DATA ACTIVITIES OF THE RADIATION SHIELDING INFORMATION CENTER*

R. W. Roussin, D. K. Trubey, Betty F. Maskewitz
Radiation Shielding Information Center
Oak Ridge National Laboratory
Oak Ridge, Tennessee, USA

ABSTRACT

DATA ACTIVITIES OF THE RADIATION SHIELDING INFORMATION CENTER

The Radiation Shielding Information Center (RSIC) is involved in many data activities, with most emphasis being placed on nuclear cross section data. 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.

RESUMÉ

ACTIVITÉS DU "RADIATION SHIELDING INFORMATION CENTER"

Les activités du Radiation Shielding Information Center (RSIC) concernent de nombreux problèmes de données, et plus particulièrement de section efficace nucléaires. Par sa coopération avec différents organisations RSIC contribue à l'amélioration des données fondamentales sur les sections efficaces, et distribue plusieurs types de bibliothèques de données utiles pour l'analyse du transport des radiations. L'effort principal de RSIC porte sur l'amélioration des techniques utilisées dans l'analyse des blindages de protection.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

*Research sponsored jointly by the Defense Nuclear Agency, the National Aeronautics and Space Administration, and the U. S. Atomic Energy Commission under contract with the Union Carbide Corporation.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Jc9

INTRODUCTION

In recent years a significant proportion of the activities of the Radiation Shielding Information Center (RSIC) has involved data of various kinds, but primarily neutron and gamma-ray cross-section data. The reason for this work is that the solution of most shielding (radiation transport) problems requires the use of large computer codes and their corresponding cross section libraries which together adequately treat the physics of neutron and gamma-ray interaction and production. As is discussed later, RSIC is involved in various aspects of this general problem by helping to provide evaluated neutron and gamma-ray cross-section data in standard formats, by packaging and distributing computer codes and associated cross section libraries, by packaging and distributing specialized libraries of various types, and by assisting in the compilation of benchmark problem data for testing computation methods and cross section data.

The first two sections which follow outline the role of RSIC in the cooperative effort to develop evaluated cross-section data in Evaluated Nuclear Data File (ENDF) format [1] adequate for shielding calculations. There follows a description of the activities associated with the acquisition and distribution of specialized data libraries for use in treating various types of radiation transport problems.

This work involves collaboration with others, including the National Neutron Cross Section Center (NNCSC) at Brookhaven National Laboratory, the Shielding Subcommittee of the Cross Section Evaluation Working Group (CSEWG), and the Defense Nuclear Agency (DNA).

CLEARINGHOUSE FOR CSEWG SHIELDING EVALUATIONS

RSIC has always been concerned with cross sections and the problems associated with the proliferation of data in non-standard formats. Thus, the development of the ENDF program was supported by RSIC from inception. An RSIC staff member participated in the early planning stages, but more significant contributions were possible once the CSEWG Shielding Subcommittee was organized early in 1967. Since then, RSIC participation has been extensive, with emphasis on areas of vital interest to the shielding community.

RSIC continues to collaborate with NNCSC at Brookhaven National Laboratory and the CSEWG Shielding Subcommittee. The Center's role in this activity 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 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.

By early 1972, twelve evaluations had been received by RSIC, processed through checking codes, modified to conform to the ENDF format as necessary, and forwarded to NNCSC, which prepared and distributed a packet for Phase I¹

¹Phase I testing eliminates clerical and format errors and results in a data set which seems reasonable. Phase II testing involves the use of the data to compare radiation transport calculations with integral experiments and results in knowledge about the adequacy of the data.

data testing. To assist in preparation of Phase I testing materials, RSIC helped coordinate the updating of computer codes PLOTFB and CHECKER [2] to handle gamma-ray production data (ENDF files 12-16) in the present formats. The revised codes are now available.

The ENDF/B-III library, released officially in January 1972, contained for the first time evaluations which included photon production data. These evaluations are listed in Table I.

In addition to the above activities, RSIC has coordinated the writing of a computer code [3] to translate, and subsequently has translated, the UKAEA library to ENDF/B format for NNCSC.

