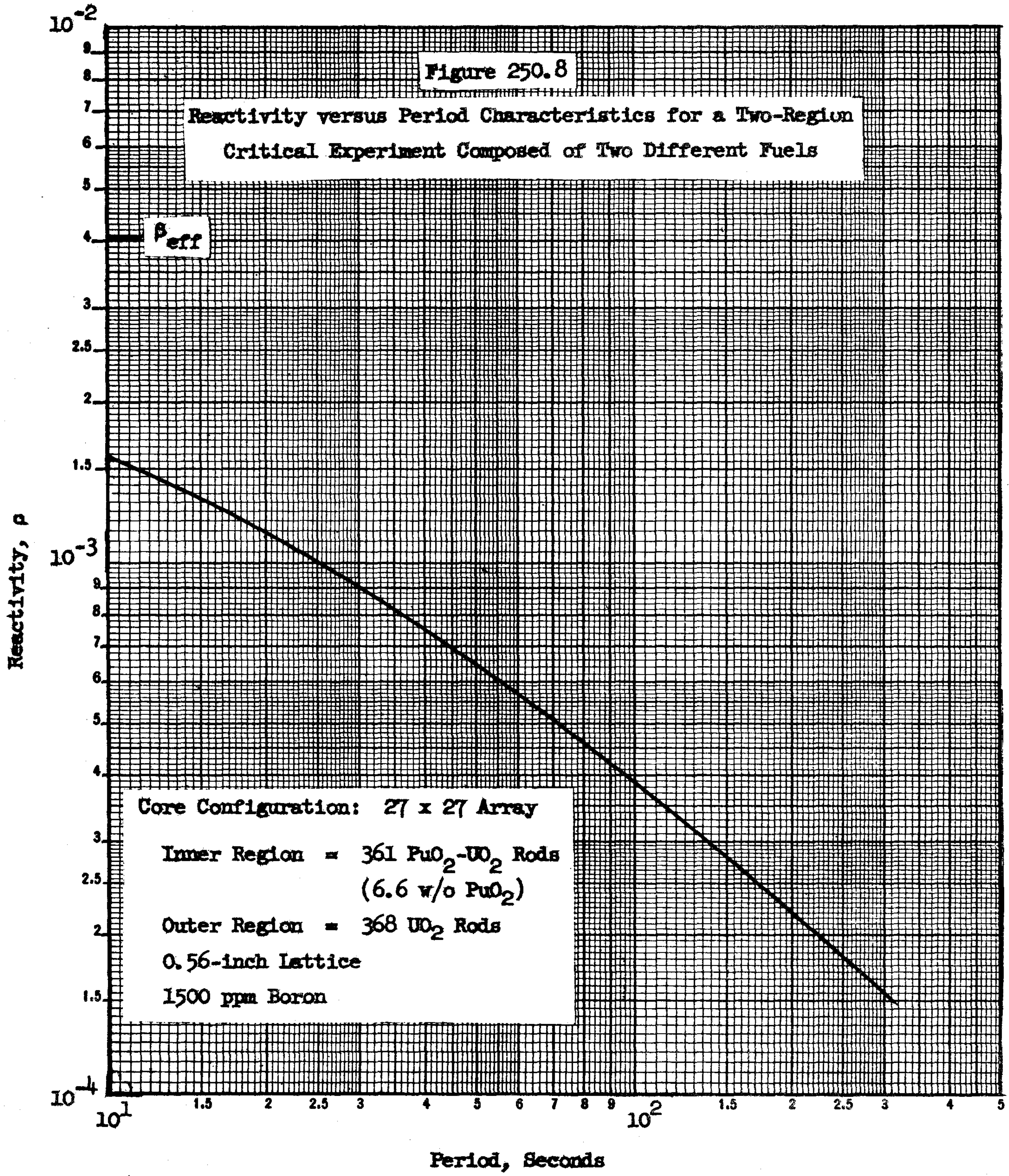


Figure 250.8
Reactivity versus Period Characteristics for a Two-Region Critical Experiment Composed of Two Different Fuels
β_{eff}
Core Configuration: 27 x 27 Array
Inner Region = 361 PuO_2-UO_2 Rods
(6.6 w/o PuO_2)
Outer Region = 368 UO_2 Rods
0.56-inch Lattice
1500 ppm Boron
Reactivity, ρ
Period, Seconds
10^{-2}
10^{-3}
10^{-4}
10^{1}
10^{2}

References

/1 N. R. Nelson, "Saxton Plutonium Program Quarterly Progress Report for the Period Ending December 31, 1964," WCAP-3385-2 (1965).

