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SUBACCOUNT TITLE: Basic Shielding Analysis

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STATEMENT OF PROBLEM

A model has been derived for a minimum weight radial reflector for SNAP reactors. The present study investigates the effect which the use of this optimal reflector has on radiation shield weight requirements.

ABSTRACT

Weights of systems employing conventional and optimal radial reflectors are compared using the FARSE and FARSER computer codes. It is found that for the configuration under study additional shield weight required when the optimal reflector is used is in excess of the reflector weight savings.

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In an earlier paper C. M. Podeweltz applied a variational method to develop a mathematical model of an optimally shaped radial reflector for SNAP reactors[1]. The calculation involved minimizing radial reflector weight subject to the constraint of constant total radial reflector worth. It was found that a reflector weight savings of 12% could be attained if the optimal shape were employed.

The present study employs the FARSE[2] and FARSER[3] computer codes to determine what effect use of the optimal reflector has on shield weight. The FARSE and FARSER codes calculate the dose rate from a reactor-reflector configuration at various points on a target plane for a given radiation source density distribution.

The models used in the codes are illustrated in Figure 1. The radial reflector shape employed in the FARSE code is conventional in that its outer boundary is cylindrical (Figure 1a). The FARSER code is a modification of the FARSE code in which the outer boundary of the radial reflector corresponds to the optimal shape suggested in Ref. 1 (Figure 1b). This outer boundary is the surface of revolution obtained by rotating the curve given in cylindrical coordinates by

$$r = a(1-bZ)^{1/4} \qquad Z \geq 0$$

$$r = a(1+bZ)^{1/4} \qquad Z < 0$$

about the Z axis. (The Z axis corresponds to the axis of the cylindrical reactor. The plane represented by the equation Z=0 is the reactor midplane.) a and b are parameters which depend upon the reactor dimensions and the assumed reactivity worth distribution in the radial reflector.

The dimensions shown in Figure 1 were used in the present study. The reactor size is the same as that assumed in Reference 1. The shield is a shadow shield, i.e. lines drawn from any point in the reactor or reflector to any point in the target plane must pass through the entire shield. The shield boundary AVA is a section of a parabaloid of revolution. The Z coordinates of the vertex point V and the intersection points A are input to the codes.

The weight study was carried out as follows: A conventional reflector configuration was set up on the FARSE code and a calculation was made. The identical configuration (except for radial reflector shape) was then set up on the FARSER code and the Z coordinates of the points A and V were then adjusted until the dose rates obtained from the FARSER code at all target points were within 2% of those obtained from running the same configuration on the FARSE code. Reflector and shield weights were then compared with the following results:

Radial Reflector - beryllium; density = 114.9 lbs/ft^3

Shield - lithium hydride; density = 46.8 lbs/ft^3

	Conventional - Weight lbs.	Optimal - Weight lbs.
Radial Reflector	103.0	90.9
Shield	492.3	509.8
Total	595.3	600.7

To within the limits inherent in the use of the FARSE and FARSER codes, it is seen that use of the optimally shaped reflector necessitates additional shielding so that the net result for the system is a weight increase.

The additional shield weight required when the optimal reflector is employed can be explained as follows:

First, the larger radial reflector boundary requires a larger radial boundary for the shadow shield.

Secondly, the optimal reflector can be thought of as a modification of the ordinary reflector obtained by removing material from the reflector ends and replacing some of it around the center. However, the assumed radial reflector source density is considerably higher at the center than it is at the ends. Thus the net reflector source strength is increased by the optimal reflector. Furthermore, because of the reflector modification there is less reflector material located in a position where it can serve as an effective attenuator of radiation. Therefore, additional shielding material is required to reduce the dose to the proper value.

REFERENCES

1. Podeweltz, C. M., "Shape of a Minimum Weight Reflector", NAA-SR-TDR-5982, December, 1960.

2. Rooney, K. L., "FARSE 1A - A Modification of FARSE To Include Angular Dependence of Shield Leakage", NAA-SR-TDR-7590, December, 1960.

