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INMM

NUCLEAR MATERIALS MANAGEMENT

Vol. VII, No. 2
Summer 1978

TECHNICAL CONTENT

JOURNAL OF THE INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

EDITORIAL

Are You Provoked?

By W.A. Higinbotham
Brookhaven National Laboratory
Upton, Long Island, N.Y.

Writing editorials for this Journal is like spitting from the top of the Empire State Building; you don't hear it hit, or get any praise or complaints. A few friends have commented approvingly on an editorial or two, but no one has written an angry letter, which suggests that almost no one reads this column, or that it is too bland.

Under these circumstances, I propose a challenge to our select readership. In the following I will describe some of the things which I read in the papers, in more serious publications, or have run into lately. My fond hope is that this will provoke the rest of you who are involved in nuclear safeguards, and read about it, and think about it, to take over the responsibility for contributing the editorials, project reviews, and provoking commentary.

At the end of last summer, the International Nuclear Fuel Cycle Evaluation (INFCE) got off to a shaky start and the U.S. and Japan arrived at a compromise for operation of the reprocessing plant at Tokai-Mura. At about the same time, the Congress passed the ERDA appropriation bill with a rider, requiring ERDA to make an evaluation of how the Barnwell reprocessing plant might be utilized in support of the U.S. non-proliferation policy, and appropriating $1 million for a six-month study. I'll take these up in reverse order.

The Congressional request to ERDA asked for: (1) an evaluation of how Barnwell might be utilized to assess international or multinational reprocessing arrangements; (2) an evaluation of how it might be utilized to test or to evaluate alternative operational modes; (3) an evaluation of how it might be employed to assist the IAEA; (4) how it might be utilized to test and to demonstrate advanced safeguards techniques; (5) a discussion of the relation of any activities proposed for Barnwell to safeguards exercises at Tokai-Mura or Windscale; and (6) a discussion of whether and how the U.S. Government might take-over the Barnwell facility.

The questions were not too difficult to answer. To spend the $1 million in six months was more of a problem. The report was delivered on schedule, on April Fool's Day, by means of an incredible amount of effort on the part of a few technical people, and much last minute re-editing by policy types. The executive summary and the main report (Vol. 1) are pretty bland. The conclusions are that you can study institutional alternatives regardless of Barnwell; that alternative fuel cycles could not be tested in time for INFCE; that while IAEA or other safeguards experiments could be performed, that nothing should be undertaken which might in any way suggest that the U.S. might consider reprocessing. Moth-balling or dismanteling of Barnwell were discussed, but no mention of any Governmental responsibility. A reference to Tokai and Windscale

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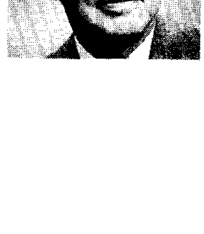

Dr. Higinbotham

Composition
K-State Printing Service
Kedzie Hall
Manhattan, Kansas 66506

NUCLEAR MATERIALS MANAGEMENT is published four times a year, three regular issues and a proceedings of the annual meeting of the Institute of Nuclear Materials Management, Inc. Official headquarters of INMM: Mr. V. J. DeVito, INMM Secretary, Goodyear Atomic Corp., P.O. Box 628, Piketon OH 45661. Phone: 614-289-2331, Ext. 2182 or FTS 975-2182.

Subscription rates: annual (domestic), $30; annual (Canada and Mexico), $40; annual (Other Countries), $50 (shipped via air mail printed matter); single copy regular issues published in spring, summer, fall and winter (domestic), $9; single copy regular issue (foreign), $11; single copy of the proceedings of annual meeting (domestic), $20; and single copy of proceedings (foreign), $35. Mail subscription requests to NUCLEAR MATERIALS MANAGEMENT, Journal of INMM, Kansas State Universty, 20 Seaton Hall, Manhattan, KS USA 66506. Make checks payable to INMM, Inc.

Inquiries about distribution and delivery of **NUCLEAR MATERIALS MANAGEMENT** and requests for changes of address should be directed to the above address in Manhattan, Kan. Allow six weeks for a change of address to be implemented. Phone number of the I.N.M.M. Publications and Editorial Office: Area Code 913-532-5837.

Inquiries regarding INMM membership should be directed to Mr. V. J. DeVito, INMM Secretary, Goodyear Atomic Corp., P.O. Box 628, Piketon OH 45661.

Third-class postage paid at Manhattan, Kansas 66506.

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INMM In Its 21st Year: Proud Past; Challenging Future

By G. Robert Keepin
INMM Chairman
Los Alamos Scientific Laboratory
Los Alamos, New Mexico

A recent League of Women Voters Newsletter carries the catchy slogan "You've come a long way baby, ... but we ain't there yet." This sentiment also seems in many ways appropriate to the INMM as we enter our third decade of service.

Our very memorable 20th Anniversary meeting in Cincinnati certainly did provide a fitting occasion to take stock of the Institute's track record of accomplishments and service over the years. Despite all the uncertainty and turmoil that has beset the nuclear industry, the INMM has grown and prospered. And in just the past year or so, we've seen our specific area of professional activity thrust into prominence as a major issue in nuclear energy policy and planning in the United States and, through INFCE, in several other countries of the world.

At this time of transition, it is important for all of us in the INMM not only to look back, but also to look ahead to the goals, challenges and future directions of our Institute. To help in this important task, the "INMM Member Interest Questionnaire" was distributed to all members who attended the Cincinnati meeting, and has been mailed to all other members who could not be with us in Cincinnati. This "full scope" questionnaire covers the complete range of Institute activities, organization, administration, future directions, membership interests and participation. A number of important questions bearing on policy, organizational and procedural alternatives are raised for individual member consideration—and the resulting choices can greatly influence the future course of the Institute. This in-depth questionnaire—which was very thoughtfully developed by **Dennis Wilson**—provides for either anonymous or identified response, with further provision for direct personal reply from INMM on any specific topic, if such is requested by the respondent. Clearly, it is very important for each member of the INMM to take time to complete and return this questionnaire as the results will form the basis for planning future goals, directions, and activities of the Institute.

The basic objectives of the INMM, as set forth in our Constitution, are to further the advancement of all aspects of nuclear materials management, safeguards and security; to promote R&D, including standards development and application, in the field of nuclear materials management; to develop and improve the professional qualifications and effectiveness of those engaged in nuclear materials management; to increase and disseminate knowledge in the field—to both practitioner and layman alike; and to foster and promote professional interaction and cooperation among materials managers at all levels of activity—local, national and international.

While significant progress has been made in each of these broad areas, there is clearly much that remains to be done. In the vital area of consensus standards development, the Institute has achieved, over the years, a very impressive track record despite occasional problems of coordination, some endorsement difficulties, and a recent dry spell in published standards. The INMM N-15 Standards writing activity is currently expanding its efforts, with the nine N-15 Standards Committees having held some twenty working sessions at Cincinnati and producing some 8 draft standards in final or near-final form, most of which are expected to be ready for balloting in the fall. The Institute has achieved an excellent record of N-15 Standards work under the very able leadership of **John Jaech** during the past four years. As John will be taking on the heavy responsibilities associated with his new appointment as INMM Program Chairman, **Dennis Bishop** who has been chairman of INMM-9, will now chair our N 15 Standards Committee; this vital work of the Institute will need our full support, both collectively and individually as participants in INMM standards writing activities in our respective areas of special knowledge and expertise.

In the closely related areas of Education and Certification, there is a clearly recognized need for formal training and recognition of nuclear materials specialists at both the professional and the para-professional levels. Efforts are underway to address both these needs—in the first instance through formal training and certification of professional qualification criteria in three categories: (1) Nuclear Material Measurement; (2) Material Control and Accounting; and, (3) Physical Security and Protection. At the para-professional level, a

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Dr. Keepin

ANSI Standards Explained

By John L. Jaech, Chairman
Exxon Nuclear Co., Inc.
Richland, Washington

Note from Author: This is my last article as N 15 chairman. Effective July 1, 1978, **Dennis M. Bishop** (General Electric—San Jose) became Chairman of N 15. I wish to thank all subcommittee chairmen and members of the writing groups for their cooperation and efforts during my tenure as Chairman—**John L. Jaech.**

Those of us in the INMM family who have in the past and/or are currently involved in standards activities sometimes get so involved in our own standards that we lose sight of how our standards fit into the larger picture. Some background information may be helpful.

A standard has been defined as "a prescribed set of conditions and requirements, usually in the form of a document, established by custom, general consent or authority aimed at promotion of optimum benefits and intended to satisfy recurring or anticipated needs." There are about 25,000 nationally recognized standards, and about 5,000 international standards.

Five purposes of a standard have been identified.

1) To establish recognized levels of quality, performance, and safety

2) To help reduce misunderstandings between producers and users

3) To provide a rational basis for contracts

4) To simplify procurement and repair by providing interchangeable parts and sizes

5) To increase opportunities for trade

Obviously, not all of the purposes apply to each standard. For the most part, N15 standards are related to purpose 1.

ANSI standards are prepared by volunteers, are approved by consensus of balanced interests, and are invoked voluntarily by contract or incorporated in government regulations. Sometimes there is misunderstanding as to what is meant by **consensus** approval. This means that a substantial agreement has been reached by concerned interests according to the judgment of a duly appointed authority. It implies that all dissenting viewpoints have been considered and that an objective effort has been made toward their resolution. Although consensus approval does not necessarily mean unanimity, it does imply much more than a simple majority. The exact requirements, however, are not specified, except that individual standards writing bodies may set their own requirements. In N15, for example, we call informally for an 80 per cent majority within N15 before proceeding further and may withdraw a proposed standard even without this 80 per cent agreement depending on circumstances.

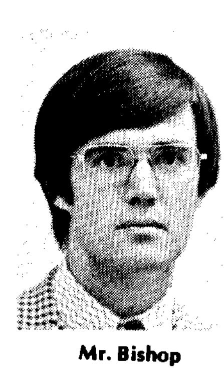
Historically, standards development in the USA goes back to 1898 when ASTM organized for "the development of standards on characteristics and performance of materials, products, systems, and services." In 1911, ASME established a committee "for the purpose of formulating standard rules for the construction of steam boilers and other pressure vessels." Since then, about 50 professional societies started preparing standards, thus necessitating some coordination of effort. In 1918, the American Engineering Standards Committee formed and, in 1928, it was expanded and renamed the American Standards Association. This was reorganized and renamed the American National Standards Institute (ANSI) in 1966.

ANSI, headquartered in New York City, is a federation of standards developers and users. It includes about 900 companies, 200 trade, technical, scientific, professional, labor, and consumer organizations. There are other groups that impact on ANSI even though not members. INMM, as a society, for example, participates through N15 in writing standards for ANSI approval but INMM is not a member of ANSI.

Within ANSI, there are 18 Standards Management Boards. One of these is Nuclear (NSMB). The NSMB consists of 20 voting members and 33 information members. It is responsible for 25 consensus bodies, 16 N committees (including N15), and 9 ASME subcommittees. Currently, about 700 projects are under NSMB supervision. These involve about 8,000 volunteer participants.

I hope this background information is helpful in providing some of the motivation needed to maintain our commendable track record as a standards writing organization. I am grateful to **Roy E. Tomlinson** of Exxon Nuclear Company, Inc. for providing me with much of the above background information. Mr. Tomlinson is a member of N46, Chairman of N48, member of ANS Standards Steering Committee, and Head of the U.S. Delegation of ISO TC85/SC5.

Mr. Jaech



Mr. Bishop

Regular Column Initiated

By James E. Lovett
INMM Past Chairman
Vienna, Austria

Some months ago, I chanced to make the offhand suggestion that it might be desirable to include in **NUCLEAR MATERIALS MANAGEMENT** a column reporting on activities by INMM members in Europe, or events of possible interest to European members. As it turned out, it was decided that regular input from the Institute's growing constituency in Europe was a good idea, and so, "Perspectives from Europe" is being initiated with this issue as a regular feature of the INMM journal.

The first thing to report, I think, is the growth of INMM in Europe. Total European membership is now 46 according to the latest membership list I have, with only 11 being Americans who brought their membership with them. Indeed, only 16 of those 46 are in Vienna. Where are the rest? Karlsruhe, Julich, Ispra, various facilities in the U.K., wherever there is a safeguards-related nuclear activity in Europe there is an INMM member.

I have no figures at hand regarding INMM membership in Europe say five years ago, but I do recall that in 1975 I argued that a European (or indeed, any non-American) who felt that he had done publishable work in the safeguards field had only limited possibilities for publication. A few weeks ago I argued that the INMM Journal "was generally known and generally available," and that the IAEA need not and should not re-publish material already accepted for publication by the INMM.

Part of the explanation for this growth, of course, is the INMM Journal itself. Why should anyone not resident in the U.S. belong to the INMM? Certainly not for the $5 differential in attending meetings. It's a small sum anyway, and it completely disappears in the $1000 cost of crossing the Atlantic for a three day meeting. To be sure there are altruistic reasons, professional pride, etc., but the prime attraction is the Journal. The growth of INMM in Europe exactly parallels the growth of the INMM Journal as a professional quality technical periodical, and the correlation is not coincidental.

What then are European INMM Members doing? I will only attempt to give some general answers this issue, and hope that my colleagues will help me out by volunteering material which they think might appropriately be included in subsequent issues.

First, European INMM members are busily writing papers for the IAEA symposium, **"International Safeguards Technology—1978"** to be held in Vienna from 2 to 6 October. IAEA safeguards symposia have in the past been scheduled at five year intervals, and I had thought that by advancing the schedule two years I could reduce the quantity of reportable work accomplished, and correspondingly reduce the number of papers submitted. I was wrong. The total number of papers submitted in 1975 was 110. The total number of papers submitted this year **so far** is 129, and I am aware of perhaps 10 late submissions. Since there are always a couple of totally unexpected late submissions, the final total undoubtedly will exceed 140. U.S. submissions are slightly below the 1975 level, undoubtedly at least partly due to the current emphasis on physical security measures in the U.S., but world-wide interest in international safeguards technology has never been higher.

Some European INMM members are busy with the many INFCE **(International Nuclear Fuel Cycle Evaluation)** subgroups. For most groups the first phase was questionnaire writing, and now the second phase, questionnaire answering, is in full swing. I made one prediction, that INFCE would come out solidly against proliferation and for safeguards, but I think I had better leave the crystal ball gazing alone. Most of the groups plan to start drafting reports late in 1978, those early drafts should give some insight into what the final reports will say and how hard the fights will be.

Any report on safeguards activities in Europe really should include a report on ESARDA, the **European Safeguards Research and Development Association.** Unfortunately, my efforts to obtain a report on ESARDA from someone "inside" have so far not been successful. Hopefully one can be included in the next issue.

Mr. Lovett

Need for Formal Training

By Dr. Frederick Forscher, Chairman
INMM Certification Committee
Pittsburgh, Pennsylvania

It is clear to all informed people that, irrespective of what safeguards system—domestically or worldwide—is finally agreed upon and implemented by the various national and international regulatory bodies, all depend in the final analysis on the competence, experience and motivation of the individuals in industry and government, who are charged with its execution.

The INMM has recognized for years the need for professional recognition. We are trying to formalize the process of certification by establishing professional qualification criteria in three categories:

a. Material Measurement and Accounting Specialist.

b. Material Control and Protection Specialist.

c. Material Protection and Security Specialist.

It is recognized that there is a certain overlap in the subject matter of these specialties.

With a growing demand for qualified people, there is also the growing need for institutions of higher learning that provide the necessary professional training for nuclear material specialists. This training is not yet forthcoming. Yet, the subject matter of interest can be found in well defined academic disciplines such as statistics, chemistry, accounting, engineering, instrumentation, metrication, materials handling, police and security work.

I have made an informal survey of nuclear engineering departments in American universities and reached the following conclusions:

1. There is general awareness by the Department Heads that this problem exists, and that the need is real.

2. There is no generally accepted curriculum, no way of accreditation, no texts books, and not enough instructors.

3. Universities, in general, are in difficult financial positions. I heard suggestions for seed money for curriculum development, instructors and lecturers, text books, etc.

In this connection we face the old chicken-and-egg routine. If government agencies would 'require' professional training and certification, this could possibly provide sufficient financial incentive for a 'safeguards option' in one or two nuclear engineering departments. However, such requirement will only be formalized if a sufficient number of 'qualified' people are available. And without formal training this will not come about.

In order to break this deadlock the following actions should be considered:

1. An intensive teacher's training course to be offered jointly by DOE/NRC/NBS. Each interested academic institution could send one or two qualified instructors to be indoctrinated. This would be free of charge, and could even be subsidized as far as living expenses is concerned. Participating Universities would have to commit themselves to offer a "Safeguards Option" within a year after completion of this training course.

2. The subject matter for this curriculum would reflect all the subjects that the INMM professional requirements demand. The detailed course content would yet have to be worked out by a task force of DSS/NRC/NBS personnel. This should not be too difficult with the groundwork provided by the INMM Certification Committee. Advantage should be taken of ongoing "formal training" in this area by INMM Safeguards courses, LASL, ANL, BMI, University of Idaho, etc.

3. Another major input to this curriculum could be expected to come from the IAEA; possibly via ISPO at BNL, or ACDA. While it is not recommended to have foreign nationals attend the intensive training course (Item 1) it is clear that such attendance would be encouraged at the Universities themselves. It is expected that the Washington, DC area universities would be most interested and the first to offer Safeguards options in their curriculum.

4. A variation to Item 1. Instead of concentrating on academic nuclear engineering departments across the country, one could invite police academies, military command schools and institutions specializing in industrial security. The rationale for this is as follows. In many respects Safeguards is a protective institution of society, in the sense that law enforcement, fire protection, and the national defense establishments are protective institutions. On this basis, one could call on the schools that train our professionals for the military, police and industrial security. This approach would, perhaps, make it a bit more difficult to open it to the international community.

In the next issue of the Journal, we shall report the responses from DOE, NRC, NBS and others to this initiative.

Dr. Forscher

Breadth Unequaled

By Harley L. Toy, Chairman
INMM Education Committee
Battelle Columbus Laboratories
Columbus, Ohio

The spring edition of **John Jaech's** "Selected Topics in Statistical Methods for SNM Control" was presented to thirteen attendees at Battelle's Columbus Laboratories the week of May 22. All responses from "course evaluation questionnaires" proved once again that the course is most beneficial, relevant, and fulfills specific needs in current and future statistical data analysis programs. This reinforces our plans to continue John's course on a spring and fall schedule. We are still considering plans for presentation of a one- or two-day statistics seminar for non-statisticians in managerial positions. Such a mini-seminar could be held in conjunction with our annual meeting.

Your Education Committee will be meeting in Cincinnati to finalize the educational program for the coming fiscal year. The following members of the Education Committee will be attending this meeting: **Dick Chanda,** Rocky Flats; **Jim Patterson,** NRC Region III; and **Vince DeVito,** Goodyear Atomic. Items to be discussed and resolved at this meeting include:

- Review of results of current programs
- Coordination of plans with NRC and DOE
- Resolve physical security training program
- Review Dr. **Fred Forscher's** academic program relative to certification
- Feasibility of topical educational programs

As noted in Fred Forscher's Certification Report in this issue, "in the final analysis the effectiveness of any safeguards program depends upon the **competence, experience,** and **motivation** of the individuals charged with its execution." This essentially sums up the significant role education and training plays in the domestic and international safeguards arena. This education and training will necessarily evolve from a number of sources: Industry, Academic, Federal Agencies, and Professional Societies. The INMM is confident that we can and will make a contribution in the training and education of qualified individuals charged with implementing the safeguards program. Financially our resources may be limited, but the breadth of our knowledge and experience in nuclear materials management and safeguards is unequaled.

Look forward to an exceptional meeting in Cincinnati.

Plans are underway to offer the INMM course, "Selected Topics in Statistical Methods for SNM Control," this fall according to the Institute's education chairman, Mr. Marley L. Toy (standing left) of Battelle Columbus Laboratories. The course, taught by John L. Jaech (seated fourth from left) of Exxon Nuclear Co., Inc., Richland, Wash., was attended by 13 persons May 22-26 at Battelle Columbus. Seated from Left: Willard D. Altman, USNRC Hqs.; Daniel J. Holody, USNRC Region I; D. Loucetta Rathgens, National Lead Co. of Ohio; Mr. Jaech; Mary A. Bates, B&W; Nicholas J. Roberts, UC, LLL; and Laura Johnson, Union Carbide. Standing from Left: Mr. Toy; John Gonzalez, LASL; John Sanborn, Brookhaven National Laboratory; Darrell A. Huff, USNRC Hqs.; Cliff Rudy, Mound Laboratory; Kenneth W. Foster, Mound Laboratory; Loren E. Shuler, Rockwell International; Frank Shu, General Electric; and Lavella Adkins, Battelle Columbus (Secretary to Mr. Toy).

Total for Year Reaches 91

By James W. Lee, Chairman
INMM Membership Committee
North Palm Beach, Florida

The Membership Committee of INMM is pleased to report that as of June 1, 1978 the total of new members in the Institute since July 1 has reached 91.

The following categories of membership employers were represented:

- Corporate Membership 1
- Government and Government Contractors 39
- Industry 25
- Utilities 1
- Foreign 25

A new procedure for acknowledging applications from prospective members has been set up. Each new member receives a letter from the Chairman of the Membership Committee together with a Membership Card, Constitution and By-Laws, Membership Directory, membership materials for his or her files, and any Publications (Proceedings, issues of the *Nuclear Materials Management* and special reports) which he or she is entitled to receive.

Members of the Membership Committee are **Vincent J. DeVito,** Goodyear Atomic Corp., Piketon, Ohio; **Edward Owings,** ORNL Y-12 Plant, Oak Ridge, Tenn.; and **James R. Patterson,** U.S. NRC, Safeguards Branch, Region III, Glen Ellyn, Ill.

New Members

The following 21 individuals have been accepted for INMM membership as of June 1, 1978. To each, the INMM Executive Committee extends its welcome and congratulations.

New members not mentioned in this issue will be listed in the Fall, 1978 issue (Volume VII, No. 3) to be sent out November 1, 1978.

Steven W. Combs, Statistician, Union Carbide Y-12 Plant, Oak Ridge, TN 37830.

James P. Crane, Director, U.S. Department of Energy, P.O. Box 5400, Albuquerque, NM 87115.

Joseph R. Dettorre, Group Manager, Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201.

W.T. Dickenson, E.I. DuPont, Savannah River Plant, Aiken, SC 29801.

Robert J. Gregg, Manager, Quality Assurance, United Nuclear Corp., Wood River Junction, RI 02894.

Luciano Guitierrez, U.S. Department of Energy, P.O. Box 5400, Albuquerque, NM 87115.

Robert A. Harris, Statistician, U.S. Department of Energy, Oak Ridge Operations Office, P.O. Box E, Oak Ridge, TN 37830.

Mark H. Killinger, Battelle Memorial Institute, Battelle Human Affairs Research Center, 4000 N.E. 41st Street, Seattle, WA 98105.

Erwin Ulrich Kotte, Safeguards Systems Analyst, International Atomic Energy Agency, P.O. Box 645, A-1011 Vienna, Austria.

Harry C. Linton, Jr., Accountant, Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201.

William T. Mee, Department Head, NMS & DYMCAS, Union Carbide Corp., Nuclear Division, P.O. Box Y, Oak Ridge, TN 37830.

Stanley T. Mrus, Burns Industrial Services Corp., P.O. Box 663, Paramus, NJ 07652.

Dr. Leonard J. Nugent, National Sales Manager, Nuclear Enterprises, Inc., 931 Terminal Way, San Carlos, CA 94070.

Dr. James R. Phillips, Staff Member, Nuclear Safeguards Program, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

H. Carreira Pich, Deputy Director, Junta De Energia Nuclear, Av. Da Republica 45-5.° Esq., Lisboa, Portugal.

Barry L. Rich, Manager, Nuclear Support, TRW Energy Systems Planning Div., 7600 Colshire Drive, McLean, VA 22101.

Dr. Nora G. Smiriga (L-310), Lawrence Livermore Laboratory, P.O. Box 808, Livermore, CA 94550.

Gregory C. Smith, Safeguards Auditor, U.S. Nuclear Regulatory Commission, 631 Park Avenue, King of Prussia, PA 19406.

Eddie M. Stone, Union Carbide Corp. Nuclear Division, P.O. Box P, Oak Ridge, TN 37830.

Mr. Lee

Kouts Elected to National Academy

Dr. **Herbert J.C. Kouts,** Chairman of the Department of Nuclear Energy at Brookhaven National Laboratory, Upton, N.Y., has been elected to the National Academy of Engineering. He was cited for his "contributions in nuclear engineering, especially physical principles and safety of nuclear power reactors and **nuclear material safeguards.**"

Election to the Academy is the highest professional distinction that can be conferred on an engineer and honors those who have made important contributions to engineering theory and practice, or who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology.

When Kouts, a physicist, came to BNL in 1950, he started a series of measurements on the effects of voids and channels on radiation penetration through shields. Soon thereafter, he formed the Experimental Reactor Physics Group and was responsible for an extended program of reactor physics measurements which continued until 1969. These bench mark measurements provided a basis for developing, confirming, and improving analytical models which are necessary for the design and operation of nuclear power reactors. The critical and sub-critical experiments involved Uranium-233, 235, 238, thorium and plutonium in a wide range of rod sizes and isotopic enrichment; with graphite, water, and heavy water moderation. They provided integral data on buckling, fast fission effects, resonance and thermal neutron capture, and slowing down and diffusion parameters. Definitive results of these experiments are still in demand by the designers of present-day nuclear power reactors, as well as advanced U^{233}-thorium reactors. In addition, Kouts was responsible for critical experiments that preceded the design and construction of the High Flux Beam Reactor and the Brookhave Medical Research Reactor.

In 1968, Kouts and others at Brookhaven recognized the importance of establishing a credible system for safeguarding of nuclear materials in the peaceful uses of atomic energy. This new activity was organized in the Department of Applied Science as the Technical Support Organization. The name chosen indicated that this group would be concerned with the technical aspects of safeguarding nuclear material and that it would work principally as an advisory body to the responsible government officials. Again, as was the case with reactor criticals, Kouts established a comprehensive, scientifically sound program which is still used as the basic guide for continuing research in this field.

In 1973, **Dixy Lee Ray,** Chairman of the Atomic Energy Commission, determined to establish a nuclear reactor safety program which would be independent of the developmental and promotional aspects of reactor development. Kouts was chosen to head this activity within the Atomic Energy Commission where he successfully established a comprehensive program of nuclear safety. Later he became the first Director of Nuclear Regulatory Research in the Nuclear Regulatory Commission when the responsibility for safety research was transferred to that agency. The research conducted in these programs covered all aspects of nuclear power safety.

On his return from Washington in 1976, Kouts was appointed head of the Brookhaven Fusion Energy Project, an interdepartmental effort initiated to coordinate the Laboratory's programs in this area. In October 1, 1977, he was named chairman of the newly created Department of Nuclear Energy.

Other recognition of his work has included the AEC Distinguished Service Award in 1975 and the **E.O. Lawrence** Award in 1963.

Dr. Kouts

Jennie Lee Tischhauser, Staff Member, Sandia Laboratories, P.O. Box 5800, Org. 3414, Albuquerque, NM 87123.

Mohamed Mahmoud Yousif, Safeguards Officer, International Atomic Energy Agency, Karntnerring 11, 1010 Wien, Austria.

Address Changes

The following seven changes of address have been received as of June 1, 1978 by the INMM Publications Office (Phone: 913/532-5837) at Kansas State University, Seaton Hall, Manhattan, Kansas 66506.

Mr. Clinton P. Dorriss, Rural Rt. #1, P.O. Box 5246, Richland, WA 99352.

Dr. Rudolf Hass, Principal Administrator, Commission of the European Communities, Bld. Jean Monnet A3066, Kirchberg, Luxembourg.

Mr. Paul N. McCreery, NL Industries, Inc., P.O. Box 928, Barnwell, SC 29812.

Mr. Ray Mulkin, 54 Lomas Del Escolar, Los Alamos, NM 87544.

Mr. Louis J. Swallow, 12546 Cinema Lane, St. Louis, MO 63127.

Mr. W. Bruce Taylor, 8103 Eastern Ave. #B-307, Silver Spring, MD 20910.

Mr. Tom C. Westmoreland, P.O. Box 35622, Tulsa, OK 74135.

Program Successful in First Year

By Francis A. O'Hara, Chairman
INMM Student Awards Committee
Battelle Columbus Laboratories
Columbus, Ohio

The Student Awards Committee was established at the 19th Annual (Washington) Meeting for the purposes of (1) Promoting student activity in the area of nuclear material management and safeguards, (2) Rewarding accomplishments by students in these areas, and (3) Stimulating student interest in the Institute.

As a means of accomplishing these objectives, it was proposed to conduct a student paper competition. The winning paper in the competition would be presented at the Annual Meeting and a cash award given. Members of the Committee, in addition to the Chairman, include Mr. **Bernard Gessiness** and Dr. **W.A. Higinbotham.**

Shortly after the first of the year, the Committee sent letters to the Chairman of Nuclear Engineering Departments at approximately 70 schools throughout the country.

This letter announced the Award Program and the competition for the 1978 Meeting, and provided the information and specifications for entries. Department heads were asked to forward the information to other potentially interested departments in their university and encouraged to recommend topics in nuclear materials management for future student research.

Two entries were received in the 1978 competition and reviewed by the Committee: (1) "Analyzing the Reprocessing Decision: Plutonium Recycle and Nuclear Proliferation"; and "Differences in Licensee-Contractor Requirements for the Control of Special Nuclear Materials." One had been the product of a masters degree program and the other the result of doctoral research.

The winner of the 1978, 20th Annual Meeting competition was determined by the Committee to be: Ms. Carolyn Heising, Department of Mechanical Engineering, Stanford University.

Ms. Heising's paper "Analyzing the Reprocessing Decision: Plutonium Recycle and Nuclear Proliferation" was presented at the Annual Meeting June 28. She was awarded a plaque acknowledging her achievement and presented a check for $500. In addition, the Institute paid the cost of her attendance at the meeting. Publicity was planned with an announcement and article sent to appropriate media.

The Student Award Program appears to have been successful. It has made universities more aware of the Institute and rewarded students for their achievement in the areas of nuclear materials management. The first winner expects a long and fruitful association with the Institute. More time will be required for this competition to result in significant research activity in nuclear materials management, but it is felt that this Program will be a vehicle toward this end.

Recommendations for the future are: (1) Publicity concerning the presentation of the award, (2) An early follow-up letter to NE department heads, (3) Development of a more extensive list of correspondence, and (4) An earlier announcement for next year's competition (sometime in the early fall).

Dr. O'Hara

Another Viewpoint—The Next 20 Years

By John Ladesich
Southern California Edison
Rosemead, California

The Institute of Nuclear Materials Management is celebrating its 20th anniversary this year and it seems appropriate to make some comment in this regard and to contemplate what is in store for the future. Over the years, the Institute has maintained a consistent objective, which is to provide a professional forum through which persons interested in the field of nuclear materials management and safeguards can express their views, interests and accomplishments. The Institute has done this and has sustained a steady growth to several hundred members culminating last year to the establishment of its first international chapter in Japan.

In April of 1977, when **President Carter** announced his controversial nuclear nonproliferation policy, he indirectly gave a significant boost in professional standing for nuclear materials management. President Carter's concern over nuclear proliferation and his desire to limit the spread of nuclear weapons brought to the forefront the importance of the work being done by many members of the Institute. His policy not only enhanced the work on a domestic basis, but on an international basis it also gave tremendous support to the IAEA and other foreign institutions. However, his moratorium on reprocessing and recycle of spent fuel from power reactors has opened up new avenues of concern to the industry. The nuclear opponents have taken advantage of the situation and raised many issues regarding the safeguards, transportation, interim storage and permanent disposal of radioactive waste. These issues are presently the center of a very intense debate and the public's interest is in obtaining an answer to the question, What assurance do we have of proper safeguards for our health and safety? The Institute will play a very, very important role in providing the answers. There are, however, a few other problems which must be overcome.

The utility industry has been the driving force for commercialization of the nuclear power industry. But what has happened? On the domestic scene, it has been over two years since the last order was placed for a nuclear power plant. On the international scene, there have been a few new orders placed by countries ignoring the President's policy. Projections for the growth of nuclear power in the United States which have become steadily more pessimistic show a continual decline in the future installed nuclear capacity. The most recent forecast by the Department of Energy uses as a reference case 111 GWe by the year 1985, 197 GWe by the year 1990, and only 380 GWe in the year 2000. Not too long ago, the forecasted installed capacity for the year 1980 was 180 GWe and well over 1000 GWe for the year 2000. This substantial decline in the forecasted growth coupled with the almost religious zeal that opponents of nuclear power have been promoting alternate "soft" energy resources, such as solar, wind and geothermal, is shaking the confidence of the professional people as to the future potential for personal career growth in the industry. By this I mean that I believe the industry will have a very difficult time to attract new, young, highly qualified individuals to carry on the work of those professionals who founded the industry. Unless we can find the incentive for future career growth, we may not find sufficient people to do the job in the future. The Institute appears to be in a paradoxical situation, wherein the future of the nuclear industry, in the U.S. at least, is waning, while the need for highly qualified nuclear materials managers in safeguards and accountability is increasing rapidly.

The atmosphere under which the nuclear industry is presently existing and the competition it is receiving from the glamour "soft" energy resources will make it exceedingly difficult to attract college students into the nuclear field. Therefore, we should be expecting a shortage of qualified persons in the near future. It appears that the nuclear materials managers of today who have worked so diligently to develop the industry have another great challenge before them: how to maintain par excellence in the profession under the pressure of increasing responsibility and accountability without adequate assistance. The next 20 years will certainly be equally or more interesting than the last 20 years.

Mr. Ladesich

International Arrangements for Nuclear Fuel Reprocessing, edited by Abram Chayes and W. Bennett Lewis, Ballinger, Boston, 245 pp., 1977

By William A. Higinbotham
Brookhaven National Laboratory
Upton, Long Island, N.Y.

King Arthur called in his scientists and said: "You got us into this mess, now find a way out." So the scientists organized studies, and two years later reported that there was no technical fix to the proliferation of bows and arrows. However, there was an institutional fix. The technology would be protected and all those who swore to use bows and arrows only for hunting would be invited to participate in an international B&A center to produce bows and arrows and to lease them only for peaceful purposes. However, others reinvented bows and arrows, and King Arthur and his neighbors were never able to agree on where the I.B.A.C. should be located.

Inspired by Candidate **Jimmy Carter's** commitment to cope with nuclear weapons proliferation, the **Pugwash Organization** arranged for a group of interested and knowledgeable people to discuss the subject of multinational or international nuclear fuel centers in the comfortable and secluded retreat named **Wingspread,** near Racine, Wisc., designed by **Frank Lloyd Wright.**

Several of the contributors now have responsible positions related to the International Nuclear Fuel Cycle Evaluation discussions on nuclear resources, nuclear fuel cycles, and proliferation: Prof. **Albert Carnesale** of Harvard, presently head of the US-INFCE team; Prof. **Lawrence Scheinman** (Cornell), special assistant to **Joseph Nye** in the State Dept.; and Prof. **Ted Greenwood** (M.I.T.), on loan to the President's Science Advisor.

