# RSIC Newsletter

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*The great end of living is to harmonize man with the order of things*
*... Oliver Wendell Holmes*

## 6th ICRS Highlights—Butler Summary

The very successful 6th ICRS is now history and we forge full speed ahead into the future. We don't know how widely the published proceedings have been circulated and we again call your attention to the availability of the document from M. Kato, International Congress Service, Inc., 2-7-4, Nihombashi, Chuo-ku, Tokyo 103 Japan.

We include here the excellent summary of the conference as presented in the closing address of John Butler, AEE Winfrith, United Kingdom, and published in the proceedings of the conference.

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To summarise a Conference such as this is indeed a Herculean task: over 200 participants, 150 papers and 24 sessions; it has however been greatly facilitated by the excellent summaries of the individual sessions which have been prepared by the Chairmen. We heard all about the history of these International Conferences from Betty Maskewitz in her luncheon speech: Studsvik, Sweden, in 1962; Harwell, 1967; Paris, 1972; and Knoxville in 1977. Each of these occasions has proved to be a milestone in the development of shielding, and clearly Tokyo will be no exception. Indeed we might say that this occasion marks a turning point for the nuclear industry—the papers reflecting as they do our current preoccupations with the management of fission waste and decommissioning, on the one hand, and the aspirations of fusion reactor designers, on the other.

During these years we have seen the remarkable development of shielding as a scientific discipline. The shielding calculator now finds himself to be increasingly in demand: in the domain of the reactor physicist, shielding codes and data are required for the calculation of in-core heating; shield designers are involved in a variety of multi-disciplinary tasks concerned with the transport of activity in circuits and the atmosphere, optimisation studies are required for the implementation of the ALARA principles and in the materials dosimetry field, the shield designer is called upon to predict the fluence in pressure vessels. In the fields of medicine, manufacturing industry, and mineral exploitation on land and at sea, the shielding practitioners are called in to design a whole range of diagnostic and process-control devices involving the use of accelerators or radioactive isotopes.

Shielding has indeed come of age and this is reflected in the wide range of applications covered in our papers. I think you will all agree that Dr Asaoka and his committee are to be congratulated on their choice of topics and their selection of papers which have produced such a well-balanced programme.

It would be appropriate to look first at the development of methods for solving the Boltzmann equation in bulk shields. We should remember that in the real world of nuclear plant design and construction, the first reason for choosing a particular method or code is the same as that given rather eloquently by Mallory, the Victorian mountaineer, when he was asked why he wanted to climb Everest: "because it is there." Now here I must pay tribute to Betty Maskewitz and, of course, Dave Trubey for the outstanding contribution RSIC has made in disseminating shielding codes and, in particular, the discrete-ordinate codes ANISN and DOT. They have been so successful with this code package that indeed "it is there" whenever required in almost every part of the world. At a stroke, RSIC has been able to put into the hands of the most humble and inexperienced calculator a very sophisticated suite of codes. They have been misused of course, adapted for this or that particular problem, pushed to

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the limit in situations which would doubtless horrify their authors; nevertheless, RSIC remains unsurpassed in its achievement of raising the standards of radiation shielding practice throughout the world.

With such widespread use of discrete-ordinates codes, it is not surprising that this method has been the subject of so much development work. Two papers described modifications to the Sn method: the albedo-Sn method of Dr Kawai and the streaming-matrix method from Los Alamos. Both of these are intended to circumvent the problem of ray-effects in large problems containing voided regions. The disadvantage of albedo methods is that they do not predict the flux distribution within the walls of the void space but it will be interesting to see whether either of these can be exploited to facilitate the treatment of reactor cavities which always pose problems due to the need for boot-strapping runs and biassed quadrature sets. In this context we must also note the remarkable speed of Dr Takeuchi's direct integration code PALLAS which uses a discrete-ordinates representation for the angular mesh. This approach circumvents the problem of multigroup cross-section averaging and its three-dimensional version provides strong competition for Dr Nishimura's discrete-ordinates code ENSEMBLE which has now been extended to R.Θ.Z. geometry and represents a major advance in Sn capability.

The question of speed of execution brings me to the second reason for choosing a particular code, which used to be that it was economical in computing time but here I detect a marked change in emphasis. Several times this week I have heard comments to the effect that while computing time is cheap, man-hours are expensive, and elapsed time in a critical path can greatly increase project costs. So in the applications of Monte Carlo, for example, it is perhaps no longer necessary to carry out numerous trial and error runs to optimise the splitting; the job can be resubmitted for a few more hours to get better statistics. Monte Carlo has always been an expensive method; indeed, the critics used to say that it is only useful for those problems where one reaction-rate is required at one position and a fairly good approximate answer is already available! Dr Miller described a fully-automatic version of the McBEND CG code which is accelerated by approximate importance functions derived from adjoint solutions obtained with a finite-element diffusion code. Here is the user-friendly, push-button Monte Carlo which designers have always wanted, but has he simply shifted the burden for the user from that of choosing the splitting surfaces to that of setting up the finite-element mesh?