/2 R. F. Barry, "LEOPARD - A Spectrum Dependent Non-Spatial Depletion Code for the IBM-7094," WCAP-3741 (1963).

/3 W. R. Cadwell, et.al., "PDQ-3, A Program for the Solution of the Neutron Diffusion Equations in Two-Dimension on the IBM-704," WAPD-TM-179 (1960).

/4 G. H. Minton, C. P. Saalbach, "Numerical Solutions of the Reactor Kinetic Equations," Transactions of the American Nuclear Society, Volume 2, No. 2, November 1959, p. 65.

/5 H. P. Flatt and D. C. Baller,"AIM-5 - A Multi-Group, One-Dimensional Diffusion Equation Code," NAA-SR-4694 (1960).

SAX-F-310 Fuel Fabrication - Materials

R. J. Allio, A. Biancheria, M. D. Houston

The objective of this sub-task is to procure the required number of PuO_2-UO_2 bearing fuel rods for the program and to assure that manufacturing process procedures meet Westinghouse requirements.

Vibrationally Compacted Fuel

The first batch (72 Kg - Batch A) of densified 6.6 w/o PuO_2-UO_2 powder prepared by the Battelle Northwest Laboratories was below density specifications. The powder is being out-gassed and upon completion will be recycled through Hanford's Nupac process in an attempt to increase the density.

Approximately half the powder has been heat treated to date. Trial densification of the out-gassed powder has been delayed due to a broken die punch in the dynapak unit. Repair of the unit is expected to be completed by April 9.

The second batch of PuO_2-UO_2 powder (48 Kg - Batch B) prepared by Battelle was within density specifications. Blending of this batch was initially delayed because furnace operating difficulties resulted in insufficient out-gassing of the UO_2, and because of an error in chlorine analysis. The total out-gassing specification on this batch was relieved from 0.06 scc/gm to 0.067 scc/gm. The deviation in specification was relieved because of the compensating low water content, 44 ppm compared to the specified 100 ppm. Chemical analysis also indicated that the tin content was slightly high and the zinc content was "less than 50 ppm." The specification calls for 20 ppm of zinc or less and the UO_2 portion of the powder was tested by Westinghouse as 20 ppm or less. However, for PuO_2-UO_2 powder Battelle's detection limits do not go below 50 ppm. Consequently, Battelle is subcontracing for a referee analysis on each of the two batches of PuO_2-UO_2 powder processed.

Battelle's Manufacturing Processes for welding Zircaloy end closures were approved subject to quality control sampling and approval after cross-sectioning of one dummy rod per weld box load of 19 production rods. Should the dummy rod fail to meet a minimum thickness of 21 mils at the weld, two production rods (one welded in sequence just prior to the dummy rod and one just after) will be cross-sectioned. If both of these rods meet the minimum wall thickness of 21 mils, the lot will be accepted; if either one fails to meet the specification the entire lot will be rejected.

To date, Battelle has loaded, welded, inspected and autoclaved 84 rods including the special 3 x 3 subassembly removable rods. The rods were loaded with Batch B powder. The completed rods in the first lot are expected to be shipped from Battelle on April 19th. The rest of the order should be finished by the end of April.

Pelletized Fuel

Numec process outlines were received and approved with some changes. Numec completed its weld development and the qualifying welds for Zircaloy and stainless steel rods were approved. However, difficulties were encountered during production and Numec requested and received approval to use a 10% Argon - 90% Helium weld box atmosphere as opposed to 100% Helium. The qualifying samples for the new atmosphere indicated a change in welding parameters was required. The second set of qualifying welds were approved. An additional welding problem arose as a result of an error in locating the center punch marks required on the end caps. These punch marks raise shoulders which serve to hold the end cap in place in the tube during welding. A number of qualifying welds were attempted to circumvent the problem without success. The difficulty was resolved by re-machining the outer extremeties of the end plugs to remove the incorrectly located punch marks. The re-machining resulted in shortening the end plugs by approximately .115 inches and in increasing the fission gas end gaps in the rods by the same amount.