3. Bernick, R. L., "FARSER - A Modification of FARSE To Include a Minimum Weight Radial Reflector", (Unpublished).

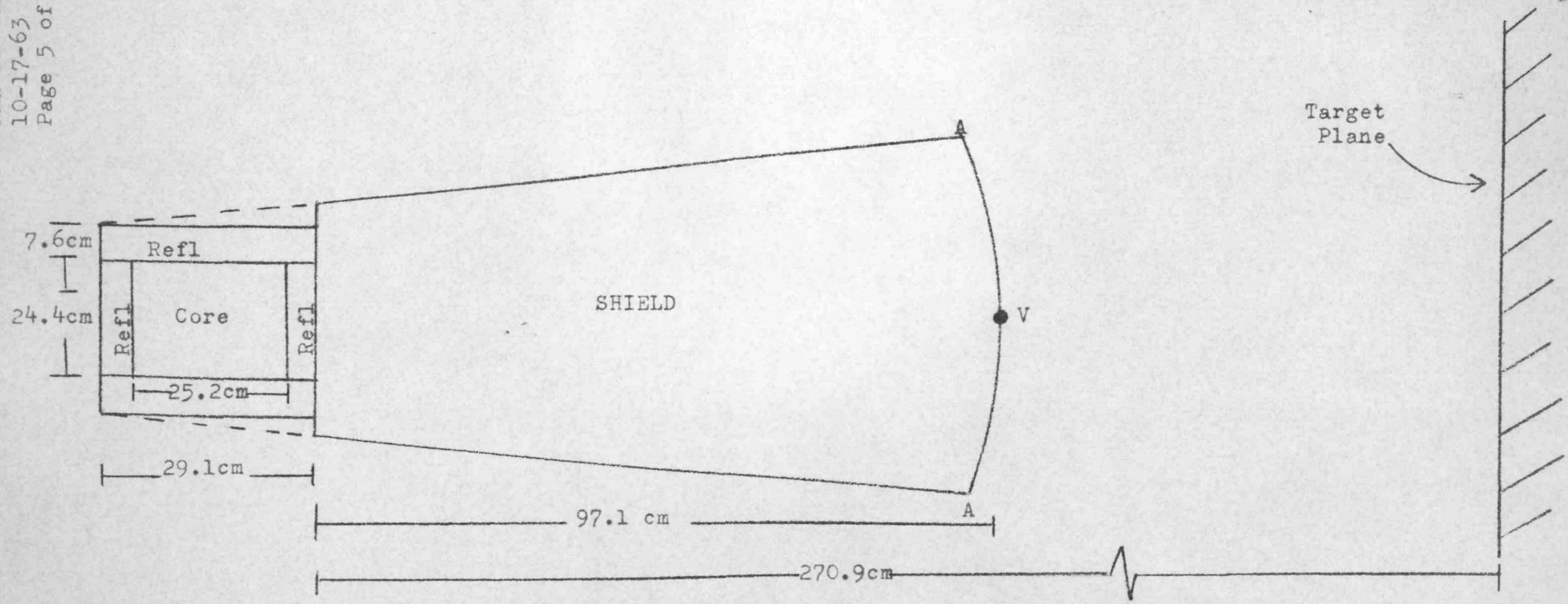

Figure 1a - FARSE Configuration

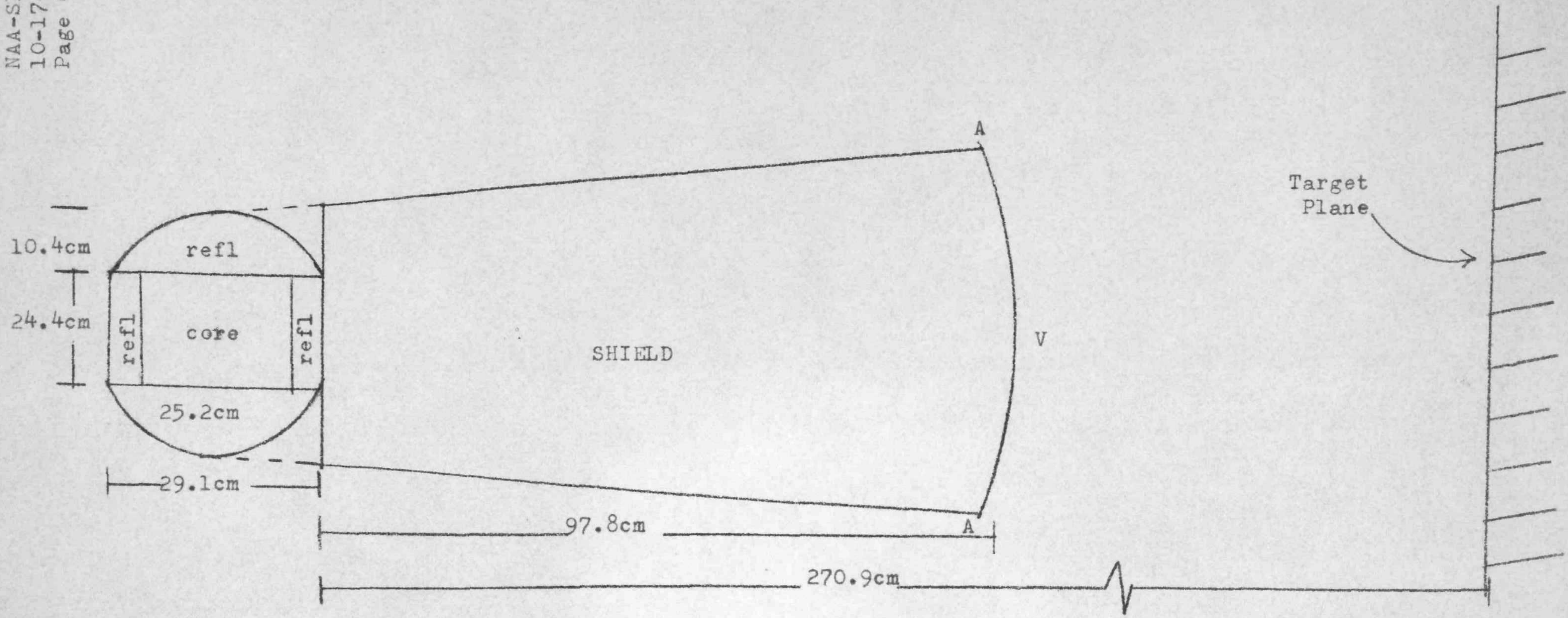

Figure 1b - FARSER Configuration