In the session on deterministic methods we also had two original papers by Dr Ackroyd and Dr Fujimura describing finite-element transport codes—albeit at an early stage of development. Why has the finite-element method arrived so late on the scene? It is, of course, widely used in engineering design for heat-transfer and stress-analysis calculations but shielding, perhaps, is more demanding. The reasons are not far to seek: it is necessary to mesh the whole structure in a shielding problem including the holes which are of little consequence in a bridge or an air-frame; there is a much larger range of materials in a typical shield and they have markedly different attenuation properties giving rise to steep gradients at boundaries. Will the finite-element method stand alongside the other principal methods which will be described at the Seventh ICRS? I venture to predict that it will because it is a deterministic method which can handle irregular complicated geometries and, moreover, it does not involve iterative solutions, so the codes will have large potential gains in speed on modern parallel processing machines, in contrast to Sn methods which are not really suitable for vectorisation. A low-order few-group finite-element transport calculation might be fast enough to generate vector importance functions for accelerating Monte Carlo in ducts and voids but we have seen an alternative approach to angular biasing for this type of problem utilising the weight- window concept in Dr Booth's paper.

Again, we saw examples in the TRIPOLI papers of some very sophisticated biasing procedures which can be exploited in complex problems by an experienced user. Another approach for the treatment of the long ducts, which are of increasing importance in fusion reactors, is the recursive Monte Carlo method described by Professor Goldstein. This works well in simple geometries but I wonder how easy it will be to extend it to three-dimensional problems. There is no doubt that streaming problems, which were with us long before Theodore Rockwell made his profound observation about water having no cracks, will continue to dictate the course of development for both stochastic and deterministic methods in response to the needs of fusion reactor projects. Thus, even in the most recent developments such as the Inertial Confinement Fusion Reactor system described by Dr Sawan, the principal problem is again streaming through the injector ports.

Turning now to nuclear data, it is a relief to see that everybody is now moving over to the ENDF format, and we also note that a new library which is known as JEF (the Japanese and European Data Library) has been born. Processing problems have always caused difficulties and there is still considerable effort devoted to the development of data processing capabilities. Dr Gonnord described the recent development of THEMIS-4 which is a most elegant coherent point and multigroup library in the TRIPOLI Monte Carlo code. Both this, and the Los Alamos code MCNP, have a fully detailed n-γ coupled capabilities. The need for these dedicated libraries is very apparent when you consider the findings of the IAEA Cross-Section Processing Code Verification project reported by Dr Cullen. It is important for Monte Carlo packages to have both point and multigroup capabilities; Dr Salvatores drew our attention in his report on the NEA benchmark exercise for the notional FBR radial shield problem to the fact that the fluxes calculated at the IHX position with an 8000 energy-point scheme and the EURLIB 100-group library differed by a factor of 4. The message is clear: a 100-group scheme is too coarse for deep-penetration calculations in non-hydrogenous shields. It is interesting to note that many users are changing over from MORSE to MCNP, presumably to benefit from the point cross-section capability.

This brings me to the validation of nuclear data sets — a subject which always seems to raise the temperature of debate, as we saw in Session 2 on Wednesday when Dr Hehn reported that his adjustments had reduced the iron inelastic cross-section of the ENDFB/IV library down to a value close to that in the JENDL compilation, much to the consternation of Dr Kikuchi who claimed that JAERI integral experiments showed the reverse trend! The shielding community is of course sharply divided into the Adjusters, the Anti-Adjusters and the Agnostics and I must confess here to a little agnositcism myself in spite of Mr McCracken's remarkable curve which showed close agreement between adjustments to the iron cross-section de-

rived from shielding benchmarks and fast reactor criticals. There is a strong case for adjustment of cross-sections in the field of fast reactor physics because the range of extrapolation from a critical core mock-up to a power reactor is relatively small, covering only the effects of temperature and burn-up. There is usually a much greater extrapolation involved between a slab penetration experiment and a power reactor shield. Nevertheless, some powerful techniques have been reported this week such as Dr Salvatores' PROPANE-D1 system for the design of Super Phenix, and the adjustments described by Dr Hehn and Mr McCracken in steel-water systems.

The Anti-Adjusters argue that adjustments in deep penetration calculations are necessarily system-dependent and that it is not practicable to implement an adjustment scheme for large complex shields involving a variety of different materials in different configurations. The role of data adjustment is simply to derive a set of empirical design parameters for extrapolating from mock-up experiments which do not necessarily reflect real shortcomings in the basic cross-sections and may obscure errors attributable to the method of calculation. In practice, most reactor shields are too large and complicated to be mocked-up in a laboratory experiment, and we must have recourse to data-testing benchmarks. With the availability of Monte Carlo perturbation codes such as DUCKPOND, or the correlated-tracking method described by Dr Rief, it is now feasible to carry out a detailed sensitivity analysis of a complex practical shield. The aim is then to design the benchmark experiment with the aid of further sensitivity calculations to reproduce similar sensitivity profiles for those reaction-rates which can be measured so that an adjustment procedure can be performed. The only configuration which properly reproduces these sensitivity profiles however, is a mock-up of the shield! This might be called the Benchmarker's Catch-22.