Through active participation in the CSEWG Shielding Subcommittee, RSIC seeks to help meet the needs of data requirements for various problem areas. For example, the Shielding Subcommittee is presently considering possible formats for handling time- as well as resonance-dependent photon production data in anticipation of the need for these types of data.

THE DEFENSE NUCLEAR AGENCY WORKING CROSS SECTION LIBRARY

RSIC maintains and distributes the DNA cross-section library [4]. 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 element or elements. He is then responsible for authorizing changes in evaluations for those elements. The evaluated data are for those materials of interest to DNA, whose cross-section values are in a state of rapid change, and emphasis is placed on neutron energies up to 20 MeV and on secondary gamma-ray production. Evaluations of interest to DNA which are not in a state of rapid change are found in the ENDF/B library, which is available in the USA from NNCSC at Brookhaven National Laboratory.

The clearinghouse for the DNA program is RSIC. Initial versions of evaluations are received, processed through checking codes to eliminate obvious format errors, and modified as necessary in collaboration with the evaluator. Next, DNA Phase I data testing is performed whereby selected reviewers are provided with listings, output from checking codes, graphics, etc., and are asked to review the data and feed back their comments. These will be relayed to the evaluator and, upon his instruction, appropriate changes will be made. Changes are initiated only by the evaluator and each change is documented so that users can, at any time, refer to an identifiable data set when reporting results of their calculations.

Because the data are apt to be revised with some frequency, each evaluation is designated by a DNA MAT number and a MOD number. The DNA MAT number is a unique identification number for an evaluation and is equal to the corresponding NNCSC-assigned ENDF MAT number plus three thousand for those evaluations which are submitted for inclusion in the ENDF/B library. The MOD number designates the number of times the DNA evaluation has been modified since its initial availability through RSIC. The current contents of the DNA library are listed in Table II.

Since the DNA library is in ENDF format and is available for consideration by CSEWG to become part of the ENDF/B library, the DNA program offers a good opportunity for improving the state of shielding cross sections.

This is illustrated by noting that of the twelve "shielding" evaluations in ENDF/B-III listed in Table I, nine came from the DNA library.

The data, along with available documentation, are distributed upon request. The users are asked to feed back any comments they have, based on experience in using the data.

THE RSIC DATA LIBRARY COLLECTION

The performance of digital computer calculations, in general, may be thought of as a three-part process, which can be identified with three components. The first part is the acquisition and preparation of a data base to be processed. The second is the development and use of a computer program to operate on the input data, perform certain logical operations, and finally produce output data. The output data, the third component, is then analyzed, often with the aid of machine manipulation. The output, after reduction, finally appears in reports and journal articles.

In radiation transport calculations, the three components normally take the form of (1) cross-section libraries, (2) radiation transport computer codes, and (3) radiation transport results (output).

Since inception, RSIC has been deeply involved, through its computer code library, in the second component mentioned above. In addition, a data library collection has been developed such that it can include not only component (1), cross-section libraries, but also component (3), radiation transport results. The data sets are packaged in a manner analogous to the RSIC code collection. [5] 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.

Data libraries were first announced as available from RSIC near the end of 1968. At that time it became evident that a collection of data libraries would be an extremely helpful companion to the RSIC Computer Code Collection. The main objective is the interchange of technology among installations engaged in radiation transport research, development, and applications. The current contents of the Data Library Collection are listed in Table III.

The philosophy behind the packaging and distributing of these data libraries is to preserve and make available in an easily usable form, data which may be useful to those utilizing or performing radiation transport calculations. Since this usually involves the use of large computer programs, several of these libraries are multigroup cross sections in the format utilized by many such programs.

There are problems which lead to great differences in opinion in regard to the desirability of collecting, packaging, and distributing reference data, especially standard multigroup libraries for general use. There is the danger that the prestige of a center can give the impression that data is of better quality than it actually is. Experience demonstrates that in many cases a standard, fixed energy group library cannot be used to obtain accurate radiation energy spectra. Examples of this are deep transport calculations in materials such as air, iron, and sodium. Even using a complex weighting spectrum with a standard group structure (such as 100

groups) will not provide accurate results. In these cases the most important requirement is that the group structure must resolve energy range where cross sections vary rapidly. On the other hand, experience has shown that standard group structure libraries will work for hydrogenous systems and many complex mixtures where cross section details are not very important.