It is comforting to know that the subject of international centers, which a lot of people appear to believe to be simple to establish and automatically reliable, has been carefully considered. This volume shows that establishment of even a minor multinational nuclear center will be quite an exercise, and that the ability of such institutions to defer proliferation depends on a lot of things.

Chapter 1, by **George Rathjens** of M.I.T. and Carnesale describes the connection between nuclear energy programs and proliferation, rationally and dispassionately, noting for example that the independent, dedicated facility route is not only possible, but could be the preferred route in some cases. I just can't summarize this excellent article in a few words. Everyone contributing to INFCE should read this as well as those who suspect that the Administration has lost its senses. I can't resist quoting the last paragraph:

"Although this paper has focussed primarily on the technical and economic factors relating the nuclear fuel cycle to the proliferation of nuclear weapons, it is clear that the proliferation problem is fundamentally a political one. Searches for a solution in the form of a "technical fix" or an "irresistible economic inducement" are bound to end in failure. If a solution exists, it undoubtedly is a concoction of technical, economic, and political ingredients. Among the tests that must be applied to any proposed solution are:

"1. Would it retard (or at least not accelerate) the spread of technologies for the production of nuclear weapons?

"2. Would it lengthen (or at least not shorten) the time required from the decision to acquire a weapons capability to the achievement of that capability?

"3. Would it raise (or at least not lower) the threshold of the decision to acquire a nuclear weapons capability?

"4. Would it decrease (or at least not increase) the dangers of theft and sabotage?

5. Would it support (or at least not undermine) other efforts to halt the spread of nuclear weapons, such as increasing incentives to subscribe to the NPT, strengthening the safeguards effort of the IAEA, negotiating among the supplier nations agreed restrictions on exports, establishing nuclear free zones, and pursuing a comprehensive test ban?"

Ted Greenwood discusses briefly the incentives and disincentives for other nations to undertake or make use of reprocessing. The economic considerations on reprocessing are presented by **S.R. Hatcher** and **W.W. Morgan** of AECL, who may be less suspect than U.S. analysts of this subject. Scheinman has studied and written on proliferation issues and the IAEA for a number of years. His chapter on safeguards of reprocessing plants by the IAEA or at multinational centers is fine—but too short.

The problems to be faced in negotiating and implementing constructive multi-national reprocessing or more extensive nuclear centers are discussed in Chapter 8 (technical and operational considerations), Chapter 10 (physical security, esp. pp. 134-141), and Chapter 11 (institutional arrangements). Before anyone rushes off to advocate multinational centers, he should study these chapters and be prepared to explain his proposal in some detail.

I **am** in favor of such institutions, if they can be arranged, will be reasonably efficient, and provide discernible benefits to the parties involved and to the

(Continued on Page 16)

Dr. Higinbotham

BOOK REVIEW

Nuclear Proliferation and Safeguards, Report No. PB-275 843, Office of Technology Assessment of the U.S. Congress, Praeger Publishers, New York (June, 1977)

By Eugene V. Weinstock
Brookhaven National Laboratory
Upton, Long Island, N.Y.

Back in 1976, **Senators Ribicoff, Glenn, and Percy,** of the Senate Committee on Government Operations, requested that a comprehensive analysis of the issues involved in nuclear proliferation be prepared by the Office of Technology Assessment for Congress, to aid it in its deliberations on legislation related to this subject. OTA is, of course, Congress's own technical advisory agency, set up to provide Congress with expert technical analysis independent of the Executive branch.

The result is this report, in three fat volumes, two of them consisting of detailed appendices providing the (mostly) factual material on which the main report is based and written by various outside consultants (usually called "contractors" in government jargon, conjuring up a picture of a bunch of men in painters' overalls carrying stepladders), and by OTA staff members.

The report is written by a committee and shows every evidence of it. The individual chapters range from excellent to terrible. We will comment on the substance first and the style later.

The main report consists of ten chapters, each devoted to a specific subject, but with so much overlap that the overall effect is one of extreme repetitiousness; this effect is much increased by the bureaucratic custom of overloading all reports with introductions, summaries, and executive summaries at the front end, all saying pretty much the same thing, so that by the time you get to the main text everything has already been said three or four times.

Chapter I introduces the subject by giving a short history of past efforts to control proliferation, listing some of the broader issues, and defining the purpose of the present study, which is "not to recommend a particular perspective or policy, but to provide the reader with the tools for informed policy choice." It does, in fact, succeed in being reasonably impartial, although at the expense of seeming overly bland and accommodating to all points of view, but in no way does it provide a "tool" for choosing between policies, if by that is meant a systematic, objective, and reasonably rigorous method of analyzing and weighing alternatives and coming up with a demonstrably correct solution. In that respect it is no more successful than all the other, past studies of proliferation, and for the same reasons: the subject is too complex and fraught with uncertainty to lend itself to neat abstractions.

Chapter II, which is summary in nature, consists of a section entitled "Proliferation Issues and Findings" and that device so dear to the hearts of the so-called decision-makers in Washington, presumably too busy to read anything but bare conclusions, the "executive summary." The chapter is a mixed bag. The issues are presented in the form of twenty-four questions and their ostensible answers, as determined by the study. Unfortunately, most of the "answers" are as hedged as a stock-market newsletter and, consequently, useful more as a capsule elucidation of the issues than as a guide to action. A few questionable statements are made; for example, in a consideration of the feasibility of using commercial nuclear reactors as a source of weapons material it is suggested that the use of spent fuel "in a reactor" for that purpose would probably result in a loss of power, thus ignoring the availability of spent fuel in the reactor storage pool. Elsewhere it is maintained that the existence of a dedicated facility to support a large weapons program would be unlikely to escape detection, yet the existence of the diffusion plant that supplied the Chinese with U^{235} for their weapons program was unknown to us till **after** their first test. And what is one to make of the following answer to the question of whether a non-state adversary could design and construct a nuclear explosive: "given the weapons material and a fraction of a million dollars, a small group of people, none of whom ever had access to the classified literature, **could possibly** design and build a crude nuclear explosive device" (emphasis added)? The phrase "could possibly" covers such a wide spectrum of probabilities, from the infinitesimally small to the absolutely certain, as to be useless for assessing the **likelihood** of success, which is what a Congressman presumably most wants to know.

The executive summary covers much the same ground, but with fuller discussion. The description of the domestic and international safeguards systems are especially good and clearly written, as is an analysis of policy implications. Among the interesting points made in connection with domestic safeguards are that the question of a special federal guard force for nuclear materials should be reconsidered, that a gun-type weapon is roughly as difficult to build as an implosion type, and that the emphasis in a plant safeguards system should be on **delaying** attackers until stronger off-site forces can arrive. In the international area, the inadequacy of pure material accountancy and the need for greater reliance on surveillance and containment techniques are emphasized, and it is pointed out that attempting to safeguard an enrichment plant without full access to the cascade area is barely credible. (The exclusion of inspectors from "sensitive" areas of enrich-

Dr. Weinstock

ment plants is supposedly based on the proliferation danger of the spread of the technology, but, in fact, there is good reason to believe that equally important is the desire for commercial advantage, both in the U.S. and abroad.) The chapter is marred by the inclusion of an incomprehensible table purporting to represent, by means of unexplained numerical ratings, the resistance of various reactor systems to proliferation. This table is somewhat better explained in Chapter VII, but presumably the Congressmen for whom the executive summary is intended will never get that far.

The policies available in the international arena are covered more thoroughly in Chapter III, which begins by presenting and analyzing three possible "perspectives" on proliferation and nuclear energy. In the first of these, adequate world energy supplies are given the highest priority, while proliferation concerns are minimized, the argument being that proliferation is inevitable and may even have a stabilizing effect. In the second, the relative importance of energy supplies and non-proliferation is reversed, the former being entirely subordinated to the maintenance of the latter. The third perspective represents a middle ground between these two, favoring both the peaceful use of atomic energy and, at the same time, stringent efforts to contain the spread of weapons.

Each of the three positions is reviewed critically, but major attention is given to the compromise view. By and large, the analysis is thoughtful and astute. A few provocative quotations: concerning the primacy of non-proliferation, "the higher the priority accorded non-proliferation, the higher the potential costs in terms of other foreign policy objectives"; on de-emphasizing the international value of nuclear weapons in order to discourage their spread, "power remains the principal arbiter of international relations, and the contribution of nuclear weapons to national power in real terms in undeniable;" on alternative fuel cycles, "new reactor systems would have to be clearly superior to existing or planned systems on many counts besides non-proliferation before other suppliers would turn to them." The chapter concludes with a list of propositions concerning non-proliferation policy, most of them rather general and conventional. To this reader, the most interesting and valuable contribution of this chapter is to the understanding of the many constraints and conflicts operating in the area of foreign policy, severely limiting the number of practical choices.

Incentives and disincentives for proliferation are discussed in Chapter IV. Capsule case histories of the five weapons powers and India are presented, and these are followed by an analysis of the situation in three potential "Nth"countries, Argentina, Pakistan, and Taiwan. About the only conclusion one can draw from these is that the weapons powers evidently did not find the arguments they use against others acquiring nuclear weapons very compelling for themselves.

The next chapter is devoted to the "non-state" adversary (i.e., criminals) and the effect of safeguards on civil liberties. It and Chapter IX (see below) are by all odds the worst chapters in the report. The section on criminals and terrorists as potential nuclear adversaries is amateurish, speculative, and conspicuously lacking in hard evidence or persuasive argument. Thus, it quotes **L. Douglas DeNike** to the effect that "it is credible that organized crime would engage in nuclear activity," without offering a single shred of evidence in support of this conclusion. In a discussion of threats by psychotics, it notes that of all categories they are the least competent, but follows this by the observation that "there are some brilliant psychotics . . . If one such also has the will to cause destruction and has access to weapons material, he would constitute a formidable adversary." If this kind of thinking is what passes for "analysis" in the Government, no wonder nuclear power is in trouble.

The discussion of civil liberties is pretty much standard stuff, full of carefully hedged pros and cons, and in the end leading nowhere except to the advice that guarding against safeguards infringements on civil liberties will require eternal vigilance! Certain obvious issues that cry out for analysis are ignored altogether. For example, the discussion of the effect of clearance and classification programs on workers in the nuclear industry is discussed from the point of view of the number that would be affected, as though that were the most important thing. Far more significant is the precedent that would be set by requiring clearance for workers in a purely commercial, non-defense related industry, but this issue is not even raised; nor is the related but larger question of the propriety of the extension of the national security concept to a material (plutonium) in ordinary commerce. Finally, a threat not merely to constitutionally guaranteed privacy but to life itself is totally ignored. I have in mind here the recurrent proposal to spike plutonium lethally to protect it against unlawful seizure or theft. One would think that this would arouse at least as much indignation among civil libertarians as hypothetical warrantless searches for stolen plutonium.

Chapter VI, on nuclear weapons, is a generally factual, well-written chapter, despite the fact that it is the origin of the "could possibly" quote in Chapter II (see above). It is difficult to assess the material in this chapter, since it is based on classified sources to which most readers, including this reviewer, will not have access. Nevertheless, one may be skeptical about the "minimum" personnel requirements of a nuclear terrorist group: "a person capable of searching and understanding the technical literature in several fields and a jack-of-all-trades technician." The discussions of low-technology explosives and of peaceful nuclear explosives are informative and interesting.

The various possible sources of nuclear weapons material are considered in the next chapter. The assessment of alternative fuel cycles is reasonable and fair, and contains much useful descriptive material. However, it does not tackle the crucial question of the time scale for the introduction of new reactor types. So-called non-proliferating reactors such as the gas-core reactor are simply too speculative and too far off to be of much interest in controlling proliferation, yet they are considered as serious potential alternatives here. What is also not clear is just how, in the name of non-proliferation, the U.S. is going to persuade other countries to abandon reactor types in which they have invested heavily, in favor of reactor types they have already rejected for other reasons or which have not yet been commercially demonstrated.

The section which follows, on "Dedicated Facilities," is a good account of the various routes a country might take to make weapons material in facilities specifically designed for the purpose. I especially liked it for a refreshingly modest and frank statement on the effectiveness of a safeguards system for the laser isotope separation process: "It is not possible to assess a nonexistent safeguards system on a nonexistent plant containing a nonexistent process." This may come as a surprise to some government officials.

The last section in Chapter VII, on purchase and theft as a source of nuclear materials, is another one that is long on speculation and short on facts. A number of the statements made in it are questionable. Thus, it is stated, without proof or evidence, that an assault by 8 to 20 attackers aided by one or more insiders in order to seize a nuclear weapon would be "difficult to mount without giving some warning to appropriately oriented intelligence activities." Also, that only "highly motivated, well-organized, and well-armed attackers would have much chance of overcoming effective military security surrounding weapons." In view of the recent surreptitious attack on U.S. military aircraft at a domestic base, during which the weapons they carried were reportedly damaged, one is entitled to doubt this statement also. The rumor that Libya's **Colonel Qaddafi** once offered to buy a nuclear weapon is quoted as fact. I checked the cited reference; all it said was that "Colonel . . . Qaddafi . . . **is said** to have offered over $1 billion in 1970 to China or France for fissile materials or weapons" (emphasis added). In fact, I have tried on numerous occasions to track down this alleged offer of Qaddafi's, so far without any success whatever. Did it ever really happen, or is it just one of those rumors that acquires a life of its own?

An excellent description of the domestic and international safeguards systems and non-proliferation controls is given in Chapter VIII (and summarized in Chapter II). It is here, of all places, that the appropriateness of endowing attacks against private nuclear facilities with national security significance is questioned. It is also here that it is pointed out that although the theft of nuclear material is a Federal crime, "it is not clear if this crime, by itself, is a dangerous felony. The use of deadly force is justified only to prevent a dangerous felony." Safeguards measures such as spiking, denaturing, and coprocessing of nuclear fuels and co-location of processing facilities are assessed. IAEA and Euratom safeguards are also reviewed, and there is an account of the activities of the **London Suppliers Group.** An analysis of the pros and cons of multinational fuel-cycle centers and a discussion of the problems of safeguarding enrichment plants are especially interesting.

The less said about the next chapter, "Comparison of Routes to Nuclear Material," the better. It is full of platitudes, gross oversimplifications, and a laboring of the obvious, in the form of three "country case studies." It is painfully superficial and utterly useless. Its only saving grace is its brevity (four pages, but one of them, unfortunately, in fine print).

The final chapter is a good, straightforward, and balanced account of the international nuclear industry, with much useful data and some recent projections. The important point is made that certain less developed countries have a compelling need for nuclear power and that "a major effort . . . would be required to convince them to eliminate . . . nuclear energy altogether."

For safeguards professionals, the most useful part of the report will be the two volumes of appendices. For the most part, these are by well known experts in the field, and are a gold mine of information. Not having been homogenized in the committee blender, they retain a refreshing individuality of style that makes some of them, at least, fascinating browsing. These alone, as the old cliche goes, are worth the price of admission. The two volumes, PB-275 844 and PB-275 845, are available from the National Technical Information Service, in Washington, D.C.

A word or two about the writing style of the main report. In places it is very good. In others, it is abysmal. Repeatedly, the word "presently" is used for "at present," "technological" for "technical," and "alternate" for "alternative." The Administration is described as making proliferation control "a very high-priority objective," and it is stated that a "nuclear weapon capability will augment national military and political power in real terms," and also that "a high level of harm . . . would be done" by an explosion of diverted nuclear material. Elsewhere, we are assured that "The dedicated facility route . . . would probably be the most probable" (!). Inept and amateurish prose like this shouldn't be inflicted even on a Congressman. **—E.V. Weinstock.**

Review: International Arrangements

(Continued from Page 13)

rest of the world. To get there we will have to do a lot of clear thinking, and honest persuasion.

Some illustrations of existing multinational projects, and of experiences in forming them are presented in Chapters 12 (URENCO), and 15 (INTELSAT). There is a sensitive discussion of the FRG-Brazil agreement by **W.W. Lowrance** (Harvard), and a description of the IAEA study of multinational fuel cycle centers by **D.A.V. Fischer,** an Assistant Director General of the Agency.

I was disappointed in the contribution of **Charles Beets,** director of safeguards at MOL, Belgium and a superb technical safeguarder. The great **W.B. Lewis** kept him company with a short chapter on storing radioactive wastes on cooled pebbles. Probably it is a great method, but quite out of place here.

This very instructive and timely volume is composed of the papers which the participants prepared and revised after the critical exchange at Wingspread and editing by Chayes and Lewis. The chapters are short, to the point, and provocative. It seems to me unfortunate that this wasn't conveniently available until recently. The U.S. might have saved a lot of money on assessment of alternative fuel cycles, etc. Oh well, better late than never, as Merlin said. **—W.A. Higinbotham.**

Former INMM Officer Retires from U.S. DOE

McLean, Va.—**Russell E. Weber** has joined the staff of NUSAC, Inc. where he will once again be working with **Doug George** and **Ralph Lumb,** this time as a materials safeguards consultant to licensees.

Russ' responsibilities at NUSAC include the design and administration of nuclear safeguards programs for the purpose of evaluating the validity and significance of nuclear material data. He will be developing and improving nuclear material control and accounting systems for NUSAC's clients in order to assist them in meeting overall material safeguards policies and program objectives.

NUSAC provides consultation and technical services to the nuclear power generation industry in a number of diversified areas. These include nuclear materials control and accounting, physical protection of nuclear plants and materials, fuels quality assurance, and UF_6 confirmation.

Russ is looking forward to this new challenge to work in an industrial environment.

Mr. Weber retired from the U.S. Department of Energy this past June, culminating over 30 years of service, of which all but the first was in the nuclear materials management and safeguards field.

Russ is a charter member of the INMM and served as its Treasurer from 1964 to 1972. During that stretch, his continuity in office provided stability and counsel to a number of Executive Committees and Chairmen. He also served as chairman of one of the initial ANSI subcommittees sponsored by the INMM, and in 1967 received the "Certified Nuclear Materials Manager" designation from the Institute.

Weber was born in Buffalo, New York, where he lived until going to the University of Oklahoma. There he earned a B.S. degree in Business Administration in 1943. Twenty years later, he was awarded an M.B.A. in Industrial Management from the University of New Mexico, Albuquerque.

His initial contact with the nuclear energy field came in 1944, when after a year and a half in the Field Artillery, he was assigned to the Manhattan Engineer District, Y-12 Operations, Oak Ridge, Tennessee, as its accountability officer.

Weber left active duty in 1946 and moved to Philadelphia where he was employed for the next four years as a staff accountant with Price Waterhouse & Co. During that period, he became a Certified Public Accountant after passing the Pennsylvania examination.

In 1950, Weber moved to Tulsa, Oklahoma as the first Comptroller of the U.S. Junior Chamber of Commerce. In that capacity, he was instrumental in guiding approximately two thousand local chapters as well as the fiscal policies of the national headquarters.

Russ was drawn back to the nuclear field by the needs and challenges described to him by another accountant who was already with the Atomic Energy Commission, **Doug George.** It was as a result of that meeting on a snowy winter Saturday in Tulsa, that Russ joined the Santa Fe Operations Office at Los Alamos, New Mexico in July, 1951, the same year the Office moved to Albuquerque, N.M., and took that name. Weber served in the Albuquerque Office in its nuclear materials management organization for twelve years, becoming Deputy Director of the Division. During that time, he had the opportunity to participate in the growth of the energy programs under Albuquerque and see the slow, but welcome shift from weapons oriented programs to peaceful applications. He was also able to inaugurate a computerized accountability system for the field office's nuclear materials, and it was this that led to his transfer to the AEC's Washington Headquarters in the summer of 1963.

Weber's basic charge when he reported to Headquarters was to "automate the system and its related records and reports." By 1965, it was started, and with the superb support of Union Carbide's Computer Sciences Division at Oak Ridge, he has left us a legacy, the Nuclear Materials Management and Safeguards System (NMMSS). The System, with more than 30 modules, serves over 150 user organizations through more than 200 different programs and reports. It is recognized as the national safeguards information system and will be instrumental in fulfilling the U.S. Government's Non-Proliferation Treaty reporting requirements to the International Atomic Energy Agency.

Russ remarried about a year ago and he, his wife, Phyllis, and his daughter live in Montgomery Village, Maryland. From there, he plans to continue his outdoor interests of hiking, tennis, skiing, scuba diving and rafting, as time permits.

Mr. Weber

Proposed NRC Amendments

Physical Protection

The Nuclear Regulatory Commission is proposing to amend its regulations for the protection of nuclear materials and nuclear facilities other than power reactors and independent spent fuel storage installations.

The amendments are designed to provide a level of protection against theft of special nuclear material of low and moderate strategic significance equivalent to that recommended in Information Circular/225, which was published by the International Atomic Energy Agency in June, 1977.

Special nuclear material of low and moderate strategic significance is not directly usable in the manufacture of a nuclear weapon, but nevertheless could be of assistance in such a project.

Material of moderate strategic significance includes (1) between 500 grams and 2 kilograms of plutonium or uranium-233, (2) between 1 and 5 kilograms of uranium-235 enriched to 20% or more, and (3) 10 kilograms or more of uranium-235 enriched to at least 10% but less than 20%.

Material of low strategic significance includes (1) between 15 and 500 grams of plutonium or uranium-233, (2) between 15 grams and 1 kilogram of uranium-235 enriched to 20% or more, (3) between 1 and 10 kilograms of uranium-235 enriched to at least 10% but less than 20%, and (4) 10 or more kilograms of uranium enriched above its natural state but to less than 10%.

The NRC's proposed physical protection measures for special nuclear material of low strategic significance basically require that licensees use and store the material in a controlled access area, continuously monitor the controlled access area to detect unauthorized activities, and transport the material under controlled and planned conditions.

The proposed requirements for material of moderate strategic significance are similar, except that licensees are additionally required to limit access to the material to authorized individuals whose trustworthiness has been previously determined.

Physical protection requirements for nuclear power reactors and independent spent fuel storage installations are covered in the NRC's current regulations and therefore are not included in the new proposals.

Licensee Safeguards

The Nuclear Regulatory Commission is amending its regulations to require licensees to develop contingency plans for responding to attempted sabotage of a nuclear facility or theft of nuclear materials.

Licensees covered by the amendments are involved in the processing, handling, and transportation of strategic quantities of nuclear materials or in the operation of nuclear reactors—primarily those used in the production of electricity.

Each of these licensees already has an NRC approved plan covering in-place physical security systems. The contingency plans will augment existing physical security procedures by outlining data needed and criteria to be followed in reaching decisions on what action to take in the event of a threat to facilities or materials. The individuals, groups and organizational units responsible for each decision and subsequent action also will be identified.

Safeguards contingency plans, like physical security plans, will be exempt from public disclosure.

The licensee safeguards contingency plans will be designed to:

- organize the response effort at the licensee level;
- provide structured responses by licensees to safeguards contingencies; and
- achieve a measurable performance in responsive capabilities.

Those responsible for responding to a specific threat situation, and the scope of that responsibility, will be identified.

Under the Energy Reorganization Act of 1974, the NRC is responsible for nuclear contingency planning at the Federal level. This covers coordination of responses by various Federal agencies, including the NRC, the Federal Bureau of Investigation, the Department of Energy and the Department of Defense to threats against commercial nuclear activities. NRC will also assure that licensee safeguards contingency plans will be integrated and coordinated with the Federal Planning effort.

Rule Changes

The Nuclear Regulatory Commission is publishing for public comment proposed new regulations which would implement the United States/International Atomic Energy Agency (IAEA) Safeguards Agreement when it becomes effective.

In 1967, the United States volunteered to have IAEA safeguards applied to all major U.S. nuclear activities with the exception of those having direct national security significance. This offer was made to encourage the widest possible adherence to the Treaty on the Non-Proliferation of Nuclear Weapons, by demonstrating to other nations that they would not be placed at a commercial disadvantage by application of safeguards under the treaty. The offer also was a manifestation of U.S. support of the international safeguards system and demonstrated the U.S. belief that IAEA safeguards would not interfere with peaceful nuclear activities.

Following formal negotiations between the U.S. and the IAEA, the IAEA Board of Governors approved the proposed US/IAEA Safeguards Agreement on September 17, 1976. The Commission wishes to extend to the public the opportunity to comment on proposed regulations which would be used to implement the agreement.

The implementing regulations are contained in a proposed new Part 75 of NRC regulations, "Safeguards on Nuclear Material—Implementation of US/IAEA Agreement" and amendments to Parts 40, 50, 70 and 150. They include provisions to permit IAEA inspection of certain licensed installations; a requirement for licensees to prepare and submit information about their installations; provisions for the NRC to transfer such information to the IAEA subject to special precautions in case of proprietary or other sensitive information; a requirement for submitting reports required by the Agency; and requirements for material accounting and control.

Regulations on Shipments

The Nuclear Regulatory Commission is proposing to further strengthen its regulations for safeguarding the shipment of formula quantities of special nuclear material (high enriched uranium and plutonium). This would be done by extending present safeguards requirements for NRC licenses to cover carriers, freight forwarders, warehouse organizations and shippers' agents.

At present, NRC licensees who actually ship the material—or shippers' agents or carriers which represent the licensees and have pre-approved physical security plans—are responsible for assuring that shipments are properly safeguarded.

Under the proposed amendments, the NRC would issue a general license governing any shipment of a formula quantity of special nuclear material. Under this license, the organization responsible for arranging for the shipment would be required to have an NRC-approved physical security plan. Any other organization possessing the material during the course of the shipment also would be directly responsible for seeing that the applicable approved physical security plan is properly implemented.

The general license requirement will create direct authority for NRC inspection of shipments and other shipment-related functions, and provide a legal basis for taking enforcement action against any organization involved in shipments of strategic special nuclear material. Under the present regulation, the shipper licensee is held responsible for any transport organization which violates the applicable approved transportation security plan and the applicable NRC physical security requirements during shipments.

Superconductivity Achievement Revealed

LOS ALAMOS, N.M.—The discovery that a highly radioactive manmade element is superconducting has been announced by scientists at the Los Alamos (N.M.) Scientific Laboratory (LASL) and the Oak Ridge (Tenn.) National Laboratory.

The announcement was reported in the May 5, 1978 issue of Science Magazine by Dr. **James L. Smith** of LASL's Chemistry-Metallurgy Division and Dr. **Richard G. Haire** of Oak Ridge.

According to the scientists, the element americium becomes superconducting at a temperature near absolute zero (−458.3°F). It is the first of the "heavy" radioactive manmade elements (heavier than uranium) to demonstrate superconducting properties. Superconductivity is the loss of all electrical resistance at very low temperatures, so that the material becomes an infinitely good electrical conductor.

Dr. Smith explains that perhaps one-third of the more than 100 elements in the periodic table are known superconductors. All are stable isotopes (as opposed to radioactive) with the exception of technetium, a radioactive manmade element with the atomic number 43. Americium is the first of the heavier elements classed as "actinides," with atomic numbers ranging from 89 to 103, to demonstrate the phenomenon of superconductivity.

Equally surprising, from a scientific point of view, is that americium is grouped on the periodic table with magnetic elements which, because of their magnetic properties, cannot become superconducting.

"Normally, you expect elements in specific groups to have like properties," Dr. Smith comments. "Technitium is an exception. It is radioactive, although grouped with stable elements. Americium is apparently also an exception—a superconductor in a group of magnetic elements."

The LASL scientist describes the successful experiment as "discovering a piece in a long-term puzzle. By identifying all of the elements that are superconducting, we can better determine which alloys or compounds may be superconducting, and these materials are of interest to industry."

Although direct application of superconducting americium metal is uncertain, Dr. Smith believes the discovery may ultimately have potential value in both the nuclear weapons program and in energy research.

"We are still trying to fill in the blanks (in our knowledge of the periodic table)," the physicist declares, "and it is important that those of us whose laboratories are equipped to handle radioactive isotopes should continue to work with them."

Dr. Smith's achievement was the result of basic research in low temperature physics. The americium metal for his experiment was supplied by Dr. Haire.

NRC Names Director of Office of Management and Program Analysis

The Nuclear Regulatory Commission announced today that **Norman M. Haller** has been appointed Director of the agency's newly established Office of Management and Program Analysis, effective April 17.

Mr. Haller has been Director of the Division of Safeguards Inspection in the NRC staff Office of Inspection and Enforcement since June of 1977.

In his new position, Mr. Haller will provide NRC policy makers and operating officials with management information and program analysis. His new duties will include developing information on NRC program status, scheduling, and resource utilization; conducting analyses of programs relative to agency objectives and providing independent analyses of major program issues; providing information and analyses on operating experience at licensed facilities; and developing and implementing automated management information systems for the NRC.

Mr. Haller came to the NRC in April of 1975 from the Department of Defense where he had served two years as Director of the Strategic Defensive and Special Weapons Division of the Office of the Assistant Secretary of Defense (Program Analysis and Evaluation). After serving 10 months as Assistant Director for Technical Review in the NRC's Office of Policy Evaluation, he was named Assistant Director for Safeguards in the Office of Inspection and Enforcement.

Mr. Haller graduated from the Air Force Academy in 1960 and was awarded a master of science degree in aeronautics and astronautics by the Massachusetts Institute of Technology in 1962. He also received a masters degree in economics from the University of Maryland in 1968.

Mr. Haller served as an astronautical engineer, navigator and electronic engineer at the Air Force Research and Technology Division, Wright-Patterson Air Force Base in Ohio from 1962-69, except for one year of graduate work at the University of Maryland. In 1969, he became an operations research analyst in the Strategic Defense Division of the Office of the Assistant Secretary of Defense (Systems Analysis) at the Pentagon. In 1972, he was named Director of that division.

Mr. Haller was awarded the Secretary of Defense Meritorious Civilian Service Medal in 1975.

He is married to the former Elizabeth Frasch. They have four children and live in Vienna, Virginia.

Si Smiley, 56, INMM Speaker

BETHESDA, Md.—**Seymore (Si) Smiley,** 56, died Saturday, March 11, of a heart attack while jogging on the Atlantic City, N.J., boardwalk. He and his wife were attending a religious adult education meeting.

A frequent speaker at annual meetings of the INMM, "He was not only a highly qualified, well respected individual in the field of nuclear materials management, but was also a sincere friend with whom many of us enjoyed a very pleasant personal relationship," commented **Roy G. Cardwell,** Chairman of INMM, to the late Mr. Smiley's widow.

"He has on many occasions responded to requests from the Institute to speak to us to work with our in our various endeavors. We always looked forward to having him with us when he could be present. His absence will be very prominent, and we shall sincerely miss him," Cardwell added.

A Nuclear Regulatory Commission official, Mr. Smiley had spent 22 years at Oak Ridge Gaseous Diffusion Plant before leaving Oak Ridge in 1967.

Mr. Smiley came to Oak Ridge in 1945, after joining the Manhattan project in 1943. He was named superintendent of engineering development and reprocessing at ORGDP in 1953.

At the time of his death, Mr. Smiley was deputy director of NRC's office of nuclear material safety and safeguards.

He had been associated with the nation's nuclear energy program for 35 years.

After obtaining a bachelor's and master's degrees in chemistry from New York University in 1943, Mr. Smiley joined the Manhattan project at the Kellex Corp. in New Jersey.

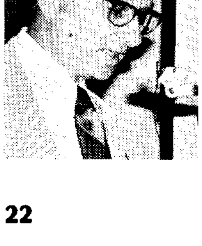
He worked there on problems associated with the new gaseous diffusion process of uranium enrichment, transferring to ORGDP in 1945.

Mr. Smiley held several patents on the gaseous diffusion process, and was the author of more than 200 articles. He had been a guest lecturer at M.I.T., and the University of California.

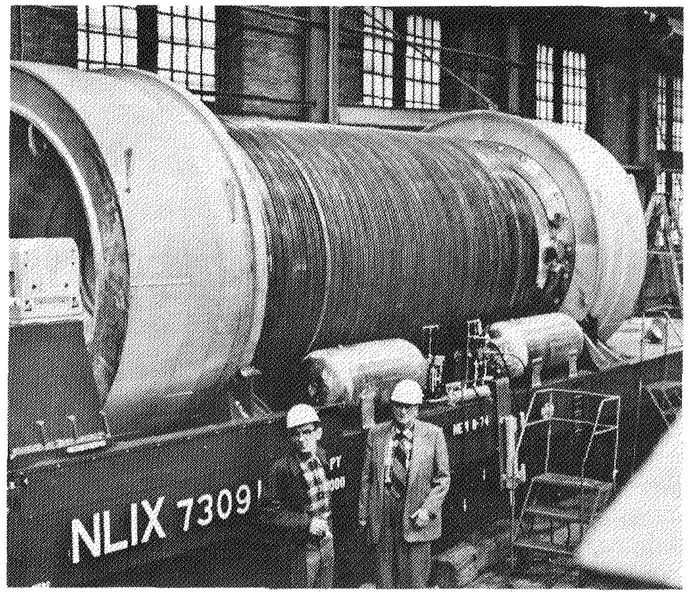
He left Oak Ridge in 1967 to become manager of research and development for nuclear materials at the Equipment Corporation in Pittsburgh, Pa.

In 1971, he joined the regulatory staff at the former Atomic Energy Commission in Washington as deputy director for fuels and materials licensing.

At the NRC, Mr. Smiley directed a congressionally-mandated study dealing with nuclear energy centers. He also worked on studies dealing with the safeguarding of nuclear materials.



Mr. Smiley



First NL rail cask system in final stage of completion in NL's Wilmington, Delaware plant.

NL Completes First Rail Cask

NEW YORK—The Nuclear Division of NL Industries, Inc. recently completed production of its first 10/24 rail cask at its Wilmington, Delaware plant. The cask is designed to transport more commercial spent nuclear fuel than any cask system licensed to date. The unit has been dispatched to Allied-General Nuclear Services in Barnwell, South Carolina, where it will be used in cask handling experiments being conducted under the auspices of the Department of Energy.

NL's 10/24 rail cask system was granted a Certificate of Compliance by the U.S. Nuclear Regulatory Commission in June, 1976. The cask has a carrying capacity of 4.75 metric tons of uranium. It is the only licensed rail system which transports commercial spent fuels "dry". Double containment and low pressure are added safety features of this system. The fully loaded cask weighs 100 tons. It is mounted on a specially designed 59' rail car which is designed to permit unlimited interchange on the railroads.

In addition to its 10/24 rail system, NL has a 1/2 truck system and is the only company in the free world with both a rail and a truck system licensed and in operation. NL's Nuclear Division supplies total transportation systems for the shipping of irradiated nuclear fuels, and is the major domestic producer of depleted uranium metal for shielding, counterweights and high kinetic energy applications.

The division recently completed the first decommissioning of a commercial nuclear reactor in which the site was released for unrestricted use. The division has made the technology and expertise gained in the decommissioning project available to the nuclear industry on a project-consultant basis.

NL Industries, with sales of over $1.5 billion, is a leading manufacturer and supplier of petroleum services and equipment, chemicals and metals.

World's Largest Laser Reaches Full Power

LOS ALAMOS, N.M.—On April 12, in the first full-power demonstration at the Los Alamos (N.M.) Scientific Laboratory, an eight-beam carbon dioxide laser delivered approximately 8,400 joules, in less than a billionth of a second, corresponding to a power of more than 15 trillion watts, making this the world's most powerful known laser to date.