Perhaps there is a way to reconcile these apparently conflicting views. It is generally accepted that it is necessary to carry out an adjustment of the data in order to draw quantitative conclusions from the analysis of a benchmark experiment. The sense and magnitude of these adjustments will serve as useful pointers for the evaluators who may be able to revise their conclusions and produce an updated file. This, in turn, is processed and the calculation for the benchmark experiment is repeated to observe the expected improvement in the accuracy of prediction. There is a great deal of information locked up in the high-quality penetration-experiments which are now being performed in several different laboratories and the advent of tools for multi-dimensional sensitivity analysis has provided the key. This in turn, has focussed attention on the error-correlation files, and penetration benchmarks in which simultaneous measurements of the spectrum are made over a wide energy range from about 5 keV to 10 MeV afford what is probably a unique source of information on both partial and energy-dependent correlations.

In contrast, I note that all the papers presented at this Conference which utilise variance-covariance information have had to rely on the preliminary multi-group matrices produced by Drischler and Weisbin at Oak Ridge in 1976. Moreover, for some important shielding materials which are not included in that compilation, it has been necessary to extract estimates of the variance from that monumental work of Dr Schmidt which dates back to 1965! I understand that the authors of ENDF/BV have taken cognisance of some of the Oak Ridge benchmark results and it will be interesting to see the scope and nature of the information they have been able to extract. Those of us who are looking to the development of JEF must make our needs known and be prepared to furnish the appropriate analyses of our integral benchmark experiments. The Shielding Community must become more directly involved with the assessment and improvement of nuclear data—as the great French statesman Talleyrand might have put it: "Data evaluation is much too serious a thing to be left to evaluators."

Whilst on the subject of benchmarks, it is very encouraging to see such an excellent standard of documentation. In the Shielding Benchmark Programme sponsored by the NEA we campaigned for many years to improve the standards. A benchmark report must contain a full specification of the source-shield-detector system to enable completely independent analyses of the experiment to be conducted at other laboratories. We have seen many such examples this week; Dr Gonnord described TRIPOLI calculations for a linac time-of-flight experiment performed at Oak Ridge and also for Dr Santoro's 14 MeV duct attenuation experiment; Dr Hehn has analysed the EURACOS II sodium benchmark experiment; and Mr Avery has predicted that streaming of 14 MeV neutrons along a labyrinth studied on the FNS facility at JAERI. Several laboratories have analysed the Winfrith iron benchmark and, of course, the record must surely be held by Oak Ridge and HEDL because their PCA experiment, performed in the NRC LWR Pressure Vessel Surveillance Dosimetry Improvement Programme, has been analysed by eleven different laboratories in a so-called Blind Test.

Again on the subject of measurements, I recall making a plea at the Paris Conference in 1972 for more experiments to be carried out on operational reactors which are the essential complement of experiments in laboratory facilities. At that time there were remarkably few such experiments in the literature apart from radiological protection measurements. When attempts are made to analyse routine dosimetry surveys normalised to the quoted power level it is seldom possible to draw meaningful conclusions about the accuracy of the calculational method. The essential requirement is a carefully controlled experiment with detailed records of the irradiation history, measurements of key dimensions and, if necessary, analyses of samples to determine the chemical composition. These data must be obtained for the plant as built. Dr Bunch reminded us the other day, in his anecdote about the shield door and the alignment of fabrication gaps in plugs, that few plants are built exactly according to the drawings! The characterisation of the FFT radiation environment described in his paper is a model for us all, one cannot help being impressed by the detail of the scans and the variety of the detectors employed. This reactor is, of course, an MTR but we have also seen several other examples of power reactor measurements: flux and dose scans were made in the difficult area of the dry well on the Coarso BWR in Italy; and here in Japan, measurements have been made by Dr Nakai on a BWR, and a comprehensive programme has been carried out on the fast reactor prototype JOYO.

Some interesting controlled experiments have also been reported on transport flasks. These measurements afford the ultimate test of our calculational capabilities and large discrepancies are frequently discovered when a carefully benchmarked code is applied to an operational plant. A great deal can be learned from the analysis of these discrepancies about the mod-

elling of large complex structures to complement the findings of laboratory experiments. I know that proposals have been made for shielding measurements to be carried out on TFTR and JET. Let us make sure that these and similar programmes on other plants come to fruition—there will no doubt be resistance from the operators, as there always was on the thermal reactors, but at least they cannot claim that the experiments cause them to lose money by not generating electricity!

