# RSIC Newsletter

RADIATION SHIELDING INFORMATION CENTER

OAK RIDGE NATIONAL LABORATORY

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*I find the great thing in this world is not so much where we stand as in what direction we are moving.* . . . *Oliver Wendell Holmes*

## ANS DIVISION HONORS GOLDSTEIN AND PROFIO

At its June 1977 meeting in New York City the American Nuclear Society Radiation Protection and Shielding Division presented awards for outstanding service to Herbert Goldstein and A. Edward Profio. Goldstein, first Vice Chairman (1961–62) of the original Shielding Division and second Chairman, is Professor of Nuclear Engineering at Columbia University. Profio, member of the Executive Committee (1969–72), former program Committee Chairman and ANS-6 Benchmark Problem Working Group Leader, is Professor of Nuclear Engineering at University of California, Santa Barbara.

The citations presented by Division Chairman, Fred R. Mynatt, read as follows:

*On behalf of the American Nuclear Society, the Radiation Protection and Shielding Division is pleased to present to*

***HERBERT GOLDSTEIN***

*its award for Outstanding Service to the Division and to the shielding community by virtue of the following special contributions:*

*His textbook in reactor shielding. His thorough knowledge of the subject and his clear presentation have made this book useful for over ten years to nuclear engineering students and shielding specialists.*

*His efforts to organize the Shielding Division as a vehicle for promulgating and exchanging technical information, and his service as the first Vice-Chairman and second Chairman of the Division.*

*His contribution to gamma-ray shielding theory through the calculation and tabulation of buildup factors. This concept has been extremely useful and these original tabulations have withstood the test of time exceedingly well.*

*His insight into the impact of neutron-cross-section behavior on transport, and his encouragement and participation in early attempts to calculate neutron cross sections. This work was invaluable in bridging the many gaps that existed in experimental data.*

*His contribution as an outstanding teacher. Many of his students have gone on to assume positions of leadership in the nuclear engineering community.*

*On behalf of the American Nuclear Society, the Radiation Protection and Shielding Division is pleased to present to*

***A. EDWARD PROFIO***

*its award for Outstanding Service to the Division and to the shielding community by virtue of the following technical contributions:*

*He has made important contributions to the field of neutron transport while working in an industrial research laboratory, in a combined experimental-theoretical program. His part in many technical papers on this subject are well recognized in the field of pulsed neutron source research, in research with exponential and critical assemblies, and in spectrum measurements.*

*He has continued his strong technical contributions as a Professor of Nuclear Engineering, imparting his knowledge and experience to students in the formative stage of their careers.*

*He has written a text on Experimental Reactor Physics, which brings together in one volume, much of the practical knowledge on experimental techniques in this field, which is one that has contributed strongly to reactor development in the United States.*

*He has fostered the development of standards and benchmark problems in neutron shielding. He has stimulated and participated in a special ANS panel in this area and has expended considerable effort in further studies of the results of the benchmark work and in documentation of the panel output.*

The honorees have each exercised a continuing beneficial influence on RSIC since its beginning. Herbert Goldstein was involved in the discussions which led to RSIC's establishment in 1962 and has served as an advisor through the years. He led the Ad Hoc Advisory Committee which performed an in-depth review of

RSIC operations in February. Ed Profio collaborated with RSIC research staff members and others in work (ANS-6, Standards) leading to RSIC publication of ORNL-RSIC-25 (ANS-SD-9) *Shielding Benchmark Problems,* for which he served as editor.

We heartily endorse this ANS action and congratulate our respected colleagues for this well deserved recognition of their efforts.

## RADIATION EFFECTS DATA BASE – FEEDBACK REQUESTED

One of the suggestions that was made repeatedly in the RSIC survey of needs in the nuclear power industry (B. F. Maskewitz, et al., *Survey of the Radiation Protection, Radiation Transport, and Shielding Information Needs of the Nuclear Power Industry,* EPRI NP-155, 1976) was that RSIC undertake to provide radiation effects data. It was pointed out that there is no similar source of such information since the Battelle Radiation Effects Information Center was terminated.

