Computer Code Abstract

SPAR1

1. Program Name (and Title): SPAR1, A Semi-Analytic Point-Kernel Computer Program for Shielding.

2. Computer and Language(s): CDC-6600, FORTRAN IV, (some environmental routines are used[1]).

3. Problem Solved: SPAR1 calculates exact gamma-ray fluxes from uniform sources with the shapes of slabs, disks, lines, cylinders, truncated cones, toroids, and spheres. Gamma-ray dose rates and energy absorption rates can also be obtained by including in the program input data gamma-ray buildup factors expressed in Taylor Exponential Coefficient form. Furthermore, SPAR1 will calculate fast-neutron dose rates and thermal-neutron fluxes in those cases where the use of neutron-removal cross sections is valid. In general, all three-dimensional sources having curved surfaces (cylinders, spheres, and toroids) may have both curved and slab shields intervening between the source and the detector point. Slab shields are allowed in all cases. Both slab and curved shields are assumed to be laminar. Source self-attenuation is always included in flux calculations, and multiple energy levels may be considered. Both interior and exterior detector points are allowed for cylindrical, slab, and spherical sources, and line sources may be tilted with respect to their slab shields. The detector point associated with a cylindrical volume source may be arbitrarily located, and a finite cylindrical shield may be considered. A cylindrical surface source is also available.

4. Method of Solution: Some of the semi-analytic calculation algorithms used in SPAR1 came directly from Refs. 2, 3, and 4. The exact semi-analytic formulas for the fluxes from cylindrical, spherical, and toroidal sources were derived by Wallace, based on the work reported in Refs. 4, 5, and 6. In all cases, uniform source strength, laminar shields, and the validity of the point kernel are assumed. It is always possible, for the source shapes treated in SPAR1, to formally integrate over at least one dimension of a three-dimensional source, leaving a nonsingular integrand to be numerically evaluated over, at most, two dimensions. This numeric integration is done using Gauss-Legendre quadrature. The derivations are given in detail in Ref. 7, and the program is fully described in Ref. 8.

5. Restrictions on Complexity of the Problem: No more than 20 energy levels, 20 slab and 20 curved shield laminas, and one detector point can be considered in one case. Up to 250 cases can be grouped in one run.

6. Unusual Features of the Program: SPAR1 is designed to furnish quick answers to simple shielding problems such as those encountered in scoping studies and in answering urgent questions, and thus to save engineering time. SPAR1 requires minimal input, and jobs can be submitted via remote terminals. A special output file formatted for display on a terminal is always written by the program.

7. Estimated Typical Running Time: Varies from 0.33 to 2 s per case, depending on the option selected.

8. Status: In production.

9. Verification: All SPAR1 options have been verified by comparison with SPAN4 (Ref. 9) calculations. Hand calculations have also been made to verify the more simple SPAR1 options.

10. Machine Requirements: 50K central memory and one system disk. Operating system: SCOPE 3.1 as described in Ref. 10.

11. Other Programming Information: This program is structured into distinct parts or overlays that are loaded into the central memory as required. The use of such overlays is treated in Ref. 10. The main or root overlay is always in memory; in addition, a particular primary overlay may also be in the central memory. SPAR1 has a root overlay and four primary overlays. The primary overlays are loaded and executed through calls on the NEXT subroutine described in Ref. 1.

12. Availability: The program and copies of Refs. 7 and 8 can be obtained from

    Argonne Code Center
    Attn: Mrs. Margaret Butler
    Argonne National Laboratory
    9700 South Cass Avenue
    Argonne, Illinois 60439.

    References 7 and 8 can also be obtained from

    National Technical Information Service
    U.S. Department of Commerce
    5285 Port Royal Road
    Springfield, Virginia 22151.

13. *References*:

[1]W. R. CADWELL, Ed., "Reference Manual—Bettis Programming Environment," WAPD-TM-1181, Bettis Atomic Power Laboratory (1974).

[2]T. ROCKWELL, Ed., *Reactor Shielding Design Manual*, D. Van Nostrand, Princeton, New Jersey (1956).

[3]R. G. JAEGER, Ed., *Engineering Compendium on Radiation Shielding*, Vol. 1, "Shielding Fundamentals and Methods," Springer-Verlag, Inc., New York (1968).

[4]H. ONO and A. TSURO, *Nucl. Sci. Technol.*, **2**, 229 (1965).

[5]A. TSURO, *Nucl. Sci. Technol.*, **2**, 261 (1965).

[6]D. F. RHODES, R. A. STALLWOOD, and W. E. MOTT, *Nucl. Sci. Eng.*, **9**, 41 (1961).

[7]O. J. WALLACE, "Semi-Analytic Flux Formulas for Shielding Calculations," WAPD-TM-1197, Bettis Atomic Power Laboratory (1976).

[8]O. J. WALLACE, "SPAR1, A Semi-Analytic Point-Kernel Computer Program for Shielding," WAPD-TM-1196, Bettis Atomic Power Laboratory (1976).

[9]O. J. WALLACE, "SPAN4—A Point-Kernel Computer Program for Shielding," WAPD-TM-809, Bettis Atomic Power Laboratory (1969).

[10]"Control Data 6400/6500/6600 Computer Systems Scope 3.1 Reference Manual," Publication Number 60189400A, Control Data Corporation, Documentation Department, 3145 Porter Drive, Palo Alto, California.

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Received August 27, 1976