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THE EFFECT OF FRINGE POISON ON HEAT GENERATION IN THE SHIELD COMPLEX

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E. G. Peterson
W. L. Bunch

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THE EFFECT OF FRINGE POISON ON
HEAT GENERATION IN THE SHIELD COMPLEX

INTRODUCTION

The existing Hanford production reactors are enveloped by a graphite reflector, a cast iron thermal shield, and a biological shield consisting either of laminations of iron and masonite or of high density concrete. Cooling tubes were bonded into grooves in the cast iron thermal shield blocks with lead. As the graphite moderator continues to contract as a function of exposure, it is felt that the bond between the cooling tubes and the top cast iron blocks will be broken since these blocks are supported by the graphite. In the limit, the cooling tubes undoubtedly will pull from the grooves and be suspended between the cast iron and the top biological shield. In this event the effectiveness of the cooling system will be impaired severely, yet it will be necessary to limit the maximum temperature in (and the temperature gradient through) the top biological shield to assure its integrity. The calculations reported herein were made to provide heat generation rates in the shield complex as a function of fringe poison so that temperature distributions could be calculated for various postulated conditions of the cooling system. Thus, it should be possible to estimate the potential for controlling shield temperatures with fringe poison as the cooling system deteriorates.

SUMMARY AND CONCLUSIONS

Heat generation rates were calculated using the shielding program written for the IBM 7090 computer to determine the neutron and gamma flux distributions throughout the shield complex. Three cases were studied: (1) with all process tubes loaded with uranium, (2) with the top row of process

tubes loaded with lithium-aluminum alloy target material, and (3) with the top two rows of process tubes loaded with the same target material. The results of these calculations are presented in Figures 1, 2, and 3. The calculated neutron and gamma fluxes are in fair agreement with the experimental data which is available for similar cases; therefore, it is concluded that the heat generation rates provide a reasonable basis for estimating shield temperatures as a function of fringe poison for various postulated cooling system parameters.

DISCUSSION

The calculations were made using the shielding code (MAC)⁽¹⁾ and were normalized to known values at the interface between the core and top shield assembly of 105 DR reactor. To obtain the fission density (number of fissions per cm³ per sec), the power of several tubes was measured; the results are given in Table I. With a knowledge of the fast neutron flux, the spectrum at the interface between the core and shield (Row 45) was calculated using experimental results obtained previously.⁽²⁾ These results were used to obtain the distributions shown in Figure II. The average tube power measured in Row 45 was used as a basis for the other calculations. The distributions shown in Figure I were calculated using an average tube power of 580 KW in Row 46. This value was obtained by increasing the value 480 KW by a factor determined experimentally⁽³⁾ when measurements were made before and after fringe poisoning. The distributions shown in Figure III were calculated using an average tube power of 480 KW in Row 44. The shield assemblies for the three cases studied are given in Table II.

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The heat generation rates were obtained from the seven gamma energy groups generated by the program by the use of tabulated energy⁽⁴⁾ absorption coefficients.

TABLE I

Measured fringe tube power in top of 105-DR. (Total power was 1570 MW with fringe poison in Row 46.

		Tube Power in KW			
Row Col.		46	45	44	43
64			513	716	771
65	Fringe		493	697	784
66	Poison		509	679	792
67			493	668	807
68			490	672	781
69			474	678	804
70			481	671	791
71			477	835	828
72			486	704	821
73			478	690	803
74			479	679	804
75			483	682	815
76			481	692	804
77			469	677	798
78			470	679	802
79			459	658	752
80			473	655	792
81			480	642	775
82			474	664	765
83			469	667	742
Average			480		

TABLE II
Shield Assemblies

<u>Case - 1</u>	<u>Material</u>	<u>Thickness Inches</u>	<u>Density</u>
Reflector	Graphite	18.84	1.60
Thermal Shield	Cast Iron	8	7.10
*Biological Shield	Iron Limonite	48	4.23
 Case - 2			
Poison	Lithium-Aluminum Alloy	8-3/8	--
Reflector	Graphite	18.84	1.6
Thermal Shield	Cast Iron	8	7.1
Biological Shield	Iron-Limonite	48	4.23
 Case - 3			
Poison	Lithium-Aluminum Alloy	16-3/4	--
Reflector	Graphite	18.84	1.6
Thermal Shield	Cast Iron	8	7.1
Biological Shield	Iron-Limonite	48	4.23

*Iron-Limonite was used for these calculations whereas the actual shield is Iron-Masonite.

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FIGURE 1

Neutron and Gamma Distributions Without Fringe Poison
(0 is Centered at Row 46)

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FIGURE 2

Neutron, Gamma and Heat Generation Distributions with Fringe Poison
In Row 46 (0 is Centered at Row 45)

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FIGURE 3

Neutron, Gamma and Heat Generation Distributions with Fringe Poison
In Rows 45 and 46. (0 is Centered at Row 44)

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