We are considering the possible starting of a pilot project to provide such data – probably using a computer-based data base system. We would like to have your opinion on the need. What data are needed? Who would use it? How would we support such an effort? Let us hear from you.

## NEEDED: FEEDBACK FROM ETRAN USERS

CCC-107/ETRAN, the Monte Carlo code system for electron and photon transport through extended media was contributed by the Center for Radiation Research, National Bureau of Standards in late 1968. Within a few years, proliferation of ETRAN versions made maintenance of the open code package difficult. In late 1973 we asked for a review of the several versions by the original contributor, Martin Berger (NBS), and for his recommendations. The result of the review was a new package which included all the essential provisions and options, but which RSIC had running only on the IBM 360 computer series.

The RSIC-packaged ETRAN includes: DATATAPE-2C Library, DATAPAC-6 (cross section handling routine), ETRAN-16D (1-D), ETRAN-18G (cylinders), INCLUDE (auxiliary to 18G), and input and output from running sample problems through the several codes. The code package has been sent to many requesters through the years but we have received very little feedback from its use. Rather than query each person to whom we sent the code package, we use this method to remind users of their implicit responsibility to keep us informed!

Are you using ETRAN? In what applications? Have you converted the codes to run on other than IBM computers? If so, will you let us know and return to us the new hardware version? Have you modified the codes? If so, let us know the nature and extent of the modification. Have you changed the ETRAN documentation in any way? If so, please send us a copy showing your changes.

We need immediately a version of ETRAN-16D operable on UNIVAC computers and will appreciate an immediate response from anyone having one. Call 615-483-8611/ 3-6944 or FTS 850-6944, ATTN: Betty McGill or Nancy Hatmaker, or write to RSIC Codes Coordinator, ORNL, P. O. Box X, Oak Ridge, TN 37830.

## CHANGES IN THE COMPUTER CODE COLLECTION

The following changes were made in the computer code collection during the month of June:

CCC-164/NAC

Versions A and C of this neutron activation code were updated to correct an error called to RSIC attention by J. Jedruch, Westinghouse Electric Corp., Pittsburgh, and Sue Gooden NASA/Lewis Research Center, Cleveland. Details of the update may be requested from RSIC. FORTRAN IV; IBM 360 and CDC-7600.

CCC-293/TRIDENT

This two dimensional multigroup discrete ordinates radiation transport code package was extended to include an IBM version (B). Los Alamos Scientific Laboratory contributed both A (CDC) and B versions.

CCC-294/HYACINTH

This heavy isotope point burnup and decay code system for predicting the heavy isotope content of reactor fuel during and after irradiation for any reactor design and any irradiation history was contributed by Central Electricity Generating Board, Berkeley Nuclear Laboratories, United Kingdom. Reference: RD/B/N3564 and RD/B/N3693. FORTRAN IV; IBM-360.

CCC-296/APARNA II

This one dimensional neutron transport code with anisotropic scattering, slab geometry for deep penetration studies was contributed by Reactor Research Centre, Kalpakkam, India. Reference: FRG-RP-123. FORTRAN IV; IBM-360.

## CHANGES IN THE DATA LIBRARY COLLECTION

The following changes have been made to the data collection during June.

DLC-31/(DPL-1/FEWGI)

A card image-to-binary format conversion code, LIBGEN, was added to this 37 neutron, 21 gamma-ray group coupled (DNA Few Group Cross-Sections) library in ANISN format. No changes were made to the data. It is now recommended that LIBGEN be used for conversion to binary format rather than the ARID collapsing code that is also packaged in DPL-1. ARID should be used only to collapse the true cross sections on the tape and not the "dummy" material which contains various response functions. The designation of this version will remain DLC-31/(DPL-1E).

