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TECHNICAL DATA RECORD

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TITLE Fast Neutron Flux Through the SNAP 10A Shield as Computed by Several Methods

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PROGRAM

SNAP 10A
Reactor

SUBACCOUNT TITLE

Shield Analysis

DISTRIBUTION

Standard SNAP 10A
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Nuclear & Control
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STATEMENT OF PROBLEM

What is the fast neutron flux through the SNAP 10A shield? How do various methods of computing the flux agree? Is the present lithium hydride removal cross section of 0.128 cm⁻¹ valid?

ABSTRACT:

Fast neutron fluxes through the SNAP 10A shield as computed by several methods are compared. The methods and the codes using the methods are: (1) neutron transport - DTK, (2) neutron diffusion - AIM-6, (3) Monte Carlo - FMC-N, and (4) neutron removal theory - 14-0. These various methods predicted fluxes through the shield which agree reasonably well. On the basis of these analyses and recent Shield Test Facility experiments, a lithium hydride removal cross section of 0.156 cm⁻¹ is recommended for use in removal theory code studies of the SNAP 10A shield. Comparable analysis of the SNAP 2 shield indicates that a removal cross section of 0.160 cm⁻¹ is valid for use in SNAP 2 shielding studies.

A correlation analysis, which was performed in order to correlate a removal cross section for the 14-0 code with the computed fluxes obtained using the AIM-6 and DTK codes, is discussed in Appendix A (Addendum 1)

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INTRODUCTION

Figure 1 is a comparison of the fast neutron fluxes (0.1 to 10.0 Mev) through the SNAP 10A shield as computed by several methods. The methods compared are neutron transport (DTK), neutron diffusion (AIM-6) and fast neutron removal theory (14-0). Preliminary results from Monte Carlo (FMC-N) were obtained from Reference 7 but are not shown. The family of fluxes obtained from 14-0 may be compared to the fluxes calculated by DTK and AIM-6 to determine the removal cross section which makes the 14-0 removal theory calculation most consistent with the DTK and AIM-6 nuclear calculations.

AIM-6 AND DTK

The AIM-6 calculations shown are the result of a core buckling iteration problem. Identical bucklings were used in the DTK S_4 option. Both AIM-6 and DTK approximated the SNAP 10A shield configuration using an axial model consisting of a series of cylindrical slabs of varying radii. These slabs had different densities, reflecting the temperature change through the shield. Figure 2 shows a sketch of the nuclear calculational model.

On Figure 1, two AIM-6 cases are shown. One AIM-6 case employs a zero transverse buckling term and should be compared with the infinite media 14-0 code calculation. The other AIM-6 case, and the DTK cases used transverse shield buckling terms = $(2.405/R)^2$, where R represents shield radius. DTK results are shown using both an anisotropic and an isotropic scattering cross section for the hydrogen in lithium hydride. The DTK and AIM-6 cases with finite buckling terms are believed to predict reasonably realistic fluxes for a finite shield. However because of boundary and convergence criteria inaccuracies, they probably underpredict fluxes near the bottom shield boundary.

FLEXIBLE MONTE CARLO NEUTRON CALCULATION

The preliminary flux calculated by FMC-N, Reference 7, falls within the range of the curves shown on Figure 1 and lies near the DTK (anisotropic) and AIM-6 (with buckling) cases. Final FMC-N results will be available this quarter.

14-0 REMOVAL THEORY

Fluxes from 14-0 were obtained using several LiH effective neutron removal cross sections. The 0.128 cm^{-1} value presently used is based on information presented in Reference 1. This value assumes an infinite medium shield and can be expected to overpredict the flux especially near the bottom boundary. This flux should be compared to the AIM-6 no buckling flux.

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Considering both the absolute magnitude and the attenuation of the fluxes through the shield as calculated by DTK (anisotropic) and AIM-6 (with buckling), a better removal cross section for use in 14-O would be between 0.15 and 0.16 cm^{-1} . This cross section is considerably higher than the value of 0.128 cm^{-1} now used for SNAP 10A or the 0.132 cm^{-1} value used for SNAP 2 calculations.

EXPERIMENTAL RESULTS

Recent experiments conducted at the STF, which were reduced by the Applied Physics Group, 721-13, indicate a removal cross section between 0.166 and 0.170 cm^{-1} for lithium hydride having a density of 0.756 gm/cc (Reference 6). These experiments used three and five foot square LiH slabs in an air medium. If the 0.168 cm^{-1} cross section is density corrected to conform to the 700°F SNAP 10A shield having a density of 0.7 gm/cc (Reference 1), the revised cross section would be 0.156 cm^{-1} . A comparable removal cross section for the 600°F SNAP 2 shield having a density of 0.721 gm/cc (Reference 8) would be 0.160 cm^{-1} .

SUMMARY

The absolute magnitudes of fast neutron fluxes computed by several methods agree quite favorably through the entire shield. A LiH removal cross section for use with removal theory codes (14-O and FARSE) which would give a similar flux magnitude should be put into use.

A value of 0.156 cm^{-1} will yield a flux through the shield consistent with the flux from DTK (anisotropic), AIM-6 with buckling, and FMC-N, and may be verified by recent experimental measurements. Use of 0.156 cm^{-1} instead of 0.128 cm^{-1} will lower the flux at the SNAP 10A mating plane centerline by about a factor of six.

Comparable analysis of the SNAP 2 shield indicates that a removal cross section of 0.160 cm^{-1} is valid for use in SNAP 2 shielding studies.

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MODEL

FIGURE 1

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SNAP 10A
SHIELD MOCKUP

FIGURE 2

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APPENDIX A

"LiH Cross Section Determination for
Removal Theory Code"

See:

NAA-SR-TDR-8768 Addendum

R. D. Anderson, Jr.

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