INMM

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EDITORIAL

Should You Publish in INMM'S Journal?

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

Once a year the INMM holds its annual meeting, which is well attended by those interested in safeguards. The papers and panels cover all aspects of safeguards, domestic and international. The proceedings issue of the INMM Journal are thick and filled with useful information. During the remainder of the year committee activities continue, and three thin issues of the Journal are published. In my opinion, the non-proceedings issues should be a lot more substantial.

The non-proceedings issues contain editorials, committee reports, and news items, which appear to be well received by the membership. There are also a few technical articles which are of interest to a few readers. Are you satisfied with this? If not, here are some suggestions as to how you might help to make the Journal a more effective instrument of the Institute.

The program committee for the last annual meeting was deluged with contributions. Many valuable papers were turned down due to the limited time available for presentations. The authors of the rejected papers should submit them for publication.

Not everyone who does interesting work on safeguards can attend the annual meeting. Such individuals have a duty to report on their work. Where else but in this Journal would you look for safeguards papers?

There are a lot of contractors, these days, pouring out all sorts of studies. I would not suggest that INMM would care to recapitulate this mountain of reports. However, it would be useful, indeed, to be able to list the titles and sources; perhaps even better to publish abstracts. Let us be more specific: The Government sponsors of safeguards R&D and the contractors performing that R&D could perform a responsible public service by listing reports in the Journal, in sufficient detail so that interested members would know what to order.

As you know, the technical articles in the non-proceedings issues have covered only a few areas of safeguards, whereas the annual meeting contributions address all areas of policy, instrumentation, and analysis. All of these subjects are just as welcome for the other issues. In fact, if the Institute is to convince the skeptics that safeguards is receiving the attention that it deserves, and that safeguards can indeed be effective and credible, then all of its members should feel a special responsibility to demonstrate our concern and our knowledge in every single issue of the Journal.

Dr. Higinbotham

MUF
The Misunderstood Factor

By Roy G. Cardwell, Chairman
Institute of Nuclear Materials Management, Inc.

As a result of the Freedom of Information Act, ERDA and the NRC are now making public inventory differences of special nuclear material at all facilities under federal ownership or license.

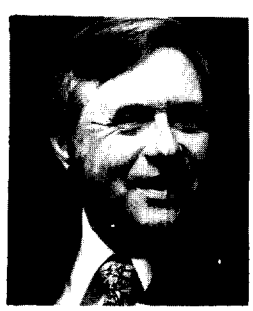
The anti-nuclear forces are expected to have a field day with this latest turn of events, shouting loudly that the materials are missing, of course, and that some shady group is at this moment putting together a nuclear device to blow us all to kingdom come. For an opportunity like this one to scare the public with things they have not had the opportunity to understand would be completely unexpected and out of character for some of these folks.

And of course the public doesn't understand MUF and LEMUF! Most people don't even understand book-physical inventory differences in a grocery store, much less in a facility where process flow is involved. Yet here we are with the problem of either giving them a satisfactory explanation they can comprehend and relate to, or else give the appearance of having egg on our face.

But can we? **Harley Toy**, our Education Chairman, has often said to me that anything can be explained if it is reduced to understandable terms. We are too prone, he says, to babble in our own professional jargon when talking with non-nukes as we do with each other.

Think about it. The usual social or public contact for us (unless of course we are teaching) is a peer of equal or better educational background but entirely different discipline. Suppose you are having lunch with an M.D. at the Wednesday Rotary Club. You have been having a rather frequent pain in your abdomen, which you describe in certain detail and ask him to diagnose. If he gives you a friendly opinion, he doesn't tell you that you may have *cholecystitis* that might require a cholecystechtomy. He says you may have a problem with your gall bladder and that it might have to come out. Conversely, if he asks you about the possibility of "all that uranium and plutonium being stolen," you shouldn't launch into a tyrade of terms and acronyms like MUF, LEMUF, NDA, batch balance, process through-put, and unrecoverable scrap. Common examples should be used; like attempting to measure the amount of lean beef in hamburger, or making chocolate bars in the candy factory where chocolate sticking to the pans and spoons is recycled in the succeeding run. It is surprising how many of us seem to assume that because a person has a similar educational background in another discipline, he is automatically able to understand ours.

Cardwell



John A. (Red) Jones (Center) Director of the National Training Program for the International Union of Operating Engineers, AFL-CIO, was flanked by two INMM Executive Officers—Roy G. Cardwell (left), INMM Chairman, and Edward Owings (right), INMM Treasurer—at the Chairman's Reception at the 1977 annual meeting in Washington, D.C.

Having taken the common example approach, and if we make a clear case to our peers in other professions, we shall also have taken a giant step toward making a clear case to the public. Why? Because our *cross-disciplined peers* also move about and work in circles where we do not. When the nuclear subject arises (as it frequently does these days) they will have a common explanation for our problem which they understand and can relate to others. Of course, our educational responsibilities do not end here, but **cross-peer contacts** are a valuable dissemination point in our struggle to overcome public fear and misinformation.