To put this into perspective, the total electrical generating capacity of the United States is about half a trillion watts. The laser will be focused onto a suitable fuel pellet to make further advances in the harnessing of thermonuclear power to provide an inexhaustible energy source for the future.

LASL Director Dr. **Haro'^ M. Agnew,** in announcing the test results, said, "This feat was made possible by the expertise and dedication of many people who contributed to this important effort."

Dr. **Roger B. Perkins,** head of the Laboratory's Laser Fusion Program, described the success of this initial test as an extremely important contribution to the overall laser fusion program. "This is a 'pacing' item, and it is very significant," he said. "The laser system performed as expected and exceeded its power design value of 10 trillion watts."

Perkins added that the eight-beam system was brought to design power about half a year ahead of the original schedule. "LASL was asked to accelerate development of this gas laser system, and the recent full-power demonstration was our response," he said.

Perkins states, "The eight-beam system forms an intermediate stepping stone toward our primary goal of scientific breakeven, where fusion energy out of the pellet equals the laser energy in. This is the goal of the Antares laser now under design at Los Alamos and scheduled for completion in 1983."

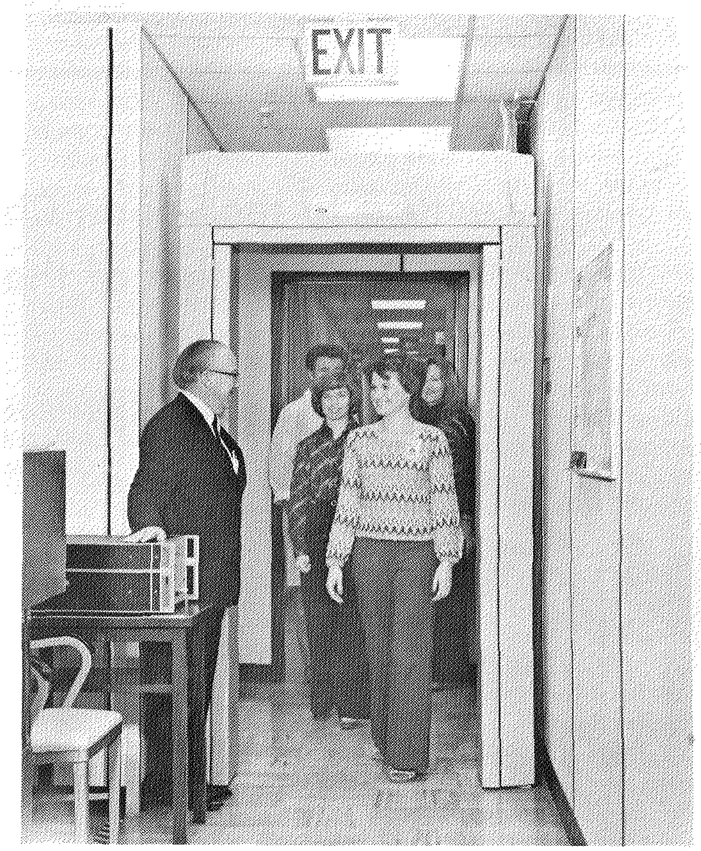
Antares is designed to be 10 times more powerful than the present eight-beam system. Ground was broken last summer for Antares, a $55-million CO_2 laser research facility.

Nuclear Reactors Built, Being Built

This compilation contains current information about facilities built, being built, or planned in the United States for domestic use or export which are capable of sustaining a nuclear chain reaction. Civilian, production, and military reactors are listed, as are reactors for export and critical assembly facilities.

Revisions are published twice a year, and the information presented is current as of June 30 or December 31.

The publication (48 pages, 8 x 10, paperback) is available as TID-8200-R37, for $3.25 from National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.



Portal Radiation Monitor

A new data sheet describing IRT's PRM-110 Portal Radiation Monitor systems has just been completed and is available on request. The Portal Radiation Monitor is a nuclear safeguard, security system that can detect the passage of minute quantites of radioactive material, such as ^{235}U and ^{239}Pu, through doorways without impeding traffic flow. The PRM-110 data sheet describes the basic system plus several options including one which allows a single control unit to monitor up to six portals. Contact W.M. Hawkins, Jr., at IRT Corporation, 7650 Convoy Court, P.O. Box 80817, San Diego, CA 92138 (Phone: 714/565-7171).

Pepperdine Offers MBA In Energy Management

LOS ANGELES—Pepperdine University's School of Business and Management will offer a Master of Business Administration degree in Energy Management which will begin in the fall of 1978.

The new MBA program is designed for key management personnel with five or more years of experience in energy user and producer industries. Objectives of the program include providing managers with both theory and practice in developing a systems approach to energy decision making.

Geared for working professionals in top line and staff positions, the energy management program will enable students to study and attend classes while maintaining a full working schedule.

Students will participate in five consecutive trimesters of nine credit units each. Program instruction is offered in a week-end mode and will include seminars, workshops, laboratories and case studies. Instruction will focus on solving various, real world energy problems.

Lecture to the Japan Chapter on the Occasion of the Presentation of their Charter in April 1978

By Roy G. Cardwell, Immediate Past Chairman
Institute of Nuclear Materials Management
Oak Ridge, Tenn.

Editor's Note—Chairman **Roy G. Cardwell** made an official visit to the Japan Chapter at a meeting of that group on April 11, in Tokyo. The Chairman delivered and presented their official Charter to the Chapter culminating a three year-effort by American and Japanese members of INMM to establish the first Institute chapter.

On invitation of the Chapter, the Chairman also presented an institute lecture at the meeting and took the same opportunity to present official INMM lapel pins to each member of the Chapter.

While in Japan, he was a guest of the University of Tokyo Faculty of Engineering, the Japan Atomic Energy Research Institute (JAERI), and the PNC Corporation where he was favored with extensive tours of all installations. He presented safeguards management seminars at both the University and PNC.

Chairman Kawashima, Officers, Executive Committee, and members of the Japan Chapter, it is not only a great pleasure but also a great honor to be standing here today speaking to this eminent group of individuals in the Japanese Nuclear Industry—the officers and members of the First Chapter of the Institute of Nuclear Materials Management. Several of you are already my good friends, and I hope that before my visit to Japan is concluded we shall all be good friends.

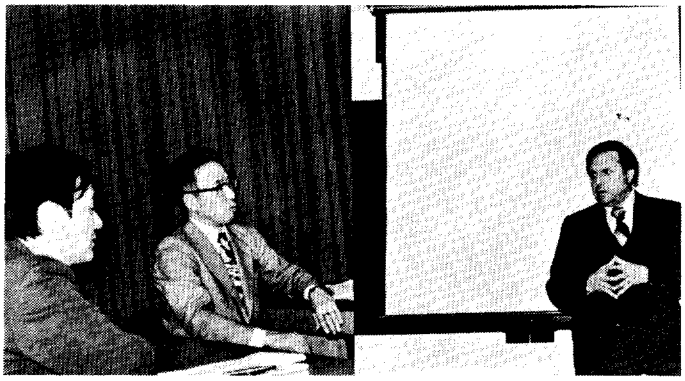
It was a much smaller group than this one that created the Institute itself on May 17, 1958, in Pittsburgh, Pennsylvania. Indeed, our beginnings were so humble that the members had to "pass the hat" (an old American expression meaning collect funds among ourselves) to help pay the expenses of some of the first technical meetings. Since that time our organization has evolved and grown into a membership of over 600 individuals, and is the only organization devoted exclusively to advancing safeguards and nuclear materials management. You can all take pride in being members of this internationally recognized group, and particular pride in the fact that you are the first to be chartered as an official chapter of the Institute.

I would like for you to think with me for a few minutes this afternoon about the contributions we, as a nuclear society, might make to the advancement of the nuclear energy concept and about some of the ways we might go about this effort. First, the relationship created between each of us by membership in the Institute is very important. By meeting and discussing our individual problems with each other, we are better able to understand those problems on a personal basis; and it becomes much less difficult to communicate with each other. A telephone call from a personal friend in another facility will usually receive a more understanding response than a call from someone you have not personally met.

This personal relationship is further enhanced by the fact that the membership of INMM, unlike most technical societies, is made up of so many different disciplines and specialties of work, yet we each have a common purpose. I have often said that INMM is made up of an uncommon group of people with a common need. Having colleagues in other specialties who are as dedicated to the nuclear endeavor as you are can be very helpful.

As an international society, we have relationships developing both here and in Europe. Other countries, as well as yours and mine, are already becoming leaders in the nuclear energy effort. The Institute offers a perfect forum for bringing our problems together for discussion outside the formal channels and agencies, but with the intent of making these formal relationships work through understanding what each of us is trying to accomplish.

Members of the Japan Chapter pose with their new Charter presented by Chairman Cardwell at the meeting of the chapter in Tokyo. Seated (left to right): J. Bloom, U.S. Embassy; Chairman and Mrs. Cardwell; Chairman Kawashima; Vice-Chairman Kiyose. Standing (left to right): R. Hara, N. Kaseda, K. Nakajima, H. Nishimura, H. Kurihara, T. Osabe, K. Tsutsumi, K. Ikawa, and T. Matsura.



The Chairman listens to a question from Professor Ryo Kiyose, Chairman of the Nuclear Engineering Department at the University of Tokyo. This was the first of three lectures given by Cardwell during his Japan visit.

Each of us has the same goal . . . to make a better world by providing an adequate supply of clean, safe, economical, dependable energy. In addition to the pollution and other real dangers generated by burning fossil fuels and the economic implications of their supply, both of which are significantly problematical, I feel that converting these materials into carbon dioxide when they can be made into so many other useful products is a very wasteful practice. A barrel of oil will make many products. It seems a shame to burn it.

It is also interesting to note that uranium, thorium, and plutonium make essentially no useful products except energy. It would seem logical that conservationists everywhere would be solidly behind the nuclear effort for that reason. I belive that true conservationists are. I am a conservationist, and I certainly am.

How much energy will these materials provide? Current estimates, although no one really knows how accurate they are, indicate with the planned expansion of light water reactors, all uranium sources will be committed by the late 1990's. With a significant breeder reactor economy, however, (and this can be calculated with more accuracy), we could supply necessary energy to a growing world economy for a minimum of 3000 years. Gentlemen, the world needs the breeder reactor!

Of course conservation can be a contributor to solving our energy problems. During the past two winters in the United States we have, I believe, made significant savings in our energy consumption with very little disruption. We are all finding out that we have been energy

Chairman and Mrs. Cardwell visit with Professor Dr. Sumiji Fujii (right) Dean of the Faculty of Engineering, and Professor Kiyose at the University of Tokyo.

"unconscious" for too many years. As my friend, Dr. **Frederick Forscher,** says, "Energy cannot be recycled," and we are at this moment at the Oak Ridge National Laboratory, as well as other laboratories, beginning several new programs to study means and methods of conserving this resource. Some solar may be relied on for home heating, but the cost implications for solar installations on a major scale are very large making the unit electrical cost rather impractical.

It is very obvious that we in the nuclear energy field offer the most logical and dependable source of energy for the world's near term requirements and probably for the long term as well. Unfortunately, we also have the most controversial source. Controversial, I believe, more so because of misunderstanding by the general public than because of its nature. A misunderstanding that has actually been promoted by an often clever misstatement of facts, half-truths, and innuendos on the part of antinuclear forces.

All of which brings me to what I believe to be the second function of our society, Public Information. We in INMM are the individuals who deal in the control and

The Chairman presents the Charter to Chairman Kawashima.

management of the materials of our nuclear energy machines. We are responsible for them. We are closer to, and therefore are better acquainted with the intricate steps that are being taken to safely use and protect these materials. I believe that we, more than any other group, are qualified to lead the general public into a better understanding of nuclear energy machines and what they can provide. This year I have appointed **Sylvester Suda** of the Brookhaven National Laboratory (who is known to several of you, I am sure) as Chairman of our standing committee on safeguards. Suda has already selected several highly qualified, well known individuals in the nuclear field to serve on the safeguards committee. One of their primary activities will be to function as an information team when the occasion arises; to inform or correct misinformation given out to the public. In addition, we are now trying to select a prominent individual, qualified both in the nuclear field and in the workings of the press, to be the spokesman for the Safeguards Committee and the INMM. Between these two coordinated functions, we are very hopeful for a "real time" response in the nuclear public information arena.

I encourage you, the Japan Chapter, to conduct a similar public information program. It will not be an easy task, but the fact that you are an organized chapter of the Institute should provide a logical base for the effort, and I believe we could give you a great deal of assistance.

An organized chapter here in Japan will also provide us with an opportunity to share our education programs with you. A particular one now proposed by our education committee under **Harley Toy** of Battelle Columbus Laboratories would provide an extensive continuing seminar on guard force (plant protection) organization and management. This course would be designed for the individual who is given the responsibility of organizing, implementing, or managing a protective force for a nuclear facility. This particular course is only an example of what we in INMM can contribute to the continuing education process. Since the problems of plant protection are similar everywhere, courses such as this should be internationally adaptable with only a reorientation to the particular country required.

A highlight of the trip was a very interesting visit with the Chairman of the Japan Atomic Energy Commission, Dr. G. Inoue, shown here with Cardwell and Kawashima.

The certification of nuclear managers has also been a regular activity of the Institute until two years ago when we deferred any more certificates pending a reevaluation of the program. Certification, we agreed, was heavily dependent on recognition of nuclear materials management as an important profession. Methods would have to be found for us to achieve both this recognition and the implementation of our recognized professionalism throughout the nuclear industry.

We first approached the problem through the writing and acceptance of an American National Standards Institute standard. We are, in the United States, the officially designated society by the American National Standards Institute (ANSI) for the creation and publication of standards for the control of nuclear materials (more commonly known to us as N-15).

After a very concerted effort by the Certification committee, they decided that this was not the best approach. Instead, they are now working on a proposal to certify qualified individuals by a standard written examination. Some consideration is being given to certify by specialty. If their proposal is adopted, INMM will seek recognition of the certificate by both industry and the government, giving a greater credibility to it. Both the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission are interested in this program,

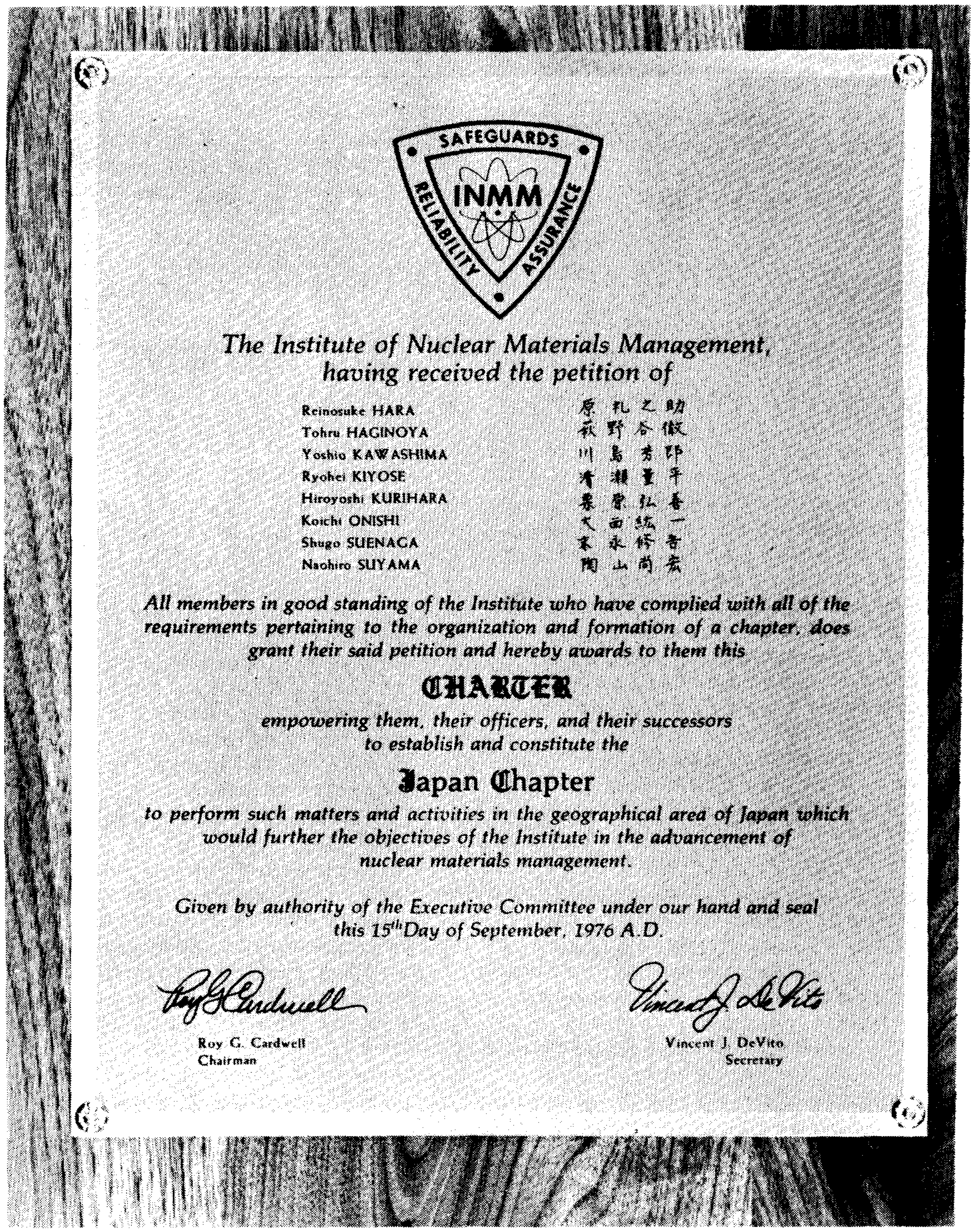
An evening at the Chin-san-so (Camelia-hill-village) was enjoyed by both officers and their ladies. Left to right in the lovely garden surrounding the popular restaurant in Tokyo is Dr. Kawashima, Mrs. Kiyose, Dr. Kiyose, Mrs. Cardwell, and Mrs. Kawashima.

and we believe that we will eventually be successful in our efforts.

By design, this will automatically be an international program. As INMM members, you will each be eligible to apply for certification; and we shall work together for an international recognition of the certificate. Perhaps we could approach this problem through a cooperative effort with the International Atomic Energy Agency (IAEA). In fact, I believe we should enlist their cooperation in all of our international efforts.

As for our general program on ANSI standards, we are now very heavily involved in that effort. I am aware that you do have your own standards program, and I am attempting to become familiar with it. I hope you will be interested in how ours is operated, if you do not already know, so that together we can consider how we can develop international standards that would be both useful and acceptable to everyone. Again, I feel that here is another important area where international cooperation can contribute much to progress.

JAPAN CHAPTER EMBLEM—This emblem for the new Japan Chapter was presented to the membership at their first annual meeting in Tokyo by Chairman Roy Cardwell during his official attendence there. It was designed by the Chairman and James T. White of the Oak Ridge National Laboratory Graphic Arts Department. Special gifts utilizing the emblem cast in metal were given by the Chairman on behalf of INMM to Chairman Kawashima, the officers, and members of the Japan Chapter Executive Committee.



SAFEGUARDS
INMM
RELIABILITY
ASSURANCE

The Institute of Nuclear Materials Management,
having received the petition of

Reinosuke HARA
Tohru HAGINOYA
Yoshio KAWASHIMA
Ryohei KIYOSE
Hiroyoshi KURIHARA
Koichi ONISHI
Shugo SUENAGA
Naohiro SUYAMA

All members in good standing of the Institute who have complied with all of the requirements pertaining to the organization and formation of a chapter, does grant their said petition and hereby awards to them this

CHARTER

empowering them, their officers, and their successors to establish and constitute the

Japan Chapter

to perform such matters and activities in the geographical area of Japan which would further the objectives of the Institute in the advancement of nuclear materials management.

Given by authority of the Executive Committee under our hand and seal this 15th Day of September, 1976 A.D.

Roy G. Cardwell
Chairman

Vincent J. DeVito
Secretary

The Japan Chapter Charter.

In summary, because you are an officially organized, operating chapter of INMM there will be many opportunities for cooperation between us. I believe, as others do, that international organization and cooperation on the widest possible scale is the best prospect for overcoming our current problems and stimulating a new renaissance in which the benefits of nuclear energy can be made available to all. Too, I am deeply concerned about the possibility of a conflict between those countries bearing the flag of non-proliferation and those with the flag of energy supply. Both of these matters should be of great concern to all nations of the world, and it is necessary to arrive at an international concenus on the best way to reconcile the areas of conflict. I am also firmly convinced that one of the surest ways to profilerate nuclear material used for weapons is to attempt to deny nuclear energy to developing nations. For in abundant energy there is food, clothing, shelter, and the desire to build and produce—not to tear down and destroy.

I truly believe that we in the nuclear industry offer the logical major energy source of both the present and the future, and that we in the Institute of Nuclear Materials Management may well hold the key that unlocks the door to both the public understanding and international cooperation that will provide this source of energy to a needy world. We look to the Japan Chapter, the NI-HON HON-BU, for leadership and cooperation in our expanding international effort. Thank you very much.

Titles and Abstracts of Recent Safeguards R&D Publications and Reports

Editor's Note—As you may recall, the summer 1977 issue of **NUCLEAR MATERIALS MANAGEMENT** contained a plea that agencies and R&D laboratories regularly send in titles and abstracts of articles and reports of interest to others working in the field of safeguards. Los Alamos Scientific Laboratory presented its titles and abstracts in the winter issue. Mound Laboratory operated by Monsanto Research Corp., Miamisburg, Ohio, supplied a listing for the spring issue. Now Argonne (Ill.) National Laboratory has furnished similar information.

We hope to publish another listing in the new fall issue. The deadline is September 1, 1978. Please call or write to Dr. **William A. Higinbotham** (516/345-2908, or FTS 664-2908) at Brookhaven National Laboratory, Upton, Long Island, NY 11973)—**Thomas A. Gerdis.**

1) J.F. Staroba and T.W. Knoerzer, *Radiographic Inspection and Densitometric Evaluation of CP-5 Reactor Fuel,* ANL-77-85 (February, 1978). The main objective was to perform a one-hundred percent radiographic inspection of the fuel tubes and to derive a quantitative relationship between fuel thickness and film density with the use of fabricated fuel step wedges. By the use of tangential X-ray techniques, measurements were made of fuel peaks or "hot spots" that protruded above the main fuel line.
2) G.H. Winslow, *A Problem Related to Grubbs Technique: The Distribution of Method Variance Estimates for Known Product Variance,* Journal of the INMM, **V**, No. 4, 26 (Winter, 1976-1977). The distribution of estimates of measurement method variance made by subtracting a known product variance from the total variance is shown to be the noncentral chi-square. Probabilities of finding that estimate to be negative, zero, or in a range of twice its expected standard deviation centered on its expected value are calculated for various conditions.
3) G.H. Winslow and A.L. Harkness, *Report on an International Atomic Energy Agency Inventory Verification,* Nuclear Technology **36**, 163 (1977). A five-member team from the IAEA conducted a plutonium-inventory verification at Argonne National Laboratory in February, 1976. The technical requirements, and the operations carried out to meet those requirements are described.
4) A.L. Harkness, *The Effort of Obtaining A Random Sample,* Journal of the INMM, **VI**, No. 1, 34 (Spring, 1977). The problem is considered of locating items with particular randomly chosen serial numbers in an inventory where it is known which serial numbers are in which container, but the items within a container are randomly positioned. It is found that, if the purpose is to demonstrate that no items are missing, a 100-percent piece count could be made with little more, perhaps less, effort, and the conclusion would be positive, as opposed to the ambiguity of a statistical conclusion.
5) S.B. Brumbach, *Experimental Program for Development and Evaluation of Nondestructive Assay Techniques for Plutonium Holdup,* ANL-77-23 (May, 1977). The current state-of-the-art in holdup measurements is reviewed. The measurement techniques considered are those using gamma-ray counting, neutron counting, and temperature measurement. Experiments are proposed to determine the effects of such problems as variation in sample thickness, in sample distribution, and in background, as well as experiments to quantify the uncertainties for each measurement.
6) A.L. Harkness, *A Statistical Study of EBR-II Fuel Elements Manufactured by the Cold Line at Argonne-West and by Atomics International,* ANL-77-66 (September, 1977). Nine elements from each batch of fuel elements have been analyzed for U-235 content by NDA methods. The results, together with those of the manufacturers, are used to estimate the product variance and the two method variances. A method is derived for resolving the several variances into their within-batch and between-batch components.
7) S.B. Brumbach and R.B. Perry, *Autoradiographic Technique for Rapid Inventory of Plutonium-Containing Fast Critical Assembly Fuel,* ANL-77-67 (October, 1977). This technique, using the spontaneously emitted gamma rays to form images of fuel elements on photographic film, has the advantage that containers need not be opened nor fuel handled. Missing fuel elements, substitution of nonradioactive material, and substitution of elements of different size are detectable.

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Material Control and Accounting

An NRC staff task force has completed a two year study of the role of material control and accounting in the Office of Nuclear Material Safety and Safeguard's program to safeguard plutonium, high-enriched uranium-235 and uranium-233 from theft or diversion of such material.

Material control has its roots in traditional management procedures that are meant to insure the efficiency of manufacturing processes. Material accounting incorporates material measurements with traditional bookkeeping procedures to periodically balance the nuclear material books.

The purpose of the study was to: (1) define the roles and objectives of material control and accounting in the safeguards program; (2) recommend goals based on the defined roles and objectives; (3) assess the extent to which the existing safeguards program meets or provides the capability to meet the recommended goals; and (4) provide direction for material control and material accounting development, including both near-term and long-term upgrading.

The task force report has four major findings:

(1) The primary role of material control in the safeguards program should be to provide continual awareness of the status of nuclear material in a given facility as well as a timely detection capability—to prevent theft or diversion or to initiate a response if theft or diversion already has taken place. The primary role of material accounting is to assure that the material is present in assigned locations and correct amounts. Material accounting—through a system of measurements, records and statistical analyses—should provide a capability to detect a loss of material to complement the more timely detection potential of material control and physical protection.

(2) Goals for material control include, but are not limited to: detection of the loss of a significant quantity of strategic special nuclear material within 24 hours; detection of the cumulative loss of such material during the inventory period in which it occurred; provision for the rapid assessment of safeguards alarms—such as those arising from alleged losses; and assurance that any loss of strategic special nuclear material would be detected in a timely manner. Goals for material accounting include, but are not limited to: provision for after-the-fact detection of significant losses over both short and long-term periods; provision for a precise method to determine the extent and nature of a supposed or actual loss of material; and provision for long-term assurance that no significant loss has taken place.

(3) A comparison of the goals established by the task force indicates that current safeguards requirements address many of the goals developed for material control, but are less specific in nature. In general, the goals closely parallel current requirements where separation of functions and custodial responsibilities are concerned, but the goals are more stringent in the areas of loss detection, alarm assessment and rapid loss

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Qualifying Nuclear Materials Specialists

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In recent years there has been an ever increasing emphasis on additional education for professional personnel. It is essential that the nuclear industry personnel be provided the opportunity to establish and have recorded the fact they have professional and technical competence in the Nuclear Materials Management area. Further, the nuclear industry and the general public requires assurance that the personnel assigned to Nuclear Materials Management have the training, ability and attitude to perform its important function.

Nuclear Materials Specialists should be qualified. To be considered for qualification, a candidate must have sufficient education and experience to provide the capability for understanding the principles and procedures for those methods in which they are to be qualified.

The primary purpose of a qualification program in Nuclear Materials Management is to encourage a high level of competence in those individuals practicing in this area. This purpose, however, will only be attainable to the extent that the standard for qualifications are high and reflect the ability of the individuals to qualify themselves through the suggested program.

Public recognition of this profession can be enhanced by the development, publication and utilization of the criteria and standards that define the awarding of a Certificate of General Proficiency in Nuclear Materials Management.

The corporate personnel who are responsible for Nuclear Materials Management makes decisions that affect not only the corporate image, but also our national security, personnel health and safety, environmental quality, along with the company's profitability.

At present nineteen programs leading to a Certificate of General Proficiency are being offered by the Idaho National Engineering Laboratory in cooperation with the University of Idaho and Idaho State University. These programs were used as a guide in arriving at the suggested course content for a Certificate of General Proficiency in Nuclear Materials Management. The Management and the Health Physics curricula given in Table I, which are approved by the University of Idaho, are representative of the nineteen programs offered.

TABLE I

Health Physics

Course Title		Semester Hours
Biological Science		3
Engineering Graphics		2
Chemistry		3
English Composition		3
College Algebra		3
Speech		2
Technical Writing		3
Management Theory		3
Physics		3
Radiological Health		6
On-the-job Checklist		-
	Total	31

Management

Course Title		Semester Hours
Fundamentals of Accounting		3
Statistical Methods for Supervisors		3
Introduction to Management Theory		3
Financial Management		3
Fundamentals of Economics		3
Approved Electives		9
	Total	27

These programs do not lead to a professional certification such as the Institute of Nuclear Materials Management (INMM) is now developing, but are essentially Specialists qualifications. For example, the Health Physics Program graduate would not be recognized as a "certified" health physicist by the Health Physics Society.

The candidate for the Nuclear Materials Management Certificate should demonstrate knowledge and understanding of nuclear materials safeguard principles, concepts, methods, and techniques as applied to:

1. Plant Design and Security.
2. Nuclear Materials Accounting.
3. Nuclear Materials Control.
4. Measurement Systems.
5. Physical Inventories.
6. Statistical Program.

The following curriculum as given in Table II, is proposed to qualify a person for a Certificate of General Proficiency in Nuclear Materials Management.

TABLE II

Nuclear Materials Management

Course Title	**Semester Hours**
Intermediate Accounting	6
Auditing Theory	3
Statistics	3
Introduction to Nuclear Engineering	3
Principles of Nuclear Materials Management and Safeguards	3
Nuclear Materials Processing, Handling and Waste Management	3
Nuclear Materials Management, Theory	3
Nuclear Materials Management, Application (Case Studies)	3
On-The-Job Checklist, oral and/or written tests	-
Electives (One of the following)	
Computers in Business	3
Introduction to Radiological Health Physics	3
Health Physics and Industrial Safety	3
Total	33

If such a qualification program were functioning, it would help corporations in recruiting qualified personnel for the nuclear materials area. Moreover, qualified personnel would also become available for insurance inspectors and for regulatory agencies, both at home and abroad. And, it would also provide a first step toward a truly professional certification program as is now being developed by the Institute of Nuclear Materials Management.

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Material Control and Accounting

(Continued from Page 29)

assessment. The material accounting goals are more demanding for loss detection capability, validation of accounting data, alarm assessment and long-term control of inventory difference performance than are the current requirements.

(4) The task force also recommends that the NRC issue upgraded material control and material accounting requirements; develop specific quantitative goals and objectives for the total safeguards program and monitor safeguards systems using these goals; and implement specific research and technical assistance programs to support the goals-oriented approach to materials control and materials accounting.

The task force is seeking comments from members of the public as well as other members of the NRC staff on the "Report of the Material Control and Material Accounting Task Force." These comments will be used in developing specific recommendations to be considered by the Commission at a later date. Comments from members of the public were to be received by July 15, 1978, and should be addressed to the Director, Division of Safeguards, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission, Washington, D.C. 20555. A limited number of copies of the report are available by writing to the same address. Copies also will be available in about two weeks from the National Technical Information Service, Springfield, Virginia 22161. The report, identified as NUREG-0450, will be priced at $31.75 for the five-part set. Individually, the Executive Summary will be $4.00 and Volume I (Summary) will be $4.50. Volumes II and III will be $8.00 each and Volume IV $7.25.

An Overview of the DYMCAS Program At Y-12

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INTRODUCTION

At the Oak Ridge Y-12 Plant,* work has started on developing and installing an automated nuclear material control and accountability system. The system, called Dynamic Special Nuclear Material Control and Accountability System (DYMCAS), will have significantly improved capabilities for data collection and data analysis. When finished, it will provide a real-time, perpetual book inventory of identified items, an estimated inventory for non-identified material in process, and will automatically call attention to any situation that warrants investigation. In addition to improving the ability of the Plant to detect a diversion, it will also greatly improve the speed with which the diversion would be detected, should such occur. Primarily intended to operate on the material balance area (MBA) level, it can also, if desired, operate on the minibalance level. In either case, DYMCAS will be a significant deterrent for any unauthorized use of special nuclear material.

ORGANIZATION AND PLANNING

The organization and planning of the DYMCAS program proceeded through several distinct steps. First, a tentative description of the desired system was developed. Second, a program management team was formed. Next, the team established the procedures and guidelines it would use in carrying out its tasks. After that, the team compiled a list of the features DYMCAS should have. The list was then ordered according to the importance of the features, and from this, a more detailed system description was developed. After that, schedules were drawn up for the purchasing, testing, and installation of the DYMCAS hardware, for the development of the software, and for the conversion from the present paper-system to the final, automated DYMCAS.

The first step toward DYMCAS was to develop a tentative description of the desired system. Although quickly replaced by a more detailed description, the tentative description was very important because it provided the basis from which it was decided how the program management team should be organized and staffed.

*Operated by the Union Carbide Corporation's Nuclear Division for the United States Department of Energy.

The tentative description indicated that in addition to a program manager and representatives from the organizations involved with development and installation of DYMCAS, the team should include representatives from the Y-12 organizations that will be the users of the system. A system designed, developed, and installed by a team so composed should be able to satisfy all of the Y-12 safeguards needs with a minimal amount of disruption to the operation of the Plant. Presently, the team consists of a program manager, with whom final responsibility resides, and representatives from Chemical Processing, Machining, Casting, Metal Preparation, Rolling and Forming, Reprocessing, Shipping and Receiving, Plant Engineering, Material Control and Accountability, Development, Statistical Services, and the Plant Computing Center. Once formed, the team was instructed to:

> "define, procure, install, implement, and maintain an efficient dynamic special material control and accountability system that will improve the reliability and timeliness of SNM accountability data and provide an improved capability for detecting diversion of SNM."[1]

The procedure used by the team to carry out these instructions is to partition the required effort into specific tasks called action steps. Then, each action step is assigned to a particular member of the team whose responsibility it becomes to see that the action step is completed by a specific date. This information, in addition to a brief description of the status of each action step, is published in a document called an action plan. Updated quarterly, the action plan is not only used as a record of the progress of the team but is also used as a vehicle for disseminating information concerning the current activities of the team.

With a team as large as the one at Y-12, the task of keeping each member informed of the progress being made by the other members of the team needs special attention. In addition to the action plan, a quarterly status report is prepared and distributed to the team members and to the higher management of the Plant. Once a month, the entire team meets to discuss the status of the project, and, as often as needed, the individual team members meet with the project manager.

In addition, when an action step is completed, its solution is extensively documented, and made available to the other members of the team.

One of the first steps taken by the team was to establish the set of guidelines it would use in carrying out its instructions. This step ended with the formal adoption of the following nine guidelines:

(1) To concentrate effort only where effort is needed. (A concept similar to this is used by the Department of Energy where it is called the graded safeguards concept).
(2) To consider physical security in conjunction with material control and accountability plans.
(3) To minimize disruption of the present material control and accountability system.
(4) To minimize disruption of production.
(5) To minimize data entry requirements.
(6) To design and test a prototype of a field station located in an operations area, and to utilize as much as possible the information and insight learned from the experience.
(7) To utilize as many of the features of the present NMA system as can be efficiently automated.
(8) To permit as much interaction as necessary with other on-line systems (i.e., Production Control and Product Certification).
(9) To minimize handling of SNM.