Where available, RSIC seeks to obtain multigroup data sets which have been shown to handle adequately a particular problem or class of problems for which a standard multigroup approach is inadequate. This has led to the question, "Is it better to make available poor data or no data?" Probably a better question is, "Is it better to make available state-of-the-art data, i.e., the best obtainable at present, or no data?" We believe the answer to this question should be to make available the best data obtainable, even though there is some risk that the recipient may not fully appreciate the limitations. The recipient, however, must be the person responsible for the effects of its use.

In addition to the cross section sets, certain radiation transport results have also been packaged. In some cases, the volume of data from a problem may be so great that it is not feasible to publish it all. One can then publish samples of the results but place the entire output on magnetic tape for distribution, as needed, by RSIC. Processing codes for performing editing, plotting, interpolation, and certain integrations accompany the data. An example is the DLC-5 Hallmark data (see Table III).

Documentation is very important. The abstract format used for the DLC sets is similar to that used to describe the code packages. Care was taken to make the format include all of the information necessary for adequately describing the contents and purpose of each data library. The abstracts of the DLC sets are published in Ref. [6]. The main purpose of the abstracts is to give to a potential data library user several criteria for deciding whether or not he wishes to obtain the data.

ADDITIONAL ACTIVITIES

A continuing project, in cooperation with the American Nuclear Society, is to collect, edit, and publish reference data in the form of "benchmark problems." 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 [7] so that revisions and additions can be easily made. Contributions to the benchmark collection are sought by the Benchmark Problem Group. In conjunction with the benchmark work, data sets are packaged which allow the recalculation, with a particular calculational method, of already published results. An example is the data in DLC-8 which allows the calculation of American Nuclear Society Shielding Benchmark Problem Number 3. This kind of calculation is useful for testing a new computer code or theoretical treatment.

It has always been RSIC policy to discuss with users their needs and recommend codes and data libraries. Insofar as possible, we assist those who are implementing codes and data at their installations. In cases where we lack experience to advise in particular problem areas, we call upon other experienced personnel locally and elsewhere to help them. This takes the

form of offering advice on solving particular problems, as well as helping to diagnose problems in implementing calculational procedures.

As always, RSIC relies on members of the shielding community to share their ideas, codes, and data so that technology as a whole may be advanced.

Table I. Evaluations in ENDF/B Version III
which contain gamma-ray production data

Material	ENDF/B MAT
Nitrogen	1133
Oxygen	1134
Aluminum	1135
Lead	1136
Hydrogen	1148
Chlorine	1149
Potassium	1150
Silicon	1151
Calcium	1152
Beryllium	1154
Sodium	1156
Iron	1180

Table II. Contents of the DNA Working Cross-Section Library

Material	Evaluators	DNA		Date of
		MAT	MOD	
Nitrogen	Young, Foster - LASL	4133	3	2-72
Oxygen	Young, Foster - LASL	4134	1	2-72
Aluminum	Foster, Young - LASL	4135	2	2-72
Lead	Fu, Perey - ORNL	4136	2	4-72
Hydrogen	Stewart, LaBauve, Young - LASL	4148	1	2-72
Silicon	Drake, Kinsey - BNL	4151	1	2-72
Calcium	Fu, Perey - ORNL	4152	2	5-72
Beryllium	Howerton, Perkins - LLL	4154	0	2-72
Tantalum	Howerton, Perkins, MacGregor - LLL	4179	0	2-72
Iron	Penny, Kinney, Wright, Perey, Fu - ORNL	4180	1	8-72
U-238	Howerton, MacGregor - LLL	4187	0	7-72
U-235	Howerton, MacGregor - LLL	4188	0	7-72