DLC-42/CLEAR

This 126 neutron, 36 gamma-ray group 36-material cross section library was contributed by Oak Ridge National Laboratory under ERDA/DRDD sponsorship. It was produced by collapsing data from the 171 neutron, 36 gamma-ray library, DLC-41/VITAMIN-C, using a Pu-239 fission spectrum. The library was generated from ENDF/B-IV, using the ORNL version of MINX for the neutron cross sections and self shielding factors and the AMPX system for the gamma-ray production and interaction cross sections. The materials included are $^{1}$H, $^{2}$H, $^{6}$Li, $^{7}$Li, $^{9}$Be, $^{10}$B, $^{11}$B, $^{12}$C, $^{14}$N, $^{16}$O, F, $^{23}$Na, Al, Mg, Si, K, Ca, V, Cr, $^{55}$Mn, Fe, Ni, Cu, $^{93}$Nb, Mo, Pb, $^{234}$U, $^{235}$U, $^{236}$U, $^{238}$U, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, and $^{241}$Am. Data are available in neutron, gamma-ray production, and gamma-ray interaction files in both AMPX and CCCC interface formats. (See the February 1977 newsletter for a discussion of the features of multigroup libraries in these flexible formats). Retrieval codes are provided for merging, editing, checking, BCD-binary conversion, coupling, energy group collapsing, and production of working libraries in various formats. Resonance self shielding and temperature dependence can be obtained using the SPHINX code. Procedures have been developed which allow the user to work in the CCCC interface system if he desires and still have the capability to produce coupled neutron and gamma ray production cross section libraries. Reference ORNL-TM-5142, ORNL/TM-3706. Transmittal can be made on four full reels of magnetic tape (blocked). IBM 360/91.

DLC-43/CSRL

The $P_3$, 218-neutron group cross section library has been contributed by Computer Sciences Division, Union Carbide Corp., Nuclear Division at Oak Ridge National Laboratory, Oak Ridge, Tennessee. The data, in AMPX master interface format, has been generated under sponsorship of the Nuclear Regulatory Commission by AMPX module XLACS from ENDF/B-IV data for 65 nuclides of primary interest in criticality safety calculations. Modules AIM, AJAX, MALOCS, NITAWL, and ICE from the AMPX system are packaged for retrieving the data for subsequent use in transport codes ANISN, XSDRN-PM, or KENO-IV. The 218 group structure contains 140 epithermal above and 78 thermal groups below 3.05 eV. The group structure was chosen to fit reaction thresholds and major resonances of the nuclides included. Parameters are included in the master library for the subsequent processing of resolved resonance cross sections by the NITAWL code.

Several weighting spectra were used to prepare the fine group data in the master cross-section library

from the ENDF/B point data. For nonresonance materials, a fission-1/E3$s_T$-Maxwellian weighting spectrum was used. Materials with resonance parameters were processed with a fission-1/E-Maxwellian weighting function. In addition to being processed with the resonance material weight function, Fe, Ni, and Cr data sets were weighted over a 1/E2$s_T$(inconel)-Maxwellian and over a 1/E2$s_T$(stainless steel 304)-Maxwellian weight function.

Requests for DLC-43 should be accompanied by two full reels of magnetic tape. Reference: ORNL/CSD/TM-4. FORTRAN IV; IBM-360/91.

## CURRENT WORK AND PROBLEMS

A few years ago, we ran a series of articles describing current work and problems as outlined by individuals from a questionnaire which we circulated. The series was popular, and there have been many requests for a repetition. Because of the chronic RSIC manpower shortage we have been unable to allocate effort to collecting this information. We do, however, welcome voluntary contributions and offer the RSIC newsletter as a communications channel for sharing such information. We ask that when you give us information about your work, you indicate what should be held privileged and that which we have your permission to share through the newsletter.