Next, the team prepared a list of all of the features DYMCAS was desired to have. Using the nine guidelines just mentioned, the features on the list were ranked according to their importance. After examining the ranked list, it was decided that any system that did not have all of the first eleven features could not satisfy the Y-12 safeguards needs. The eleven mandatory features are:

(1) Capability to satisfy all current and foreseeable DOE material management and accountability reporting requirements.
(2) Capability to collect SNM data in a timely manner through the use of a network of intelligent, remote terminals located throughout the Plant.
(3) Capability to calculate an on-line book inventory consisting of net weights of discrete items and the total net weight of all other (non-item) material. Also, the capability to calculate a timely uranium material balance around MBAs using DYMCAS data as well as laboratory analysis and assay data.
(4) Capability to detect most operator-generated errors through the use of format checks, an in-transit file, and the book inventory file before the transmission is accepted by the computer.
(5) Ability to obtain overnight complete item histories including traceability of batch make-ups and disposals for a specified time period.
(6) Capability for authorized access to the on-line book inventory and in-transit files.
(7) Provision for on-line automated scale and NDA verification where required.
(8) Capability for only NMA personnel to perform data base corrections.
(9) Provisions for protection against unauthorized terminal use and data base manipulation.
(10) Capability for timely statistical analysis.
(11) Capability for system expansion to satisfy changing DOE requirements.

At this point, the team had acquired enough insight into what DYMCAS must be able to do that they were able to describe the system which is now being developed and installed. In addition to the eleven mandatory features just given, the DYMCAS program described in this step will have the following features:

(1) Capability of random verification of the book inventory.
(2) Provision for an on-line file of items in-transit to ensure timely verification of shipment and receipt of SNM transferred between certain MBAs.
(3) Ability to calculate minibalances around selected unit processes by analyzing appropriate transaction in a batch mode.
(4) Reduction of present paper work through the use of item ID follow cards and associated computer-generated transfer documents.
(5) Capability of using Production Control information in a batch mode to obtain more reliable estimated weights for machine turnings and in-process part weights.
(6) Capability to do both data collection and batch functions on either of two dedicated processors.
(7) Capability to interact with other on-line systems.

The final step in the planning of DYMCAS was to schedule the purchasing, testing, and installation of the DYMCAS hardware, schedule the development of the software, and schedule the conversion from the present paper-system to the final, automated DYMCAS. These activities, of course, have been partitioned into action steps which are presently in the process of being accomplished by the management team.

DESCRIPTION OF HARDWARE

The hardware being purchased for DYMCAS will consist of a central computer system, ten building processors, twenty-six input stations, and various measurement devices. The hardware will be located in buildings situated throughout the Y-12 exclusion area which requires a Q-clearance to enter.

Housed in a special annex to the principal Y-12 computer center, the DYMCAS central computing system will consist of two identical systems, with one system being used as a backup for the other. Operating on a non-interruptable power supply, each system is to have a central processing unit (CPU) and peripherals. The CPUs will be dedicated, high-range mini-computers with random access memory capabilities, and the peripherals will include cathode ray tube (CRT) terminals, teletypewriters, paper tape reader/punches, real-time clocks, and multichannel communication controllers.

Located in buildings scattered throughout the Plant, the ten building processors are to serve as links between the central computer system and the input stations. Nine of the processors are to be located in separate production buildings and the tenth is to be located in the building housing the nuclear material accountability (NMA) group. Connected to the central computer system by two pairs of secure communication lines as much as 4000 feet long, the building processors will be used both for local editing of data entered at the input stations and for error checking of transmitted data. In the event that communication between the central computer system and a field station is lost, the building processor, each of which will contain a buffer, will store the accountability data normally transmitted to the central computer until communication is reestablished, thereby allowing the production staff to continue with their normal activities.

Connected to each building processor will be one or more input stations. As much as 800 feet away from the building processor, the input stations are to be the primary means of entering data into DYMCAS. Called operator stations, the twenty-four input stations connected to the processors located in the production buildings will each consist of a CRT with keyboard, a medium speed line printer, and at least one card/badge reader. Interfaced to each station will be weighing devices and whatever other nondestructive assay (NDA) equipment is appropriate for the DYMCAS needs for the operation in which the station is housed. The two input stations connected to the building processor located in the NMA building are called management stations. Although similar to the operator stations, they are equipped somewhat differently and, as is discussed in the next section, are to be used for different purposes. They will have CRTs with keyboards, display terminals, card readers, and keyboard printer terminals which will be interchangeable with those associated with the operator stations, but they will have larger and faster line printers and will not be interfaced to any NDA equipment.

In addition to the hardware just described, DYMCAS will have a diagnostic station. Separated from the rest of the system, the diagnostic station will be connected to a building processor identical to those used in the main system. Interfaced to at least one of each of the pieces of equipment or hardware used at the operator stations, it will be used to run diagnostic checks on existing equipment and systems, to train maintenance personnel, to field test changes in the rest of the system without interrupting normal use, and to perform routine tests on DYMCAS peripheral equipment.

SYSTEM OPERATION

As was mentioned earlier, operator stations and management stations will be used for different purposes. In general, the operator stations will be used for entering and receiving data concerning only the MBA in which the station is housed, while the management stations will be used for plant-wide purposes such as making corrections to any part of the accountability data base.

To use an operator station, the operator must first identify himself. This will be done by badge insertion and by the use of passwords. After properly signing on, the operator will then have a choice of one of several material transactions to perform. However, the options available to any given operator will be limited to the specific set authorized by the operator's badge, password, and operator station being used. Any attempt to perform an unauthorized transaction, e.g., request inventory data from another MBA, will be automatically detected by the system. In addition to not performing the unauthorized action, DYMCAS will notify the system security officer of the attempt.

Although DYMCAS will reduce the paper work, it will not do away with it entirely. For instance, all material in the system will be accompanied by an identification follow card as it moves between, and sometimes within, each MBA. The identification card, along with operator badge, weight, operator-keyed messages, and, as appropriate, NDA instrumentation readings, will provide the inputs that will identify each item as well as describe and authorize the transfer of materials from one point to another. Some, if not all, of these inputs will also be used to describe material dispositions within an MBA.

At the start of each transaction a list of possible operations will be presented on the CRT. After an operation has been selected, the constant data associated with that type operation will be displayed on the CRT. Inserting the material follow card into the card/badge reader, the operator will then use whatever weighing devices and NDA equipment is desired to measure the material. Electrical outputs from the card/badge reader, weighing devices, and NDA equipment will fill in appropriate blanks on the CRT display, and the operator will fill the remainder of the blanks from the keyboard and check entries for accuracy. When all information is entered and judged by the computer to be complete and compatible for the type of transaction selected, a message will be displayed telling the operator to enter the data into the computer system. This is done by command from the keyboard. Once the data are entered, the appropriate number of transfer documents will be printed on the terminal printer. These documents are to be retained so that they may be manually audited. In the event of local terminal failure, operation will revert to fully manual. Data, entered on appropriate forms will be taken to existing keypunch facilities where cards will be punched for entry into the computer system. Delays of more than one hour due to manual entry of data for a transaction are not anticipated.

To be used only by certain authorized NMA personnel, the management stations will be employed for a wide variety of tasks. For instance, in addition to SNM, certain other accountable material will be covered by DYMCAS; data for this material will be entered through a management terminal. Besides being used for the entry of data for other accountable materials, the management stations will be used for the entry of data from certain low-traffic MBAs that process SNM. More importantly, the management stations will be used for certain operations not permitted at any of the other field stations. These operations include such things as entering of all SNM data associated with interplant transfers, making corrections to the data base, handling all NMMSS data, and receiving and printing lengthy summary reports generated by the central computer system.

Of course, there will be some over-lap in the uses of the two kinds of input stations. For instance, although extensive use of NDA equipment is planned (e.g., gamma ray spectrometers to verify isotopic assay, neutron interrogators to measure quantity, etc.), there are certain situations for which other measurement systems such as laboratory analysis will provide better accountability data. In these cases, the data may be entered into DYMCAS either through an operator station, a management station, or through a tape fed directly into the central computer.

Regardless of how it was entered, once the data reaches the central computing system, it will have one or more operations performed on it. For instance, the central computing system will receive routine transaction data, perform checks on the data to determine its validity, update book inventories, generate reports of system status, produce nuclear materials management and safeguards system (NMMSS) reports, and produce outputs for use by other systems such as Production Control. Acknowledgement of receipt of material by an MBA office will be registered at the NMA office. The SNM data will be kept in at least three files: an on-line, intransit file for items between MBAs, an on-line book inventory file for items in MBAs, and the main data base which includes data on all accountable material. The first two files will be updated as each transaction is performed, and the main data base will be updated on at least a daily basis.

PROTOTYPE

A prototype of an operator station was tested for several months in an MBA in which SNM machining is done. The station, operated by the same MBA personnel who will operate the finished DYMCAS, consisted of a remote station computer, hardware interface, card reader, CRT, lineprinter, stabilized assay meter, and digital scales.

The station was used to transmit material control and accountability data to a central data base where an item inventory of the SNM contained in the MBA was maintained. During the time the station was in operation, the accountability system to be replaced by DYMCAS was also in use, and comparisons between the two systems were performed. These comparisons indicated that the DYMCAS prototype station provided not only a more timely item inventory, it provided improved accountability data as well. In addition to demonstrating that the general guidelines set forth by the DYMCAS management team could be satisfied in a production environment, the station provided valuable insight into such things as format specifications, uses of passwords, and learning curves for operations personnel. Viewed as a success, the experiment has greatly aided the management team in developing and installing DYMCAS.

DISCUSSION

Several other important characteristics of the DYMCAS program should be emphasized because they have had a significant effect on the way DYMCAS has been planned and developed.

The first characteristic to be emphasized is the extensive use of on-line weighing devices planned for DYMCAS. In order to avoid having a diversion detected on the basis of weight alone, a diverter will be forced to take additional steps, such as making substitutions for the stolen material, breaking seals, etc. Of course, each additional step will increase the likelihood of his detection by some other device or technique. In addition to being a deterrent to diversion, the weighing devices, which will enter the weights directly into DYMCAS without the need of human intervention, will decrease the probability of errors such as transposition of digits, key-punch errors, etc.

Another characteristic that should be emphasized is the extensive quality assurance (QA) effort applied to the DYMCAS program. This effort, which takes the form of formally and systematically identifying potential problems in the key steps of the process of installing and operating DYMCAS, has proven quite helpful. When a potential problem is located, the QA team responds with recommendations for a solution. A continual, ongoing process, the QA effort has been very useful in keeping progress on schedule.

Because a large part of future safeguards activities will involve verification procedures, work started early in the DYMCAS program on developing procedures that would not only satisfy all current and foreseeable DOE requirements but, at the same time, would make the maximum use of DYMCAS. This work, now completed, produced a set of procedures which, in addition to being consistent with the DOE graded safeguards concept, have been approved by the Oak Ridge Operations Office.

Progress toward completing the system is going according to schedule. Detailed specifications for the computer hardware have been written and submitted for bids. Specifications for NDA equipment are in the process of being written, and the scheduling of software development has begun. The DYMCAS program is scheduled to begin operations on April 1, 1980.

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The Effects of Background Gamma Radiation on the Sensitivity of Hand-Held Special Nuclear Materials Monitors

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ABSTRACT

The detection system of a hand-held special nuclear materials monitor was tested at a number of fixed gamma-ray background levels. The system produced an alarm when the gamma-ray counts, which were accumulated during any counting interval, equaled the trip level. Tests were conducted by rotating a standard 10-g ^{235}U test source past the detector and recording the detection probability for a series of trip level settings at each of eight background radiation levels. The results show that with appropriate trip level settings, it is possible to exceed the required 50% detection probability at background levels that range from 38 counts (produced by our local background of 20 μR/h) to 400 counts per 0.3-s counting interval.

Introduction

The Department of Energy's increasing concern with the prevention of diversion of special nuclear materials (SNM) has led to the development of a number of types of SNM monitors. One type is the hand-held monitor that can be used for personnel or vehicle searches at temporary or low traffic exits or, in the event of a positive indication by a portal monitor, can more quickly narrow the search for any SNM. Los Alamos Scientific Laboratory has developed such a monitor,[1] which is now available commercially. This monitor accepts gamma-ray pulses from a NaI(Tℓ) detector, integrates for a preset counting interval (typically 0.3 s), and produces an audible alarm whenever the counts in the interval equal the trip level. This report describes the effects of different background gamma radiation levels on this monitor's detection capability. The test results also are applicable to all monitors using a 38-mm diameter by 38-mm long NaI(Tℓ) crystal for the detector, provided gamma-ray pulses that exceed the lower level discriminator setting of approximately 50 keV are accumulated into 0.3-s counting intervals with alarm production occurring when the count equals the trip level.

Test of Detection Sensitivity

Laboratory testing of SNM monitor sensitivity should simulate, as accurately as possible, an actual search. We have devised such a testing method for simulating the procedure for personnel searches. A personnel search consists of four scans by the monitor over the subject's body. The operator starts with the monitor at the subject's head level, moves the monitor down the right front of the subject to the floor, then up the left front to head level. This is repeated for the back of the subject, thus making four scans in all. During these scans the monitor is kept at a distance of 0.10 to 0.15 m from the subject and moved at a speed of about 0.5 m/s. Thus, no matter where a source is concealed on the subject, the monitor will at some point in the search pass within 0.25 m of the source. Our laboratory test method simulates an actual search by moving a test source past the stationary monitor at a speed of 0.5 m/s with the distance of closest approach 0.25 m.

Our proposed standard for hand-held SNM monitor detection sensitivity stipulates the ability to detect, with greater than 50% probability, a standard test source being moved by the monitor as described above. The standard source consists of a sphere of uranium containing 10 grams or less of ^{235}U, with an enrichment of 93% or greater.

Laboratory Testing of the Monitor Detection System

Detection sensitivity tests were conducted using a laboratory type pulse amplifier, lower level discriminator, high voltage power supply; and for the detector, a factory encased NaI(Tℓ) crystal/photomultiplier. Gamma-ray pulses exceeding the 50 keV lower level discriminator setting produced logic pulses that were accumulated in the counting register of a digital logic system. Any desired integer could be selected for the system trip level. The number of counts accumulated during any 0.3-s counting interval was continuously compared with the number selected for the trip level. An alarm occurred whenever the accumulated counts equaled the trip level. The alarm continued to the end of the 0.3-s counting interval, at which time it stopped. The system immediately began to accumulate counts into the next counting interval and, if the trip level were equaled again, the alarm sequence was repeated. Detection sensitivity was determined by the test method described above. The 10-g standard ^{235}U test source was rotated past the detector face by means of a 0.796-m radius arm attached to a 0.1-rps motor. The point of closest approach of the source to the detector face occurred on the detector's longitudinal axis. Detection probability and the average count rate were determined from data obtained from an automated system that used timer-scalers to record: the elapsed time, the number of times the source passed the monitor, the number of gamma counts, and the number of detections. A detection is defined as the first alarm occurring during a 1.75-s period centered 0.3 s after the time when the source is closest to the detector. Thus, no more than one detection could occur per pass even though several counting intervals might produce alarms. Background radiation levels above normal were produced by positioning a ^{137}Cs source at appropriate distances from the monitor.

For data plots, we use the number by which the trip level exceeds the mean background count per interval and call this number the "Delta Count". The trip level minus the mean background count per interval is thus equal to the delta count, which is a more useful parameter than the trip level for plots of the data. We assumed that the average background rate, obtained during the 40,000-s or longer counting period required for each run, was indistinguishable from the mean. The average background count rate was determined by subtracting the previously determined signal count rate produced by the moving ^{235}U source from the average count rate obtained from the entire run. At each background radiation level, various trip level values were used to produce detection probabilities that ranged from approximately 50% to the highest probability compatible with an acceptable false alarm rate. Each run consisted of more than 4000 passes of the source past the monitor and determined one detection probability.

Figure 1 illustrates the effect of different delta counts on detection probability for our local background rate of 20 μR/h, which produces 38 counts per interval, and for a rate of 78 counts per interval produced by the addition of radiation from a ^{137}Cs source. Similar plots were obtained for each of six higher background count rates up to 400 counts per interval. The data obtained from all runs with detection probabilities less than 99% are shown in Figure 2, where detection probability as a function of the background count rate is plotted for delta counts ranging from 20 to 42. The plotted curve for each delta count is extrapolated to the background count rate which produces a 3.0% false alarm rate, which we arbitrarily define as an excessive rate. These calculated false alarm rates agree well with the experimentally determined ones.

Figure 3 illustrates another way of displaying the same data. Delta counts to produce a 50% detection probability and delta counts for a 3% false alarm rate are plotted versus the background count rate. The cross hatched operating area is the area covered by our data and obviously could be extended to higher and lower background rates. The more accurate Poisson distribution was used up to the limit of the available tables.

Discussion

The 38-mm diameter by 38-mm long detector crystal may appear, at first glance, to be overly long because the 186-keV gamma rays from ^{235}U have a mean free path of only 7 mm in the crystal. With this extra length, the detector presents approximately the same cross sectional area to a source regardless of view direction. Thus, detection sensitivity for sources which pass the detector off axis will not be lower than that given by this report. This is a desirable feature for a simplified instrument designed for use by an operator with little specialized training.

When the point of closest approach of the source to the detector is on the detector's axis as it was for these data, the count rate produced by the passing source exceeds 80% of the peak rate for 0.8 s, almost three counting intervals. At its peak, the source-produced rate is about 26 counts per interval. A delta count of 31 and a background of 38 per interval produces a detection probability of 50%. At its peak, the background plus signal is equal to 38 + 26 = 64 counts per interval; the trip level is 38 + 31 = 69 counts per interval. From the Poisson distribution, the probability of obtaining an alarm during a counting interval centered on the peak is 28%, but our measured probability was 50%. This higher measured probability occurs because the two adjacent intervals, with source-produced counts only about 3 less than peak, have a 17% probability each of producing an alarm. Thus, the probability of failing to alarm during the three intervals is the product of the failure probability for each interval, namely, $0.72 \times 0.83 \times 0.83 = 0.50$, which explains the 50% detection probability. Our longer detector, by producing a broader peak of source counting rate, increases detection probability by making detection more probable during several counting intervals. This effect also explains the increase in the delta count for a 50% detection probability from 31 to 45 as the background increases from 38 to 400.

Trip Level Determination

Monitors routinely used in a wide range of background levels should be designed so that the appropriate trip level for each background situation can be easily determined. An appropriate trip level is one which falls within the operational envelope shown in Figure 3. The optimum trip level is the sum of the delta count for the maximum permissible false alarm rate of 3% and the particular mean background count. The trip level obtained is the lowest possible if the false alarm rate is not to exceed 3%, and it is optimum because it produces the highest detection probability as illustrated in Figure 1. In like manner, the maximum permissible trip level is that which produces a 50% detection probability at this same background rate. From Figure 3, we find for a background rate of 38 counts per interval that the maximum permissible delta count is 30.5, and that the optimum delta count is 12.3. The range of allowable delta counts at this background rate is bounded by these two values; thus, the total range is 18.2. The range of allowable delta counts, and hence the range of allowable trip levels, decreases with increasing background rates. At a background rate of 400 counts per interval, the range is only 6.5 counts.

To obtain a confidence level of 95% that the trip level will lie within the operating range at background rates of 350-400 counts per interval requires a background accumulation time of approximately one minute. Update times of 5- to 10-s are adequate for backgrounds up to about 150 counts per interval.

Our monitor, mentioned previously, is the HSS-1050, Mod III. It is quite adequate when used in background radiation fields which produce 60 or less counts per 0.3-s interval. Its method of trip level determination is not adequate for operation at higher background levels. This monitor's trip level is determined by collecting background counts for a time interval that is 10 times the product of the counting interval and the alarm level. The alarm level, selected by an interval jumper, can be set for multiples of the background: 1.0 to 1.9 (in 0.1 increments) times the accumulated background. With an alarm level of 1.4 and a 0.3-s counting interval, the trip level accumulation time is 10 x 1.4 x 0.3s = 4.2s. If the background rate is 100 counts/s, then 420 counts are collected and scaled by 10 (divided by 10 and truncated to an integer). The result, 42, is increased by one to become a trip level of 43. Thus, with the background of 30 counts/interval, the delta count (the number of counts above the mean background needed for alarm production) is 13. The 95% confidence range for this trip level is 43 $\pm$ 4, which is well within our extrapolated range. If the background level is three times higher, 90 counts/interval, the delta count becomes 37, which is outside the operating range. With this trip level, almost three times the source strength is required for a similar alarm production probability. If we know that the background rate will remain constant, we could set the alarm level to 1.2 and thus regain most of the detection sensitivity. However, a decrease in background to the 30 counts/interval level would result in an intolerable false alarm rate with the 1.2 setting.

We plan to use our experimentally determined range of appropriate trip levels as a function of background radiation to design and construct a monitor with the capability for operating in background radiation levels of 400 counts/interval or less.

Conclusions

With appropriately selected trip levels, hand-held SNM monitors can maintain adequate detection sensitivity in backgrounds producing 400 counts/0.3-s interval or less.

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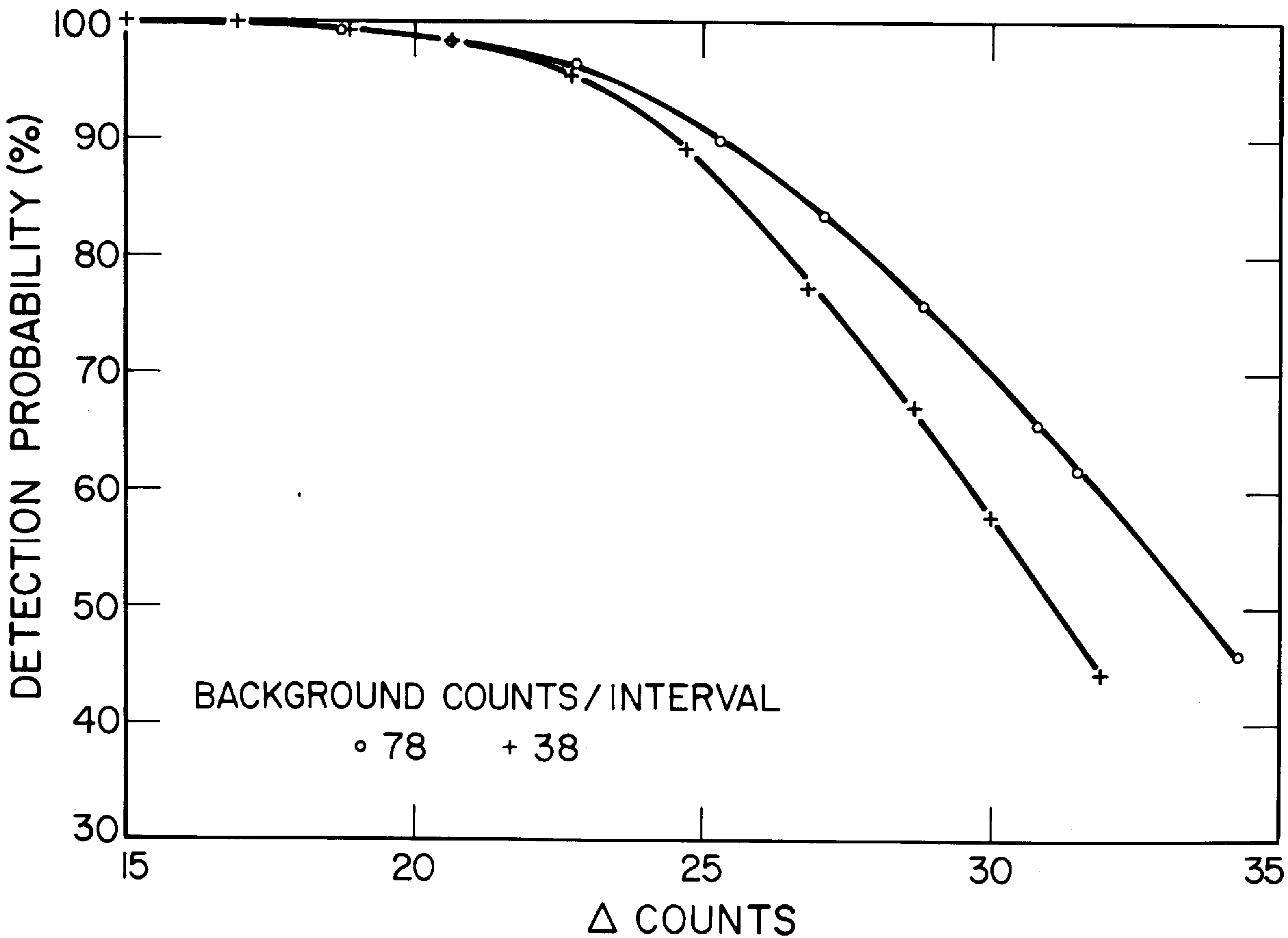

Fig. 1 Detection probability versus delta counts for background count rates of 38 and 78 per interval. The delta count is the number by which the trip level exceeds the mean background count per interval.

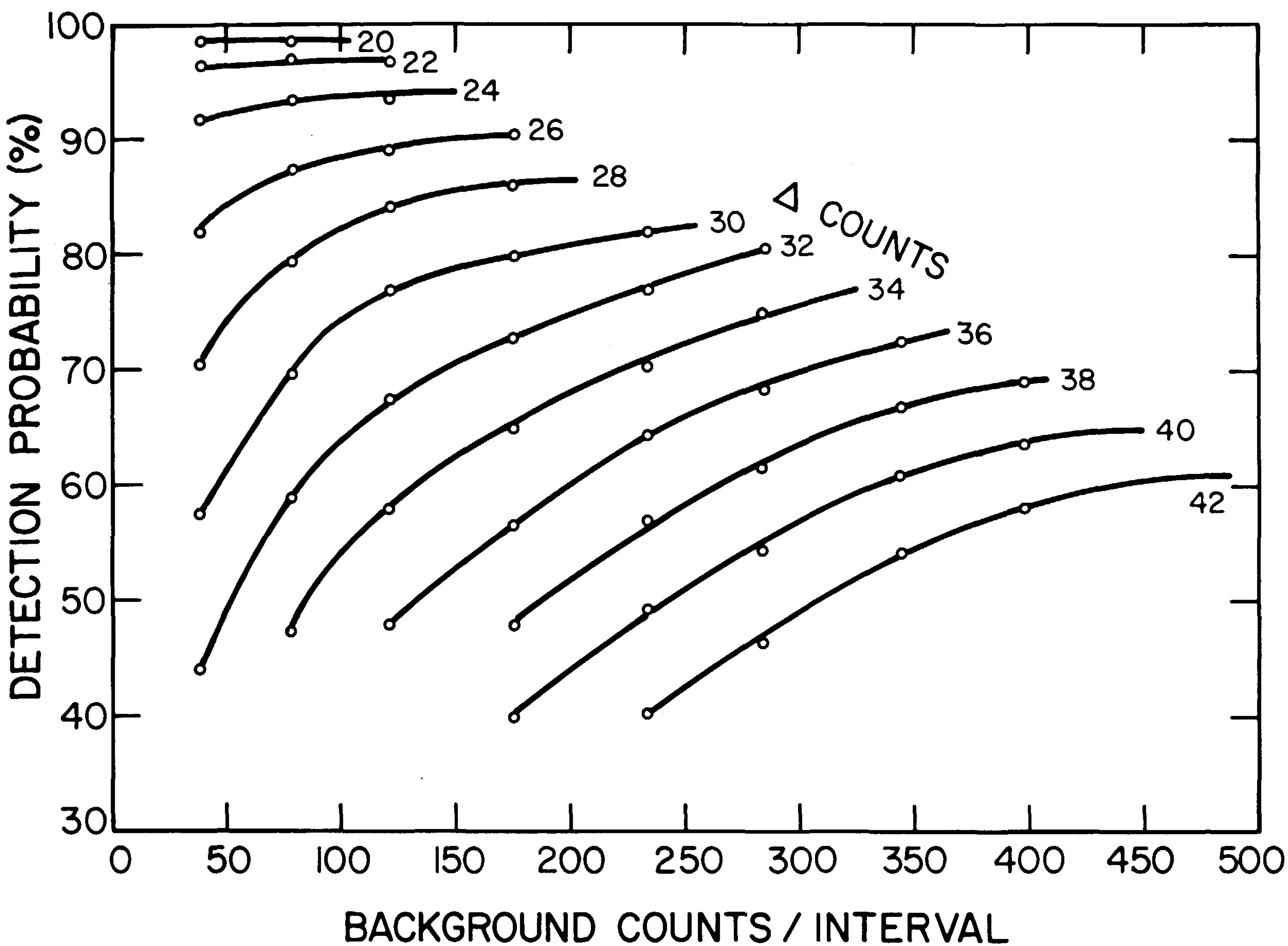

Fig. 2 Detection probability versus background counts per interval for delta counts ranging from 20 to 42.

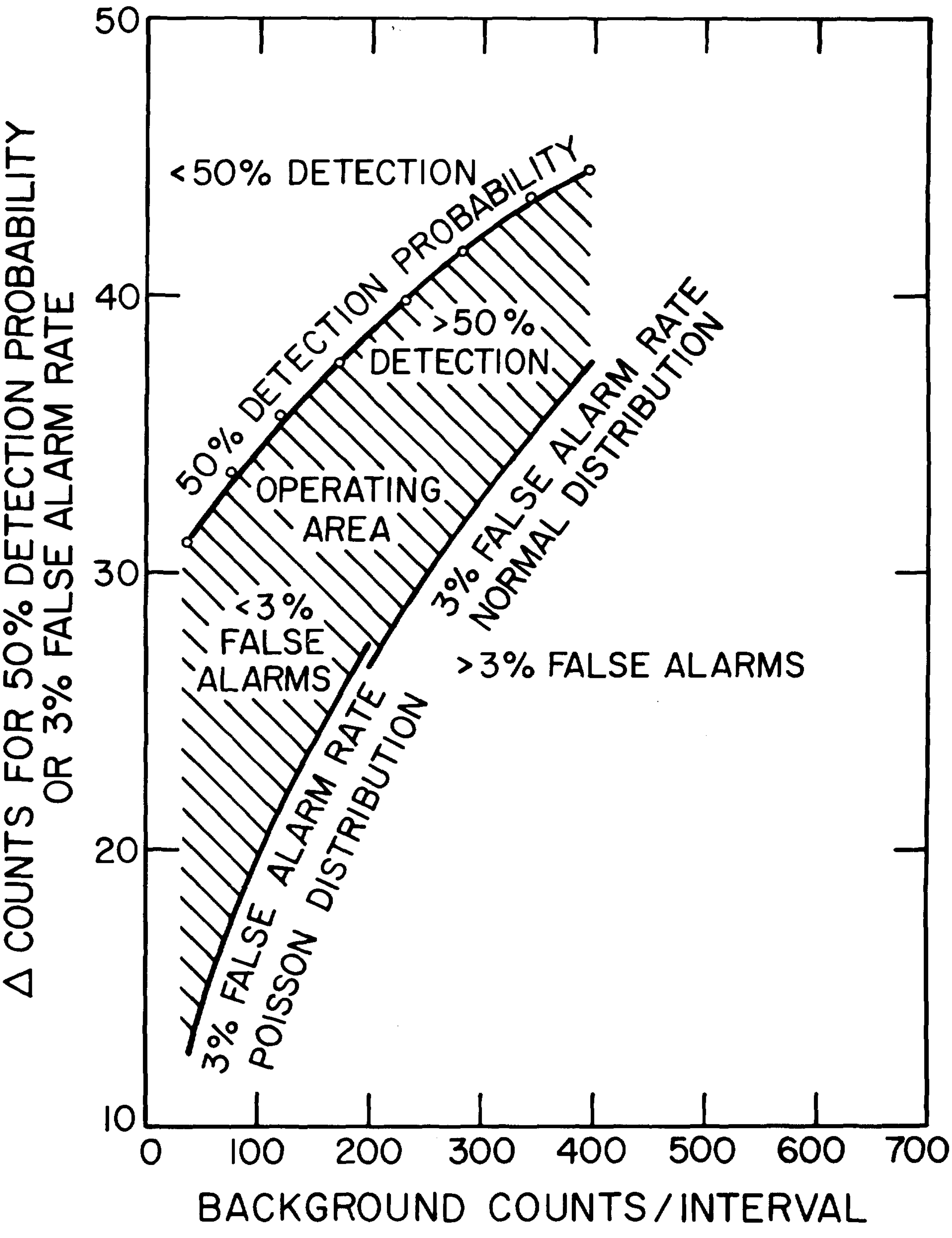

Fig. 3 Plot of delta counts for a 50% detection probability and also for a 3% false alarm rate. Points falling within the operating area meet the criteria of a greater than 50% detection probability and a less than 3% false alarm rate.

Neutron Coincidence Counters for Plutonium Measurements

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ABSTRACT

We have designed and tested new thermal-neutron well detectors and associated electronic coincidence circuits. The new instruments make it possible to extend the range of thermal-neutron coincidence counting to 1 - 2 kg plutonium samples.

I. Introduction

A useful nondestructive technique for the assay of plutonium samples is neutron coincidence counting in a thermal-neutron well detector. ^{240}Pu undergoes spontaneous fission at a rate of 460 fissions/g-s with an average of 2.14 neutrons emitted per fission. These neutrons are thermalized and then recorded by ^{3}He or BF_3 detectors. An electronic circuit is needed to extract the time-correlated fission neutron events in the presence of random events caused by strong backgrounds or (α,n) reactions in the sample. Coincidence circuits that have been used before are the variable deadtime counter (VDC)(1-3), the non-updating one-shot circuit(4), and the shift register(5,6). These circuits have been limited to count rates on the order of 10 000 counts/s because of electronic deadtime and pulse pile-up. Since 1 kg of PuO_2 (10% ^{240}Pu) will yield a total count rate of about 40 000 counts/s in a detector of 20% efficiency, it is not possible to assay high-mass plutonium samples. In order to extend the range of this assay technique to 1 - 2 kg samples of plutonium metal or oxide, we have designed, constructed, and evaluated new versions of the above three circuits that are capable of counting at rates on the order of 100 000 counts/s.

In addition to improvements in the electronics, the design for the thermal-neutron detectors has been optimized to facilitate the counting of high-rate samples. Cadmium sleeves have been inserted in the neutron moderator to absorb the thermalized neutrons at distances greater than ∿1 cm from the ^{3}He tubes, resulting in lower neutron die-away times and fewer pulse pileup problems. The resulting detectors can use shorter coincidence time gates. Two new LASL thermal well counters designed for use with large mass plutonium samples are described.

II. Thermal-Neutron Detector Design Principles

Computer calculations employing Monte Carlo codes for neutron transport have been used to optimize the design of ^{3}He neutron coincidence detector systems. The following parameters are important in the design: 1) total neutron efficiency for spontaneous fission neutrons, 2) sensitivity to sample matrix materials, 3) neutron die-away time in the moderator of the detector, and 4) weight and cost of the system. Neutron coincidence counters have been applied to the assay of a wide range of plutonium masses and container sizes, making it necessary to emphasize different parameters to achieve specified detector characteristics. The present work focused on two detector designs, a large detector system that could assay a wide range of plutonium masses and a lightweight unit for field applications.