We have also had a number of interesting papers dealing with other aspects of operational plants including the control of operator exposure and the assessment of radiation damage in LWR pressure vessels. The programmes currently in hand for the surveillance of some of the older vessels show the high precision and consistency that can be achieved in measurements of fluences on operational plant when the cost-benefit arguement is clearly defined. We have, however, had only two papers on cost-benefit analysis, namely those from Dr Jarvis and Mr Taylor in this morning's session on Standards. Again, shield optimisation is the subject of only two papers, one on fusion-reactors and the other by Dr Gandini describing the use of GPT methods. Perhaps one of the reasons why these methods do not find more general application is that it is difficult in practice to make allowance for all the individual components of the cost. In the case of concrete biological shields, for example, large sums of money may be spent on the labour-intensive job of erecting the shuttering and the cost of adding a few inches to the thickness to accomodate uncertainties in the shielding calculations is usually negligibly small.

This review would not be complete without reference to the German papers on Decommissioning and Waste Management. The fact that the Otto Hahn is at sea again, and the excellent progress being made with decommissioning of the small pressure tube reactor described by Dr Hehn gives credibility to the ambitious programme of decommissioning in the Federal Republic. I have no doubt that our plans to restore power reactor sites to green fields do lack credibility among the environmental pressure groups. Dr Burstall described the decommissioning of a somewhat larger plant, the Windscale AGR, which will also be restored to green fields as a demonstration exercise.

Mr Chairman, it only remains for me to thank our hosts and, I believe, I am expected to drop a hint about the Seventh ICRS. We are greatly indebted to Dr Fujinami, the President of JAERI, who is our host for what has truly been a very enjoyable and interesting Conference. We must also express our gratitude to Dr Ishikawa and members of his National Organising Committee, and also to Dr Asaoka and Professor Hyodo for their work on the International Technical Programme Committee. However, special thanks must be reserved for Dr Asaoka: those of us who have organised major international conferences know very well the problems that he has had to deal with. He has, however, always been available, coping with crisis after crisis with that cheerful smile which has been an inspiration to his staff of charming young ladies who have provided such excellent administration services. Finally I should like to thank the Session Chairmen for their stirling efforts, working late into the night in their hotel rooms to produce such excellent summaries which made my task so much easier.

We have now five years in which to organise the Seventh ICRS and that is by no means too long for all the negotiations and planning which must take place. ●

### Interested in EDO?

RSIC has received EDO, a code system in FORTRAN V for evaluating doses to man during normal operation of a nuclear power plant. The documentation for the code is written in Spanish and we would like to determine if there is enough interest in the user community to warrant translating it for RSIC packaging. Please let us know if you have an interest in this code system.

The code permits the evaluation of dose-equivalents received by individuals and the population in the neighborhood of a nuclear power plant due to emission to the atmosphere of rare gases and other gaseous emissions, as well as to the discharge of liquids in the water environment during normal operation of the installation. The code is written for a UNIVAC 1108 computer.

## CHANGES TO THE COMPUTER CODES COLLECTION

During the month a new peripheral shielding code was packaged and a change in the documentation for an existing code package is noted.

### CCC-371/ORIGEN-2-82 Document Correction

Page 121 which lists the packaged sample problem in file 2 for the above version of ORIGEN has errors in the data listed on cards numbered 261, 262, and 263. The data should read as follows (note that the changed numbers are boxed):

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OPTL 8 8 8 8[8 8 8]8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
OPTA 8 8 8 8[1 8 8]8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
OPTF 8 8 8 8[1 8 8]8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
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The change to the input data in the code package was noted in the December 1983 issue of the *RSIC Newsletter.*

### PSR-205/BAYES

This general purpose code system for fitting a functional form to experimental data was contributed by the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee. Solving "Bayes' equations" for updating parameter values, uncertainties, and correlations, BAYES can be used for an arbitrary problem much as one would use a generalized least-squares solver. Bayes' equations are derived from Bayes' theorem using linearity and normality assumptions. Reference: ORNL/TM-8185. FORTRAN IV; PDP-10.

## CHANGE TO THE DATA LIBRARY COLLECTION

During the month one new data library was packaged.

### DLC-108/JFS3J2

This 70-group neutron, fast reactor cross-section set based on JENDL-2B was contributed by Japan Atomic Energy Research Institute, Tokyo. These multigroup cross sections were used in benchmark calculations for the 23 fast critical assemblies using one-dimensional diffusion theory. The data for 30 elements were prepared from a recent version of Japanese Evaluated Nuclear Data File (JENL-2B) using the TIMS-1 and PROF-GROUCH-GII processing system. Shielding factors are provided for 8 background cross sections (0 and 1 to $10^6$ in decades), temperatures of 300-, 800-, 2100-, and 4500-K, and 4 mutual shielding parameters for important heavy resonant materials. The format of the data is included as part of the documentation but no retrieval routine has been provided. Reference: JAERI-M 82-135 and informal notes. FACOM M-200.

