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SUBJECT: Wall Power Density and Neutron Absorptions
in HRE-3 Core-Inlet Pipe

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ABSTRACT

The reduction in HRE-3 breeding ratio resulting from neutron absorptions in the core-inlet line was examined for spherical and cylindrical cores; it was found to be less than 0.5% if the pipe does not extend more than $1/4$ the way from the top to the bottom of the core. The power density at the end of the pipe would be 57 kw/l if it extended 5 in. into the sphere.

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WALL POWER DENSITY AND NEUTRON ABSORPTIONS
IN HRE-3 CORE-INLET PIPE

M. W. Rosenthal

Flow studies of re-entrant spherical cores¹ indicate that the inlet line should probably extend somewhat (about 1/2 pipe I.D.) into the core region to insure adequate mixing. Only preliminary investigations of cylindrical models have been made, but it is likely that good mixing will necessitate extending the inlet pipe a comparable distance into cylindrical cores. In order to see what effect the inlet line will have on breeding ratio, estimates of neutron absorptions have been made for two cylindrical cores and one spherical core, with the inlet Zircaloy pipe projecting various distances into the core region. The power density in the fuel solution at the end of the pipe was also computed.

A two-group model for neutron behavior was used, and the inlet pipe was assumed to have no effect on the flux distribution. The flux distribution in the sphere was computed using an ORACLE routine for multi-region reactors; the fluxes in the cylinders were obtained by treating the cores as one-region reactors with 6-in. extrapolation distances. Studies of spherical cores have indicated that this method yields results that are in reasonably good agreement with multi-region treatments if the blanket has a high thorium concentration.

Table 1 lists the cases studied. The cylinders were treated as if the ends were flat. In all three cases the inlet pipe had a 10-in. diameter and a 1/2-in. wall thickness.

In Fig. 1-a the reduction in breeding ratio is plotted as a function of the fractional penetration (the distance the pipe extends beyond the core wall divided by the length of the vessel). The curves show, for example, that if the line extended 5 in. into the 4-ft sphere, the breeding ratio would be 0.0013 less than if the pipe were not present. The reduction would be 0.006 for a 2-ft penetration into the 7-ft cylinder.

The power density at the exit end of the pipe is shown in Fig. 1-b for a core power of 50 Mw. The results for the sphere have been corrected to allow for the effect of the inlet-outlet line on the local power densities. The flux distributions used in making the correction were obtained from two-space-variable (CURE) computations.² Both the corrected and uncorrected (flux distribution obtained assuming no inlet pipe) values are plotted in Fig. 1-b. As shown, the flux distortion resulting from the presence of the "neck" increases the power density near the wall but decreases it at the center. The values for the cylinders have not been corrected in this manner.

If the criterion were established that the maximum power density at the pipe surface should be no greater than the maximum at the core-vessel wall given in Table 1, the pipe could extend only 5 in. into the 7-ft cylinder and 10 in. into the 10-ft cylinder. Of course, any penetration beyond the wall of a sphere would lead to higher power densities; at 5 in. the power density would be 57 kw/liter at the end of the pipe compared with 23 at the sphere wall.

TABLE 1

FEATURES OF REACTORS ANALYZED

Core Geometry	Core Volume liters	Mean Core Power Density, kw/liter	Max. Core-Wall Power Density without Inlet Line, kw/liter
4-ft I.D. Sphere	950	53	23
3-ft I.D. x 7-ft cylinder	1400	36	26
3-ft I.D. x 10-ft cylinder	2000	25	19

REFERENCES

1. L. B. Lesem and P. H. Harley, "Scale-up of Alternate HRT Core," ORNL-CF-54-5-47 (May 7, 1954).
2. M. Tobias, personal communication.

Reduction in Breeding Ratio

0.025

0.020

0.015

0.010

0.005

0

100

75

50

25

Power Density (kw/l)

a

Fig. 1

(a) Breeding Ratio Reduction Due to Neutron Absorption in Pipe, and (b) Power Density in Fuel Solution at End of Pipe vs. Fractional Distance of Penetration of Inlet Line into Possible HRE-3 Cores

Core Power 50 Mw
Inlet Pipe Material Zircaloy-2
Inlet Pipe I.D. 10 in.
Inlet Pipe Wall 1/2 in.

3-ft 1.0 x 10-ft Long Cylinder
4-ft 1.0 Sphere
3 x 7 Cylinder

b

Fractional Penetration, x/L

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