III. Dual-Range Detector

For many applications of neutron well coincidence counters, it is desirable to assay samples with masses in the range from less than 1 g to greater than 2 kg of PuO_2. To achieve this wide-range capability, the dual-range coincidence counter has been designed and fabricated. The dual-range capability is achieved by having two removable cadmium sleeves near the ^{3}He detectors. These sleeves can be inserted for low-efficiency operation with a short die-away time and removed for high-efficiency counting with a long die-away time.

The geometry of the counter is shown in Fig. 1. The cadmium sleeves on both sides of the middle polyethylene cylinder (moderator) are removable. The detector consists of 20 ^{3}He tubes of 2.54 cm diam filled to a pressure of 4 atm. The inner and outer CH_2 cylinders (moderators) are each 3.0 cm thick. The cadmium sleeve (1.0 mm thick) on the inside of the well stops low-energy neutrons from returning to the sample position, thereby minimizing criticality problems and reducing multiplication for high-mass loadings. The outer cadmium sleeve improves the effectiveness of the exterior CH_2 shield.

Thus, there are two modes of operation, (1) the low-mass range with both removable cadmium sleeves removed for maximum efficiency and (2) the high-mass range with all the cadmium sleeves in place to give a short die-away time and correspondingly short electronic gate width in the coincidence circuitry. For operational mode (1), the singles efficiency is 20-25% and the neutron die-away time 50 μs. For operational mode (2) the efficiency decreases to 6-10% and the die-away time decreases to 15-25 μs.

Monte Carlo studies were performed to determine the physical dimensions of the counter that would yield the desired efficiency, die-away time, and matrix material insensitivity. The efficiency is especially dependent on the thicknesses of the polyethylene moderators. In the Monte Carlo program, the thicknesses of the inner and outer moderators were taken to be equal and were varied simultaneously to determine the optimum thickness. The results of this study are shown in Fig. 2 for both configurations (cadmium sleeves in and out). The results indicate that thicknesses of about 3.5 cm for both the inner and outer moderators combines high efficiency with relative insensitivity to matrix effects for both configurations. At this design thickness, an amount of hydrogen or other moderator equivalent to up to 1-cm wall thickness of CH_2 can be added to the sample matrix with little change in the counting efficiency, as can be seen in Fig. 2. The calculated efficiencies of the counter shown in Fig. 1 were about 25% in the high-efficiency configuration and about 7% in the low-efficiency configuration. The corresponding die-away times were approximately 45 and 15 μs, respectively. These calculated design parameters agree well with measured values.

IV. High-Level Neutron Coincidence Counter

A portable High-Level Neutron Coincidence Counter (HLNCC) was designed for plutonium oxide samples in the high-mass range extending up to 2 kg of PuO_2 (20% ^{240}Pu). Because the detector is intended for portable use by International Atomic Energy Agency (IAEA) inspectors, restrictions were placed on the counter's weight and size to facilitate the transportation and handling of the detector. The detector was fabricated as six separate slabs that form a hexagonal shaped well as shown in Fig. 3. This design provided flexibility in the detector's physical configuration, enabling it to accommodate a wide variety of sample containers. The width of the well (18 cm minimum) accepts standard-size PuO_2 sample cans, and the slabs can be further separated to accept larger containers, or, alternatively, two slabs can be used in a sandwich configuration to measure small samples or fuel rods. Each of the six sections of the hexagonal counter contains three 2.54-cm-diam ^{3}He tubes (pressurized to 4 atm) embedded in polyethylene.

The HLNCC has three 0.4-mm-thick cadmium liners. The outside liner shields the detector from low-energy room background neutrons. The liner on the inside of the well prevents low-energy neutrons from scattering in the counter and returning to the sample to cause fission neutron multiplication. The middle cadmium liner serves both to reduce the detector die-away time and to minimize the sensitivity to hydrogenous materials in the sample or container. The detector shown in Fig. 3 has an efficiency of approximately 11% and a die-away time of approximately 28 μs.

The HLNCC is usually used to assay PuO_2 in cans. The fill height of the PuO_2 in the cans will vary with the mass and density of material in the can, and it is desirable to have the detector's counting efficiency insensitive to these height variations. One way to achieve a flat efficiency is to place plugs at both ends of the counter well to reflect back into the detector those neutrons that would otherwise escape through the ends.

To evaluate the effectiveness of end plugs, a series of measurements was made using a ^{252}Cf spontaneous fission-neutron source. The neutron source was moved along the axis of the HLNCC, recording both total counts and coincidence counts. Figure 4 shows the measured profiles (normalized to unity at the center) obtained with and without the 7.6-cm-thick polyethylene end plugs. The plugs greatly flatten the efficiency. The improvement is greater than for most neutron well counters because the HLNCC is undermoderated.

V. Coincidence Circuit Analysis

The thermal-neutron well counters described in the preceding sections were used to study the VDC, updating one-shot, and shift register coincidence circuits. The ^3He tubes in these well counters had response times on the order of 2.5 µs(7), much less than the detector die-away times. The output signals from three to six ^3He tubes were ORed together into one preamp and then fed into a bipolar amplifier with a time constant of 0.20 µs. Four to six of these fast amplifiers were used with each well counter to reduce amplifier deadtime and pileup problems. The amplifier output signals, typically 0-6 V in amplitude, were then fed into discriminators set at two volts. The 200 ns-wide discriminator outputs were ORed together and fed into the coincidence circuit under study.

Each coincidence circuit was tested by assaying a ^{252}Cf source (to simulate a fissioning sample) in the presence of a strong AmLi source (to simulate random backgrounds) whose strength was varied by placing it at varying distances from the well counter. If the circuit was not sensitive to pileup, and if the proper deadtime corrections were applied to the data, the Cf assay was independent of the AmLi source strength. Linearity of response was then determined by assaying a variety of large and small plutonium samples.

Efforts to calculate the response of the circuits from first principles were made in parallel with these experimental tests. The calculations were based on a study of the distribution of events in time. This distribution consists of occasional fission bursts interspersed between many random events. The circuits used here to extract the fission events from the random events are autocorrelation circuits. As described above, all signals from the well counter were ORed together to form a single input to the coincidence circuit. The circuit then splits the incoming stream of events into two channels. One channel provides the input to a relatively long one-shot called the "gate." The other channel provides the input to a relatively short one-shot called the "trigger." Coincidences are formed from the logical AND of these two channels. (In the more conventional cross-correlation circuits, coincidences are formed from the logical AND of two separate input signals.) For the autocorrelation circuits the probability of a coincidence event is given by the product of the probability of generating a gate times the probability of finding a trigger in coincidence with this gate.

The probability of gate generation is calculated from the distribution of time intervals between events. This distribution is given by (8)

$$P_{gate}(O,t) = e^{-\int_0^t Q(t)dt} \quad . \qquad (1)$$

Here $P_{gate}(0,t)$ is the probability of detecting an interval of length t. Q(t) is the probability of an event as a function of time. Fig. 5 illustrates an interval distribution measured in the laboratory in conjunction with these experiments. It consists of a random distribution [Q(t) = constant, P(0,t) = exponential, yielding a straight line on semilogarithmic scale] with a more complex fission distribution superimposed.

The probability of detecting a trigger in coincidence with the gate is calculated from the Rossi-α distribution, with t = 0 defined by the beginning of the gate. In this distribution the fission events produce an exponential spectrum superimposed on a constant random background. Thus, the probability of detecting a trigger in coincidence with the gate is proportional to

$$P_{trigger} = \int_0^{\tau} \left[A + Re^{-t/\tau_d}\right] dt. \quad (2)$$

Here R = real coincidence rate, proportional to the amount of fissionable material,
A = accidental count rate due to random events,
τ_d = exponential die-away time constant of the detector,
τ = gate length.

The probability of detecting two events in coincidence is then proportional to the product of equations 1 and 2. The deadtime correction formulas given below for each of the three circuits were derived from this product.

VI. Variable Deadtime Circuit (VDC)

This circuit consists of two nonupdating one-shots of variable length (cf Fig. 6). A scaler is attached to the output of each one-shot. The first one-shot is typically of short duration, so that its scaler records most of the fission events. The second one-shot is much longer and creates large deadtimes, so that its scaler records few fissions. Then the difference between the scalers is a measure of the rate of fissions. The LASL VDC circuit gate lengths are precisely determined by counting a 20 Mhz crystal-controlled oscillator. This feature eliminates the need for calibration with an accidental source as well as the need for arbitrary correction factors in the data analysis.

The probability of gate generation in the VDC circuit is $1/(1 + T\tau_1)$ and $1/(1 + T\tau_2)$, for the first and second gates, respectively.
Here T = total count rate = R + A,
τ_1 = gate length of first nonupdating one-shot,
τ_2 = gate length of second nonupdating one-shot.
The probability that a real fission event will not be in coincidence with the gate is proportional to $e^{-\tau_1/\tau_d}$ or $e^{-\tau_2/\tau_d}$. A simple formula for the real coincidence rate based on these concepts is

$$R = \frac{\dfrac{S_1}{1-S_1\tau_1} - \dfrac{S_2}{1-S_2\tau_2}}{e^{-\tau_1/\tau_d} - e^{-\tau_2/\tau_d}} . \quad (3)$$

Here S_1 = count rate in scaler attached to first one-shot,
S_2 = count rate in scaler attached to second one-shot.
Equation 3 is inadequate even at relatively low rates because the assay is the difference of two large numbers, each of which does not include an adequate deadtime correction. A correct separation of real and accidental events is required to calculate the exact deadtime correction. An approximate solution to this problem is outlined in the Appendix, and the results of that calculation are the following two equations, which involve no free parameters:

$$R = \frac{\left[\dfrac{S_1}{1-S_1\tau_1} - \dfrac{S_2}{1-S_2\tau_2}\right](1 + T\tau_d)}{e^{-\tau_1/\tau_d} - e^{-\tau_2/\tau_d}} , \quad (4)$$

$$A = \frac{S_1}{1-S_1\tau_1} - \frac{R}{1+T\tau_d}\left[T\tau_d + e^{-\tau_1/\tau_d}\right] . \quad (5)$$

Equations 4 and 5 are coupled equations that are most easily solved by iteration. Very few iterations are required, because R << A for those cases where the equations represent a substantial correction to Eq. 3. The new equations yield an assay that is independent of accidental background rate. An example of this is given in Fig. 7. The term $(1 + T\tau_d)$ in the numerator of Eq. 4 is similar to an empirical correction factor used by Berg, et al.(2). Eqs. 4 and 5 have given correct results for all values of R, τ_1, τ_2, τ_d, and A (up to 80 000 counts/s) that have been tried. 50 000 to 80 000 counts/s is probably the maximum useful rate because of the approximations made in the derivation.

An approximate expression for the relative error in the VDC real coincidence rate is

$$\frac{\delta(R)}{R} \approx \frac{1}{\sqrt{C}} \frac{\sqrt{R_m + 2(S_1 - S_2)}}{R_m} , \quad (6)$$

where C is the total counting time, and the measured real coincidence rate R is given by the numerator of Eq. 3. The scalers S_1 and S_2 are strongly correlated, but the difference $(S_1 - S_2)$ is not. This difference corresponds roughly to the accidental coincidences that would be generated by a gate of length $\tau_2 - \tau_1$.

VII. Updating One-Shot Circuit

The second circuit studied consists of two updating one-shots of equal length τ, one delayed with respect to the other, as illustrated in Fig. 8. Scaler S_1 records real coincidences caused by fission events and accidental coincidences. A long delay is introduced to break the correlation between the gate and the trigger, so that scaler S_2 records only accidental coincidences. The difference $S_1 - S_2$ is a measure of the sample fission rate. This circuit is similar to an earlier one that employed nonupdating one-shots(4). The new LASL version is somewhat easier to construct and to analyze.

At high count rates where $R << A$, the probability of gate generation is $e^{-T(\tau + \delta)}$. δ is the amplifier deadtime, which was not included in the discussion of the VDC because it was overridden by the nonupdating one-shots. The probability of detecting a trigger in coincidence with the gate is proportional to

$$e^{-\delta T}\int_{PD}^{PD + \tau} dt\,(A + Re^{-t/\tau_d}). \qquad (7)$$

From these relations one can derive the following expression for the coincidence rate:

$$R = \frac{\left[S_1 - S_2\right] e^{(\tau + 2\delta)T}}{e^{-PD/\tau_d}\left[1-e^{-\tau/\tau_d}\right]\left[1-e^{-D/\tau_d}\right]} \qquad (8)$$

Here PD = predelay, which is introduced to make the two gates have the same effective length despite amplifier deadtime. PD must be $>\delta$.
D = length of the long delay.
T = R + A = total count rate, and is given by $T = T_{meas.}e^{\delta T}$.

Fig. 9 demonstrates that this formula correctly predicts the coincidence rate within statistical errors. In this example δ is about 0.6 μs.

Another version of this updating one-shot circuit that was built at LASL lengthens the assay time to correspond to the true livetime. This circuit eliminates the large $e^{\tau T}$ deadtime correction and requires only the small $e^{2\delta T}$ correction due to amplifier deadtime.

Deadtime effects in the circuit reduce the measured count rate, but do not affect the variance of the data, which is determined by the variance in the number of detected fissions. A simple approximation for the relative error is

$$\frac{\delta R}{R} \approx \frac{1}{\sqrt{C}} \frac{\sqrt{R_m + 2\tau T^2}}{R_m} \qquad (9)$$

where R_m is the numerator of Eq. 8.

VIII. Shift Register

This circuit is similar to the updating one-shot circuit described above. The most important difference is that incoming events are shifted through a register for a time τ, the gate length. In effect, there is a new gate for each trigger, so the major source of deadtime in the previous circuits is eliminated. The new LASL shift register is illustrated in Fig. 10. Some of the features that distinguish it from the previous LASL shift register(6) are the following:

1. The new circuit has only one shift-register gate and two triggers (one prompt and one delayed), thereby eliminating several integrated circuits. The operating principle is identical to that of the earlier unit, except that the time ordering of triggers and accidental gates is reversed.

2. The delayed trigger is now delayed 1000 μs, hence no real events will be coincident with the accidental gate.

3. A fixed clock frequency of 2 Mhz is used for all timing applications. The timing is more stable and does not depend on the choice of gate length (8 to 128 μs).

4. The predelay can be varied from 1 to 32 μs, in 1/2 μs increments, independent of gate length. At high count rates it is essential that the predelay be long enough to override all amplifier deadtime and pileup effects.

5. The up-down counter has a capacity of 99 counts, as compared to 9 in the older circuit. This is

essential for high count-rate applications. For example, at 100 000 counts/s the average number of events in coincidence with a 64 μs gate is 6.4, and 9 is exceeded about 11% of the time. This is a large effect, which preferentially reduces the counting of fission events.

6. The scaler readout has been increased from seven to nine digits to accomodate larger counts without overflowing.

At high count rates where $R << A$, the probability of gate generation is $e^{-\delta T}$, and the probability of detecting a trigger in coincidence with the gate is given by Eq. 7. The coincidence rate is

$$R = \frac{\left[S_1 - S_2\right] e^{2\delta T}}{e^{-PD/\tau_d}\left[1-e^{-\tau/\tau_d}\right]\left[1-e^{-D/\tau_d}\right]} . \quad (10)$$

Again, the total count rate $T = T_{meas.} e^{\delta T}$. A separate scaler is included to measure T. Fig. 11 demonstrates that the new LASL shift register can be used at much higher counting rates than the old. Since Fig. 11 is a semilogarithmic plot, the slope of the solid line is 2δ, where the amplifier dead-time $\delta \approx 1$ μs.

The difference between the dashed and solid line in Fig. 11 is due to an imbalance in effective gate lengths between the prompt and delayed gates. This bias was measured by counting a random AmLi source separately. It is not caused by the coincidence circuit but by the time required for the amplifiers to return to zero baseline. At high count rates even a slight deviation from zero will affect the ability of closely following pulses to trigger the discriminator. Bipolar amplifiers (as were used here) tend to produce a negative bias; unipolar amplifiers, a positive bias. An examination of the interval distribution at the input to the shift register at 120 000 counts/s revealed not only a 1 μs deadtime (δ) but also a slight negative bias due to pulse pileup extending beyond 5 μs. Thus the 4½ μs predelay used for this measurement was not sufficient.

For the shift register, a very thorough analysis of the expected count rate errors is given by Böhnel(5). He finds some correlations between the prompt and delayed gates that tend to decrease the relative error and some terms due to multiple neutrons per fission that tend to increase the relative error. These correlations are small for the values of detector efficiency and neutron multiplicity encountered in practice, and the observed errors are well represented by

$$\frac{\delta R}{R} \approx \frac{1}{\sqrt{C}} \frac{\sqrt{R_m + 2\tau T^2}}{R_m} \quad (11)$$

with R_m given by the numerator of Eq. 10. By differentiating this expression with respect to τ, it can be shown that for $R << T$ the minimum relative error is given by a gate of length

$$\tau = \tau_d \left[e^{\tau/\tau_d} - 1\right]/2 \approx 1.257\tau_d . \quad (12)$$

The shift register is subject only to relatively small amplifier deadtimes and not to deadtimes of order $e^{\tau T}$, because a new gate is initiated for every trigger. Thus the assay is based on a deadtime-free Rossi-α distribution. This raises the question of whether the circuit registers some events more than once. In fact, the circuit registers counts for all intervals between events, not just contiguous ones. A fission yielding four detected neutrons would produce three counts in the VDC or updating one-shot circuit but would give six counts in the shift register. This feature of the shift register is of no advantage or disadvantage in practice for the following reasons: 1. For a practical detector of 5-20% efficiency, multiple neutron events are rarely recorded. So the shift register will yield only a few extra counts compared to a conventional circuit.
2. The variance of the assay is determined by the number of detected fissions, not by the number of neutrons per fission that are counted.
3. The calibration of the coincidence circuit in terms of coincidence counts/gram will take this effect into account. This calibration will be slightly more dependent on fission multiplicity than the calibration of a conventional circuit.

IX. Comparison of Circuits

Fig. 12 illustrates the assay of 200g of PuO_2 (6% ^{240}Pu) with a VDC circuit and a shift register. The circuits simultaneously processed events from the High-Level Neutron Coincidence Counter described in Sec. IV. Each data point represents five 1000-s runs made in the presence of a nearby AmLi source used to increase the accidental background rate. For the first data point the ratio of accidental to coincidence events is 100 to 1. This ratio is due primarily to the low spontaneous fission multiplicity of ^{240}Pu and to the low efficiency of the well counter, which cause most fissions to be registered only as single events. Under these conditions the assay precision is typically 1-5% for a single 1000-s run. For the last data point the ratio of accidental to coincidence events is 1000 to 1 because of the strong AmLi source. This ratio represents the useful limit of these coincidence circuits for practical counting times. (Of course, if the accidental rate of 40 000 counts/s observed here were due to 1 or 2 kg of PuO_2 rather than to an external AmLi source, the ratio of accidental to coincidence events would be only 100 to 1.) From the comparison in Fig. 12, it is clear that for both the VDC and the shift register the assay is independent of accidental rate within statistical errors. The real coincidence rate for the VDC and the shift register was calculated from Eqs. 4 and 10, respectively, and the VDC statistical error, from Eq. 6.

Fig. 13 compares the relative error in the VDC, updating one-shot, and shift-register circuits for measurements using 32 μs gates. All measurements were made for the same real time intervals of 1000 s. Total count rates T were identical, but the coincident count rates R varied greatly because of deadtime losses. It is somewhat surprising that three different circuits with vastly different deadtime losses should yield the same relative error. A careful analysis of these circuits, taking into account all correlations present in the data or in the circuits, would probably show that the errors are not quite identical. However, for low fission multiplicity and low detector efficiency, which implies $R \ll T$, the measured errors are the same within 10 to 20%. This is believed to be due to the following effects: (1) All three circuits are extracting information from the same distribution of intervals between events; the variance in the number of spontaneous fissions and the variance in the total background rate are already determined before events enter the circuits. (2) Within the circuits, strong correlations are introduced by deadtime effects; although circuits with different deadtimes yield different assays, these correlations cause the relative errors to be the same. For all three circuits, the relative error will then depend only on R, T, and the resolving time τ.

Another comparison of the three circuits concerns the effect of a large change in accidental background during a data-collecting run. Such a change could occur, for example, in a production plant if samples are brought in or removed from the vicinity of the well counter while an assay is in progress. A somewhat extreme example of such a change is tabulated in Fig. 14. Run 1 represents a 1000-s assay of an amount of fissionable material equivalent to 480 g of PuO_2 (18% ^{240}Pu). During Run 2 an additional background rate equivalent to the accidental rate from 800 g of PuO_2 was present inside the well counter. During Run 3 this additional material was introduced halfway through the run. The VDC scalers record only the total counts received during the run, so the VDC is completely vulnerable to such a change. The updating one-shot and shift-register circuits record real and accidental coincidence events on a real-time basis and are insensitive to such changes, although corrections for amplifier and electronic deadtimes may be affected by a few per cent.

X. Conclusions

The experiments and calculations involving thermal-neutron well counters and coincidence circuits described in this paper yield the following conclusions:

1. Neutron well counters can be designed to have readily selectable counting efficiency and die-away time to accomodate a wide variety of measurement applications. Plutonium samples ranging in mass from < 1 g to > 2 kg can be conveniently assayed using the dual-range coincidence counter. Assay problems associated with neutron moderation in the sample matrix have been minimized by optimizing the thickness of CH_2 moderator in the detector.

2. The relative error in the assay is typically proportional to

$$\frac{\delta R}{R} \approx \frac{\sqrt{R_m + 2\tau T^2}}{R_m} \approx \frac{\sqrt{2\tau\ T}}{R_m} \ \alpha \ \frac{\varepsilon}{\varepsilon^2} \qquad (13)$$

More precise assays are obtained by using a well counter with high efficiency ε, provided that the coincidence circuit is not overloaded.

3. With any of the three new coincidence circuits designed at LASL, large samples of fissionable material can be measured in the presence of random background rates of at least 50 000 to 100 000 counts/s with the constraint that the count rate due to (α,n) reactions in the sample not exceed the count rate due to the fissionable material by more than a factor of ten, as proposed at Harwell(3) . When the proper deadtime corrections are applied to the data, the assay will be independent of the background rate and proportional to the amount of plutonium. More rigorous calculations of deadtime corrections should be carried out, but the present results imply that, with the proper corrections, all three circuits yield the same assay.

4. For all three circuits the relative error in the assay is observed to be roughly the same for a given measurement time. These surprising results require confirmation by a careful statistical analysis such as that given in Ref. 5 for the shift register. If correct, these results imply that there is no reason to prefer one circuit over another on the basis of statistical error in the measurement.

5. The shift register is the best of the circuits studied because it measures a deadtime-free Rossi-α distribution and needs to be corrected only for amplifier deadtime and input synchronization time losses. The updating one-shot circuit and the VDC require large deadtime corrections. A technique requiring only small corrections to the measured response is inherently better, even if the corrections required by other techniques are well understood. Also, the VDC circuit does not form coincidences on a real-time basis and is therefore vulnerable to changes in room background occurring during the assay. (Note that a shift register that does not measure accidental coincidences would have the same problem.) The multiple counting of events by the shift register is of no disadvantage. On the contrary, this effect provides information on fission multiplicity that has not yet been exploited.

6. To use the shift register or other circuits at high count rates, it is important to minimize the bias caused by pulse pileup in the amplifiers. This can be done by distributing the output signals from the well counter among four to six fast (~0.25 μs time constant) bipolar amplifiers. Any remaining bias can be compensated for by calibrating with a random source or by using a long predelay.

When neutron detection problems are resolved by the use of instruments such as the well counters and shift register described in this report, it becomes possible to observe significant self-multiplication caused by (α,n) or spontaneous fission neutrons in plutonium metal or oxide samples(8). Current LASL research on neutron coincidence counting is directed towards achieving a quantitative understanding of these effects.

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Appendix
Derivation of VDC Real and Accidental Coincidence Rates

The formulas given in Eq. 4 and 5 of the text are based in part on formal calculations and in part on experimental observations of fission and accidental interval distributions, as described below. In this sense they should be considered semi-empirical. A derivation of more exact equations from first principles should be possible by starting with the interval distribution given by Vincent(10).

The present derivation begins with Eq. 1 of the text. The combined interval distribution for fission and accidental events should have the form

$$P(0,t) = c_1 e^{-\left[Tt + c_2 e^{-t/\tau_d}\right]}$$

If there are relatively few fission events, so that c_2 is << 1,

$$P(0,t) \approx c_1 e^{-Tt} - c_1 c_2 e^{-(T + \frac{1}{\tau_d})t} .$$

The constants c_1 and c_2 are determined by normalizing the interval distribution to

$$\int_0^\infty P(0,t)dt = A + R = T = \text{total counts.}$$

A consists of extraneous random events and all fissions in which only one neutron is detected. The first term of the normalization integral is identified with A, and the second term is identified with R. This identification is confirmed by observation of the experimental interval distribution of Fig. 5. Then

$$P(0,t) \approx ATe^{-Tt} + R(T + \frac{1}{\tau_d})e^{-(T + \frac{1}{\tau_d})t} .$$

The die-away time of LASL well counters is often determined by application of this equation to the observed interval distribution.

If the distribution is truncated by a nonupdating gate of length τ, then

$$P(0,t-\tau) \approx A_m Te^{-T(t-\tau)} + R_m(T + \frac{1}{\tau_d})e^{-(T + \frac{1}{\tau_d})(t-\tau)}$$

where A_m and R_m are the measured fractions of the accidentals A and real coincidences R, respectively. If the interval distribution is measured for a time of length L, the sum of all the time intervals must add up to L, whether or not the distribution was truncated by a nonupdating gate of length τ. This fact can be expressed by the relation

$$L = \int_0^\infty tP(0,t)dt = \int_\tau^\infty tP(0,t-\tau)dt.$$

Using this constraint and realizing that the scaler count $S = A_m + R_m$, one obtains

$$A = \frac{S}{1-S\tau} - \frac{R}{(1-S\tau)(1+T\tau_d)}\left[T\tau_d(1-S\tau) - S\tau + \frac{R_m}{R}\right].$$

R_m cannot be calculated using this approach and must be determined by considering what fraction of R is detected after a time τ. This is

$$R_m = Re^{-\tau/\tau_d} + S(R\tau)(1-e^{-\tau/\tau_d}) .$$

The second term represents the contribution from fissions occurring during the gate, which is S x Rτ x

$$\frac{1}{\tau_d^2}\int_{t_1=0}^{t_1=\tau} dt_1 \int_{t=\tau}^{t=\infty} dt\, e^{-(t-t_1)/\tau_d}$$

Events due to this term can be observed experimentally by collecting an interval distribution with large τ. Substituting the above expression for R_m into the relation for A yields

$$A = \frac{S}{1-S\tau} - \frac{R}{1 + T\tau_d}\left[T\tau_d + e^{-\tau/\tau_d}\right] .$$

This relation has the expected behavior in the limits $\tau_d \rightarrow \infty$, $\tau_d \rightarrow 0$, $\tau \rightarrow 0$. In the two arms of the VDC circuit there are two gates τ_1 and τ_2, but A is the same. If the above relation is written for both τ_1 and τ_2, A can be eliminated. From this constraint it follows that

$$R = \frac{\left[\frac{S_1}{1-S_1\tau_1} - \frac{S_2}{1-S_2\tau_2}\right](1 + T\tau_d)}{\left[e^{-\tau_1/\tau_d} - e^{-\tau_2/\tau_d}\right]} .$$

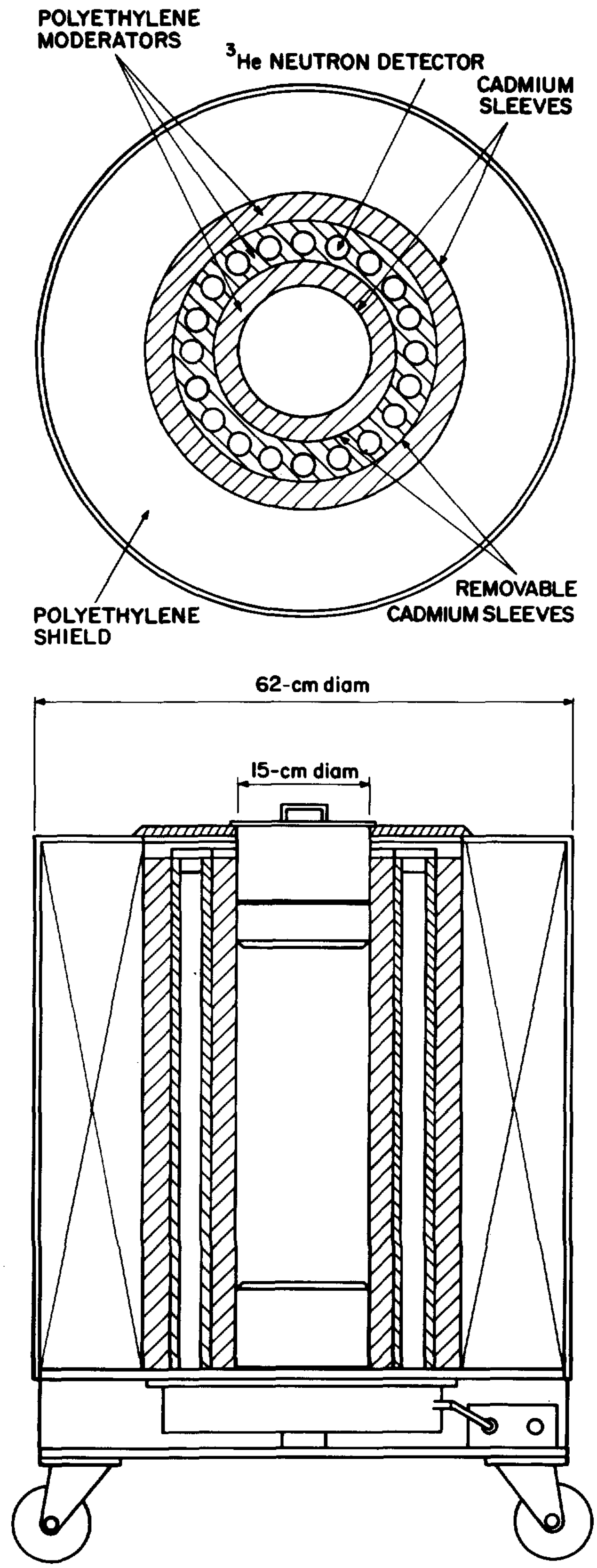

Fig. 1., Dual-range neutron coincidence counter for the assay of plutonium samples in the mass range 1-2000 g.

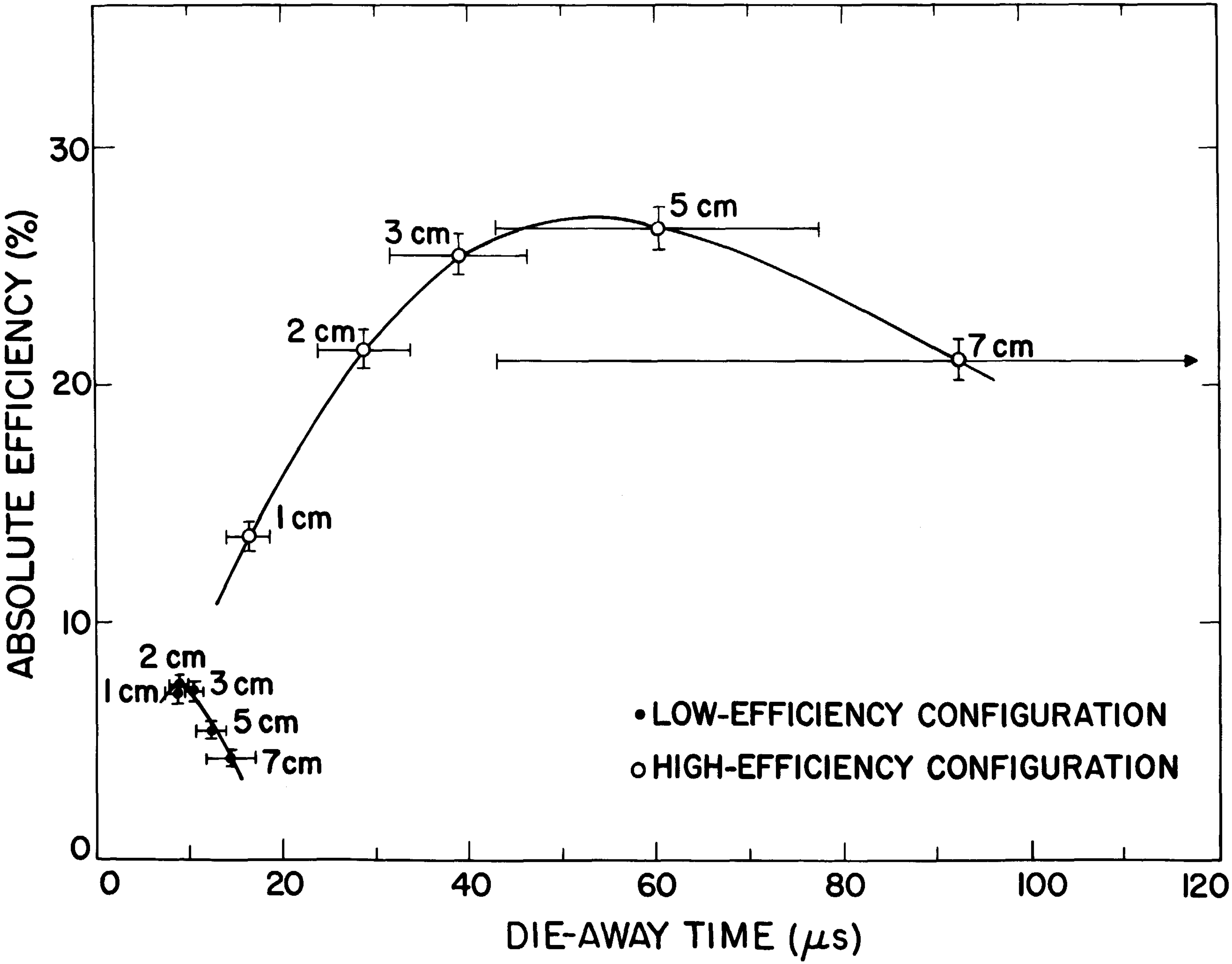

Fig. 2., Design data for the dual-range counter showing efficiency and die-away time as a function of polyethylene moderator thickness as determined from Monte Carlo studies.