Dr. R. Shankar Singh has supplied a summary of work in radiation shielding in the Reactor Physics Section, Reactor Research Centre, Kalpakkam, India. We are pleased to print his summary.

### Report of Work in Progress: Summary of Shielding Work in the Reactor Physics Section, Fast Reactor Group, Reactor Research Centre, Kalpakkam, India

*Radiation Transport in Thick Shields*

The code system designated APARNA is under development to solve the multigroup neutron/photon transport equation. The emphasis is on obtaining accurate solutions using relatively coarse spatial cells. Two algorithms within the frame work of the Discrete Integral formulation [1] have been evolved to this end. The first algorithm [2] consists in representing the source by a piecewise continuous function and analytically evaluating the angular flux within each segment. This has been employed in code APARNA-II and studied [3/4/5]. In the second algorithm, the spatial moments of the angular flux (and hence those of the source) are recursively computed. The source is then computed by method of undetermined parameters. The form of the source is assumed to be linear in these parameters, typically by way of a polynomial in space, rectifying a "guess function" of the source shape. APARNA-III[6], employs this procedure, and some numerical experience is reported in Ref. 7. The simulation of the ORNL benchmark[8] on the neutron transport through bulk sodium has been taken up[9].

*Shield Design Studies using Transport Theory Methods*

Design of neutron shield for a pool-type Fast Breeder Reactor (FBR 500 MWe) is being carried out[10] using APARNA. Relative optimisation of materials, their thickness and configuration, is underway for the neutron shield in this reactor.

Gamma-ray heating in various locations in Fast Breeder Test Reactor (FBTR) was computed incorporating the migration of the gamma rays. The discrete ordinates code DTF IV[11] was used with the coupled n,$\gamma$ library[12] DLC-23. Since the spectral shielding in cross section in this library is inappropriate to fast reactor application, these calculations are proposed to be repeated with another recently procured library[13], DLC-37. Another interesting problem is the determination of the optimum location for a boron detector in a moderator block (polyethylene) to get maximal response[14]. This is of practical significance in the delayed neutron detection system in FBTR.

*Monte Carlo Radiation Transport Studies*

Studies on Monte Carlo simulation of radiation transport through shields have been taken up. The ORNL benchmark[8] on the neutron transport through bulk sodium is being simulated[15]. The equi-probability table procedure for random sampling of the neutron scattering angle was studied[17]. This procedure was extended to account for the dependence of the scattering anisotropy on the incident neutron energy[16]. This extension is particularly suitable for incorporation in non-multigroup Monte Carlo transport codes.

Deep penetration studies are characterised by large variance. For a feasible Monte Carlo simulation, we require efficient variance reduction procedures. The techniques of track length biasing was studied. Linear and exponential forms for the dependence of the biasing on the particle direction were tried[18] and optimum biasing parameters were worked out. A self-learning procedure to obtain minimum variance biasing parameters is being studied[19].

*Radiation Streaming*

The streaming of gamma rays through annular cylindrical ducts was studied using point kernel integration with a ray-tracing procedure[20]. The scattered dose at the duct exit was computed only approximately in these studies. Monte Carlo simulation was used to compute the scattered component of the streaming flux. A program PIACID[21] was written for this purpose. The applicability of the albedo-Monte Carlo technique to radiation streaming computations is under study. A program DUST[22] to simulate neutron streaming through rectangular ducts has been developed. The ORNL thermal neutron streaming experiments[23] with square concrete ducts have been successfully simulated[22]. The program DUST[22] is being extended to study radiation streaming through milti-legged ducts.