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### PERSONAL ITEMS

In serving a specialized area of scientific endeavor, it seems important that we take note of the movement of people concerned with radiation protection, transport, and shielding in the nuclear industry. We, therefore, continue to carry personal items as they are brought to our attention. During the past month we have been informed of the following changes.

**Goldstein Honored by CON-ED**—Herbert Goldstein, first Thomas Alva Edison Professor of Nuclear Science and Engineering at Columbia University in New York City, has been selected by the president of Columbia University and Consolidated Edison Company to deliver the Con Edison Lecture on Wednesday, March 21, 1984, at 7:30 PM in the Faculty Room of the Low Memorial Library of the University. His lecture title is "The Ecology of Technology."

Herbert Goldstein, a professor of nuclear science and engineering at Columbia University for many years, became the first Thomas Alva Edison Professor on July 1, 1983. He earned his doctorate in physics in 1943 at MIT where he also participated in war-time research. After teaching at Harvard for three years he worked in industry for about a decade, joining the Columbia faculty in 1961. His main area of research has been in reactor shielding but his research has ranged as far afield as microwave radar propagation and analytical dynamics. While at Harvard he wrote *Classical Mechanics* which has remained the standard graduate text on the subject for over thirty years.

In 1962, Goldstein's research work won him the prestigious E. O. Lawrence Memorial Award of the Atomic Energy Commission (AEC). He has been a member of numerous advisory committees of the AEC, the Department of Energy, and the National Academy of Sciences, including a term as Chairman of the AEC Nuclear Cross Section Advisory Committee.

In 1976 he received the Great Teacher Award given by Columbia's Society of Older Graduates. In recent years he has become deeply involved in developing education programs in science and technology aimed at the non-scientist, both in the School of Engineering and Applied Science and in Columbia College.

He was instrumental in the establishment of an information analysis center for shielding (RSIC), has served

as an advisor, and continues to support RSIC activities. We are pleased to call attention to the well-merited recognition of his achievements.

**Yuuki Hachiya**, General Manager of the Deuterium Criticality Section for the Power Reactor and Nuclear Fuel Development Corp. (PNC) of Tokyo, is currently on assignment at ORNL where, along with U.S. DOE officials, he will coordinate and assist in the planning of experiments for the Joint U.S.-Japanese Criticality Data Development Program. The purpose of this long-range program is to develop benchmark experiments that will be useful in validating computer codes and cross-section libraries for use in the criticality safety analysis of fuel cycle facilities. Dr. Hachiya will serve in this capacity through October 1984.

**Gene Wachpress**, a General Electric-Knolls Atomic Power Laboratory (KAPL) employee for more than 30 years, is now associated with the University of Tennessee Mathematics Department, Knoxville, Tennessee. He continues to work part-time for KAPL as a consultant in methods development in reactor physics.

**Mohamed A. Abdou** has relocated to the University of California-Los Angeles where he is a professor in the School of Engineering and Applied Science. He continues to be active in the fields of fusion and nuclear engineering and has a number of research staff and graduate students working in diverse areas of fusion research including neutronics.

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We have been informed of the following changes of address: *Toshitada Hori,* from Los Alamos National Laboratory, to Sumitomo Heavy Ind. Ltd, Tokyo, Japan; *Stefan Boeriu,* from the Institute of Nuclear Technology, Bucharest, Romania, to Lab. CIRENE-PASI, Rome, Italy; *Noel A. Amherd,* from Electric Power Research Institute, Palo Alto, California, to Titan Systems, Los Altos, California; *Michael H. Fellows,* from Defense Nuclear Agency, Washington, to MIT, Cambridge, Massachusetts; *George Imel,* from Penn State University, to Argonne National Laboratory, Idaho Falls, Idaho; *Randall R. Nason,* from Sandia National Laboratories, Albuquerque, New Mexico, to C. H. Guernsey & Co., Oklahoma City; *Ezra B. Mann,* from the BDM Corp., Albuquerque, New Mexico, to EMA, Inc., also of Albuquerque; *Mary Ann Randles,* from Stone & Webster Engineering Corp., Boston, Massachusetts, to Long Island Lighting Co., Hicksville, New York; *F. D. Gault,* from the University of Durham, England, to Statistics Canada, Ottawa, Canada; *Doug Woody,* from the University of Tennessee, Knoxville, to Technology for Energy Corp., also of Knoxville; and *S. Wynchank,* from Hiddingh Ave., Newlands Cape, South Africa, to RIAAM, Tygerberg, South Africa.

## Visitors to RSIC

During the month of February the following persons came for an orientation visit and/or to use RSIC facilities: *C. A. Baldwin,* Oak Ridge National Laboratory; *Kay C. Paris,* and *C. F. Cutcher,* Project Management Corp.; *Jim T. West,* Los Alamos National Laboratory; *Bernard W. Wehring,* Univ. of Illinois, Urbana; *John F. Cooper,* MPI, Garching, Fed. Rep. Germany; *E. P. Lippincott,* Hanford Engineering Development Laboratory, Richland, Washington; *Metin Yildiran,* National Research Council, Turkey; and *Theodore A. Parish,* Texas A&M Univ., College Station.

