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AVAILABLE COMPUTER CODES AND DATA FOR RADIATION TRANSPORT ANALYSIS

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Abstract

The Radiation Shielding Information Center (RSIC) [1-2], sponsored and supported by the Energy Research and Development Administration (ERDA) and the Defense Nuclear Agency (DNA), is a technical institute serving the radiation transport and shielding community. It acquires, selects, stores, retrieves, evaluates, analyzes, synthesizes, and disseminates information on shielding and ionizing radiation transport. The major activities include: (1) operating a computer-based information system and answering inquiries on radiation analysis, (2) collecting, checking out, packaging, and distributing large computer codes, and evaluated and processed data libraries. The data packages include multigroup coupled neutron-gamma-ray cross sections and kerma coefficients, other nuclear data, and radiation transport benchmark problem results.

As an integral part of it's information collection and processing activities, RSIC collects, makes operable, packages, and distributes computer code packages to nuclear scientists and engineers engaged in shielding research or design [3-5]. The various codes are designed for calculations related to radiation from fission and fusion reactors, radioisotopes, weapons and accelerators and to radiation occurring in space. The Center uses the word "package" to mean all the items needed to utilize a code effectively. The package normally includes documentation describing the theory and code operation (contributor's report plus RSIC abstract and notes) and one or more reels of tape on which is written the source program, operating (binary or hex) program, input and output for a sample problem, data libraries, and auxiliary routines.

Most of the codes are written in FORTRAN IV, which makes them nearly machine independent. Several of the packages actually represent coding systems. These are represented in the collection by prototypes, which are not necessarily useful in themselves, but which achieve generality in that they are designed to be easily changed. Such code systems are most useful to the research worker who will invest a great deal of effort in learning to use the system. Other packages are groups of interdependent codes which constitute a complete analysis system making use of a number of techniques.

The radiation treated by the majority of the codes is either neutron or gamma radiation or both, but some codes treat charged particles. The types of geometry treated vary widely, with many codes allowing a general three-dimensional geometry.

For convenience, the available codes are grouped into two classes: (1) those which treat radiation transport and identified by Computer Code Collection (CCC) numbers, and (2) those performing auxiliary data processing useful for other radiation analysis purposes and identified by Peripheral Shielding Routine (PSR) numbers. The numerical methods applied in the CCC codes are primarily discrete ordinates (1- and 2-dimension), Monte Carlo (up to 3-dimension), and kernel integration (generally 3-dimension). The remaining include removal-diffusion (Spinney), moments, spherical harmonics, and invariant embedding transport theory codes and miscellaneous codes to calculate fission product buildup, release and resulting dose, stopping power, optimization, sensitivity analysis, and others.

The PSR codes include multigroup cross section generation and handling, nuclear models, experimental energy spectra unfolding, optimization, plotting, coupling discrete ordinate results to Monte Carlo, random number generation, and others.

As an adjunct to the computer code exchange, RSIC is involved in many data activities, with most emphasis being placed on nuclear cross section data[6]. Through cooperation with various agencies, RSIC assists in improving the adequacy of basic evaluated cross section data and packages and distributes various types of data libraries useful in radiation transport analysis. The emphasis of the effort is on the improvement of calculational tools available to the shielding analyst.

This work involves collaboration with the National Neutron Cross Section Center (NNCSC) at Brookhaven National Laboratory, the Shielding Subcommittee of the Cross Section Evaluation Working Group (CSEWG), ERDA Controlled Thermonuclear Research Division, the U. S. Nuclear Data Committee, especially the CTR subcommittee, and the Defense Nuclear Agency (DNA).