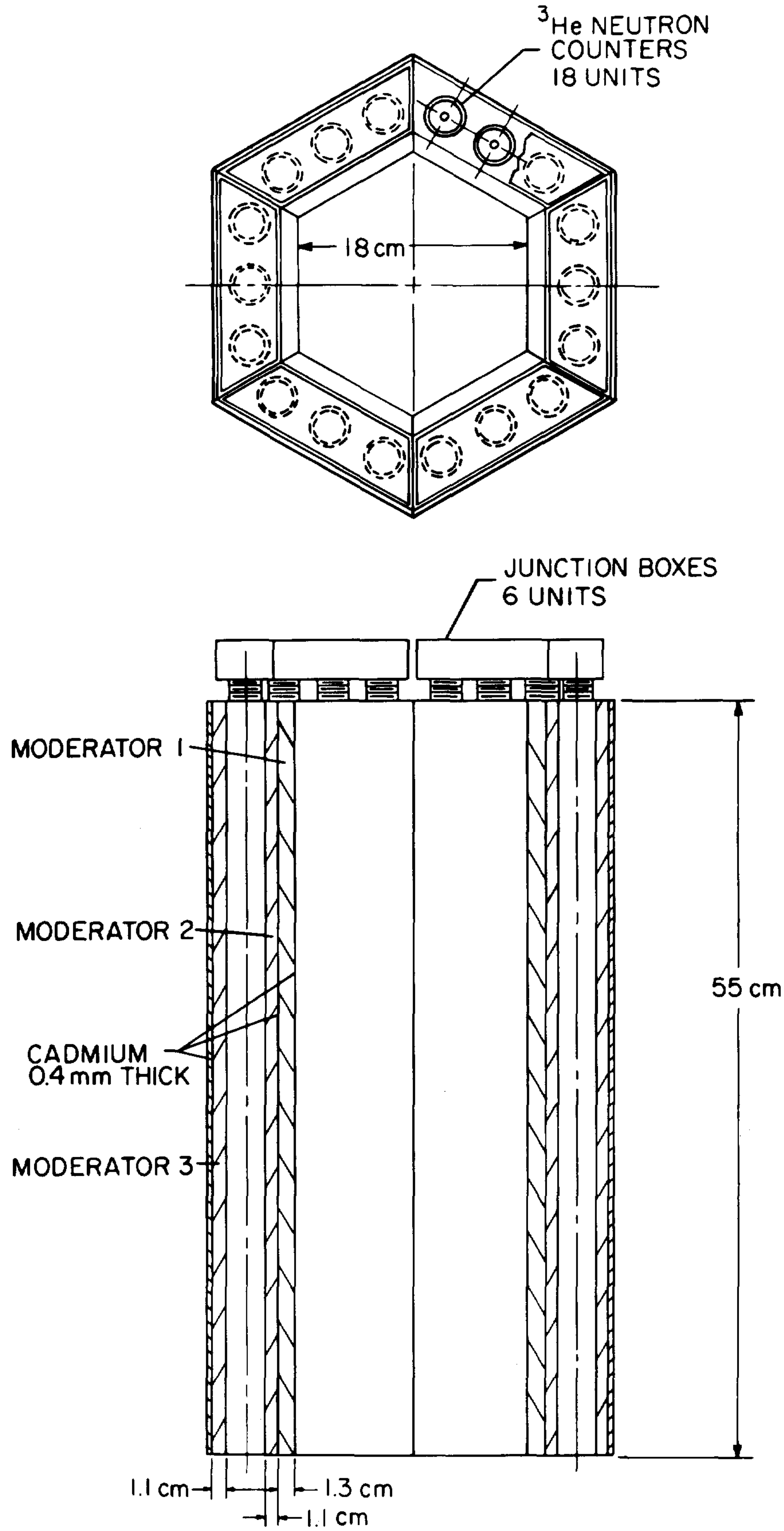

Fig. 3., Portable high-level neutron coincidence counter for the assay of high-mass plutonium samples.

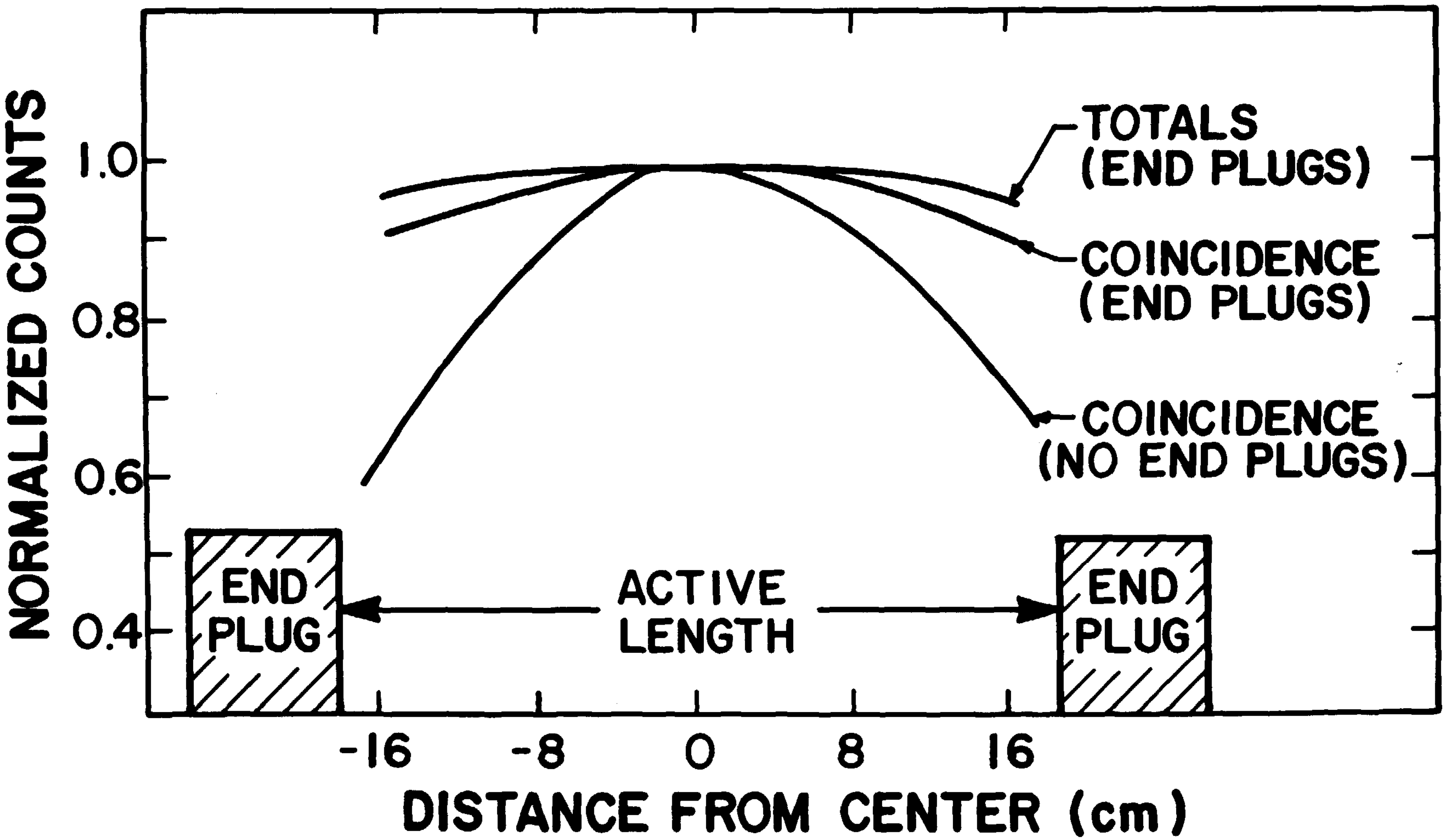

Fig. 4., Measured axial response of the high-level neutron coincidence counter, with and without polyethylene end plugs.

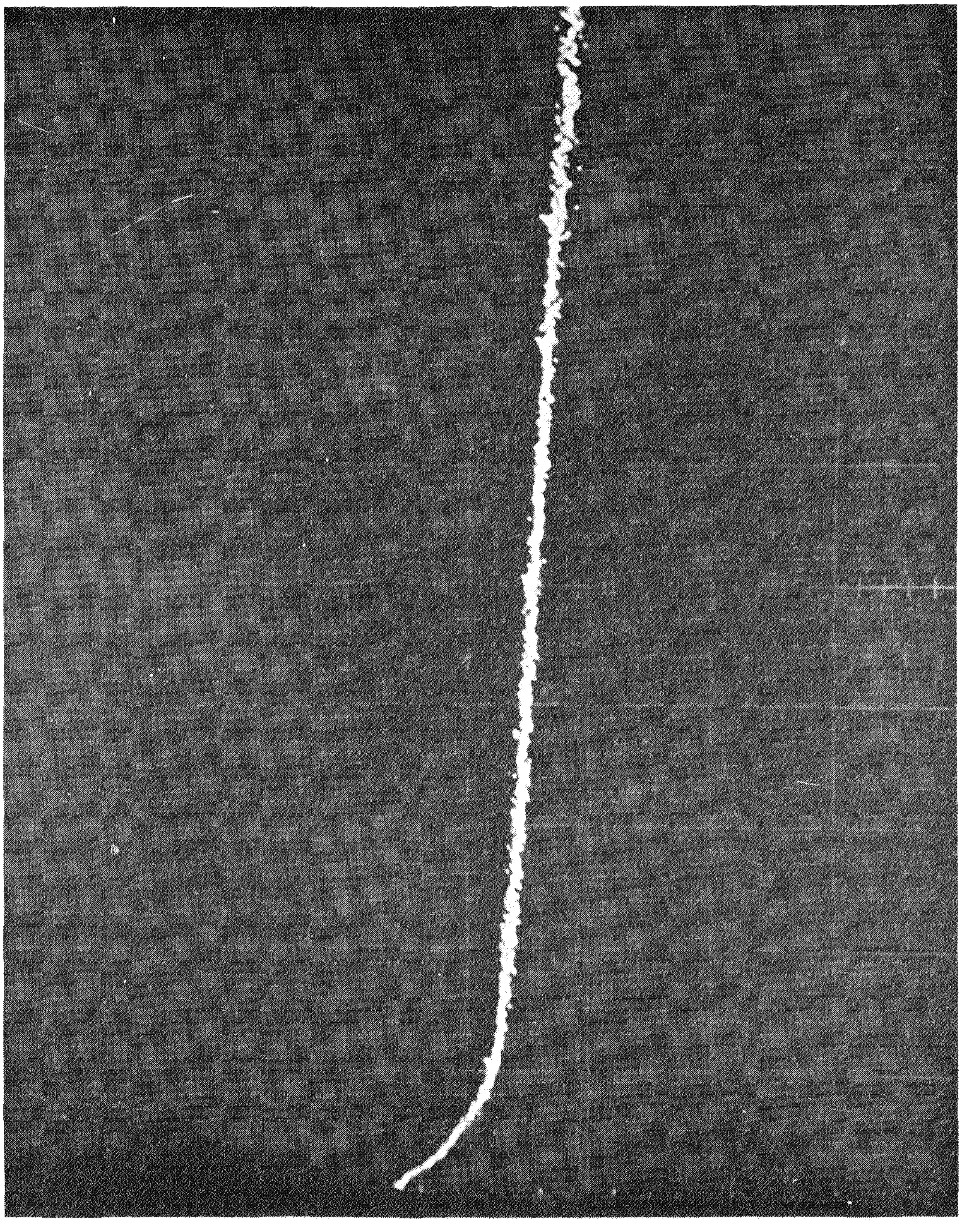

Fig. 5., Semilogarithmic display of an interval distribution formed by fission and random events. 1 μs per dot, 100 μs per division.

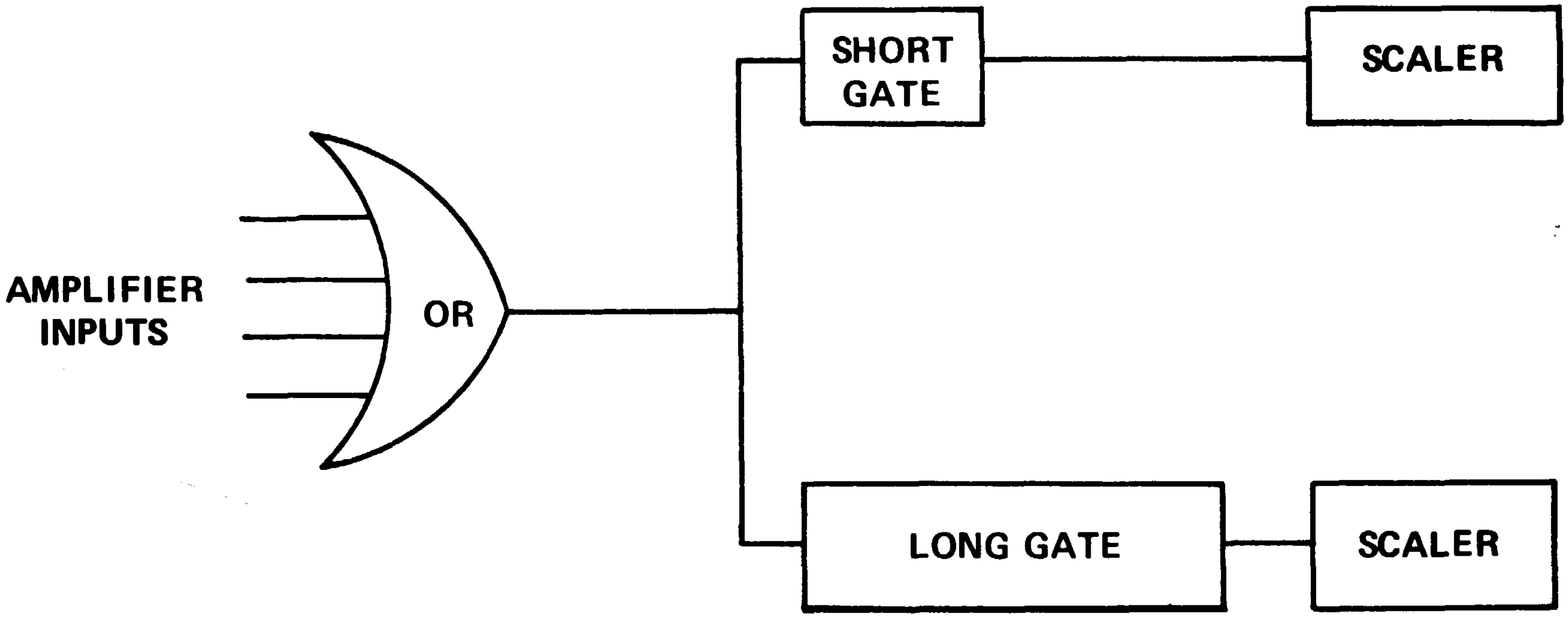

Fig. 6., Block diagram of Variable Deadtime Circuit.

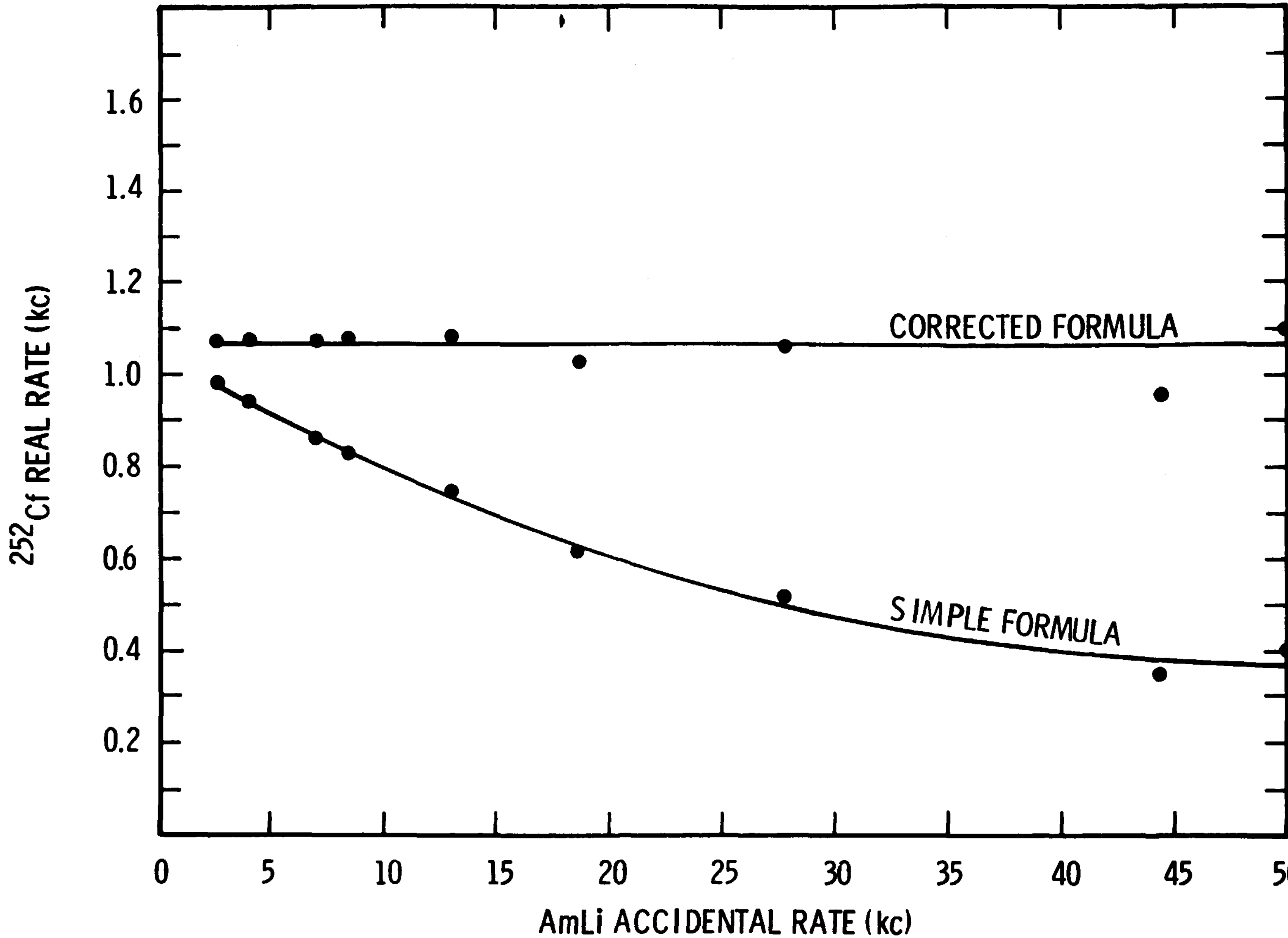

Fig. 7., VDC assay as a function of accidental rate. The simple formula is Eq. 3; the corrected formula is Eqs. 4 and 5. $T_1 = 4\ \mu s$, $T_2 = 32\ \mu s$.

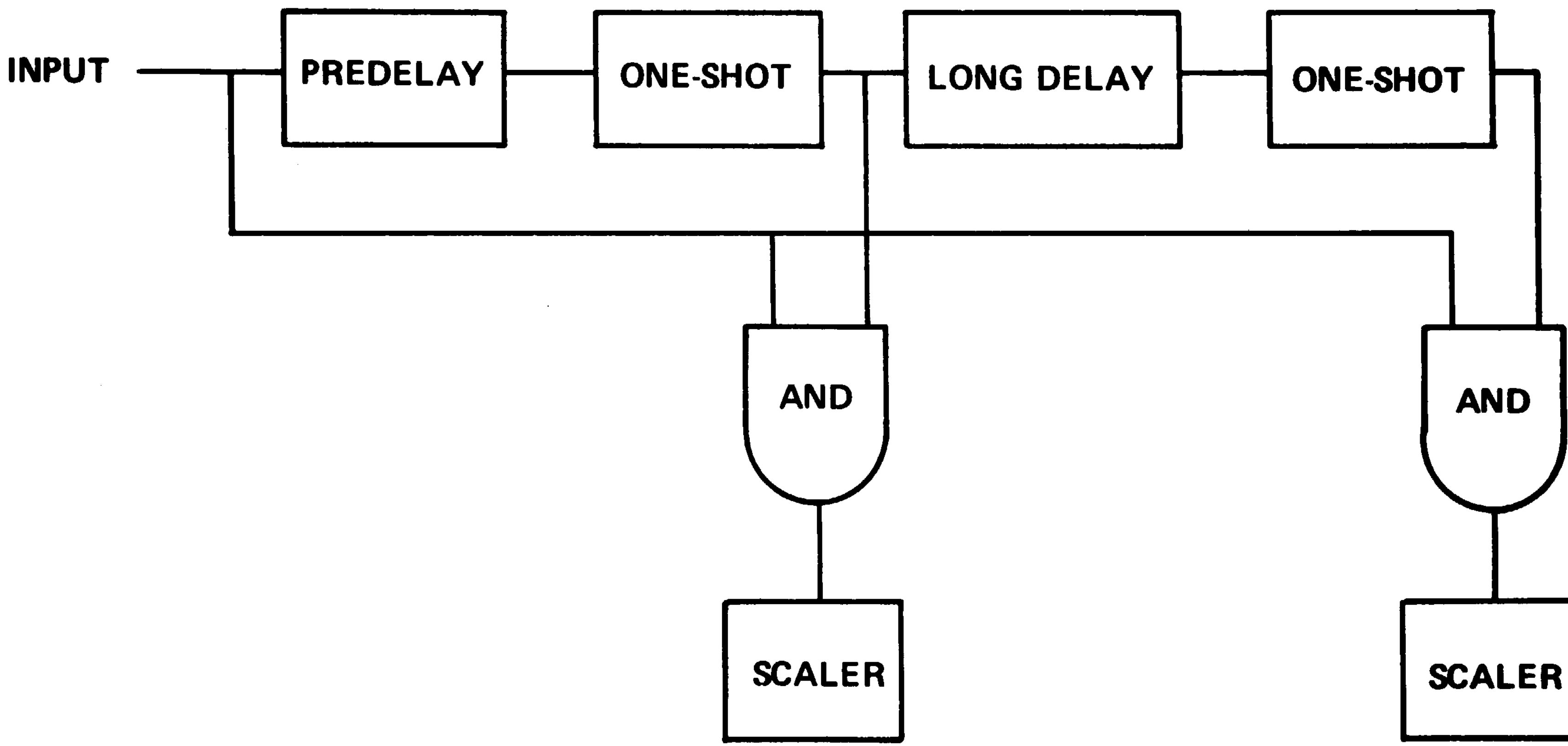

Fig. 8., Updating one-shot circuit. The two one-shots are of equal length.

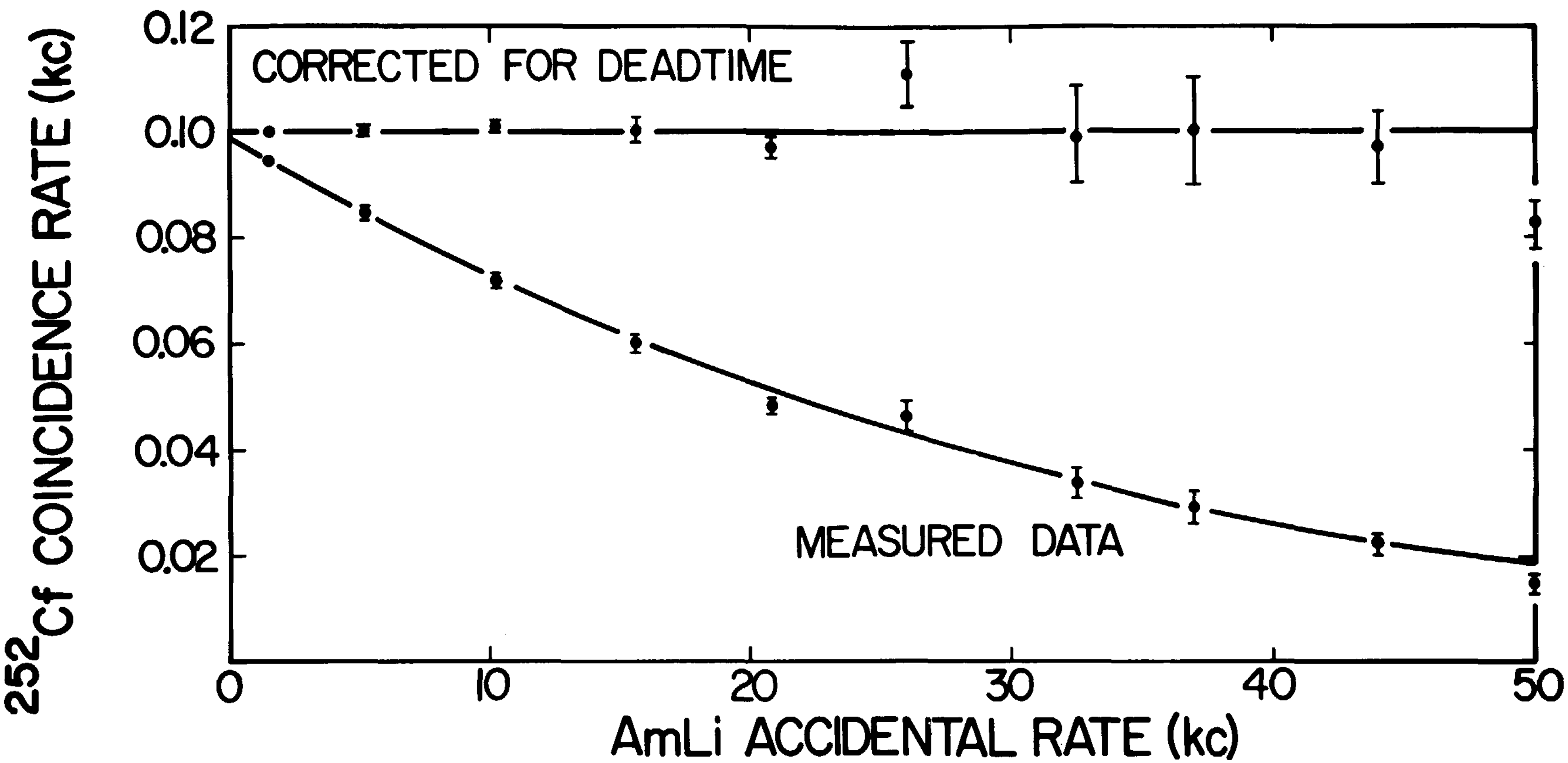

Fig. 9., Updating one-shot assay as a function of accidental rate. T = 32 μs, Predelay = 4 μs. Relative errors are derived from the observed scatter in the data.

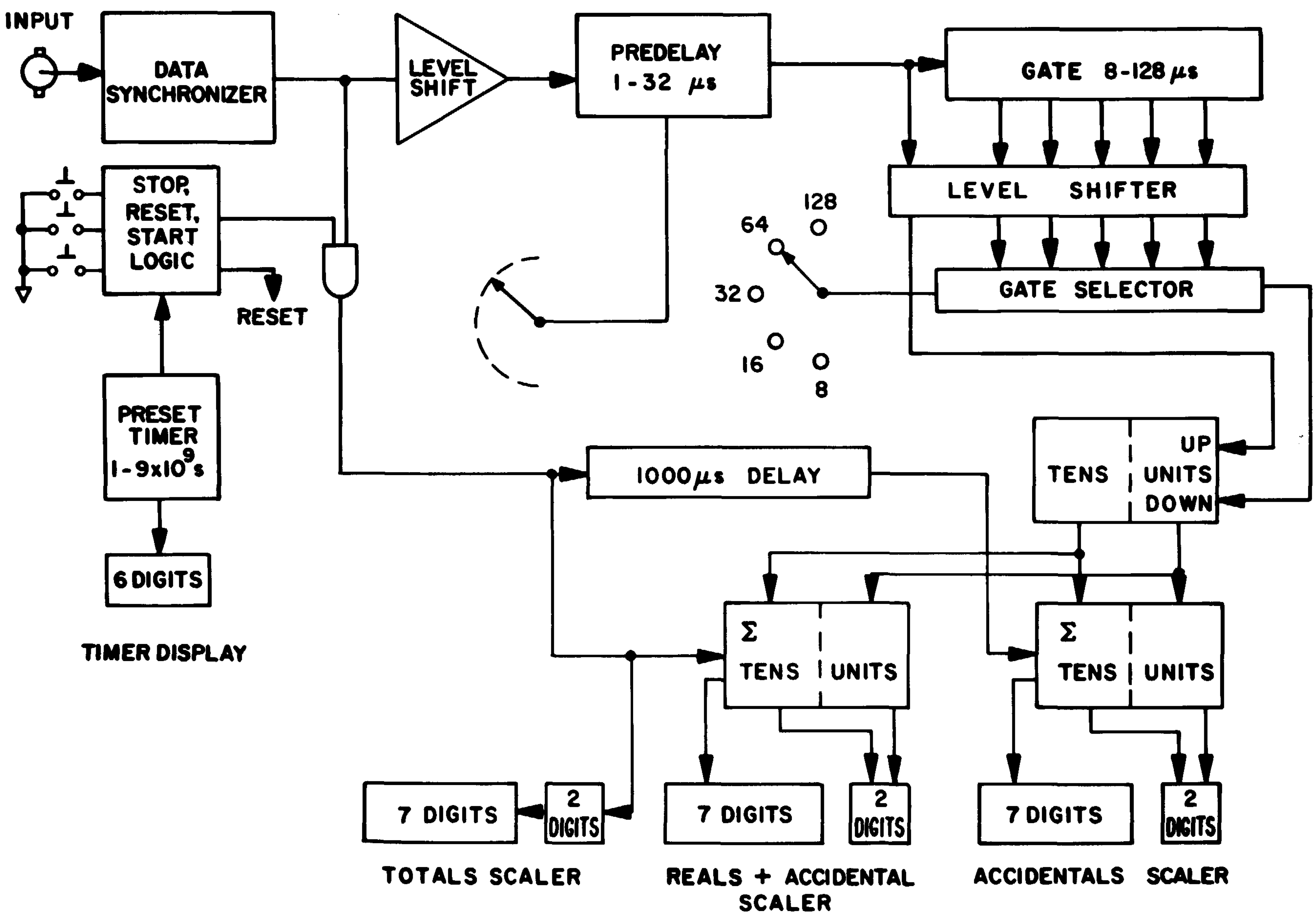

Fig. 10., Block diagram of new LASL shift register.

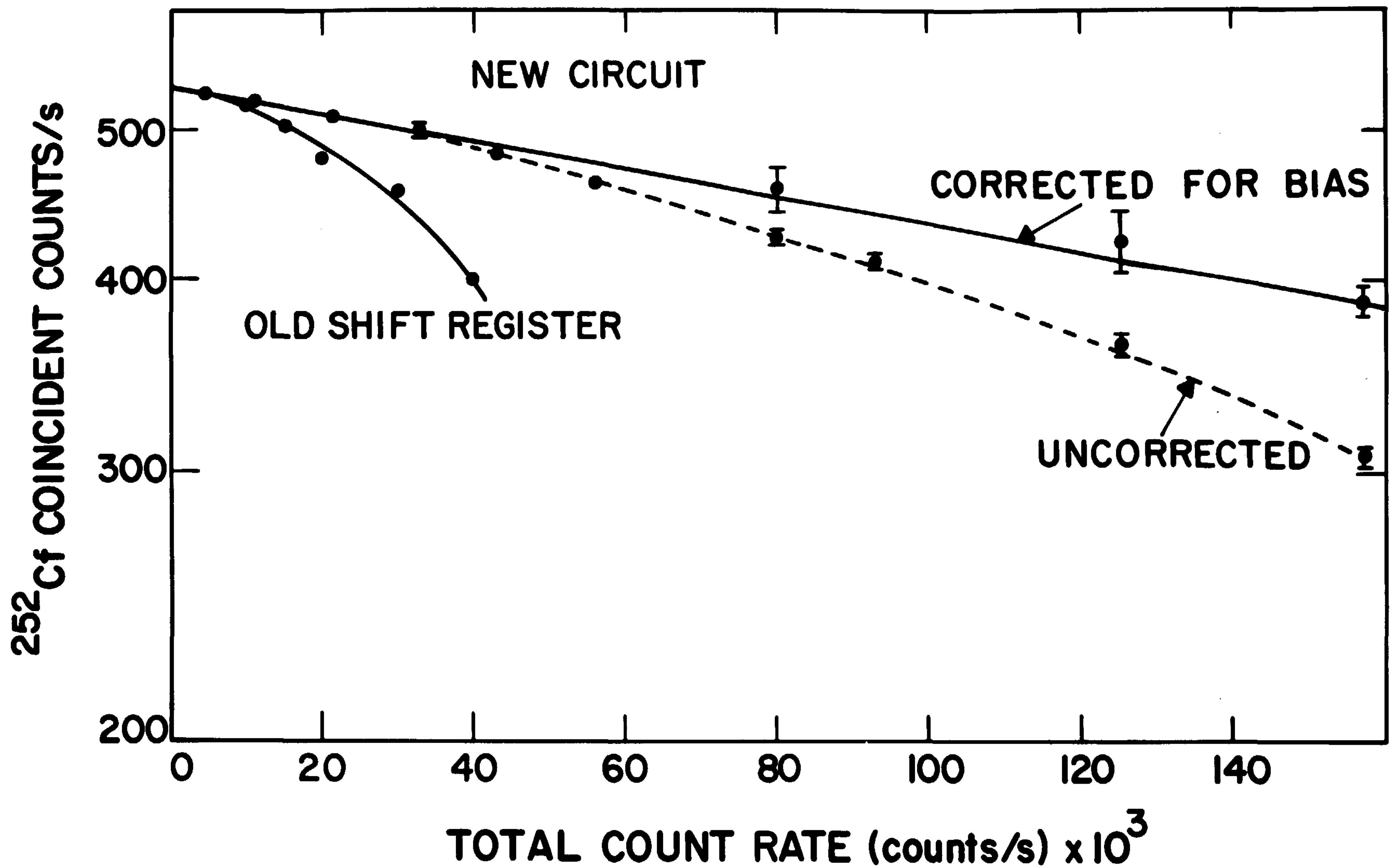

Fig. 11., Comparison of old and new shift-register circuits at high rates using four 0.2 μs biopolar amplifiers. T = 32 μs. Predelay = 4 and 4¼ μs for the old and new circuits, respectively.