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## New Publication Available

The Technical Information Center, U.S. Department of Energy (DOE), has announced the availability of *The Technology of High-Level Nuclear Waste Disposal,* the first volume in a series entitled *Advances in the Science and Engineering of the Management of High-Level Nuclear Wastes.* The book, edited by P. L. Hoffman and J. J. Breslin, is a collection of papers describing research performed within the program of the National Waste Terminal Storage (NWTS) Program of DOE. The objectives of the NWTS Program are to develop the technology and provide the facilities for permanently isolating high-level and transuranic nuclear wastes resulting from the commercial production of electric power. The major emphasis of the program is on disposal of these wastes in deep geologic formations, although several other possible disposal schemes have been under investigation for several years.

The 16 papers of this volume discuss high-level nuclear waste disposal science and technology, presenting an overview of the entire field and examining in some depth the special topics of current interest. The material is covered under four major headings:

Part I: Waste Isolation and the Natural Geohydrologic System

Part II: Repository Perturbations of the Natural System

Part III: Radionuclide Migration Through the Natural System

Part IV: Repository Design Technology

The book is available as DE82009594 [DOE/TIC-4621 (Vol. 1)] for $18 from the National Technical Information Service, U.S. Dept. of Energy, Springfield, VA 22161. (407 pages)

## UPCOMING MEETINGS, CONFERENCES, AND SYMPOSIA

Your attention is directed to the following announcements.

**Personnel Radiation Dosimetry** is a course being offered May 21–25, 1984, by the Dosimetry Applications Research Facility at Oak Ridge National Laboratory. The course will be held at Oak Ridge for a fee of $875. The registration deadline is *May 11, 1984*, and additional information may be obtained from R. E. Swaja or C. S. Sims, ORNL, P.O. Box X, Bldg. 7710, Oak Ridge, Tennessee 37831 (phone 615-574-5851).

Neutron dosimetry topics to be covered, using lectures, group discussions, and experimental work,include dosimeter types and performance characteristics, regulatory requirements, dose equivalent estimation, calibration, monitoring instrumentation, and spectral measurement methods. Additional lectures will cover gamma monitoring in mixed radiation fields, accident dosimetry, and biological effects of radiation. The Health Physics Research Reactor will be used in experimental work aimed at allowing participants to determine the performance characteristics of their dosimetry systems and to apply principles learned to actual dose measurements.

**ANS Sponsors New Orleans Courses**—Preceding the ANS Annual Meeting in New Orleans, three courses are being offered by ANS on June 2 at the New Orleans Hilton & Towers Hotel. Since courses are limited to 30 participants, preregistration is required. The fee for each course is $225 for ANS members and nonmembers.

*Fusion Plasma Engineering* is intended for scientists and engineers with a background in other aspects of fusion engineering who wish to learn more about applied plasma physics and how it influences the design of a fusion reactor.

*Personnel Neutron Monitoring* is a survey of the latest methods, instruments, and standards applicable to implementing and maintaining a neutron dosimetry program. Particular topics to be discussed include dosimeter types and performance characteristics, regulatory requirements, dose equivalent estimation, calibration, and monitoring.

*Statistical Probabilistic Methods Applied to Engineering* is an introductory course to acquaint participants with the basic concepts of statistics and probability; no prior knowledge of the subject is required.

**ARPS Conference** The Ninth Annual Conference of the Australian Radiation Protection Society is titled "The Benefits of Radiation Protection—At What Cost?" The conference will be held in Darwin, Northern Territory, Australia, July 9–12, 1984. The conference will cover all aspects of radiation protection, including: regulatory development, education, and training; philosophy of radiation protection including cost-benefit analysis; non-ionizing radiation protection; environmental radiation and radionuclides; whole body radiation dosimetry; radiation protection in all phases of uranium mining and milling; hospital and medical radiation protection; radiation protection in universities and research establishments; industrial radiation safety practice; theoretical and technical developments; radioactive waste disposal; and related occupational health and hygiene topics. A technical exhibit of related equipment and a poster display is also planned.

Additional information may be obtained from Ian Prince, Conference Convenor, 1984 ARPS Conference, C/-GPO Box 1701, Darwin NT 5794, Australia.

**Environmental Radiation '85** is the subject of the 18th Midyear Symposium of the Health Physics Society, to be held January 6–10, 1985, in Colorado Springs, Colorado. The format will emphasize scientific exchange between experts in both man-made and natural sources of ionizing radiations while providing education and training for a general audience.

Additional information may be obtained from Steve Brown, Chairman, Symposium Committee, Rockwell International, P.O. Box 464, Golden, Colorado 80401 (phone 303-430-2891).