The Center's role in the Evaluated Nuclear Data File (ENDF) development is to assist in the acquisition, checkout, and review of "shielding" cross sections in ENDF format which may ultimately be placed in the ENDF B file. In this context, "shielding" cross sections are evaluations performed in the shielding, radiation effects, or weapons radiation transport communities which are likely to have an emphasis on gamma-ray production cross sections, gamma-ray interaction cross sections, and neutron cross sections in the energy range of interest for shielding with detailed energy and angular distribution resolution. RSIC maintains and distributes the Defense Nuclear Agency (DNA) evaluated cross-section library[7]. This is a working library in ENDF format whose content can be modified and revised as often as the evaluator deems such changes to be necessary. The key to this approach is a selected evaluator, the person responsible for making the original evaluation for a particular nuclide or element. He is then responsible for authorizing changes in evaluations for that nuclide. The evaluated data are for those materials of interest to DNA, whose cross-section values were originally in a state of rapid change, and with emphasis placed on neutron energies up to 20 MeV and on secondary gamma-ray production. Evaluations which are not being modified frequently are found in the ENDF B library, which is available in the USA from NNCSC at Brookhaven National Laboratory.

For workaday problem solving, it has been found useful to generate and collect multigroup cross section sets, and package, document, and distribute them in a format suitable as input to the most-used computer codes. Each data set, packaged as a unit, carries a Data Library Collection (DLC) number. As with the code packages, a particular data package does not remain static but is subject to revision, updating, and expansion as required. Such changes are announced in the RSIC Newsletter. Other data in the collection include gamma-ray interaction cross sections, neutron induced gamma-ray production spectra, fluence-to-kerma coefficients, radioactive decay spectra and decay schemes, and detailed output from transport calculations.

A continuing project, in cooperation with the American Nuclear Society, is to collect, edit, and publish reference data in the form of "benchmark problems" [8]. The objective is to compile in convenient form a limited number of well-documented problems in radiation transport which will be useful in testing computational methods used in shielding analysis. The problem solutions, having been determined by several methods, should be representative of the state of the art. The problem descriptions are published in looseleaf form so that revisions and additions can be easily made. In conjunction with the benchmark work, data sets are packaged which allow the recalculation, with a particular calculational method, of already published results.

Lists of selected codes and data packages are given in the following table. These are typical of the most used but not necessarily the best for any particular application. Further information on these or any other codes or data are available from RSIC upon request.

1. Neutron Gamma-Ray Transport	1-Dimension	CCC-42/ DTF IV
Discrete Ordinates		CCC-82/ ANISN
Multigroup		CCC-126/ ASOP (optimization)
		CCC-130 DTF-69 (X-ray)
		CCC-204 SWANLAKE (sensitivity analysis)
		CCC-204 INAP (activation)
	2-Dimensions	CCC-222 TWOTRAN II
		CCC-209 DOT III
		CCC-230 TRIPLET (triangular mesh)
Monte Carlo	3-Dimensions	CCC-230 MORSE-CG (multigroup)
		CCC-187 SAM-CE
		CCC-262 VCS (vehicle shielding)
2. Multigroup Cross Section Processors	Neutron	PSR-13 SUPERTOG
		PSR-52 MACK (kerma factors)
	Gamma Ray	PSR-51 SMUG
	Coupled	PSR-63 AMPX
3. Kernel Integration	3-Dimensions	CCC-48 QAD
		CCC-94 KAP VI
4. Spectra Unfolding		PSR-17 FERDOR-COOLC
		PSR-41 MAZE
		CCC-112 SAND II
		CCC-233 CRYSTAL BALL
5. Fission Product Inventory		CCC-217 ORIGEN
		CCC-225 REST
		CCC-237 BURP 2
6. Multigroup Data Libraries	Neutron	DLC-2 100G (100-group from ENDF/B)
		DLC-33 MONTAGE (100-group activation)
	Coupled	DLC-23 CASK (22-n,21-γ)
		DLC-27 AMPX01 (104-n,22-γ)
		DLC-31 FEWGI (37-n,21-γ)
7. Energy Point Libraries	Gamma Ray	DLC-31 GEDTI (SAM-CE format)
	Neutron	DLC-31 NEDTI (SAM-CE format)
	n,γ production	DLC-31 GPDTI (SAM-CE format)

A recent review published by the Center [9] should be of interest to those starting work in the area of weapons radiation shielding. More detailed information is presented in the Defense Nuclear Agency *Weapons Radiation Shielding Handbook* published by the Oak Ridge National Laboratory [10-16].

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