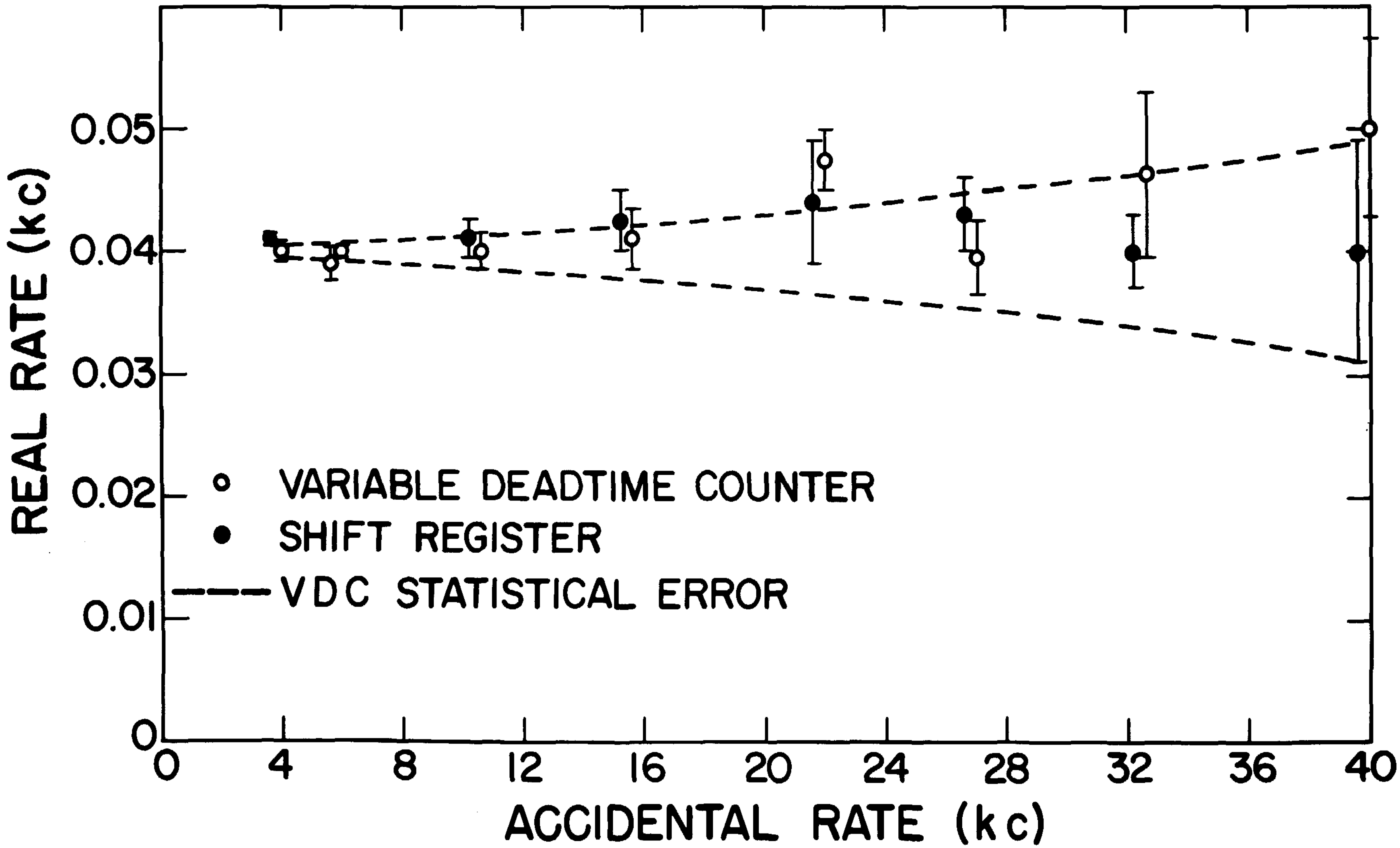

Fig. 12., Assay of 200 g of Pu as a function of the accidental rate due to a nearby AmLi source. $T_1 = 4$ μs, $T_2 = 32$ μs for VDC. Predelay = 4 μs, T = 32 μs for the shift register.

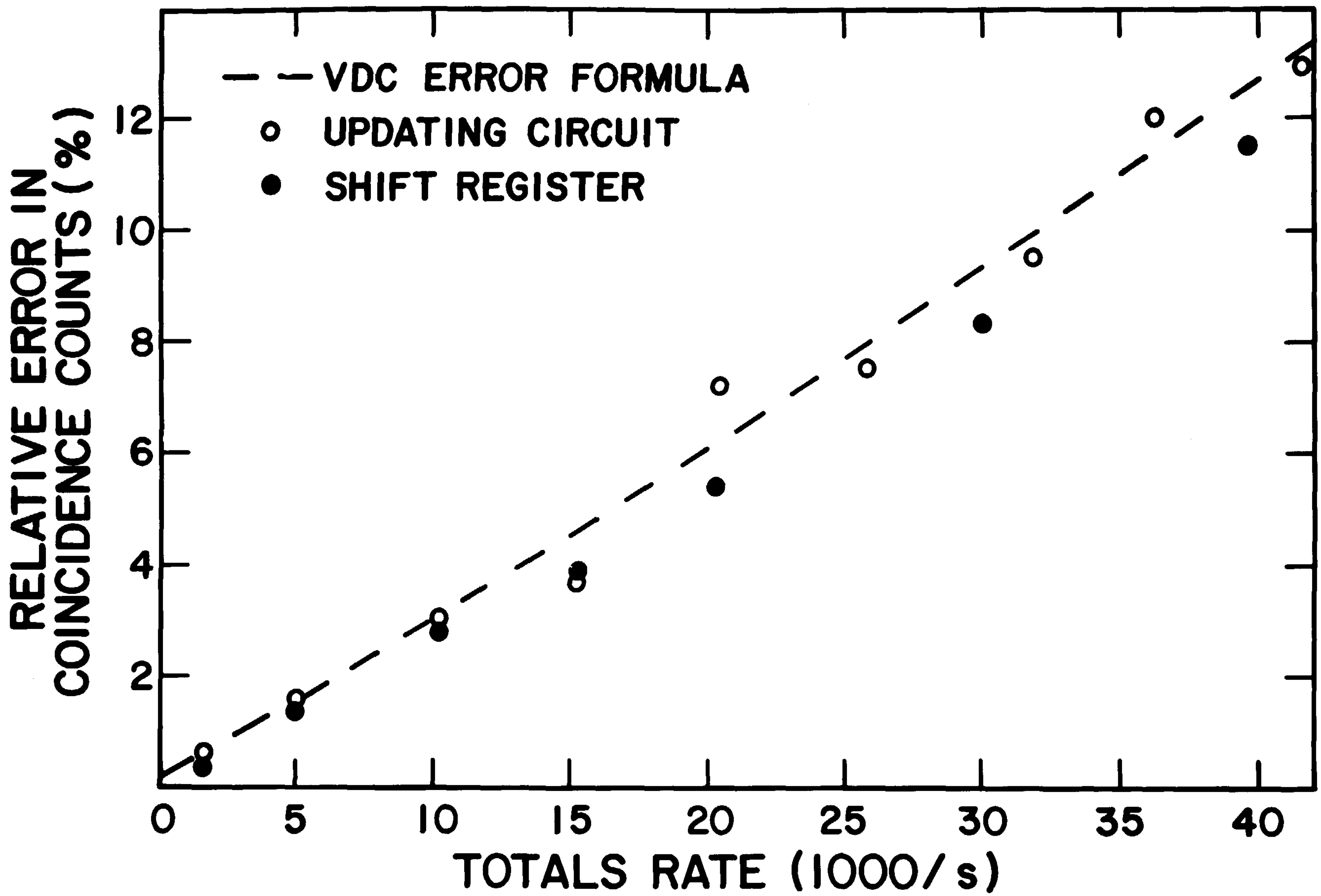

Fig. 13., Relative error in ^{252}Cf assay as a function of AmLi background rate. All predelays are 4 μs and all gates are 32 μs.

Run	Average Total Rate (kc)	VDC Assay (g)	Shift Register Assay (g)	Updating Circuit Real-Time Assay (g)	Updating Circuit Livetime Assay (g)
1	1.6	456 ± 1	482 ± 3	472 ± 2	471 ± 3
2	12.0	446 ± 5	482 ± 10	477 ± 15	480 ± 4
3[b]	6.6	3 098 ± 3	483 ± 4	481 ± 7	479 ± 4

Fig. 14., Intercomparison of thermal-neutron coincidence circuits for variable background rates. The standard deviation was obtained by repeating each three times. For Run 3, the random background was changed by more than a factor of 10 during the measurement.

Chemical and Isotopic Reference Materials in the Nuclear Fuel Cycle

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An Advisory Group meeting on the topic "Chemical and Isotopic Reference Materials in the Nuclear Fuel Cycle" was held at the International Atomic Energy Agency (IAEA) Headquarters, Vienna, from November 8 - 10, 1977. Participants from Euratom, France, Germany (Federal Republic), the Netherlands, Poland, United Kingdom, and the United States took part, as well as representatives of the International Union of Pure and Applied Chemistry (IUPAC), the International Organization for Standardization (ISO), and IAEA. This was the second meeting of its kind; the observations and recommendations of an earlier Group (1972) were not widely publicized or circulated.

The main topics of discussion were:

(i) What is the present status of reference materials for nuclear material analysis and safeguards purposes?

(ii) What new reference materials are required, and can the Agency expedite the provision of such materials?

(iii) To what extent should the Agency be involved in the area of reference materials for nuclear materials analysis and safeguards purposes?

(iv) Should a compilation be published listing the available reference materials, their cost and mechanism for procurement?

Some General Observations

It was emphasized by several participants that production quality control and safeguarding of nuclear materials implied strict analytical quality assurance programmes and that calibration and continuous monitoring of analytical procedures based on certified reference materials were fundamental elements of such quality assurance programmes. Stress was placed on the fact that primary and secondary reference materials were precious and that their preparation and characterization required a highly technical effort by experienced scientists. Accordingly, these substances should be used sparingly and, wherever possible, working calibration and test materials characterized relative to the primary reference substances should be employed.

Measurement of plutonium and uranium and determination of isotopic content was the main subject matter of this meeting. There was insufficient time to consider other topics such as cladding, structural materials, moderators, etc.

The participants had no information on the special requirements of, and availability of reference materials from countries such as the U.S.S.R., Japan, and developing nations; it was felt, however, that their general requirements would be similar to those of the other countries and organizations represented at the meeting.

Recommended Additional Reference Materials

A list of desired reference materials to satisfy present and anticipated future needs was compiled (see Table 1). Several members of the group offered the services of their institutions to help in the production and analysis of these materials. In this way, substances prepared at one institution could be characterized on a cost-free basis at others having appropriate expertise. It was emphasized that multiple-laboratory characterization of reference materials was very desirable especially when such laboratories were highly qualified for this work.

Current and Anticipated Activities of Some Standardization Organizations

Participants from the U.S. National Bureau of Standards (NBS) described ongoing and planned activities at their Institution. Two isotopic reference materials with higher ^{240}Pu contents than those presently available will be prepared on an absolute basis by blending chemically characterized enriched isotopes. The current NBS plutonium isotopic standards, which were certified based on the assumption that uranium and plutonium exhibit equal mass discrimination effects, will be recharacterized using plutonium isotope mass discrimination data obtained by blending separated isotopes. The following standards are also planned for preparation: a solution certified for ^{233}U atoms per mass and/or per ampoule, a solution of ^{230}Th, natural Th metal, a Belgian Congo ore certified for uranium isotope content, three samples of UF_6 with ^{235}U enrichment to 4.5% certified for isotopic and uranium content, and natural Nd_2O_3 and Sm_2O_3 certified for isotopic content. In addition, the existing series of 19 uranium isotopic standards will be recertified to narrower uncertainty limits.

The New Brunswick Laboratory (NBL) is preparing several secondary reference materials. These include (^{235}U, Th) carbide fuel beads containing highly enriched uranium and a specimen of 93% ^{235}U metal. Both samples will be characterized for uranium and ^{235}U content. A depleted uranium metal characterized for assay and isotopic composition will also be made available.

At CBNM, Geel (Euratom), the following reference materials have recently been prepared or will shortly be made available: heavy water (99.7% D_2O), ^{233}U and ^{242}Pu (in ampoules, certified for number of atoms), ^{244}Pu (pending provision of material by U.S.), UF_6 (up to an enrichment of 5% ^{235}U), and packaged uranium oxide for calibration of non-destructive analytical procedures (joint project with NBS and NBL). Homogeneous alloys can also be made according to customer specifications by levitation melting.

The Commissariat à l'Energie Atomique (CEA) plans to prepare a 2-3 kg batch of mixed oxide pellets which will be characterized for Pu assay, U/Pu ratio, U and Pu isotopic contents, and ten metallic impurities at a level of about 100 p.p.m. each. The participants from France did not expect any additional new reference materials to be made available in the near future. However, samples listed in the CEA catalogue (Echantillons de Reference, CEA, Nov. 1975), will be replenished as supplies diminish.

The representative of the United Kingdom stated that his country had no official programme for the preparation of reference materials. However, some working materials at present being used in various U.K. laboratories could be transferred for certification and distribution to recognized suppliers. These materials include natural uranium metal, sintered UO_2, UF_6 (with 0.3%, natural, and 93% ^{235}U enrichment), and high-purity PuO_2 with O/M = 2.000.

General Recommendations to the Agency

The participants agreed that the Agency would meet an important responsibility by providing the following services to Member States:

(a) within statutory limitations, to arrange for ready transfer among them of reference materials to be used for chemical and isotopic analyses of nuclear materials, since legal and administrative rules often render such transfers complicated and time-consuming;

(b) review on a regular basis their requirements (kinds and quantities) of reference materials,collect information from them concerning their activities related to the production and characterization of such materials, and convene at suitable intervals an Advisory Group to assess the status of, and priority needs for, reference materials identified in these inquiries;

(c) encourage them to provide, characterize and distribute reference materials to fulfill the identified requirements;

(d) promote the periodic publication of an updated edition of the existing Euratom compilation(*), listing available reference materials, their cost and mechanisms for procurement. This updating procedure should be carried out in collaboration with CBNM personnel, and the information supplied to ISO for inclusion in its compilation of reference materials;

(e) examine the possibility of more efficiently utilizing existing inter-laboratory measurement evaluation programmes. Several organizations (NBL, CBNM, NBS) have offered assistance in supplying and/or characterizing material for use in these programmes.

Specific Recommendations to the Agency

The Advisory Group recommended that several actions should be taken by the Agency. Details of those recommendations are as follows:

(a) The continuous production and guaranteed supply of those enriched isotopes which are of fundamental importance for the preparation of reference materials should be encouraged. It was stated that definite and substantial steps would have to be taken by the Agency to help overcome delivery difficulties, for example, export restrictions or transportation limitations.

(b) A practical solution of the problems associated with the disposal of wastes containing fissile materials resulting from verification

(*) Catalogue of Reference Materials of Interest to Nuclear Energy, Report No. EUR 5229 e, Central Bureau for Nuclear Measurements, Geel, Belgium (1974).

measurements should be negotiated with Member States.

(c) Participants stressed at some length the great importance of accurate measurements of plutonium and uranium in dissolver solutions of spent fuel from reprocessing plants. It was recommended that substantial support be given to the development and application of suitable in-situ spiking techniques to be used on, preferably, undiluted dissolver solutions even if this required a relatively high consumption of separated isotopes. The supply of these isotopes, a serious problem in terms of availability and cost, is a critical consideration in view of the importance of measuring and safeguarding plutonium to the highest possible reliability at the input of reprocessing plants. It was recommended that the Agency explore the feasibility of financing a supply of these isotopes.

(d) Intercomparison of existing national reference materials should be encouraged in order to strengthen international nuclear material measurement assurance. Thus, for example, the existing UF_6 isotopic reference materials should be intercompared.

(e) To promote the proper use of reference materials and compliance with internationally recommended norms, the Agency should organize the distribution of appropriate documents related to the preparation, characterization, certification, sampling and analysis of such materials. Thus, contact should be maintained with international standards writing organizations such as ISO, BSI, ASTM and IUPAC to ensure that the Agency information is adequately updated and that the requirements of Member States are taken into consideration. It was also suggested that consideration be given to the possibility of utilizing INIS for the systematization and distribution of information on written standards in cooperation with NBS and organizations such as ISO, ASTM, and BSI.

Specific Recommendations to Member States

The Advisory Group directed some specific recommendations to the Member States of the Agency.

(a) Acceptance of a reference material and its use should be based exclusively on the demonstrated high quality of its preparation and characterization, and not on consensus.

(b) Certificates of analysis should have some uniformity and should be more detailed than they usually are. The ISO representative at the meeting provided a list of items that should be included in such certificates and, following discussion, the following desiderata were recommended for uranium and plutonium containing materials:

(i) Name and address of certifying organization;

(ii) Identification of personnel and organizations involved in the preparation and characterization of the reference material to whom technical inquiries can be addressed;

(iii) Name and batch identification code;

(iv) Date of issue;

(v) Source of material and a discussion of its preparation, if appropriate;

(vi) Measurement methods used for characterization;

(vii) Values for certified components, additional values for non-certified components, if appropriate, and discussion of factors affecting the accuracy of the measurement methods employed.

(viii) Uncertainties associated with the certified values including details on the statistical treatment used to establish those uncertainties;

(ix) Information specifying proper use of the material, limiting conditions beyond which certified values no longer apply and, if appropriate, the minimum quantity required to assure homogeneity;

(x) Information on stability, and an expiration date for the validity of the certified values, if appropriate;

(xi) In the case of plutonium reference materials, the decreasing plutonium assay value, increasing uranium content, changing plutonium isotopic values, and increasing Am-241 content should be given as a function of time, as appropriate;

(xii) Literature references should be cited in which more detailed information about the preparation, characterization, and statistical data treatment of the material can be found.

(c) Whenever possible, existing reference materials intended for either fissionable isotope or element assay should be certified for both measurements.

(d) Half-lives of the plutonium isotopes should be determined as accurately as possible as these data have a crucial bearing on accurate element and isotope assay as well as on plutonium accountancy.[1]

(e) There is a need for continuous interlaboratory measurement evaluation programmes for fissionable element and isotope assay. Such programmes should:

(i) Demonstrate the inter-laboratory spread of measurement results;

(ii) Give participating laboratories the opportunity to judge their performances relative to other laboratories;

(iii) Use materials that have carefully characterized assay and isotope values so that accuracy can be assessed;

(iv) Employ coded participation. Code identity should only be disclosed with the consent of the laboratory concerned and on a case-to-case basis.

(v) Have voluntary participation.

Several of the recommendations directed specifically to the Agency Secretariat are being actively implemented. A follow-up Advisory Group meeting will be held in 1980.

[1]A current program sponsored by U.S. DOE has as its objective improved accuracy in plutonium isotope half-lives.

TABLE I - NEEDED REFERENCE MATERIALS

Material	Quantity per package	Characterized for	Supplier
^{242}Pu solution (metal?)	low mg (0.1 - 10 μg/g)	^{242}Pu atoms per g or per vial	NBS, CBNM
^{244}Pu solution (metal?)	low mg (0.1 - 10 μg/g)	^{244}Pu atoms per g or per vial	NBS?, CBNM?
^{233}U	1 mg/g in ∿10 g ampoules	^{233}U atoms per g or per vial	CBNM, NBS, CENG Grenoble
$^{233}U/^{235}U/^{238}U$: 1/1/1	low mg	isotope ratios	CBNM, NBL≠, CEA
Pu isotopic RM's	low mg	isotopic composition	NBS, CBNM (on absolute basis)
$^{239}Pu/^{242}Pu/^{244}Pu$:1/1/1	low mg	isotope ratios	CBNM
^{230}Th	low mg (∿1 μg/g)	^{230}Th atoms per g or per vial	CBNM, NBS
UF_6 (depleted, natural, low enriched)	1 g	isotopic composition	CBNM, NBS BNFL, Capenhurst Cogema, Pierrelatte
^{235}U enrichment >99.5%	100 mg per ampoule	isotopic composition	NBS
^{238}U enrichment >99.99%	100 mg per ampoule	isotopic composition	NBS
nat. Nd_2O_3	10^{-3}g	isotopic composition, purity	NBS
nat. Sm_2O_3	10^{-3}g	isotopic composition	NBS
D_2O	5-10 g	isotopic composition	CBNM
$(U,Pu)O_2$ pellets U/Pu = 3/1	∿1 g	U and Pu element content, isotopic composition	CEA, NBL, NBS, CBNM-TU

≠ currently available

TABLE I - NEEDED REFERENCE MATERIALS (contd.)

Material	Quantity per package	Characterized for	Supplier
$(U,Pu)O_2$ pellet	~1 g	O/M = 1.98	US, UK, FRG collectively
PuO_2 (10-12% ^{240}Pu)	1 - 10 g	Pu element content, isotopic composition	BNFL Windscale CBNM - NBS collectively
Th metal	1 - 10 g	Th element content	NBS*
TRISO BISO Th/U = 10/1 93% ^{235}U	5** - 15 g	U element content U isotopic composition Th element content	NUKEM KFK-Karlsruhe NBL≠
$^{nat.}UC$ PuC*** ($^{nat.}U$, Pu) C***	1 g 1 g 1 g	U element content isotopic composition C element content	CBNM AERE-TU
$UO_2(Gd_2O_3)$ (1-3-5-7-9% Gd_2O_3) ($^{235}U/U$ = 1-4%)	3-5 g	O/M ratio U element content Gd element content U isotopic composition	RBU (supplier) USA, KFK (characterization)
UO_2		U element content	BNFL Springfield
UA1 (20-25% U) (93% ^{235}U)	1 g	U element content U isotopic composition	CBNM
Different alloys made to customers' request	1 g	U or Pu element content U or Pu isotopic composition	CBNM

* by the end of 1978
** preferably 5 g
*** lower priority
≠ currently available

NRC Regulation of the Uranium Milling Industry: Problems and Prospects

Remarks by Victor Gilinsky, Commissioner, U.S. Nuclear Regulatory Commission, Presented at the Pacific Southwest, Minerals and Energy Conference, Anaheim, California, May 2, 1978.

I would like to talk to you today about the role of the agency on which I serve as a Commissioner, the Nuclear Regulatory Commission, in regulating uranium milling operations—the extraction of uranium from its ore. Our responsibility is to protect the public's health and safety and the environment and our chief concern here is the disposition of the discards, or "tailings," of the milling operation. We are being increasingly forceful in requiring improved practices for the management of these wastes. As some of you may be affected by this, I thought you might like to hear about what the Commission is doing in this area.

Tailings

I do not have to tell this audience about the importance of uranium as a nuclear fuel nor, I suspect, is there much new I could tell you about the technology of its extraction. But for the non-experts among you let me state the basic facts: A large nuclear power reactor consumes several thousand tons of uranium over a thirty-year lifetime. To extract that amount of uranium from its ore several million tons of ore have to be processed in uranium mills. The tailings, a sand-like waste material containing almost all of the original ore, are deposited near the mills.

Large quantities of uranium have of course been mined in the United States for some time and as a consequence there are now about 140 million tons of tailings at various uranium milling sites in the West. You cannot miss the tailings pile if you visit a uranium mill.

Health Problems

Unfortunately, the tailings are more than an eyesore. The difficulty is that the tailings generate a radioactive gas called radon, which decays in about four days into other non-gaseous radioactive products.

The uranium tailings are by no means the only source of radon. Radon emanating from rocks in the Earth's crust in fact forms a significant component of the lung radiation dose from natural background radiation.

As long as the uranium ore is undisturbed deep underground not much radon diffuses to the surface. But when the uranium ore is brought to the surface, radon is released into the atmosphere where it can be inhaled.

The possible health significance of these releases were not immediately recognized.[1] You may recall that during the 1950's mill tailings were used as fill material under and around new buildings in Grand Junction, and that later surveys identified hundreds of buildings with excessive radiation levels. Remedial actions are still underway to replace the original fill material.

Since radon is a gas it is also possible for large populations thousands of miles from the source to be exposed, albeit to an extremely low dose. If no steps are taken to control them the tailings can be blown about, further spreading the source.

The extent of the radioactive releases from the so-called "front end" of the nuclear fuel cycle has been persistently underestimated in official reports until quite recently. In 1975 a public interest group petitioned the Commission to amend its standard table of such releases prepared in 1974 because, it said, the NRC neglected mining releases and greatly underestimated the long-term releases associated with radon gas emitted from tailings piles. The Commission has now agreed that the current table is incorrect and is going to provide new estimates.

But even with the right numbers, assessing the health significance of radon releases from uranium tailings is not simple. On the one hand, the relative increase to the existing natural level of radioactivity, at least away from the tailings pile, is exceedingly slight. On the other hand, the tailings continue to release radon for over 100,000 years; and if the tailings are not isolated from the atmosphere the sum of the exposures for all those years could be large in absolute terms—in fact, it becomes the dominant contribution to radiation exposure from the nuclear fuel cycle. Still, how far into the future is it reasonable to count? Obviously there are no easy answers.

The best way to deal with this question would be to reduce the releases to a very low level after mill use by requiring effective isolation of the tailings from the atmosphere. This is the approach we are taking and we think it is a practical one.

1. Radon release poses health problems for uranium miners, whose occupational health and safety is the regulatory responsibility of the Labor Department.

Current NRC Authority

Our ability to carry out such a program of tailings control effectively and consistently is to some extent limited by the way governmental regulatory authority has been assigned in this area. Under the Atomic Energy Act NRC regulatory authority begins at the point uranium is extracted from its ore. But because the tailings associated with uranium milling were not regarded as material that posed significant health risks no special provision was made in the Atomic Energy Act for their direct regulation. The tailings themselves are not currently a material whose possession is licensable by the NRC. NRC control over tailings is therefore indirect: their disposal is a condition imposed on a mill's uranium possession license.

In view of this situation, after a mill's useful life there is now no legal basis for NRC regulatory control over the tailings whatever the health and environmental concerns.[2] There are about 26 million tons of tailings in this category at twenty-two abandoned mills in eight Western states[3] which produced uranium for military programs in the 1950's and 1960's.

The notion in the past that uranium mills pose relatively minor health issues has had other consequences. I mentioned NRC-licensed mills. In fact, NRC licenses only about half of the twenty mills now operating. Regulation of the rest has been delegated to states together with numerous, mostly minor, material licenses under a general delegation of authority from the NRC under the so-called Agreement States Program which dates from 1959. In the 25 states with which the NRC has signed such agreements—including such uranium producing states as New Mexico, Colorado, Texas and Washington—it is the state that exercises regulatory control over uranium milling and tailings. All of this raises questions about uniformity of standards.

NRC Regulated Mills

Where the NRC exercises direct licensing control, the Commission regulates the design and siting of uranium mill tailings disposal areas in accord with its responsibilities under the Atomic Energy Act and the National Environmental Policy Act.

NRC undertook in 1976 to upgrade tailings management at all existing NRC licensed mills. Commitments to control tailings at the end of mill life have been received from all uranium mills licensed by NRC and are being implemented in the form of license conditions. The basic current objectives set by the NRC are to reduce radon release to about twice the natural background level by isolating, or stabilizing, the tailings, and to do this in such a way that it is unlikely the tailings will be disturbed by natural forces in the future. We have required mill operators to set up a financial bonding arrangement to insure that stabilization is actually accomplished before the mill closes.

2. EPA, Under the Resource Conservation and Recovery Act, does have regulatory authority over uranium mill tailings after the NRC license is terminated. However, EPA has no authority over the generation of the tailings and it has taken no active steps to exercise its existing authority.

3. Arizona, Colorado, Idaho, New Mexico, Oregon, Texas, Utah, Wyoming.

For new mills, two basic methods have been proposed by license applicants to meet the objectives. The first is a surface burial method. Among other things, this involves suitable siting of the tailings, and radon control through placement of a one-foot clay cover over the tailings followed by at least five feet of earth appropriately contoured and planted to minimize the effects of wind and water erosion.

The second method of meeting the performance objectives is underground burial of the tailings. Some license applicants have proposed return of the tailings to open mine pits. These proposals are currently under review by NRC with particular emphasis on environmental impacts on groundwaters. Certainly, tailings disposed of in this way are less likely to be disturbed by natural erosion forces and dispersed by winds.

I would like to emphasize that the performance objectives were designed to allow industry some flexibility in proposing various engineering solutions for disposal of tailings. We look to the uranium industry to take the lead in developing specific methods to meet the objectives, although we are strongly encouraging some type of below-grade disposal.

Uranium Mill Regulation in Agreement States

We are also urging the Agreement States to adopt similar objectives for the mills under their jurisdiction. But regulatory procedures are not uniform.

One of the anomalies of the State Agreements Program is that Agreement States do not have to prepare federal environmental impact statements in connection with uranium mill licensing as would normally be done by the NRC. Mills in these states are in effect exempt from the federal environmental review process, a matter which has attracted a good deal of attention in recent months. The issue of environmental impact statements for uranium mills in Agreement States was specifically raised by the Natural Resources Defense Council in a suit filed against New Mexico and NRC now pending in the Federal District Court in New Mexico.

The NRC's legal position is that the Agreement States act independently from the NRC. Therefore, even though NRC licensing of a mill is considered a major federal action for the purposes of the National Environmental Policy Act and therefore requires an environmental impact statement, licensing of a uranium mill in an Agreement State does not constitute a major federal action and does not require an environmental impact statement.

Whether or not an environmental impact statement is legally required for licensing actions in Agreement States, we do belive that a comprehensive independent analysis of the environmental issues is desirable. This is not done in most of the states which regulate mills.

To strengthen state health and safety regulation of uranium mills, in April of this year the Commission decided to offer technical assistance to interested Agreement States on a trial basis to assist them in assessing the environmental impacts of their uranium mill licensing. The program will be reviewed annually to check whether it is indeed helping states to regulate more effectively and to develop their own capabilities, or whether the situation calls for further steps by NRC.

My own view is conditioned by the fact that wind-blown tailings and radon releases do not observe state boundaries. Tailings in New Mexico can affect exposures in New York. This suggests the need for uniform national standards. I believe mills should have to follow the same basic health and environmental rules whether or not they are in Agreement States.

Generic Environmental Impact Statement; New Legislation

Our thinking in this area will be assisted by an overview document, a generic environmental impact statement, now being prepared by the NRC on the whole subject of uranium milling operations both under NRC and Agreement State jurisdiction. (I should note that this is being done in response to a petition from a public interest group.) The report, which will be ready this fall, will emphasize the management of mill tailings. In the process of preparation of this statement, we have come to the view that it would be desirable for NRC to have direct regulatory control over uranium mill tailings. The main difficulty is that present authority does not provide long-term regulatory control of tailings following final termination of mill operations (and therefore uranium possession).

This gap in authority makes it more difficult to provide uniform and effective solutions to the long-term health problems. The simplest legislative adjustment to permit effective regulation would be to include uranium mill tailings among the licensable materials set out in the Atomic Energy Act.

The Commission has in fact decided to ask for such authority. And, I should tell you it has also decided to include a requirement that Agreement State regulation of uranium mills meet minimum federal standards to be set by NRC.

Uranium Mill Tailings at Inactive Sites

This still leaves us with the question of how to handle the twenty-six million tons of tailings at abandoned uranium mills in several western states.

A Department of Energy assessment of this problem has been performed and published. It shows that none of the sites can be considered to be in satisfactory condition from the long-term standpoint. At some sites, no stabilization of the tailings had been carried out. At others the site conditions were found to require continued surveillance and maintenance.

A plan drafted by the Executive Branch and incorporated in draft legislation submitted to the Congress a few days ago would authorize corrective actions by the federal government. These would not be subject to licensing but NRC would have a voice in the choice of remedial action—the individual plans would be subject to NRC review and concurrence. While each of the inactive sites presents a unique waste management problem, the performance criteria now being applied to new, regulated uranium mills should in my view be the objective for the remedial action program to the extent practicable.

Conclusion

I would like to make several observations in conclusion. I think it is clear that in the past the regulators paid less attention than they should have to the possible health hazards connected with uranium mill tailings. This situation was corrected in large part through useful and constructive comments on the part of individuals and groups outside the government. The NRC can take some satisfaction in the fact that it provided a vital channel for such public comment, and also in that when these comments were reviewed and assessed the NRC and other agencies of the government responded with remedial solutions for abandoned mills and improved approaches for existing and new mills. Finally, I am told by our staff that the uranium industry has generally been receptive to developing improved methods of tailings management. All of which suggests we may finally be on the way toward getting these problems under control.

John Georges Joins NUSAC

McLean, Va.—Dr. **Ralph F. Lumb,** President of NUSAC, Inc. has announced the appointment of **John Michael Georges** as a Senior Technical Associate in the Security Programs Division. Mr. Georges' responsibilities will include the development of security plans, contingency plans, and security training programs for NUSAC's clients.

Mr. Georges' previous military assignments included five years as a military intelligence officer in the United States Army in Vietnam. He served as Team Chief of Special Operations in the Counterintelligence Section, 55th M.I. Detachment.

Mr. Georges holds B.S. and M.B.A. degrees from Rhode Island University.

NUSAC is an independent consulting firm providing assistance to the nuclear power generating industry. Its services include management audits of quality assurance and physical security programs, auditing of nuclear fuel fabrication, development of material safeguards design and procedures, and the design and implementation of physical security plans and procedures.

For further information contact **Robert C. Adkins,** Director of Marketing, (703-893-6004).

Mr. Georges

Some Observations on Recent and Proposed Changes in NRC Jurisdiction

Remarks by Commissioner Peter A. Bradford, U.S. Nuclear Regulatory Commission before the AIF Workshop on Reactor Licensing and Safety, Phoenix, Arizona, April 5, 1978.

The concept of independent regulatory commissions exercising extensive powers over particular industries is said to be a uniquely American experiment, a halfway point between outright governmental takeover and unfettered private operation. Its origins lie largely in economic regulation, that is in the setting of rates for electricity, gas, water, telephones, and transportation.

The concept of regulation to protect the public health and safety and the common defense and security is, of course, as old as government itself. The exercise of this power by independent federal regulatory commissions has a less clear history. It exists at the Interstate Commerce Commission, as an adjunct to a fundamentally economically oriented mission. Similar powers are exercised by an administrator rather than a commission in all or parts of many federal agencies such as OSHA, EPA, and the Federal Aviation Administration. What seems to me to be unique about the Nuclear Regulatory Commission and the Atomic Energy Commission before it is that they were commissions, not single headed agencies, created to regulate a single technology in all of its health and safety aspects.

Because the AEC and the NRC's jurisdictions have had this vertical structure while most health and safety regulation is structured horizontally (that is, to regulate a given type of danger regardless of the industry in which it occurs), numerous overlaps with other regulatory agencies have been inevitable. In the early years of nuclear regulation, the NRC's vertical jurisdiction over the nuclear industry took clear precedence over state health and safety regulation, over labor safety regulation, over air and water pollution control, over foreign commerce, and over laws and regulations affecting transportation. The theory was that the AEC would discharge its responsibilities so as to protect the public without splitting up the jurisdiction over nuclear matters in a manner then perceived as unacceptable both for maintaining a necessary level of secrecy and for securing the rapid expansion of peaceful nuclear programs.

Over the last decade, the exclusive jurisdiction of the Atomic Energy Commission has eroded to the point at which some, both in the industry and in the environmental community, seriously question whether nuclear regulation remains so unique as to require "vertical" regulation and, if not, whether there remains a need for the Nuclear Regulatory Commission.

Time does not permit me to undertake an extensive review of how we have reached this situation. As a general matter, however, I think that it is safe to say that nature is no fonder of a jurisdictional vacuum than of any other kind. The history of the Atomic Energy Commission on safety and environmental matters, despite the absence of devastating accidents, was not a reassuring one. It was often rebuked by the courts; some studies were suppressed; others were not undertaken or were done frivolously. A great many well-intentioned and capable people worked very hard, but in an atmosphere in which the Commission itself sometimes discouraged hard questions and set up extensive mechanisms for setting such problems as waste management aside. In one illustrative example, the AEC defined away any responsibility for protecting uranium miners by finding the Atomic Energy Act of 1954's language extending AEC authority to uranium ore "after removal from its place in nature" to mean that the ore had to be out of the mine instead of out of the rock in which it had rested. Despite studies showing extraordinarily high rates of lung cancer deaths among uranium miners, the AEC also ignored its authority to regulate mining contractors under the Public Contracts Act. When the U.S. Department of Labor finally set a standard in 1967, the AEC and the Congressional Joint Committee on Atomic Energy moved promptly to have the allowable exposure more than doubled. In 1971, this weaker standard was reduced by a factor of three. Enforcement responsibility was put not in the AEC, but in the Department of the Interior from which it has now migrated to the Labor Department.