### Calendar

Your attention is called to the following additional events of interest to the radiation shielding and protection community.

**April 1984**

*5th International Conference on Nuclear Methods in Environmental and Energy Research*, April 2–6, 1984, Mayaguez, Puerto Rico, USA, sponsored by the ANS; American Chemical Society; U.S.-DOE; Univ. of Puerto Rico-Recinto; Univ. of Mayaguez; and the Univ. of Missouri. Contact: James R. Vogt, Univ. of Missouri, 214 Research Reactor, Columbia, Missouri 65211, USA (phone 314-882-4211).

*20th Annual Meeting of the National Council on Radiation Protection and Measurements*, April 4–5, 1984, Washington, sponsored by the National Council on Radiation Protection and Measurements. Contact: NCRP, 7910 Woodmont Ave., Suite 1016, Bethesda, Maryland 20814.

*Annual Meeting of the Radiation Research Society*, April 8–12, 1984, Orlando, Florida. Contact: American College of Radiology, 925 Chestnut St., Philadelphia, Pennsylvania 19107, USA.

*Tenth Personnel Dosimetry Intercomparison Study*, April 9–13, 1984, Oak Ridge, Tennessee, sponsored by Oak Ridge National Laboratory. Contact: R. E. Swaja or C. S. Sims, ORNL, P.O. Box X, Bldg. 7710, Oak Ridge, Tennessee 37831 (phone 615-574-5851).

*Radiation Protection Instrumentation Course*, April 9–13, 1984, Boston, Massachusetts, sponsored by the Harvard School of Public Health, Office of Continuing Education. Contact: Office of Continuing Education, Harvard School of Public Health, 677 Huntington Ave., Boston, MA 02115 (phone 617-732-1171).

*General Meeting of the American Physical Society*, April 23–26, 1984. Contact: The American Physical Society, 335 East 45th St., New York, NY 10017 USA.

*5th Annual Conference of the Canadian Radiation Protection Association*, April 30–May 3, 1984, Banff, Alberta, Canada. Contact: Stuart E. H. Hunt, Local Arrangements Chairman, C-7 Civil Electrical Engr. Bldg., Univ. of Alberta, Edmonton, Alberta, Canada T6G 2G7 (phone 403-432-5655).

*Control of Occupational Exposures in Nuclear Power Plants,* April 30–May 4, 1984, Boston, Massachusetts, sponsored by the Harvard School of Public Health, Office of Continuing Education. Contact: Office of Continuing Education, Harvard School of Public Health, 677 Huntington Ave., Boston, MA 02115 (phone 617-732-1171).

**May 1984**

*Applications of KENO in Nuclear Criticality Safety,* May 7–11, 1984, Knoxville, Tennessee, sponsored by Technical Management Services, Inc. Contact: Technical Management Services, Inc., P.O. Box 16, New Hartford, Connecticut 06057 (phone 203-379-2339).

*6th Congress of the International Radiation Protection Association,* and *Exhibition,* May 7–12, 1984, Berlin, West Germany. Contact: R. Neider, Bundesanstalt für Materialprüfung (BAM), Unter den Eichen 87, D-1000 Berlin 45.

*Nuclear Technology Exhibit,* May 11–19, 1984, Bejing, China, sponsored by the ANS. Contact: P. Pollock, Exhibit Manager, ANS, 555 N. Kensington Ave., La Grange Park, Illinois 60525 USA (phone 800-323-3044).

*6th Annual Symposium on Safeguards and Nuclear Material Management,* May 14–18, 1984, Venice, Italy, sponsored by the European Safeguards Research and Development Association (ESARDA) and the Commission of the European Communities. Last date for abstracts and summaries is November 30, 1983. Contact: L. Stanchi, Commission of the European Communities Joint Research Centre, I-21020 Ispra (Varese), Italy.

*Personnel Radiation Dosimetry,* May 21-25, 1984, Oak Ridge, Tennessee, sponsored by Oak Ridge National Laboratory. Contact: R. E. Swaja or C. S. Sims, ORNL, P.O. Box X, Bldg. 7710, Oak Ridge, Tennessee 37831 (phone 615-574-5851).

**June 1984**

*24th Annual International Conference of the Canadian Nuclear Association,* June 3–6, 1984, Saskatoon, Saskatchewan, Canada. Contact: J. A. Weller, General Manager, Canadian Nuclear Association, 111 Elizabeth Street, 11th Floor, Toronto, Ontario, Canada M5G 1P7.

*29th Annual Meeting of the Health Physics Society,* June 3–7, 1984, New Orleans, Louisiana. Contact: Richard J. Burk, Jr., Executive Secretary, Health Physics Society, 4720 Montgomery Lane, Suite 506, Bethesda, Maryland 20014, USA.

*ANS Annual Meeting,* June 3–8, 1984, New Orleans, Lousiana. Contact: Thomas H. Row, ORNL, Bldg. 4500, MS-S-178, Oak Ridge, TN 37831-2008 USA.

