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SUBJECT: Maximum Thermal Flux per Mw in Three-Region
Homogeneous Reactors
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FROM: T. B. Fowler

SUMMARY

The maximum thermal flux per Mw of thermal power generated was calculated for a variety of critical three-region spherical homogeneous reactors. The central region contained H₂O or D₂O, the second or annulus region contained U-235 and H₂O or D₂O, and the outside region contained D₂O. The outside radius was held constant at 152.4 cm while the radius of the central region and the thickness of the annulus were varied in order to ascertain the peak maximum thermal flux per Mw. The peak maximum thermal flux per Mw for the D₂O - D₂O - D₂O system ranged from 8.07×10^{-13} to 9.75×10^{-13} for central region radii varying from 2 to 30 cm. For the H₂O - H₂O - D₂O system, peak $\phi_{\text{Max.}}/\text{Mw} > 3.2 \times 10^{-14}$ for a central region radius of 5 cm and annulus thickness of 1 cm.

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Introduction

The maximum thermal flux per Mw was computed for a variety of critical three-region spherical homogeneous reactors containing H_2O or D_2O in the central region, U^{235} and H_2O or D_2O in the second or annulus region, and D_2O in the third or outer region. The radius of the central region was varied from zero to 20 cm, the thickness of the annulus was varied from 0.1 cm to 40 cm, and the radius of the outer region was held constant at 152.4 cm. An average reactor temperature of $80^\circ C$ was assumed for all cases. A two-group, three-region model was used for the calculation utilizing a few-group, multi-region IBM-704 reactor code.¹

Results

In all cases the maximum thermal flux per Mw of thermal power generated was calculated. Figures 2 - 5 show plots of $\phi^{max.}/Mw$ vs. $R_2 - R_1$ (see Fig. 1) for various compositions and central region radii. Figures 6 and 7 show critical concentration plotted against $R_2 - R_1$ for the cases in which the peak $\phi^{max.}/Mw$ was not obtained, and Table 1 lists the critical concentrations at the points of peak $\phi^{max.}/Mw$ for the cases where peaking was obtained.

The maximum thermal flux occurred at the center of the inner region in all cases except the $H_2O - D_2O - D_2O$ system with $R_1 = 20$. In this case the maximum thermal flux occurred close to the inner boundary of the outer region.

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Fig. 1. Schematic Diagram of Reactor

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Fig. 2. Reactor Composition - D₂O - D₂O - D₂O; Maximum Thermal Flux Per MW Vs. Annulus Thickness

Fig. 3. Reactor Composition - $D_2O - H_2O - D_2O$; Maximum Thermal Flux Per MW Vs. Annulus Thickness.

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900 822
 $\phi_{max} \times 10^{-13}$
 MW

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Fig. 4. Reactor Composition - $H_2O - D_2O - D_2O$; Maximum Thermal Flux Per MW Vs. Annulus Thickness.

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Fig. 5. Reactor Composition - $H_2O-H_2O-D_2O$; Maximum Thermal Flux Per MW Vs. Annulus Thickness.

Fig. 6. Critical Concentration Vs. Annulus Thickness

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Fig. 7. Critical Concentration Vs. Annulus Thickness

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TABLE 1

CRITICAL CONCENTRATION AT POINTS OF PEAK $\phi^{Max.}/Mw$

Reactor Composition	R_1 - cm	$(R_2 - R_1)$ -cm	Critical Concentration gm U-235/liter
$D_2O-D_2O-D_2O$	0	29	4.13
	5	21	5.50
	10	13	8.85
	20	1.5	~ 57
$D_2O-H_2O-D_2O$	0	13	51.18
	5	8	56.06
	10	4	~ 71

Two-Group Constants - 80°C

	D_1 -cm	D_2 -cm	τ - cm ²	Σ_a - cm ⁻¹
D_2O	1.265	0.885	126	7.14×10^{-5}
H_2O	1.187	0.193	32.19	0.0174

$\sigma_a(25) = 532$ barns, $\sigma_f(25) = 452$ barns, $\nu(25) = 2.46$ neutrons/fission

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1. Marlowe, Orville J., Carl P. Saalhock, Linwood M. Culpepper, Dorothy S. McMarty, "Wanda - A One-Dimensional Few Group Diffusion Equation Code for the IBM-704," WAPD-TM-28, November 1956.

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