



# AEC-NASA TECH BRIEF



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## Synthesis of Calculational Methods for Design and Analysis of Radiation Shields for Nuclear Rocket Systems

### The problem:

To devise a computer program for the complete initial and final design of nuclear rocket radiation shields.

### The solution:

Eight computer programs making up a nine volume synthesis containing two design methods. The "early design" method is appropriate for parametric and preliminary reactor design studies, while the "final design" method accomplishes the verification of a final nuclear rocket reactor design.

### How it's done:

Both design methods begin with the initial program, POINT, which contains the basic microscopic cross section library. In addition to POINT, the early design method contains three programs. Its important features are: flexibility in geometry and usage; convenience and usefulness of output; and nominal running time. The final design method, made up of five programs plus POINT, is highly accurate and has detailed output such as energy and angular distributions.

The eight programs used are:

(1) *POINT (Preparation of Input for Transport) Program*. This program calculates macroscopic cross sections readily usable in the transport programs, TAPAT and ODD-K. This calculation is achieved by employing a built-in library of region independent neutron and gamma ray microscopic cross sections. The program also calculates response functions as punched card output for use in both the TAPAT and NAGS programs to calculate, for example, neutron and gamma ray energy deposition, fixed neutron sources, or prompt and secondary gamma ray sources.

(2) *TAPAT (The Analysis Program and Transport) Program System*. This program system provides a complete, neutron and photon, one-dimensional radiation analysis of a reactor system in a single computer run.

(3) *KAP-V (Point Kernel Attenuation) Program*. This program employs the point kernel method to calculate radiation levels at detector points located within or outside a complex radiation source geometry describable by a combination of quadratic surfaces. This program can be used, for example, to calculate gamma ray and/or fast neutron flux, dose, or heating rate. Three optional fast neutron attenuation functions are included: (1) a modified Albert-Welton function; (2) a bivariate polynomial expression for computing neutron spectra using infinite media moments data; and (3) a monovariant polynomial expression for computing neutron spectra using infinite media moments data. The program handles either cylindrical, spherical, disk, line or point sources.

(4) *TIC-TOC-TOE (Temperature in the Coolant Tank and Other Calculations and for the Thermal Neutron Originating Energy) Program*. This program performs rapid calculations of heating rate distributions in on-axis liquid hydrogen propellant tanks. Basic heating rate data are interpolated from curve-fits of M. O. Burrell's Monte Carlo data which are built into the program.

(5) *ODD-K (Two-Dimensional Transport) Program*. This program is the Westinghouse Astronuclear Laboratory modification of the Los Alamos Scientific Laboratory discrete ordinate transport program, DDK. The ODD-K program numerically solves the Boltzmann transport equation using a multigroup, discrete

(continued overleaf)

direction representation of the particle flux in a two-dimension (R-Z, R- $\theta$ , or X-Y) geometry description of a reactor. ODD-K performs photon, as well as neutron, transport analysis and, in conjunction with the NAGS and DAFT codes, it provides a method for obtaining neutron and photon spatial and energy distributions throughout the reactor system, and spatial, energy, and angular distributions of leakage fluxes at the surface of the reactor system.

(6) *NAGS (Calculations of Neutron and Gamma Ray Sources and Energy Deposition in Two-Dimensional Geometries) Program*. This program is a series of routines which process multigroup neutron and photon energy fluxes for two-dimensional (R, Z or R,  $\theta$ ) geometry models. The NAGS program provides: (1) neutron and photon energy sources and distributions for use in point kernel, Monte Carlo, and photon transport analyses, (2) neutron and gamma ray dose rates, and (3) energy deposition data for use in subsequent thermal analyses.

(7) *DAFT (Preparation of ODD-K Angular Flux Tapes) Program*. This program is the data processing routine which prepares angular, spatial, and energy distribution data for input to the FASTER Monte Carlo program from the surface angular leakage flux data of the two-dimensional transport program ODD-K.

(8) *Faster Monte Carlo (A Fortran Analytic Solution of the Transport Equation by Random Sampling) Program*. This program calculates energy-dependent neutron or photon fluxes at points, surfaces, and

regions of complex geometries. FASTER contains all the data processing routines required for a wide variety of nuclear vehicle applications. FASTER deals with the entire spectrum of particle energies simultaneously.

#### Notes:

1. This program is written in FORTRAN IV and MAP for use on IBM 7094 computer.
2. Although this set of programs has been designed primarily for use by personnel involved in the design and analysis of nuclear rocket radiation shields, some of the individual programs can be used by scientists involved in basic nuclear and nuclear reactor research.
3. Inquiries concerning this program may be made to:

COSMIC  
Computer Center  
University of Georgia  
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Reference: B69-10158

#### Patent status:

No patent action is contemplated by NASA.

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