TABLE III. CONTENTS OF THE RADIATION SHIELDING INFORMATION CENTER
DATA LIBRARY COLLECTION, SEPTEMBER 1972

Data Library Designation	Contributor ^a	Form	Data Type/Computer Code/Component
DLC-1/LEP	ORNL-N	16-mm microfilm magnetic tape machine listings	Bertini's low-energy intranuclear cascade results; output from ANALYSIS Codes I and II and from EVAP (ORNL-TM-1225, ORNL-3433).
DLC-2/100G	ORNL-M ORNL-N	Magnetic tape	100-group P_8 -expanded neutron cross sections for input to ANISN/DOT/DTF-IV/MORSE; produced from ENDF/B-III data by SUPERTOG (1972); energy range from 14.92 MeV to thermal.
DLC-3/MECC-7	ORNL-N	16-mm microfilm, magnetic tape, machine listings	Bertini's medium-energy intranuclear cascade results; output from ANALYSIS Codes I and II and from EVAP (ORNL-TM-3336, ORNL-3433).
DLC-4/HPICO	ORNL-N	Magnetic tape	Gamma-ray photoelectric and pair-production data in OGRE format (ORNL-3805); data same as in DLC-7.
DLC-5/HALLMARK	ORNL-N	Magnetic tape	Output from DOT, OSR-ACTIFK, and OGRE; Straker's time-dependent air-over-ground results for point isotropic sources; handling codes allow production of results for arbitrary energy spectrum; neutron sources range from 15 MeV to 3.3 keV; results include neutron and secondary gamma-ray fluxes (ORNL-4289, vol. II).
DLC-6/GAMLIB	ORNL-M ORNL-N	Magnetic tape	ORNL GAM-II library in GGC-4 format; 99 neutron group, P_3 , data for 114 nuclides based in part on ENDF/B-II data; neutron energy range 14.92 MeV to thermal (ORNL-TM-3334).
DLC-7/HPICE	LLL	Magnetic tape	Livermore gamma-ray interaction data in ENDF/B format; recommended as ENDF/B reference data; covers elements having Z values of 1-83, 86, 90, 92, and 94, and gamma rays having energies in the range from 1 keV to 100 MeV (UCRL-50400, vol. VI; UCRL-50174, Sect. II, May 1969).
DLC-8/BP-3	ORNL-N	Cards	22-group P_5 -expanded cross sections for air in the ANISN/DOT/MORSE format; data used by Straker for Benchmark Problem No. 3; neutron spectrum constructed from point sources in infinite air covering energy ranges from 15 MeV to thermal (ORNL-RSIC-25).
DLC-9/FARS	ORNL-N	Magnetic tape	P_8 -expanded coupled cross sections (104 neutron groups, 18 gamma-ray groups) for H, C, N, O, Mg, Al, Si, Ca, and Fe; data format for ANISN/DOT/DTF-IV/MORSE; compiled by F. Schmidt for concrete calculations (ORNL-RSIC-26); neutron energy range, 15 MeV to thermal; gamma-ray energy range, 10-0.02 MeV.
DLC-10/AVKER	ORNL-N	Magnetic tape	Data library of neutron fluence-to-kerma factors for many elements; retrieval program will compute energy group values for any composition for use with group fluence to calculate dose or heating (ORNL-TM-2558); neutron energy ranges from 19.2 MeV to 0.023 eV.

TABLE III. (continued)