*Fission Products Evolution Studies*

A program CHANDY[24] to compute fission product evolution in reactor core has been prepared. A library of fission product data has been compiled. The library holds data on the name, state, decay mode, half life, number of gamma rays and beta rays emitted per disintegration with their energies, etc. of about 650 fission products. These are mainly based on the compilation made by Tobias[25]. The data on the chain and fractional independent yields are those recommended by Crouch [26]. CHANDY and its library were used to compute the gamma-ray, beta-ray, and total fission product energy release rates at times ranging from seconds to several days after fast neutron fissions in $^{235}U$, $^{238}U$ and $^{239}Pu$. Our results[24] were compared with four sets of reported experimental measurements[27/28/29/30]. The energy release rates at various times after an instantaneous fission could then be integrated over the irradiation history of fuel to compute the decay power for various irradiation and cooling times. A program SEFIC[31] has been written towards this end. Extensive calculations[32/33/34/35/36] for FBTR have been made using SEFIC[31].

*Flux and Spectrum Measurements*

Shielding experiments during FBTR startup are being planned. Unfolding of the count spectrum is necessary in all experiments where pulse height is counted. A program BLOOM[37] is being developed to analytically fit monoenergetic gamma-count spectrum from NaI(Tl) crystal, for various monoenergetic gamma rays. BLOOM will then express the variation of the fitting parameters as a polynomial in energy. Response matrix obtained by this can be used in the unfolding. A detailed review of different methods available for neutron spectrum measurements and their unfolding has been taken up[38]. The emphasis will be on the procedures that help unfold the neutron spectrum from foil activation measurements. Accordingly a program, RDMM[39] has been adopted for IBM 370/155 computer. In this program, flux is expanded using known suitable polynomials. The expansion coefficients are obtained by least squares fitting of the specific activation.

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## NEW ERDA CRITICAL REVIEW

A new critical review in the ERDA series published by the Technical Information Center is now available. John A. Auxier of the Oak Ridge National Laboratory has written *Ichiban: Radiation Dosimetry for the Survivors of the Bombings of Hiroshima and Nagasaki,* TID-27080/YAS, now available from NTIS at $4.75 (USA) and $9.50 (Non-USA).

## PERSONAL AND OTHER ITEMS

Edward A. Warman has been promoted to Assistant Chief Power Engineer at Stone & Webster Engineering Corporation, Boston, MA with responsibilities in connection with fuels, radiation protection, and heat balance. Robert Vanasse is his replacement as Supervisor, Radiation Protection.

Kazunori Katsumata writes that his firm, Century Research Corporation (CRC) in Tokyo is a computer service company established in 1958 and that his section develops software for nuclear energy in Japan with some interest in radiation protection, radiation transport, and shielding.

R. F. Mambretti, Calspan Corporation, Buffalo, N.Y., writes that he is presently involved in a research project concerning the interaction of high energy particles with various materials. In these studies, he is using various computer codes, such as E-P CASCADE and OGRE-G. He has special interest in codes and literature dealing with the interaction of particles with matter.

## REFERENCES FOR PETTILLI PAPER IN ORNL/RSIC-40

It has been called to our attention that the references in the paper by M. Pettilli, *The Unfolding Code "DANTE" and its Applications*, published in *A Review of Radiation Spectra Unfolding*, ORNL/RSIC-40, have been unintentionally omitted. The references are as follows:


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6. R. Dierckx and V. Sanjust, *Unfolding Codes for Neutron Spectra Evaluation Possibilities and Limitations*, EUR/C/IS/365/75 e.
7. G. E. Russcher, *Calculated Damage Function for Determining Irradiation Effectiveness*, BNWL-1093 (Sept. 1969).


## RSIC GRAB BAG

We offer the following extra copies of documents on a first-come, first-serve basis for your reference shelf. Please order by report number. We will honor requests until the supply is exhausted.

**ORNL-5119,** *Gas-Cooled Fast Reactor Program Progress Report for January 1, 1974, Through June 30, 1975.*

**ORNL-TM-4078,** *Calculation of the Dose Induced in Tissue by Negatively Charged Pion Beams,* T. W. Armstrong, R. G. Alsmiller, Jr., and K. C. Chandler.