Numec has converted all of the Pu metal buttons to oxide by steam oxidation. The oxide was ball milled to yield a ceramic grade powder. All but approximately 4 Kgs of the PuO_2 has been blended with UO_2 and pelletized. Numec resolved the problems which had resulted in excessive cracking and poor density control on the first three batches of pellets processed.

Chemistry analyses on the thirteen pellet batches which have been processed is nearly complete. The nitrogen content of batch 2 was 110-115 ppm compared to the specified 75 ppm. The batch was released for loading because the water content and other contained gases were compensatively low and because the rods will have additional gas plenum volume as a result of shortening the end plugs.

To date, Numec has shipped 182 Zircaloy-4 clad fuel rods to the Westinghouse WREC facility. The remainder of the rods are expected to be complete by mid-April.

Numec is successfully employing an oxidation-reduction cycle to reprocess clean pellet scrap. Approximately 90% of the clean pellet scrap has been recycled and pelletized. As a result of success with their recycle technique, processing of the remaining 4 Kg of unused PuO_2 may not be required.

SAX-F-320 Fuel Inspection and Assembly

R. W. Brown, R. H. Rahiser, M. A. Parker

The objectives of this sub-task are to assist vendors of materials and of fuel rods in inspecting their products to meet specifications, to conduct receiving inspections upon receipt of the fuel rods by Westinghouse, and to fabricate and inspect fuel assemblies.

During this period, the procurement and inspection of materials and components supplied by Westinghouse to both Numec and Battelle Northwest Laboratory was completed.

The Numec quality control procedures were reviewed and approved with some changes. Procedures for end plug welding, dye penetrant testing, leak testing, and X-ray were reviewed and comments made. The standard for chipped pellets was accepted. A resident inspector was assigned full time to the Numec site and regular visits were made by Quality Engineering personnel for review and guidance.

At Cheswick, sample fuel assembly enclosures were made and approved and production of enclosures is proceeding. All grid tooling has been received and tried out. Production of grid straps is underway and sample grids have been brazed satisfactorily.

The license amendment for the Cheswick facility has been approved. This amendment covers the receipt and storage of the PuO_2-UO_2 fuel rods and their assembly into Saxton enclosures. The method of shipment for the 3 x 3 assembly has also been approved.

SAX-330 New Fuel Shipping

H. E. Walchli

The objective of this sub-task is to provide for shipment of fuel rods from the Westinghouse Reactor Evaluation Center (WREC) to the Cheswick plant and of new fuel assemblies and subassemblies from Cheswick to the Saxton Reactor.

The shipping containers used to transport SELNI fuel have been examined for use in shipping four Saxton plutonium bearing assemblies in a single container. The unit has been found to be nuclearly safe with adequate criticality margin. Design engineering has been initiated to modify the internals of this container to provide proper mechanical support for the fuel assemblies. Design is scheduled for completion during April.

The requirements for shipping a failed irradiated 3 x 3 subassembly from Saxton to Waltz Mill were examined. It appears feasible to utilize the failed fuel can and adaptor designed for UO_2 fuel should the occasion arise where canning of the subassembly would become necessary.

The displacement of fuel column holddown springs in some of the pelletized fuel rods requires that some of the fuel be shipped in a semi-vertical position. A container for this use is currently being designed.

SAX-340 Safeguards Analysis

R. C. Nichols

The objectives of this sub-task are to prepare the Safeguards Analysis and to assist Saxton in obtaining a license amendment for partial core loading of PuO_2-UO_2 fuel.

The second draft of the Safeguards Report was completed and distributed for internal Westinghouse review. Copies were also forwarded to the Saxton Nuclear Experimental Corporation and to the Saxton Safety Committee. A review of the draft of the report was conducted by the Saxton Safety Committee at its February 4th meeting. Details of the report were reviewed for the Committee by Westinghouse and changes to the draft were discussed.

The Committee was informed that a justification for removal of the unexplained reactivity limit and reactivity follow requirements for the chemical shim operation of the partial plutonium Core II would be included in the final Safeguards Report. The final form of this justification was not ready at the time of the meeting, so it was agreed to forward copies of the justification to the Committee as soon as it became available. The Safety Committee accepted the report as amended at the meeting pending their review of the justification of the unexplained reactivity limit.