Data Library Designation	Contributor ^a	Form	Data Type/Computer Code/Component
DLC-11/RITTS	ORNL-R ORNL-N CTC	Magnetic tape	P ₃ -expanded coupled microscopic cross sections (100 groups, 21 gamma-ray groups) for H, C, O, N, Na, Mg, P, S, Cl, K, and Ca; 100-group neutron cross-section set alone also provided, plus coupled macroscopic cross sections for standard man, skin, bone, tissue, brain, lung, red marrow and muscle; data format for ANISN/DOT/MORSE; neutron energy range, 15 MeV to thermal; gamma-ray energy range, 14 to 0.01 MeV (ORNL-TM-2291).
DLC-12/POPLIB	ORNL-M ORNL-N	Magnetic tape	Compendium of neutron-induced secondary gamma-ray yield and production cross-section data; data library for PSR-11/POPOP4 code; current library has 243 data sets (1971) (CTC-INF-1004).
DLC-13/GARLIB	NASA-LE	Magnetic tape	32-group resonance-region neutron capture and scattering cross sections for moderated tungsten and uranium slabs; produced by the GAROL code; group fluxes calculated by GAROL also included for further collapsing of the group structure; energy range, 1.234 keV to 0.414 eV (NASA TM X-1909).
DLC-14/AIR	ORNL-N	Magnetic tape	ANISN input data for a P ₃ S ₁₆ coupled (22 neutron groups, 18 gamma-ray groups) transport calculations for a 12.2- to 15-MeV point source in air; output from ANISN run also provided; allows users to repeat the Straker-Gritzner infinite-air calculations (ORNL-4464).
DLC-15/STORM-ISRAEL	LASL	Magnetic tape	Los Alamos gamma-ray interaction data in ENDF format for elements from Z=1 to 100; energy range, 1 keV to 100 MeV; essentially equivalent to DLC-7 but has additional data for many derived cross sections (Nuclear Data, A7, 565-681).
DLC-16/COBB	ORNL-R ORNL-M	Magnetic tape	123-group P ₃ expanded neutron cross sections for input to XSDRN; produced from ENDF/B-II data by SUPERTOG-THERMOS (30 thermal groups); energy range, 14.92 MeV to thermal.
DLC-17/NOX	ORNL-N	Magnetic tape	P ₃ -expanded coupled cross sections (86 neutron, 33 gamma-ray groups) for N and O, data format for ANISN, etc., produced from DNA MAT 4133, MOD 1 nitrogen and DNA MAT 4134, MOD 0 oxygen with SUPERTOG, NUSECT and MUG, used to analyze neutron transport and secondary gamma-ray production and transport in liquid N and air (ORNL-3635, GA-9429, DNA 2831F, ORNL-TM-3768), neutron energy range 15 MeV to thermal, gamma-ray energy range 10 to 0.01 MeV.
DLC-18/NAB	ORNL-N	Magnetic tape	100 group, P ₃ -expanded neutron cross sections for Na and Al, data format for ANISN, etc., produced from ENDF/B-III Na and Al with SUPERTOG, used to analyze ORNL LMFBR sodium benchmark experiment (ORNL-TM-3800), energy range 15 MeV to thermal.

^aLibrary contributors: CTC, Computing Technology Center, Union Carbide Corp., Oak Ridge, Tenn.; NASA-LE, NASA Lewis Research Center, Cleveland, Ohio; ORNL-M, Mathematics Division, ORNL-N, Neutron Physics Division, ORNL-R, ORNL Reactor Division; LLL, Lawrence Livermore Laboratory, Livermore, Calif.; LASL, Los Alamos Scientific Laboratory, Los Alamos, N. M.

REFERENCES

1. M. K. Drake, Editor, "Data Formats and Procedures for the ENDF Neutron Cross Section Library," BNL 50274 (T-601) ENDF-102, Vol. I (1971), and D. J. Dudziak, Compiler, "ENDF Formats and Procedures for Photon Production and Interaction Data," LA-4549 (ENDF-102, Rev., Vol. II).
2. Odelli Ozer, Editor, "Description of the ENDF/B Processing Codes and Retrieval Subroutines," ENDF-110 (Revised September 1970).
3. R. Q. Wright, S. N. Cramer, and D. C. Irving, "UKE - A Computer Code for Translating Neutron Cross Section Data from the UKAEA Nuclear Data Format to the Evaluated Nuclear Data File Format," ORNL-TM-2880, ENDF-134 (March 1970).
4. R. W. Roussin, "The Defense Nuclear Agency Working Cross Section Library: Description and Contents," ORNL-RSIC-34 (August 1972).
5. Betty F. Maskewitz, "Abstracts of the Computer Code Packages Assembled by the Radiation Shielding Information Center, ORNL-RSIC-13, Vol. I - III.
6. R. W. Roussin, "Abstracts of Data Library Packages Assembled by the Radiation Shielding Information Center," ORNL-RSIC-30 (1972).
7. A. E. Profio, Editor, "Shielding Benchmark Problems," ORNL-RSIC-25 (Sup. 1, 1970).