RSIC Newsletter

RADIATION SHIELDING INFORMATION CENTER

OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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A man can do his best only by confidently seeking (and perpetually missing) an unattainable perfection. . . . *Ralph Barton Perry*

READER RESPONSE TO SEMINAR-WORKSHOP PROPOSALS

Evidence of interest in both seminar-workshops proposed in the August issue of the newsletter continues to come in daily as readers fill out and return the attached form.

Concerning Seminar-Workshop I: Multigroup Cross Sections, most readers made a choice of formats as suggested in the form attached to the newsletter. One offer of a paper was made. Several persons, however, made extensive suggestions for subject inclusion in the seminar and for both format and subject coverage in the workshop. We urge all readers interested in the generation and/or use of multigroup cross sections, who have not yet responded, to express your needs and your interests by reviewing the August article and mailing your response to RSIC.

Many suggestions were made concerning proposed Seminar-Workshop II on sensitivity and uncertainty methodology, especially in the content and coverage of the seminar. Several offers of papers were made. One reader offered a course outline for comprehensive coverage to (a) introduce newcomers to the field, (b) assess the state-of-the-art, (c) provide a forum for the clarification of unsettled questions, and (d) give indication of future trends in sensitivity theory. If you have not taken the time to register your thoughts on this subject in RSIC, now is the time.

Some readers took the opportunity to suggest other subject areas for future seminar workshops, such as shielding calculation result analysis, system reliability analysis, radionuclide dosage calculations, calculations around a nuclear power plant, etc.

There is still ample time for reader response to either Seminar-Workshops I and/or II and/or to give us guidance for future planning for information transfer through this technique. Your feedback will be welcomed.

HELP US TO HELP YOU

RSIC has always given priority to responding to user requests and continues to do so. However, circumstances beyond our control have extended the turnaround for computer-related requests to a snail's pace! We explained the physical tape handling problem in the April 1977 newsletter issue and made a plea for your cooperation and your tolerance. The original problem is becoming more acute by the saturation of all local computers with record work loads. A current check shows an extreme example of a 6-weeks turnaround for writing 5 separate code packages at 1600 bpi on one reel of tape.

We again ask for your tolerance for a long turnaround time and ask for your cooperation as follows.

1. If you can read a tape so written, ask for 9-track, 800 bits per inch (bpi).
2. If you have any possible way to rewrite the tape locally, do not ask RSIC to write 1600 bpi.
3. If you must have tapes written 1600 bpi, ask for only one code/data package to be written on your tape at one time.
4. Failing all remedies, wait patiently!

If and when our local computer environment is more amenable to our again being able to give you fast service without disabilities, we will all rejoice.

A CASE OF NOSTALGIA

The retirement of Charles E. Clifford (see Personal Items) from the Oak Ridge National Laboratory is an occasion for a nostalgic backward look at shielding research and development with which he was associated in the first 25 years of the Laboratory's existence. Lorraine Abbott took a journey through those years in the following article which we have lifted from the bicentennial issue of ***ORNL REVIEW****, Fall 1976, Volume 9, Number 4. The issue was a retrospective look at the Laboratory—how it evolved, its history, and a selection of anecdotes and personal recollections. The Abbott article, which is in this style, follows.*

The Origin of Shielding Research at ORNL

One of the oldest continuous programs at ORNL is the radiation shielding program of the Neutron Physics Division. As would be expected, it had its origin at the X-10 Pile soon after that reactor went critical on November 4, 1943. Although the X-10 Pile (also called the Clinton Pile) was built as a pilot plant for the larger plutonium-producing Hanford Reactor already under construction several features of the two reactors were quite different, one being the difference in their shields. The X-10 Pile was surrounded with 5 feet of barytes-haydite concrete between two 1-foot thicknesses of ordinary concrete. But since surrounding the higher-powered Hanford Reactor with concrete would have required a thickness too large to be practical, a laminated steel and Masonite shield was designed instead. A test of its adequacy comprised the first major experiment at the X-10 reactor.

C. E. Clifford, a Du Pont engineer at the time, participated in that first experiment and has engaged in shielding research ever since. The experiment was performed on top of the X-10 Pile, with a test section of the Hanford shield installed in a large hole extending through the pile shield down to the graphite moderator. Measurements of the attenuation of radiation by the Hanford sample were gratifying: the shield would be more than adequate. As it turned out, however, shortly after the reactor at Hanford had been in operation, the Masonite suffered severe radiation damage and decomposed, and a search began for alternative shield materials for a second Hanford Reactor.