A detailed review of this final draft was conducted with SNEC personnel. The review resulted in some additional changes to the report to cover typographical errors and some items that needed clarification. The review also resulted in a revised write-up of the steam break accident analysis and an additional section to justify the re-use of the UO_2 "L" assemblies and control rod followers. Proposed changes in the Technical Specifications for Core II were also proposed and discussed with SNEC. The suggested changes were generally agreed to by SNEC.

A proposed license change and a change in Technical Specifications were prepared to cover the irradiation of a Plutonium fueled 3 x 3 test sub-assembly in the present core prior to installation of the partial Plutonium Core II. These changes were forwarded to SNEC for review and submission to the AEC by the end of March.

The additional discussions and reviews with SNEC have delayed the official submission of the Plutonium Core II Safeguards Report until late March or early April. The AEC Staff indicated that the Plutonium Core II most likely would still be able to be put on the May agenda of the ACRS.

SAX-350 Alpha Monitoring Protection

J. W. Power

Westinghouse APD held a meeting with SNEC personnel to review the following areas:

(a) Saxton Sampling Room Monitoring

(b) Provision for additional Health Physics (Alpha) Monitoring equipment.

(c) Work and time scheduling of incorporating the proposed Alpha Monitoring System into the existing plant system.

Westinghouse APD has placed purchase orders for the following equipment:

(a) One (1) Permanent, Continuous, Moving Filter, Air Particulate Alpha Monitor

(b) One (1) Semi-Portable, Continuous, Fixed Filter Air Particulate Alpha Monitor

(c) Two (2) Portable Alpha-Gamma Health Physics Monitors with:

1. Alpha Probe
2. Gamma Probe
3. Filter Paper Alpha Probe

(d) One (1) Alpha Probe for an Existing Ratemeter

SAX-400 <u>Performance of Critical Experiments</u>

D. F. Hanlen

The objective of this sub-task is to conduct the program of critical experiments planned in SAX-250 to provide data necessary to evaluate nuclear design methods and to calculate the reactivity and power distribution of the fuel rods in Saxton core II.

The Plutonium Critical Operating License was received at WREC on March 12. Two shipments totaling 467 fuel rods of the 5.7% enriched UO_2 were received during the reporting period.

Following inspections by AEC Compliance personnel and others, loading of the 5.7% fuel in the 0.560-inch pitch core plates was commenced on March 17. A critical system was established in four incremental loadings.

On March 18 the just critical best circle was established to be 339 fuel rods with a peripheral fuel worth of 6.8¢/rod. A second critical dimension was then obtained through a "loose lattice" loading in the 0.560-inch pitch plates. The resultant pitch was 0.792. A just critical loading of 172 fuel rods and a peripheral fuel worth of approximately 10¢ was established.

Experiments utilizing the UO_2 fuel in power distribution evaluations of water slots, pseudo voids and control materials are in progress.

In early April, critical experiments with PuO_2-UO_2 fuel rods will commence. The entire criticals program will be completed prior to mid-June.

Remaining Sub-Tasks

F. Langford, et. al.

SAX-510 Nuclear Analyses of Operation - F. Langford

SAX-520 Thermal-Hydraulic Analyses of Operations - E. A. McCabe

SAX-610 Post Irradiation Storage & Shipments - H. E. Walchli

SAX-620 Post Irradiation Examination - Transfer Building - D. T. Galm

SAX-630 Post Irradiation Examination - Hot Cells - D. T. Galm

SAX-640 Post Irradiation Radiochemical Examination -

SAX-650 Waste Disposal - D. T. Galm

SAX-660 Materials Evaluation - R. J. Allio

SAX-670 Fuel Reprocessing - H. E. Walchli

Technical work in the preceding areas will commence later in the program. The PERT-type summary schedule included at the end of the first Quarterly Report, WCAP-3385-1, applies in general except that the date for loading fuel in Saxton has been delayed by one month.

To disseminate knowledge is to disseminate prosperity — I mean general prosperity and not individual riches — and with prosperity disappears the greater part of the evil which is our heritage from darker times.

Alfred Nobel

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