*Twelfth International Symposium on Effects of Radiation on Materials,* June 18–20, 1984, Williamsburg, Virginia, sponsored by the American Society for Testing and Materials. Contact: James S. Perrin, Fracture Control Corp., 340-G South Kellog Ave., Goleta, California 93117 (phone 805-964-8877); or John Koziol, Combustion Engineering, Inc., 1000 Prospect Hill Rd., Windsor, Connecticut 06095 (phone 203-688-1911).

**July 1984**

*9th Annual Conference of the Australian Radiation Protection Society,* July 9–12, 1984, Darwin, North Territory, Australia. Contact: I. A. Prince, Conference Convenor, 1984 ARPS Conference, C/ - GPO Box 1701, Darwin, NT 5794, Australia.

*Topical Meeting on Fission Product Behaviour and Source Term Research,* July 15–19, 1984, Snowbird, Utah, sponsored by ANS; Electric Power Research Institute (EPRI); Canadian Nuclear Society; and the Atomic Energy Society of Japan. Contact: W. J. Quapp, EG & G Idaho, Inc., P.O. Box 1625, Idaho Falls, Idaho 83415, USA (phone 208-526-9606).

**September 1984**

*5th International Symposium on Capture Gamma Ray Spectroscopy and Related Topics,* September 10–14, 1984, Oak Ridge, Tennessee. Contact: S. Raman, Physics Division, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37831-2008 USA.

*ANS Topical Meeting on Physics and Shielding,* September 17–19, 1984, Chicago, Illinois. Contact: Leo LeSage, Argonne National Laboratory, Applied Physics Div., 9700 South Cass Ave., Argonne, Illinois 60439 USA (phone 312-972-6045).

*5th ASTM-EURATOM Symposium on Reactor Dosimetry,* September 24–28, 1984, Geesthacht, Fed. Rep. of Germany, sponsored by Commission of the European Communities, ASTM, U.S.-DOE, and U.S.-NRC. Contact: E. B. Norris, Southwest Research Institute, P.O. Drawer 28510, San Antonio, Texas 78284 (for Japanese and US authors); H. Rottger, Joint Research Centre, Petten Establishment, HFR Div., Postbus 2, 1755 ZG Petten (N. H.), Netherlands (all other authors). Last date for abstracts is December 1, 1983.

**October 1984**

*International Conference on Occupational Radiation Safety in Mining,* October 15–18, 1984, Toronto, Ontario, Canada, sponsored by the Canadian Nuclear Assoc., Canadian Dept. of Energy, Mines, and Resources, and the Atomic Energy Control Board. Last date for abstracts is January 1, 1984. Contact: Internatl. Conf. on Occupational Radiation Safety in Mining, Canadian Nuclear Assoc., 111 Elizabeth St., 11th Floor, Toronto, Ontario, Canada M5G 1P7.

*Symposium on Radiation Dosimetry,* October 15–18, 1984, Knoxville, Tennessee, sponsored by Oak Ridge National Laboratory. Contact: R. T. Greene, ORNL, P.O. Box X, Bldg. 7710, Oak Ridge, TN 37831-2008 USA.

*Meeting of the Nuclear Physics Div. of the American Physical Society,* October 18–20, 1984, Nashville, Tenn. Contact: American Physical Society, 335 E. 45th St., New York, NY 10017 USA.

*Clinical Radiophysics,* a symposium sponsored by the Clinical Radiophysics Section of the Society for Medical Radiology of the German Democratic Republic, October 28–November 1, 1984, Binz (island Rügen, German Democratic Republic). Contact: Dr. sc. techn. Manfred Tautz, 1115 Berlin-Buch, Wiltbergstrasse 50, Städtisches Klinikum Buch, Spezialabteilung Strahlenphpysik, German Democratic Republic.

*International Symposium on the Implementation of the IAEA Codes of Practice and Safety Guides for Nuclear Power Plants,* October 29–November 2, 1984. Contact: Conf. Svc. Sect., IAEA, P.O. Box 100, A-1400 Vienna, Austria.

**November 1984**

*Joint Meeting of the American Nuclear Society, the Atomic Industrial Forum, and the European Nuclear Society,* November 11–16, 1984, Washington. Contact: George W. Cunningham, Nuclear Studies, Mitre Corp., 1820 Dolley Madison Blvd., McLean, Virginia 22102 USA.

*International Symposium on Assessment of Radioactive Contamination in Man,* November 19–23, 1984, Paris, sponsored by the International Atomic Energy Agency. Contact: Conf. Svc. Sect., IAEA, P.O. Box 100, A-1400 Vienna, Austria.

*Conference on Radioactive Waste Management,* November 27–29, 1984, London, sponsored by the British Nuclear Energy Society. Contact: The Secretariat, British Nuclear Energy Society, at the Institution of Civil Engineers, 1-7 Great George St., London SWIP 3AA, UK.

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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 22161.

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