About that time, circa 1946, the Navy began feasibility studies for a nuclear-powered submarine and the Air Force began a similar study for a nuclear-powered aircraft. That same year, **E. P. Blizard,** a physicist employed by the Navy, was sent to Oak Ridge by **Captain Hyman Rickover** to attend the Clinton Laboratories Training School, which Rickover had had a hand in organizing to instruct selected individuals on matters nuclear. Blizard obtained permission to prolong his tenure at Oak Ridge to complete research for a doctoral thesis; however, in April 1947 he received a truncated telephone order from Rickover to start doing research at Oak Ridge on reactor shielding. In a letter to **Professor John R. Dunning,** his thesis advisor at Columbia University, Blizard wrote: "My plans have changed considerably during the last week due to circumstances beyond my control. . . I have hopes that I will be able at find something suitable at the University of Tennessee since they have little or no objection to a classified thesis." But Blizard never obtained his degree. Instead, as his friend **Herbert Goldstein** later eulogized, "he became the father of reactor shielding."

Blizard consulted with Clifford, who at that time was working with **Ted Rockwell** on the development of high-density concretes which Rockwell hoped would be used as reactor shields. The three men collaborated to test samples of the concretes in a 2-foot-square "core hole" through the back face of the X-10 Pile, which by then had been named the Graphite Reactor. The fast-neutron flux incident on the hole was increased by moving some of the fuel slugs in the core to a position immediately adjacent to the hole.

Use of the Core Hole Facility began in July 1947, and the several experiments performed during the next year included measurements on shield samples provided by Brookhaven National Laboratory and NEPA (Nuclear Energy for Propulsion of Aircraft), the samples for NEPA being tungsten-bearing materials

considered for shields on nuclear-powered aircraft. From these experiments, several facts became apparent, one of which was the inadequacy of the Core Hole Facility due to cramped quarters and to the streaming of neutrons around the samples through the less-efficient reactor shield. Another was that secondary gamma rays produced by neutron interactions within the samples would be an important factor in shield design. Contemplating how to design a better shield facility, Blizard wrote to a friend in April 1948: "We expect to try a lid experiment. . . . An alternative will be to drill another hole in the top. This, of course, would be a large, serious, and dangerous undertaking, but there are few things that cannot be done with sufficient perspiration and perspicacity."

The lid experiment was eventually chosen, the "lid" consisting of a thin disk of enriched uranium placed on the outside of the original core hole. Thermal neutrons from the pile induced fissions in the disk, providing a local source of fission neutrons for experiments. Clifford suggested that a large tank of water be positioned adjacent to the fission plate so that the shield materials and radiation detectors could be submerged, reducing the radiation background. The resulting Lid Tank Shielding Facility began operation in mid-1949.

The LTSF proved to be an ideal facility in many respects. It could accommodate "full-scale" mock-ups with respect to shield thickness, and just as Rickover had planned, a shielding facility was available in time to test the shields designed for the nation's first nuclear-powered submarines. Other tests aided the design of shields for several stationary reactors. In its later days, during the last several years before the Graphite Reactor was shut down in 1963, the LTSF yielded a large quantity of fundamental data on individual shield materials which tested theories advanced by those engaged in analytical shielding.

To some, perhaps the main contribution of the LTSF was that it dispelled forever the idea that reactor shielding was just a matter of deciding how much material to pile around a reactor. Realizing that shield physics should be pursued as vigorously as core physics, Blizard joined the ORNL staff in 1949. He soon headed a shielding program that expanded into a large effort for the abortive nuclear-powered aircraft program and prompted the construction of two larger shielding facilities—the Bulk Shielding Facility, the famous swimming pool reactor; and the Tower Shielding Facility. On cancellation of the aircraft program, the BSF was converted to other purposes, and the TSF was adapted to shielding research for nuclear weapons shielding, for SNAP (Systems for Nuclear Auxiliary Power) shielding, and, today, for stationary reactor shielding. But the experiments performed at the TSF nowadays are seldom of the mock-up type. Instead, the mock-ups are "constructed" on computers to a scale never envisaged by the experimentalists. The current role of the experimentalists is to devise and perform experiments that will test the calculational techniques. Blizard forecast this turn of events and saw its beginnings before his death in 1966, but those of us still with the program are sure that even he would be surprised at how completely the computers have taken over the reactor shielding program he began.