I have dwelt on this one episode because I think it helps to illustrate a major reason why the NRC today shares jurisdiction with many agencies who once had no say in nuclear matters. The Atomic Energy Commission's casual and sometimes even hostile approach toward the regulatory part of its mandate created vacuums in health and safety and environmental and export regulation that parts of the public together with other government agencies and the Congress moved to fill. In almost every instance, the jurisdictional struggles involved a push for stricter standards than the AEC or the NRC had set, and in almost every instance the standards were tightened. The industry and its defenders have tended to ascribe this result as much to the political irresistability of increased safety margins as to any real flaw in the original regulatory framework. Nevertheless the costs and other discomforts of the phenomena referred to as "backfitting" and "ratcheting" clearly flow from the same perceived inadequacy of the AEC regulatory effort that has given rise to the proliferation of nuclear jurisdictions.

Some jurisdictional overlap with the states and with other federal agencies was inevitable no matter how well the AEC had regulated. States and private citizen groups have a legitimate claim to a say on large facilities located in their midst. The State Department, the Arms Control and Disarmament Agency, and the intelligence agencies should be heard from before an export license issues. The National Environmental Policy Act of 1969 combined with the Calvert Cliffs court decision and the formation of the Council on Environmental Quality and the Environmental Protection Agency to set up an environmental bureaucracy (and keep in mind that we bureaucrats don't use that term with the same inflection as the rest of the world) with a legitimate interest in nuclear plant discharges and impacts, especially those that did not directly involve radioactivity. Finally, there was always the possibility that nuclear material might be stolen (which is the everyday word for "diverted") or nuclear facilities sabotaged by a group or a nation interested in explosives or, in the terrorist case, in the toxicity or the mystique. As the disturbing facts of the materials unaccounted for situation became public and as terrorism increased around the world, the safeguarding of both materials and facilities, including reactors, created or enlarged the links between the NRC and local police forces on the one hand and the intelligence community on the other. In this and other contexts, the NRC has been required also to establish an arms length relationship with the other, larger part of what was the AEC. That part became ERDA and is now contained in the Department of Energy.

The NRC's relationship to the Department of Energy is obviously a special case. The NRC owes its very existence to Congressional and public dissatisfaction with the combining of regulatory and promotional roles in the AEC. When that agency was divided, the NRC was given some regulatory responsibility over certain ERDA projects, including Clinch River. When ERDA traveled into the Department of Energy, it assumed a central role in nuclear energy policymaking. The overlap was given a more personal dimension when Dr. Schlesinger, a former AEC chairman, was named Secretary of Energy and when several of the Department's other top officials came from the AEC as well. Since these men were assigned the functions of rewriting the NRC's licensing process and participating extensively in the selection and confirmation process of NRC commissioners, questions about the NRC's real independence, never completely resolved in any case, have arisen again in the relevant Congressional committees.

This independence question is an exceptionally difficult one. The two agencies have an extensive shared past. There are many close personal and close working relationships. Positions and reports on different questions have been laboriously worked out jointly. The concept of an arms length relationship is not coming easily. Indeed, on subjects such as nuclear waste management, extensive cooperation and coordination remain essential if the NRC is to avoid being presented with a choice between approving a particular licensing request sometime in the mid-1980's or rejecting some five to seven years of DOE effort with drastic implications for the then existing and future power plants.

The recent report of the DOE waste management task force contemplates the NRC's licensing of future waste repositories for spent fuel. To this end, the NRC will have a nonvoting status on the President's interagency waste management task force. At the same time, we will be developing criteria for waste repositories while DOE is developing its waste repository program. It would obviously have been better to have had a running start on the criteria before designing a program to meet them, but the new emphasis on the once-through fuel cycle has given the waste management program an urgency that is compressing schedules to something less than the ideal from a program development standpoint.

I have talked at some length about the NRC's links to other federal agencies. One could go on at equal length on specific problems, on the nature of bureaucratic rivalry, on the need to eliminate redundancy, on the costs involved. However, I'd rather turn instead to our relationship with other groups that affect our policymaking. These groups include the courts, the Congress, the public interest groups, the industry, and the media.

As to the courts, our relationship appears to have been considerably redefined just two days ago by the Supreme Court's decisions in the **Vermont Yankee** and **Midland** cases. The former held that courts could not compel the NRC to go beyond the basic procedural requirements of the Administrative Procedures Act in rulemaking proceedings. It did not limit our power to do so in cases in which we ourselves felt that more formal procedures were important to an informed decision. In theory, this case should not make much difference to the way we operate. It will, however, limit the opportunity for challenges to our decisions simply on the ground that our procedures were inadequate. The only cases in which our internal workings might be affected would be those rulemakings in which we have adopted procedures that we disagree with solely to satisfy the now voided Court of Appeals rulings. There are no present cases in which I personally feel that we have adopted such excessively formal procedures.

The decision in the **Midland** case places some obligation on an intervenor to do more about an issue such as energy conservation than simply raise it and then leave it for the NRC to handle. However, the Court puts some emphasis both on the fact that energy conservation was less well understood as an alternative in 1971 than it is today and on what it viewed as an exceptionally passive performance by this particular intervenor. Because this decision puts a greater burden on intervenors is some instances, it will provide some further push toward intervenor funding. My own feeling, based on a first reading, it that this decision is not likely to have much of a specific impact outside of the **Midland** case itself.

One other possible impact of these court decisions will be on the Congressional debate over licensing reform. "Judicial interference" has been something of a rallying point for those who ascribe the industry's troubles primarily to intervenors and to the length of the overall regulatory process. Whatever substance this argument may have had—and it's hard to see very much in general or in the **Vermont Yankee** and **Midland** cases—the Supreme Court's decision represents a court step that removes some of the justification for the legislative provisions directed at the NRC hearings process and at circumscribing judicial review.

You have already heard a good deal about the new licensing bill. I would only add that its Congressional reception will in some measure be influenced by the fact that the NRC's standing in Congress is at a very low ebb. Some of this is attributable to the fact that the NRC's old and cozy relationship with the Joint Committee on Atomic Energy spawned both concern and resentment in the Committees that now have jurisdiction over us. However, Joint Committee backlash is only part of the problem. The Hart, Dingell, and Udall committees and subcommittees all feel that the NRC has misled them in ways based on a desire to protect the nuclear industry, and it is clear that they expect a very different kind of Congressional performance from us than the relationship that we had with the Joint Committee.

With regard to the media, I would only say that my own perception is that the NRC is not much driven by the media on specific issues. We have opened our processes a good deal, partly on our own and partly as a result of new laws. However, the media are not monolithic on nuclear issues, and I wouldn't begin to know how to please them as a group even if that were an NRC goal.

As I have indicated, the industry's dour view of its relations to the NRC is not shared by the rest of the world. The public interest groups are as sure that you control us as you seem on the basis of today's remarks to be sure that they do. Some of this is obviously excessive advocacy; some of it results from the fact that we make many highly public decisions and everybody can find something to criticize. Some of it must result from the fact that we don't always explain our logic, and, I'm sure that some of it comes from real instances of illogic.

I want to dwell on the backfit matter for a moment since it seems to exemplify our problem. I don't know what the ultimate standard will be, but I do know that the past regulatory history is going to produce some instances in which backfitting is necessary.

Since backfitting has been the subject of some discussion already this morning, let me discuss it in a non-nuclear context. In the absence of any accident, it is plausible to assert, as Mr. Ward has done, that we should begin our standard setting with the proposition that today's plants must be safe enough or else they would not have been licensed. However, it seems to me that this logic would also have supported the proposition that the **Amoco Cadiz** was safe enough right up until the moment that it went on the rocks off the French coast.

Indeed, I can recall back when I was involved in drafting legislation to regulate oil tankers off the coast of Maine, I believed an industry proposition to the effect that there was no likely accident in which a supertanker would spill all of its oil within a short time. The reason was that compartmentalization would prevent any one accident from rupturing the vessel in a manner that would release more than 20-25% of its cargo. The rest could then be pumped out after the storm had abated or else would stay within the vessel when it sank with consequences that unpredictable but at least were not part of the original spill.

I have no way of knowing what a Rasmussen Report on the oil industry would say about the likelihood of an **Amoco Cadiz** type accident. I do know that the tanker industry has fought against more realistic liability requirements and such technical improvements as double bottoms on the basis that an accident of major proportions was a very remote contingency compared to the cost of the proposed reforms. Those arguments must have sounded much more logical in France the day before the accident than they do today, and the **Amoco Cadiz** stands with many other industrial accidents in clear refutation of the attractive principle that everything permitted, regulated, and inspected may be presumed to be safe.

* * * *

Where then does this process leave us. If the pendulum swings away from a nuclear era in which the chief regulators viewed promotion as one of their functions, it will necessarily produce both necessary corrections and some overreactions. Where fundamental problems remain unsolved, the debate will be especially bitter, and those who profited the most from the absence of debate when it should have occurred are really not in a position to deplore it now.

There is, I think, a lesson of sorts in the fact that the electric utility industry, which in past frequently opposed extensive government involvement in land planning, is now asking various levels of government to help it bank sites as far in advance as possible. The corporate rhetoric now is that of the land planners of a decade ago—conflict must be minimized and predictability sought through decisions made in a complete manner early in the process. I would expect a similar perspective shortly on subjects such as waste management or intervenor funding. Industry may have preferred a rigged wheel, but, if I understood John Ward correctly, it is willing to settle for one that is round.

The path leading to such a result seems to me to lie in a desire on all sides to permit the remaining hard questions about nuclear power to be openly asked, thoroughly explored, and impartially resolved.

This abstract proposition is hard to quarrel with. The difficulty is that on specific issues such as waste management and proliferation, we still, twenty years into a nuclear program, don't know where it will lead us.

Editorial: Are You Provoked?

(Continued from Page 1)

was a last minute afterthought. Other parts of the report are more informative, Vol. II, and Vol. III. A large part of the study was devoted to alternative operational modes for the reprocessing plant and follow-on facilities: eight involving U and Pu, straight, blended, and with spikes; and six Thorium fuel cycles with similar variations. Some important problems with some of these are identified and discussed. There is an interesting discussion of possible institutional arrangements: private, Government, multinational, etc. There is a section on spiking. The only place that a utilization of Barnwell is mentioned is appendix D (Vol. III) on safeguards, which starts off with the statement that possible uses for training of IAEA inspectors and R & D on IAEA safeguards have been identified.

The authors of this report were in a difficult position. The Administration insisted that nothing should at this time lend any encouragement to reprocessing of anything. Alternative fuel cycles were being studied on a grand scale by the ERDA-DOE Nonproliferation Alternative Systems Assessment Project (NASAP). INFCE was just getting underway. And how could one spend $1 million in six months? In spite of this, those working on INFCE or otherwise interested in the evolution of U.S. nuclear policy will find parts of this report of considerable interest. Unfortunately, AGNS and the Barnwell staff did not fare too well. The Congress appropriated $13 million last fall for fiscal year 1978, hardly enough to keep the place heated. The AGNS personnel are conducting high class studies of alternative operations, spent fuel transportation, and are improving what is surely the best safeguards system at any reprocessing plant. DOE did not urge that these valuable programs be continued.

Japan has obtained its uranium, etc., from the U.S., Canada, United Kingdom and France. Consequently, every gram has been under bilateral or trilateral safeguards from the start. U.S. contracts specify that the U.S. must approve any reprocessing of U.S. supplied fuels. The Japanese reprocessing plant at Tokai has been under construction for several years, during which the Japanese installed weigh tanks for the dissolver solution and plutonium-nitrate product, and performed other R & D in support of the IAEA. Although the Tokai plant is only a pilot plant with a half ton-a-day capacity, reprocessing is of particular interest to the Japanese, as a necessary step toward breeder reactors. **President Carter** appealed to the Japanese to postpone the operation of Tokai, as the U.S. had done with Barnwell. The compromise agreement was that Japan would process 99 tons of spent fuel in the next two years, study the alternative of producing mixed U/Pu nitrate, rather than Pu, and perform R & D on safeguards measures which might be useful to the IAEA. The U.S. offered to assist in the latter. The preliminary discussions with the Japanese on the latter occurred last September. It took a long time for the U.S. Government to decide what role we should play. Finally, a delegation visited Japan in March. Although the U.S. visitors were somewhat worried by our sluggish response, they were pleased to find that the Japanese had been plugging along on their several projects, and that the French, who had sold the plant to Japan, were also eager to contribute. As a result, there are 13 projects slated for testing at Tokai, with good cooperation between the three countries.

It is too early to say much about INFCE, except that there are a lot of drafts circulating in the U.S. and arguments concerning them. Probably this is also taking place in many other nations. The participants agreed to a two year technical exchange. They will insist that it end in two years, in the course of which there may well be agreements to initiate more studies or substantive discussions aimed at controlling proliferation.

In the meantime, the Parliament of the UK has approved construction of a new modern reprocessing plant at Windscale, the Japanese have requested permission to invest in reprocessing plants in France and the UK, and CIVEX was invented by **Walter Marshall** and **Chauncey Starr,** as a solution to the proliferation problem.

The Marshall-EPRI papers do not propose an immediate solution. They start by explaining that a total reliance on the light water reactor, throwaway cycle produces large amounts of spent fuel, containing Pu that will be widely dispersed (in spite of centralized storage facilities), and which inevitably becomes more accessible as the radioactivity decays. The next consideration is that U-ores will run out, so we will need breeders. Breeders would require reprocessing and recycled fuel, which could be protected by extracting a mixture of U-Pu and fission products. It is somewhat misleading to call this process CIVEX, when it is just an inefficient PUREX process. It would be optimistic to conclude that this solves the proliferation problem. In the first place, it could not come into operation for 30 or 40 years if and when the majority of nuclear power plants are breeders. It is doubtful that any nation would adopt the diluted and spiked fuel operation in that distant era, with who-knows what a political situation. Besides dilution and spiking would not appear to be a significant deterrent to a nation that would want to make nuclear weapons in 2010!

While the U.S. Government is focusing its considerable resources on the International Nuclear Fuel Cycle Evaluation, the Ford and Rockefeller foundations continue to fund independent studies, fortunately. The latest Ford study, on alternatives to coal is about to start. A Rockefeller study of International Cooperation on Breeder Reactors (one of the International Policy Studies), was initiated about two years ago. Its stimulating report was released on May 10. The study was conducted by **John Gray** and friends of International Energy Associates, Ltd. A major contributor was **Myron Kratzer,** who has a long and productive association with international safeguards at the old AEC and, later, the State Department. Although breeders were The Future when this study began, the U.S. policies changed radically as the project progressed. As a result, a considerable part of this report is a dispassionate (if that is

Special DYMAC Tour at LASL

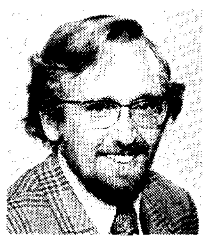
On March 10, Dr. **Ronald H. Augustson** took INMM Chairman **Roy G. Cardwell** and Treasurer **Edward Owings,** both of ORNL, and **Thomas A. Gerdis,** Editor of *Nuclear Materials Management,* on a tour of DYMAC facilities at the Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

DYMAC, acronymn for Dynamic Materials Control, is an advanced system of materials control that is being developed as a major part of the Nuclear Safeguards Program at Los Alamos. The purpose of this new system is to evaluate and demonstrate the effectiveness of state-of-the-art safeguards technology in a modern nuclear processing plant.

The DYMAC program integrates new nondestructive assay instrumentation with interactive data processing equipment and modern data-base management methods to provide "real-time" accountability and control.

Dr. **G. Robert Keepin,** Director of the LASL Nuclear Safeguards Program, noted that besides providing improved SNM accountability and safeguards, there are significant additional economic benefits of such automated in-plant instrumentation, including improved process and quality control, greater plant operational efficiency, criticality safety, and radiological protection. After an intensive program of in-plant evaluation and proof-testing at Los Alamos, DYMAC technology and instrumentation are expected to be ready for adaptation and introduction as may be appropriate into other nuclear facilities in both the government and private sector. Throughout the program, emphasis will be on developing practical solutions to generic problems and communicating those solutions to other installations for maximum utilization and benefit throughout the nuclear fuel cycle.

On the international level, new NDA instruments being developed at LASL and elsewhere are being made available for evaluation and field use by the International Atomic Energy Agency in administering a worldwide system of safeguards inspection and control. The IAEA is an arm of the United Nations that grew out of the U.S. "Atoms for Peace" program initiated in 1953 by President Eisenhower. It represents nearly all UN member states. Newly developed safeguards techniques are also applicable to certain inspection and verification functions in connection with international treaties such as the Nuclear Non-Proliferation Treaty, and possible future international agreements concerning nuclear armaments.



Dr. Augustson

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possible) presentation of the arguments pro and con breeders, as viewed by interested spectators in the U.S. and elsewhere. In contrast to the Ford—MITRE report and much of the public discussion in the U.S., which takes a parochial view, the primary effort of the IEAL study was to try to understand the situation views of other major countries regarding energy options and the breeder. The nuclear programs of these major nations are described in detail. Relevant examples of international cooperation on nuclear and other expensive and high technology projects are given. There are useful descriptions of the IAEA, Euratom, URENCO, etc. The subject of proliferation is in focus throughout, along with the other vital issues that matter to people. What emerges from this is that breeders are likely to mean a lot to the advanced nations in Europe and to Japan, even if not presently to the U.S. The Europeans, with the exception of Great Britain, have a strong cooperative development program. The UK was a leader, but is presently more relaxed due to its North Sea oil discoveries. The Japanese perceive themselves to be hard pressed and alone. The conclusion of this study, as I interpret it, is that it would be foolhardy to forget breeders and that they will cost a lot to develop, taking into account efficiency, cost, safety, and safeguards. It is not likely that LDC's will develop this technology. It would be wise, from many points of view, for the U.S. to get involved in a development, demonstration program, with the UK and Japan or conceivably with them, the Western European's, and the U.S.S.R.

There must be a number of you who could have described at least part of this history or have written critiques of CIVEX or reviews of the Rockefeller Foundation Study. OK, it's your turn. I'll only edit, promising to not distort your manuscripts.

Energy Quest Game

We thought you would be interested in hearing about the exciting new game which we have just begun marketing. Energy Quest is designed to portray the energy situation in our nation in a game format. It is a game of strategy and chance, suspense and surprise. No one knows when the Oil Embargo will end the game.

Energy Quest includes nine different types of energy on the gameboard: solar, wind, tidal, geothermal, hydroelectric, oil, coal, uranium and natural gas. "We believe it succeeds in being both entertaining and educationl" said **Ed Cerny** who is in charge of marketing this product.

If you are interested in having an exciting game with a message about a field which you have special interest Energy Quest is it. Possibly an energy game might have an interest for you in the public relations area or as an incentive tool. In any case we hope you will get Energy Quest for the fun of it.

Individual games can be purchased for $9.95 plus $2.00 postage and handling. Quantity prices are available on request from Weldon Productions, Inc., 2925 Woodland Hills East, Columbia, South Carolina 29210 (Phone 803/254-1260).

Focus on International Safeguards

Recently, representatives from the State Department, Department of Energy, Arms Control and Disarmament Agency, Nuclear Regulatory Commission, and the International Atomic Energy Agency came to Brookhaven National Laboratory, Upton, N.Y., for a four-day meeting to review the U.S. program on international safeguards which is managed by BNL's International Safeguards Project Office (ISPO).

Over the years, the United States has provided technical assistance in many fields in many countries. In no area is its support more crucial than in international safeguards for fast-growing nuclear power projects throughout the world.

The International Atomic Energy Agency (IAEA), an arm of the United Nations, is responsible for all safeguards of those Member States which have signed agreements to be included under the Agency program. In the United States, the agencies mentioned above joined in a program of technical assistance to IAEA safeguards. The aim of the program is to improve IAEA safeguards through support from DOE laboratories and others with expertise in safeguards technology.

The International Safeguards Projects Office was established at Brookhaven National Laboratory to manage and coordinate this program. Brookhaven was selected as headquarters for ISPO because of its staff experience, facilities, and accessibility to IAEA foreign visitors. **Leon Green,** Department of Nuclear Energy, heads the office.

In a report just published, ISPO reviewed some of the accomplishments of its first year of operation. Some highlights:

- In the area of measurement technology, significant progress has been made in the transfer to the IAEA of current U.S. nuclear materials measurement and verification technology and equipment. To introduce new techniques, U.S. experts, recruited by ISPO, have been sent to Vienna on cost-free contracts to IAEA.

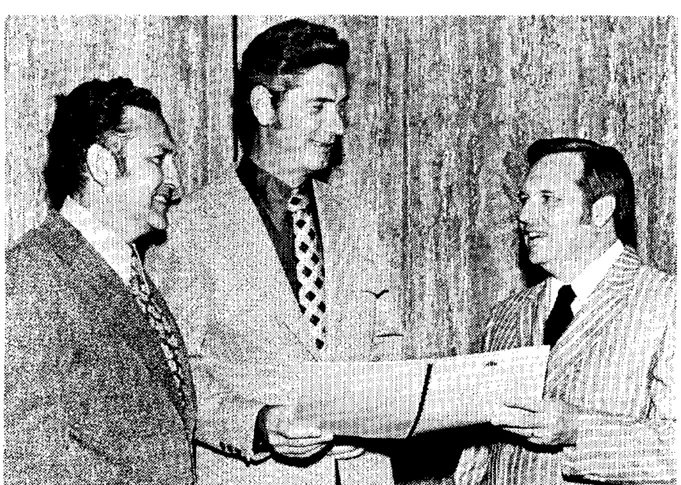
- System studies were formulated to assess the effectiveness of safeguards methods and to provide guidance for upgrading them within the framework of present safeguards agreements with Member States.

- To expand the Agency's computer based information system, a direct financial contribution to the IAEA was made to permit the acquisition of a larger computer, and cost-free experts were provided to assist the Agency in planning and programming the upgraded system.

- Work is proceeding on the immediate and important need for reliable, tamper-indicating surveillance equipment that will give timely indication of diversion.

- Integrated exercises conducted at large U.S. nuclear facilities have proven to be highly useful in establishing precedents for inspection and reporting on a worldwide basis.

Currently, ISPO has a staff of seven and a one-man liaison office in Vienna. Given the nature of worldwide nuclear expansion and the corresponding enlarged role of IAEA safeguards, this office is preparing to respond to further requests for support of IAEA.



Bill Gallagher (left), formerly of Intelcom Rad Tech (now IRT Corp.), and Ken Duffy (center), General Atomic Company, were local hosts for the 14th annual INMM meeting in San Diego in 1973, receive their "free" copy of the agenda from Roy G. Cardwell, technical program chairman that year. Gallagher is now with the USDOE San Francisco Operations Office.

John Iles (left), manager of security, and Ken Duffy (right), manager of nuclear materials at General Atomic Company, San Diego, react to the arm waving antics of the INMM Chairman Roy Cardwell of ORNL as he attempts to reassemble the attendees after the morning coffee break in Seattle in June 1976 during the annual meeting.

INDEX OF ARTICLES (1972-1978)

Editor's Note: Vol, 1, No. 3, Vol. II, No. 3, Vol. III, No. 3, Vol. IV, No. 3, Vol. V, No. 3, and Vol. VI, No. 3 are proceedings of annual meetings of INMM. Copies of the tables of contents for those proceedings are available on written request to the editors.

INMM At 20 Years

(Continued from Page 4)

qualification program has been developed and proposed which would lead to a Certificate of General Proficiency in Nuclear Materials Management. Both of these programs must be vigorously pursued, as well as the possibility of curriculum development in the areas of materials management and safeguards at appropriate institutions of higher learning (e.g., Nuclear Engineering Departments in U.S. Universities). A notable contribution in the area of Education is John Jaech's INMM Statistics Course "Statistical Methods for SNM Control" which is receiving uniformly enthusiastic response (e.g., most recently in Columbus, Ohio and Richland, Washington). Other formal training courses in the area of safeguards and materials management are currently offered by ANL, BCL, LASL, Sandia, and the University of Idaho, among others.

Our INMM Safeguards Committee is expanding its activities under the chairmanship of **Syl Suda.** Per its Charter, the Safeguards Committee is intended to provide a forum through which members of the Institute can collectively speak out, in a timely manner, on issues and problems involving nuclear materials safeguards and security. The committee will act as a clearing house for peer review, and will provide a conduit for transmitting the views and comments of knowledgeable safeguards practitioners to the media and the public. Indicative of the relevance and timeliness of the difficult issues to be addressed, the Safeguards Committee is currently examining such controversial topics as CIVEX, spiking, and other "technical fix" concepts, the implications of various alternative fuel cycles, etc.

Obviously closely related to the work of the Safeguards Committee is the Institute's program in Public Information; to improve our performance in this area, the INMM Public Information Committee is being reorganized under the chairmanship of **Herman Miller.** In addition to more effective communication with the lay public, there is an urgent need for better communication, interface with, and input to, members of Congress and the Executive Branch of Government. Many controversial concepts alternative fuel cycle proposals, related INFCE and NASAP studies etc., require considerable technical insight, understanding and interpretation before decision-makers and lawmakers can proceed knowledgeably. The possibilities are rife for misunderstanding and misinterpretation—unintentional or otherwise—in these areas, and effective communication is essential over the entire spectrum from layman to lawmaker to technical expert.

History has shown a progression from bilateral safeguards to multilateral safeguards and now to International (IAEA) Safeguards; thus growing attention is being focused on the critical issue of adequacy and effectiveness of International Safeguards. Reflecting the steadily increasing importance of international safeguards, we have seen within our own Institute the rapid growth of the Japan Chapter of the INMM: i.e., with a current membership of 36, the Japan Chapter has more than quadrupled since it was established in September 1976. Dr. **Yoshio Kawashima,** Chairman of the Japan Chapter and Executive Director of Japan's Nuclear Materials Control Center, has on several occasions stressed the importance of international cooperation, increased technical interaction and mutual exchange of ideas and experience between safeguards and materials management professionals.

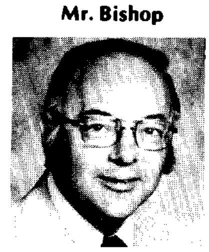
With the growing appreciation of the global nature of the safeguards problem, with the International Fuel Cycle Evaluation Program, various nonproliferation studies etc. currently underway, and with the expanding role of International (IAEA) Safeguards in inspection and independent verification of national safeguards systems under "full scope" NPT safeguards—all indicators point toward markedly increased activity in the area of international safeguards in the years just ahead.

Due to space limitations, I've confined my attention here to some of the Institute's major programs and activities; I've scarcely touched on two of our highest-profile activities—Annual Meetings and the Journal, both of which have obviously made good progress in recent years. These and other important topics will have to wait for a later column. Meanwhile, if you haven't already done so, please complete your member interest questionnaire so we can have your essential input in planning for our Institute's future.

Thanks to hard work of so many dedicated INMM officers and members through the years, we have indeed come a long way, but there's still much more that needs to be done—and like the LWV slogan says ". . . we ain't there yet!"


Mr. Bishop


Mr. Miller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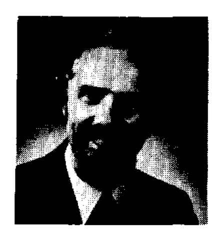

Mr. Suda


Mr. Kawashima


Mr. Wilson

Douglas R. Kunze Joins NUSAC

McLean, Va.—Dr. **Ralph F. Lumb,** President of NUSAC, Inc. has announced the appointment of **Douglas R. Kunze** as a Senior Technical Associate in the Security Programs Division. Mr. Kunze's responsibilities will include the development of security and communications design criteria and total system design concepts for NUSAC's clients.

Mr. Kunze comes to NUSAC from the Dynacon Division of Dynalectron Corporation. Previous military assignments included five years in the Security Office of the White House Communications Agency where he travelled in advance of the President and Vice President of the United States to establish communication systems.

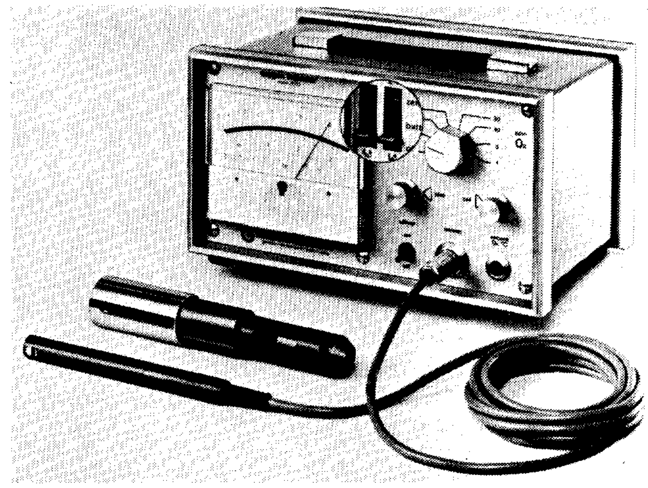
Mr. Kunze holds a B.S. degree in Chemistry from Canisius College and has completed numerous technical and business administration courses at universities and military schools.

NUSAC is an independent consulting firm providing assistance to the nuclear power generating industry. Its services include management audits of quality assurance and physical security programs, auditing of nuclear fuel fabrication, development of material safeguards design and procedures, and the design and implementation of physical security plans and procedures.

For further information contact **Robert C. Adkins,** Director of Marketing, (703-893-6004).

Mr. Kunze

Armand R. Soucy, former INMM Chairman (1974-1976), completed his two-year term on the INMM Executive Committee June 30. Mr. Soucy was Local Arrangements Chairman for the 1972 INMM Annual Meeting in Boston. He is assistant treasurer of Yankee Atomic Electric Co., Westborough, Mass. Special thanks from the Journal Staff to Mr. Soucy for several years of outstanding service to the Institute.



Measures Dissolved Oxygen

YORK, Me.—ORBISPHERE LABORATORIES, division of Orbisphere Corporation, announces the new Model 2712 Dissolved Oxygen Measurement System for Saline Waters with salinities up to 50 parts per thousand or chlorinities up to 27 parts per thousand. The instrument satisfies the needs of oceanographers and water source quality engineers when measuring in oceans or estuaries with changing concentrations of salt.

The instrument represents the first available means for dissolved oxygen analysis which takes proper account of salinity effects upon the solubility, and upon the temperature coefficient of solubility, of oxygen in water. An analog computer incorporated within the instrument automatically performs the necessary adjustment of the displayed oxygen value, using a temperature signal derived from two thermistors located in the remote probe, and the salinity value input by the user by means of digitally coded switches.

Four oxygen measurement ranges are provided, namely 0-1, 0-3, 0-10, and 0-30 ppm, with a precision of plus or minus 1% of full scale indication on each of these ranges when the measurement and calibration temperatures differ by less than 5°C, and a precision of plus or minus 4% at other temperature differences within the range 0 to 50°C. Water depths down to 200 meters do not influence the accuracy of measurement.

New Doe Office

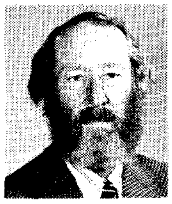
DOE nuclear waste management functions have been consolidated into one office. Secretary **James R. Schlesinger** recently established the Office of Nuclear Waste Management in the Office of the Assistant Secretary for Energy Technology.

Under the direction of **Robert L. Morgan,** Acting Program Director, the new Office will be responsible for the planning, development and implementation of defense and civilian nuclear waste processing and isolation, spent fuel storage and transfer, transportation of nuclear waste materials, and decommissioning and decontamination of the Office of Energy Technology's nuclear activities.


Ensslin


Henry


Holland


Kunz


Lowe


Menlove


Millegan


O'Hare

ABOUT THE AUTHORS

Norbert Ensslin (Ph.D. Physics, MIT, 1972) is a member of the Nuclear Safeguards Research Group at the Los Alamos Scientific Laboratory. He is involved in the development of fast and thermal neutron coincidence counters. He is interested in the count rate, self-multiplication, and self-shielding problems associated with the nondestructive assay of large uranium and plutonium samples.

Michael L. Evans (Ph.D., Physics, Texas A&M University, 1976) is a member of the Nuclear Safeguards Research and Development Group at the Los Alamos Scientific Laboratory. He is currently involved with radiation transport calculations and neutron and gamma-ray measurements for the design and performance testing of instruments for the nondestructive assay of fissionable materials.

Carl N. Henry (M.S., Physics, University of Wisconsin) is the Group Leader of the Nuclear Detection, Verification, Surveillance, and Recovery Group at the Los Alamos Scientific Laboratory. He has been involved in the development of both passive and active nondestructive assay and perimeter safeguards instrumentation for the past eight years.

Charles W. (Chuck) Holland (Ph.D., Management Science, The University of Tennessee, 1974) is currently Manager of Key Personnel Development for Union Carbide Corporation's Nuclear Division. Prior to assuming this position in February, 1978, Holland served as Manager of the Statistical Services and Nuclear Materials Accountability Departments for Union Carbide's Y-12 Plant at Oak Ridge, Tennessee. He also served as Program Manager for the Dynamic Special Nuclear Material Control and Accountability System (DYMCAS). His publications have appeared in the *AIIE Journal*, *Journal of Marketing Research*, and the *Proceedings of the Institute of Management Science*.

Walter E. Kunz (Ph.D., Physics, University of Tennessee, 1954), is a Staff Member of the Los Alamos Scientific Laboratory. For the last seven years he has been in the Nuclear Detection, Verification, Surveillance and Recovery Groups in the laboratory and his current interest is in gamma-ray detection systems with safeguards applications.

Victor W. Lowe, Jr. (M.S., Mathematical Statistics, Colorado State University) is associated with the Y-12 Plant in Oak Ridge, Tennessee, operated by the Nuclear Division of Union Carbide Corp. As head of the Y-12 nuclear accountability and material control statistical effort, Lowe helps with the planning and development phase of Y-12's Dynamic Special Nuclear Materials Control and Accountability System (DYMCAS). The system will be described in a forthcoming issue of this Journal. Prior to joining Y-12 last June, he was associated with Los Alamos (N.M.) Scientific Laboratory as a general consulting statistician and later as statistician for LASL's nuclear accountability and safeguards projects.

Howard O. Menlove (Ph.D. Nuclear Engineering, Stanford University) is Alternate Group Leader for Safeguards Technology, International Safeguards and Training at the Los Alamos Scientific Laboratory. He is active in the application of nuclear methods to the nondestructive assay of fissionable materials.

David R. Millegan is an Electronics Technician in the Nuclear Detection, Verification, Surveillance, and Recovery Groups at the Los Alamos Scientific Laboratory. His main activities consist of development of nuclear electronics instrumentation. His training was received in the U.S. Navy and Western Electronics Institute in Albuquerque, New Mexico.

Patrick A.G. O'Hare (Ph.D., 1961, D.Sc., 1971, Physical Chemistry, The Queen's University of Belfast) is a staff member of the International Atomic Energy Agency, Vienna, on leave-of-absence from Argonne National Laboratory which he joined in 1964. His research activities are concerned with the thermodynamics of nuclear materials and with chemical bonding studies.

James E. Swansen is an electronics designer in the Nuclear Safeguards Group at the Los Alamos Scientific Laboratory. He has had a long interest in the design of neutron coincidence circuits and has applied for a patent in this field. He designed and tested the circuits described in the accompanying article.