**ORNL-TM-4159,** *Calculations for Cancer Radiotherapy with Negatively Charged Pions* and *A Comparative Study of the Use of Photons, Neutrons, Protons, Negatively Charged Pions, and Heavy Ions in Cancer Radiotherapy.*

**ORNL-TM-4538,** *Gamma-Ray Production Due to Neutron Interactions with Fluorine and Lithium-for Incident Neutron Energies Between 0.55 and 20 MeV: Tabulated Differential Cross Sections,* J. K. Dickens, T. A. Love, and G. L. Morgan.

**ORNL-TM-4595,** *Approximate Numerical Solutions to the Time-Dependent Neutron Transport Equation Using the Task Algorithm,* E. T. Tomlinson.

**ORNL-TM-4791,** *Operating Instructions for the Heavy-Ion Code HIC-1,* R. T. Santoro, H. W. Bertini, T. A. Gabriel, N. M. Larson, and O. W. Hermann.

ORNL-TM-5225, *A Determination of the Neutron Energy and Spatial Distributions of the Neutron Beam from the TSR-II in the Large Beam Shield,* C. E. Clifford and F. J. Muckenthaler.

ORNL/TM-5224, *Iterative Solution of the Diffusion and $P_1$ Finite Element Equations,* E. T. Tomlinson, J. C. Robinson, and D. R. Vondy.

ORNL/TM-5612 *Measurement of the Nuetron Total Cross Section of Fluorine from 5 eV to 20 MeV,* D. C. Larson, C. H. Johnson, J. A. Harvey, and N. W. Hill.

ORNL/TM-5618, *Measurement of the Neutron Total Cross Section of Silicon from 5 eV to 730 KeV,* D. C. Larson, C. H. Johnson, J. A. Harvey, and N. W. Hill.

ORNL/TM-5677, *Charged Hadron and Lepton Currents Produced by Low-Momentum ($\leq$3GeV/c) Charged Pions in Al, Fe, and Pb Targets,* P. S. Beiser, T. A. Gabriel, and J. D. Amburgey.

ORNL/TM-5814, *Secondary Neutron Spectra from Neutron Interactions in a Thick Carbon Sample,* G. L. Morgan.

## VISITORS TO RSIC

The following persons came for an orientation visit and/or to use RSIC facilities during the month of June:

V. R. Cain, Science Applications, Inc., Oak Ridge, Tennessee; S. F. Deus, Instituto de Energia Atomica, Sao Paulo, Brazil; Jonathan L. Fales, W. B. Gardner, and Andrew Terrell, IBM, Knoxville, Tennessee; Brian W. Hooton, UKAEA, Harwell, England; Steve McNeany, Oak Ridge National Laboratory, Reactor Division, Oak Ridge, Tennessee; Albert E. Rainis, Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland; Charles S. Robertson, Jr., General Electric Company, Cincinnati, Ohio; E. A. Straker, Science Applications, Inc., La Jolla, California.

## JUNE ACCESSION OF LITERATURE

The following literature cited has been ordered for review, and that selected as suitable will be placed in the RSIC Information Storage and Retrieval Information System (SARIS). This early announcement is made as a service to the shielding community. Copies of the literature are not distributed by RSIC. They may generally be obtained from the author or from a documentation center such as the National Technical Information Service (NTIS), Department of Commerce, Springfield, Virginia 22151.

*RSIC maintains a microfiche file of the literature entered into SARIS, and duplicate copies of out-of-print reports may be available on request. Naturally, we cannot fill requests for literature which is copyrighted (such as books or journal articles) or whose distribution is restricted.*

THIS LITERATURE IS ON ORDER. IT IS NOT IN OUR SYSTEM. PLEASE ORDER FROM NTIS OR OTHER AVAILABLE SOURCE AS INDICATED.

## REACTOR AND WEAPONS RADIATION SHIELDING LITERATURE

AD-A-030762
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