— L. S. Abbott

Lorraine Abbott has been involved in technical writing at the Laboratory since her arrival in 1948. She is currently an editor and handbook compiler and an administrative aide in the Neutron Physics Division.

MAN–REM: A UNIT LOOKING FOR A QUANTITY

Radiological protection policy for the exposure to ionizing radiations of individuals or populations requires an assessment of the resulting detriment. In response to this need, the integration of the dose equivalent over populations has given rise to the unit man-rem.

It is obviously a unit, but for what quantity? "Population dose equivalent" and "collective dose equivalent" have been suggested, the latter by the ICRP (ICRP Report 22, 1973) and discussed by H. J. Dunster and S. Roe of the UK National Radiological Protection Board [see *Radio. Prot. Bull.*, No. 17, 34-36 (Oct. 1976)] and by G. A. M. Webb and A. S. McLean ("Insignificant Levels of Dose: A Practical Suggestion for Decision Making," NRPB-R62, April 1977).

Since "collective dose equivalent" has been suggested by the leading international authority, we would like to suggest its adoption by the radiation protection and shielding community, and thereby improve our English usage. We do not estimate units; we estimate the size of quantities.

PERSONAL ITEMS

The personal news item feature of the RSIC Newsletter was initiated in January 1968 to call attention to significant changes in activities or otherwise bring news of persons known in the shielding community. We do not actively seek the information, but we are pleased to have significant happenings called to our attention. The FY 1977 Users Survey indicated that a majority of our readers found the items useful, so we will continue the feature in FY 1978. We invite our readers to use this feature to communicate personal information to their colleagues in the shielding community, and to use the ***Current Work and Problems*** *feature to give information concerning research and development activities.*

William E. Hannum, former Chief of the Reactor Physics Branch, ERDA Division of Reactor Development and Demonstration and more recently, deputy manager of ERDA's Idaho Operations Office, has been selected to be deputy director general of the OECD Nuclear Energy Agency (NEA) with headquarters in Paris, France. The United States has recently changed its status from associate to full membership in the Nuclear Energy Agency. **Ian Williams,** former deputy, was recently named NEA director general.

Ronald L. Kathren, health physicist at Portland General Electric Company, is the 1977 winner of the Health Physics Society's Elda E. Anderson Award, which is presented annually to a society member under 40 years of age as a memorial to physicist Elda E. Anderson, first director of training in health physics at Oak Ridge National Laboratory. Kathren was cited for his excellence in health physics administration, research and development, training, and devotion to his profession.

J. E. McLaughlin (U.S. ERDA) was recently appointed to represent the ANS Standards Committee on American National Standards Committee N43, "Equipment for Nonmedical Radiation Applications." Selected to represent ANS on N44, "Equipment and Material for Medical Radiation Applications," was **C. M. Unruh** (Battelle Pacific Northwest Labs.). **H. V. Larson,** also of Battelle PNL, was chosen as the alternate ANS representative to N44.

G. H. Minton (Westinghouse) is the new chairman of ANS-19, "Physics of Reactor Design," taking over from **P. Greebler,** who recently resigned the ANS-19 chairmanship.

Charles E. Clifford, a veteran member of the ORNL Neutron Physics Division (NPD), has retired from the Laboratory and has joined the staff of Radiation Research Associates (RRA) in Ft. Worth, Texas as a senior staff scientist. He is in charge of developing projects in Japan where RRA has recently established representation through Century Research Corporation (CRC) in Tokyo. RRA, a consulting and engineering firm, has been traditionally associated with radiation shielding and optical radiation transport, each of which is a principal specialty of the firm. **Clifford** was associated since 1943 with the radiation shielding program of NPD, "one of the oldest continuous programs at ORNL" (see "The Origin of Shielding Research at ORNL"). He was the first head of the ORNL Lid Tank Shielding Facility, was the first head of the ORNL Tower Shielding Facility, and established the division's program for shielding integral experiments matched with state-of-the-art analysis and methods development. Most recently he was coordinator of the division's LMFBR program. We wish him well in his new adventure.

