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REVIEW OF METHODS FOR ANALYSIS OF NEUTRON STREAMING
IN THE FAST FLUX TEST FACILITY REACTOR DESIGN*

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All of the important shielding problems encountered in the FFTF design were geometrically complex, and many of these problems exhibited streaming effects in which important components of the transmitted radiation were dominated by geometric attenuation.^{1,2} These streaming effects present a methods paradox because their presence, when imbedded in bulk media attenuation regions, produces a complex problem although the streaming problem when isolated is usually quite simple.

Figure 1 shows a drawing of an R-Z model of the FFTF which extends axially from the core midplane to the top of the maintenance floor and radially from the reactor centerline to a depth of 30.48 cm into the concrete primary shield. The streaming zones are the reactor cavity, the reactor cavity shield zone, and the vessel support system zones. The actual models used for the latter two zones are much more detailed than shown in Figure 1 but are not shown because of lack of space. It is useful to consider this problem as consisting of four steps:

- (1) Calculation of the source entering the reactor cavity.
- (2) Calculation of the reactor cavity.
- (3) Calculation of the reactor cavity shield.
- (4) Calculation of the vessel support system, head, and maintenance floor shield.

The actual analysis may combine some or all of these steps, but they each have different methods requirements.

Step 2 of the problem, the reactor cavity, is a large cylindrical annulus completely surrounded by steel, concrete, and sodium, and is fed from Step 1 by a source centered on the inner cylindrical surface at the midplane and having an axial height (full height at half maximum) of approximately two meters. Experience with several alternate calculations

of the reactor cavity show that it is more of a scattering cavity than a streaming path. As such, low-order discrete ordinates or albedo Monte Carlo are the most efficient methods. Because the reflection from the cavity walls significantly affect the flux levels near the surface of the vessel, the cavity problem must be incorporated in or closely coupled with the Step 1 source problem. Also the required result from the cavity problem is an angular flux distribution for input to the next problem step. For these reasons, the cavity was included in the low-order (S_6) discrete ordinates source calculation which extended axially from 0 to 532.42 cm and radially from 0 to 555 cm. Including the cavity does not substantially increase the computing time for this problem.

Step 4 was calculated with adjoint discrete ordinates (DOT III) using a biased 166-angle quadrature to handle the streaming component. Step 3 was calculated with the three-dimensional Monte Carlo code MORSE^{3,4} coupled both to the source from Step 2 and the adjoint response from Step 4 with DOMINO.⁵ The three-dimensional calculation was verified in a simplified two-dimensional form with a DOT III biased 166-angle quadrature calculation. The fractional standard deviation on the MORSE calculations was typically 10% to 25% and the MORSE-DOT cases agreed within 10%.

The methods used for this problem were the most cost efficient possible. New developments such as the DOT IV code with zone and group variable quadrature and an adjoint difference coupling technique would substantially reduce the computer time needed and increase the accuracy of the solution of this problem.



NOTE: A reproducible copy of Fig. 1 will be sent with the paper.

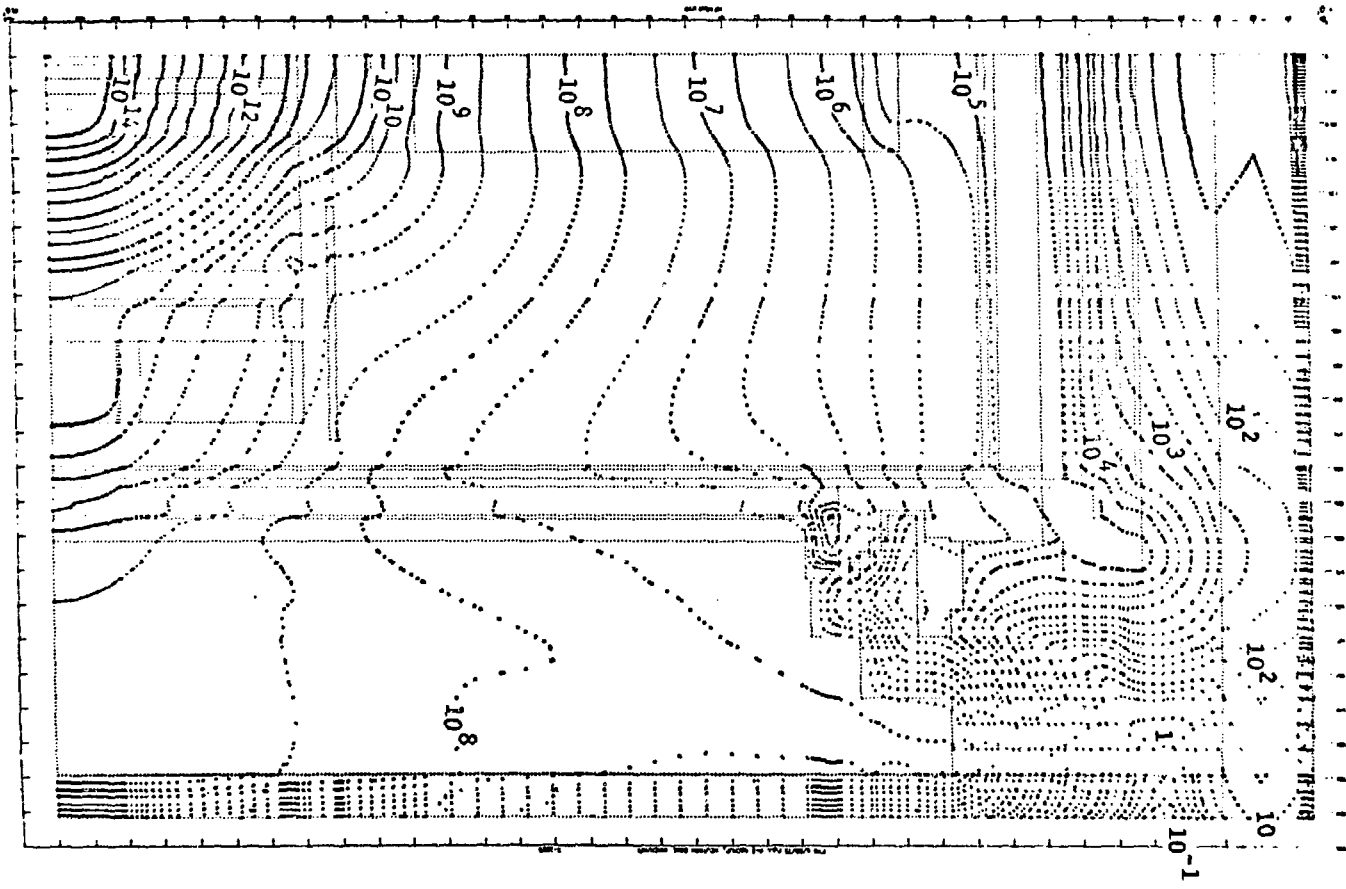


Fig. 1. Neutron Dose-Rate Contours from Step 1 of DOT r-z Calculations of PVPF. Units are mrem/hr.

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