We are pleased to announce, belatedly, the addition of **Eddie W. Bryant** to the RSIC secretarial-publications team. Ms. Bryant, among other duties, serves as managing editor of the RSIC Newsletter. She has an extensive secretarial experience with legal, financial, and educational institutions. Three summer student employees have completed their assignments in RSIC to return to school. **Ronald and Virginia Eaton** of Mississippi State University worked on the automation of RSIC's record-keeping activities, and **Jay Kurtz** of the University of North Dakota assisted in the testing and packaging of

computing technology. **Eaton** and **Kurtz** are computer science majors, and **Virginia Eaton** is in business administration.

VISITORS TO RSIC

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

John Genser, Ridihalgh, Eggers, and Associates, Columbus, Ohio; Viktor Hampel, Lawrence Livermore Laboratory, Livermore, California; Bob Howell, Science Applications, Inc., Oak Ridge, Tennessee; Gordon G. Warner, Computer Sciences, ORNL, Oak Ridge, Tennessee; John Wilson, ERDA's Biomedicine and Environmental Research, Washington, D.C.; Mark Rosh, Israel Electric Company, Haifa, Israel; W. W. Parkinson, Industrial Health and Safety Div., ORNL, Oak Ridge, Tennessee; M. Siman-Tov, Engineering, ORNL, Oak Ridge, Tennessee; C. W. (Pete) Craven, Jr. and V. R. Cain, Science Applications, Inc., Oak Ridge, Tennessee; W. P. Huxtable, Engineering Division, ORNL, Oak Ridge, Tennessee; and Larry D. Schlenker, Energy, Inc., Idaho Falls, Idaho.

CHANGES IN THE COMPUTER CODE COLLECTION

The following changes were made in the computer code collection during the month of August.

CCC-178/HETC

The Monte Carlo high-energy nucleon-meson transport code package was updated to include CALOR, a Monte Carlo code designed to assist experimentalists in evaluating and analyzing different types of calorimeter systems that are used in many high-energy physics experiments to determine the energy and direction of incident hadrons, leptons, and photons. Since CALOR depends on HETC calculations for information on the transport of hadrons and on the spatial location of the electromagnetic source energy, it has been added to the HETC package as an additional application option. Reference: ORNL-TM-5619 (March 1977). FORTRAN IV; IBM 360.

CCC-217/ORIGEN

This isotope generation and depletion code package (matrix exponential method) was updated to correct an error called to RSIC attention by David H. Berwald, University of Michigan at Ann Arbor and Charles W. Kee, Oak Ridge National Laboratory. The correction was made by inserting in Subroutine FLUXO statement numbered "FLU 1110" the statement "XDOTI=D(L)*XTEM(L) +B(L)" in place of "XDOTI = D(L)*XTEM(I)." Without this correction the code will not perform correctly with the continuous feed option (MFEED > 0) and irradiation at constant power for fluid fueled reactor applications. In effect it would ignore the feed and overestimate the required flux for a given power.

CCC-288/KENO IV

Two separate updates were made to the IBM 360 version (A) of this multigroup Monte Carlo criticality code system. One update corrected an error called to RSIC attention by Nancy F. Cross, UCC-ND Computer Sciences Division at the Oak Ridge National Laboratory. In subroutine BEGIN, the definition of STHETA (located between statement numbers 840 and 860) was changed to read "STHETA = SQRT(V**2+W**2)" instead of "STHETA = SQRT(1.0-U*U)." The original definition caused COSPHI and SINPHI to diverge from normality, which in turn caused the direction cosines u, v, and w to diverge from normality. Such divergence may affect the k-eff calculated for systems in which neutrons undergo a large number of anisotropic scatters. This correction eliminated the possibility of such a discrepancy. The correction was not necessary for the CDC version of the code package because the CDC word length is of sufficient size to prevent precision problems for this definition of STHETA. The second update extended the versatility of the code package by the addition in BCD of the KENO Hansen-Roach cross section library, the 16-group differential albedos, and the 16- and 123-group weights which were formerly present only in binary form. This BCD data is already a part of the CDC version (CCC-288B).

CCC-301/ELPHO

This 3D Monte Carlo high energy electron gamma-ray transport code was contributed by the Oak Ridge National Laboratory. ELPHO was designed as one of the calor codes developed to design and analyze calorimeter systems which are packaged in CCC-178/HETC. It is packaged separately for those wishing to do basic electromagnetic transport studies. Bremsstrahlung cross sections are provided by BREM, which is included in the package. Reference: ORNL-TM-5619 (March 1977). FORTRAN IV; IBM-360.

The peripheral-to-shielding code collection was also changed.

PSR-105/MINX

The code package of the multigroup interpretation of nuclear cross sections from ENDF/B (MINX) was extended to include a CDC version, packaged as PSR-105(B), an additional contribution of the Los Alamos Scientific Laboratory. MINX calculates fine-group averaged infinitely dilute cross sections, self-shielding factors, and group-to-group transfer matrices from ENDF/B-IV. Its primary purpose is to generate pseudo-composition independent multigroup libraries in the standard CCCC-III interface formats for use in the design and analysis of nuclear systems.

PSR-109/ESTOQ

Volume distributed first collision surface (top boundary) source data (r-z geometry) generator for use in two dimensional discrete ordinates radiation transport codes (as DOT and TWOTRAN) for avoiding the ray effect, contributed by the University of Stuttgart Institut fur Kernenergetik (IKE), FRG through the OECD-NEA Computer Programme Library, Ispra, Varese, Italy. FORTRAN IV, CDC 6600. Ref. ORNL-tr-4415. (IKE Bericht NR. 4–17).

CHANGES IN THE DATA LIBRARY COLLECTION

The data library collection was changed during the month as follows.

DLC-38/ORYX-E

The data package containing ORIGEN (CCC-217) yields and cross sections—nuclear transmutation and decay data from ENDF/B was updated to correct an error called to RSIC attention by Charles W. Kee of ORNL. The atomic abundance of $^{124}S_n$ had been inserted into the library of light elements as the atomic abundance of $^{123}S_n$. Users may make their own correction or ask for the updated package.

DLC-47/BUGLE

A broad-group cross-section library derived from ENDF/B-IV (45-neutron, 16-gamma-ray coupled set for 66 materials, P_3 expansion) for light water reactor shielding applications was contributed by the Oak Ridge National Laboratory. This data set was collapsed from the DLC-41/VITAMIN-C: 171-neutron, 36-gamma-ray-group library. BUGLE was prepared as a first-round data library for use by ANS-6.1.2 in considering the possible adoption of a few-group library for light water reactor shielding problems. Specifications for such a few-group library were suggested by ANS-6.1.2 Working Group members, summarized in an informal memo (9/3/76) by the chairman, D. R. Harris of Renssalaer Polytechnic Institute. The data set is still undergoing tests by members of ANS-6.1.2. Feedback from the entire user community, once it is in the public domain, will be most appreciated.

The data set includes 66 nuclides which are self-shielded assuming a homogeneous medium of concrete. The weighting is 1/E below 820 keV, fission spectrum 0.820-10.0 MeV, fusion peak weighting 12.57-15.57 MeV, and 1/E 15.57-17.33 MeV.

A retrieval program is provided for selecting particular data and providing output in ANISN format and for converting from BCD to binary for use in calculations.

DLC-48/PVC

A 36-group, P_5, photon interaction cross section compilation for 38 materials was converted by RSIC

from AMPX interface form (available in DLC-41/VITAMIN-C) into ANISN card image form using the NITAWL module of AMPX (PSR-63). A retrieval code, LIBGEN, which converts the data from BCD to binary is included in the package. Contributor: ORNL. Reference: Informal notes (August 1977).

TRAINING COURSES OFFERED

The Atomics International Division of Rockwell International, 8900 De Soto Avenue, Canoga Park, CA 91304 is offering the following courses for this Fall. Complete information concerning the courses is available from E. M. Rex, AI's Nuclear Training Center, telephone 213-341-1000/2811.

A. *HEALTH PHYSICS FOR RADIATION PROTECTION TECHNOLOGISTS,* September 19–23, 1977: a one-week comprehensive training course designed to help prepare Health Physics' Technicians for the written examination given by the National Registry of Radiation Protection Technologists. The lectures cover the three general areas of Health Physics Technology Fundamentals, Health Physics Measurements, and Operational Health Physics Technology. A practical approach, including extensive problem solving, will be emphasized. This course would also meet the needs for formalized training of Health Physics Technicians in the Nuclear Utility field or related organizations. Fee: $495.00.

B. *HEALTH PHYSICS,* November 7–18, 1977: a two-week course structured to help prepare nuclear utilities, university and laboratory health physicists for the American Board of Health Physics Certification Exam. This program is offered to the health physics community as an intensive training course at the professional level. Twenty-two health physics categories will be covered including sample problem solving in each area. Fee: $835.00.

SEND US YOUR REPRINTS

It is a great help to us when authors send us their reports and reprints of their published work. We are very grateful to those who do this. This procedure will not only assure that the work comes to our attention but saves us the often considerable effort of obtaining documents when we encounter titles in abstract journals, accession lists, and bibliographies. It is particularly helpful if we are placed on routine distribution lists so we receive copies automatically.

We would also welcome brief contributions to the "Current Work and Problems" section. Tell us what you are working on.

AUGUST 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

ANS-19.3.4/ANSI N676-1976
The Determination of Thermal Energy Deposition Rates in Nuclear Reactors.
Weitzberg, A. (Ch.)
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American Nuclear Society, 244 East Ogden Avenue, Hinsdale, Illinois 60521

ANL/FPP/TM-77
Revised Design for the Tokamak Experimental Power Reactor.
Stacey, W.M.,Jr.; Abdou, M.A.; Brooks, J.N.
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ANL/FPP/TM-79
Measurements of X-Ray Damage in Fusion Reactor Window Materials.
Norem, J.H.; Young, K.M.
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BNL-NCS-22865/R; CONF-770611-202
What You Should Know About ENDF/B Version V.
Kinsey, R.; Dunford, C.
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CONF-770321-4
Need for Improved Standards in Neutron Personnel Dosimetry.
Auxier, J.A.
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EGG-1183-1670
Structure Shielding from Cloud and Fallout Gamma Ray Sources for Assessing the Consequences of Reactor Accidents.
Burson, Z.G.; Profio, A.E.
December 1975
Las Vegas Area Operations, EGG, Inc., 680 E. Sunset Rd., Las Vegas, Nev. 89119

EPRI-NP-243
Analysis of N-16 Radiation Measurements at the Cooper Nuclear Station. Final Report.
Wells, M.B.; Swanson, R.L.
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EPRI-ER-328-SR
Conference Proceedings: Low Activation Materials Assessment for Fusion Reactors (Special Report) (San Francisco, California - February 19-20, 1976).
Kummer, D.L.
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Davis, J.W.; Kulcinski, G.L.
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ERDA-89
Summary of the Proceedings of the Workshop on Conceptual Design Studies of Experimental Power Reactor-1. (Held at Oak Ridge National Laboratory, September 9-10, 1975).
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The Inelastic Scattering Angle-Energy Correlation and Its Effect on the Critical Parameters of Fast Assemblies.
Vertes, P.
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Gesellschaft fur Kernforschung mbH, Karlsruhe

EURFNR-1419; KFK-2386/II
Evaluations for the German Nuclear Data Library KEDAK-3. Part I: Non-Fissile Materials.
Goel, B. (Comp.)
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IKE-6-89 (In German)
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Keinert, J.
June 1975
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Investigation of the Coupling of Transport and Diffusion Theory by Means of Response Matrices Taking the Example of a HTR Pebble-Bed Reactor with Cylindrical Cavity.
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S_n Method for Reactors Computations on BESM-6 Computer by Using 26-Group Constants in the Sub-Group Presentation.
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Selecting the Energy and Scattering Angle of Thermal Neutrons in Free Gas Model.
Lux, I.
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Madland, D.G.; Stewart, L.
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LA-NUREG-6818-MS
FPDCYS and FPSPEC: Computer Programs for Calculating Fission-Product Beta and Gamma Multigroup Spectra from ENDF/B-IV Data.
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R-Matrix Analysis of the ^{7}Li System.
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Snyder, W.S. (Ch.)
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Insignificant Levels of Dose: A Practical Suggestion for Decision Making.
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Zappe, D.; Schuricht, V.
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Plechaty, E.F.
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UCRL-78307; CONF-770409-2
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Hankins, D.E.
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