Elsewhere in this issue you will see reports on our public education and information activities, including a statement on MUF which will soon be released. My request for PI (public information) Task Force volunteers resulted in a very active group at the annual meeting that got this program off to a good start. All in all, I am very pleased with the sudden efforts and accomplishments in this area.

I believe, Like **Sonny Pruitt**, we are movin' on!.

The Washington Meeting and the Challenge to INMM

By G. Robert Keepin
INMM Vice Chairman
Los Alamos (N.M.) Scientific Laboratory

As the old saying goes, the Institute's Eighteenth Annual Meeting "had everything going for it": location, timeliness, speakers and high-interest subject matter. We fully expected to top all previous records, and indeed we did, with over 450 registrants at the Washington meeting. Needless to say this was achieved only through the hard work and close cooperation of the various annual meeting committees, to whom we are all much indebted.

The Technical Program Committee under the chairmanship of **Gary Molen** provided an outstanding agenda that lived up to all expectations of a stimulating and highly informative annual meeting carrying the timely theme "Safeguarding the Nuclear Fuel Cycle."

Befitting the setting in the Nation's Capitol, opening day provided something of a "democracy in action" flavor with well-known leaders from both the executive and legislative branches of government advancing divergent views on some key nuclear issues. In the safeguards/non-proliferation area, for example, there was clearly a common consensus on the imperatives of stringent, effective safeguards and proliferation controls, but at the same time there was considerable difference of opinion on how to achieve these necessary goals. Despite such differences there was agreement among all speakers—starting with our leadoff keynoter, **Robert Fri** of ERDA—that the development and full-scale implementation of effective safeguards, security and materials control (under whatever political and/or policy guidelines may apply) is the clear responsibility of the experts in the INMM and in the safeguards/materials management field generally.

This technical challenge is matched by an equally important communications challenge. As Bob Fri, **Mike McCormack, Rudolf Rometsch** and several others stressed at the Washington meeting, it depends upon us, the professionals in materials management to make known in understandable terms to the public and to the decision-makers (in both legislative and executive branches of government) the capabilities, and the limitations, of modern safeguards and security systems in deterring and preventing the diversion, theft, and misuse of special nuclear materials.

G. Robert Keepin

All who attended the Washington meeting will vividly recall Mike McCormack's exhortation to "see your Congressman" while in the Washington area—and indeed, during the course of the meeting, several INMM members did exactly that. We also heard Mike McCormack tell the audience on opening day June 29, of the difficulties he'd had trying to get in to see the President—something he had not yet been able to do. Interestingly enough, just two days later, on Friday, July 1, McCormack did meet one-on-one with President Carter for what McCormack described as a "vigorous exchange" on nuclear issues.

Just two weeks later, on July 14, Congressman McCormack and **Joseph Nye** of the State Department were featured on the Public Broadcasting System's (PBS) "MacNeil/Lehrer Report" in a give-and-take televised discussion of nuclear issues, with emphasis on non-proliferation, plutonium, the breeder, etc. Since all attendees at the Washington meeting had just had a first-hand opportunity to hear both of these leading spokesmen on current nuclear issues, it seemed worthwhile to provide a record of the PBS program for the INMM readership. Accordingly, a full transcript of the July 14 discussion between Mike McCormack, Joseph Nye, and Jerome Levinson (of Senator Frank Church's staff) has been reprinted, with permission, in this issue of the INMM.

In the June 30 INMM panel, "Safeguarding the Nuclear Fuel Cycle", leadoff panelist **Tom Davies** of the U.S. Arms Control and Disarmament Agency discussed the rationale and thrust of the Alternative Fuel Cycle Evaluation Program and responded to a number of questions and some skeptical comments from panel reporters. The two-hour panel discussion touched on a wide range of safeguards topics including the relative safeguardability of various fuel cycles, the problem of "abrogation risk" and the related "keep your powder dry syndrome", international fuel cycle centers, the IAEA concept of international fuel repositories and the relationship of national safeguards systems to the IAEA international safeguards system. Panelists Rudolph Rometsch, **Roy Nilson,** and **Edwin Zebroski** all pointed out that stringent safeguards will be needed for any fuel cycle, or "mix" of fuel cycles, and that international

INMM STATISTICS COURSE

Columbus, Ohio

November 7-11, 1977

The INMM, in cooperation with the Battelle Memorial Institute at Columbus, Ohio, and with the Joint Center for Graduate Study at Richland, Washington, is planning two presentations of the course, "Selected Topics in Statistical Methods for SNM Control," in the coming months. Course dates are November 7-11, 1977, at Columbus, Ohio. The course instructor is John L. Jaech of Exxon Nuclear Co. The course was last given in Richland in March 1977. (See the Spring 1977 issue of this Journal.) For further information on future courses, contact Harley Toy at Battelle, Columbus. AC 614-424-7791. Tentative fee: $350.

safeguards in a plutonium economy should be based on the policy that plutonium will not be available in any significant quantity in other than co-product form (e.g. co-precipitated with ^{238}U) for shipment, fuel fabrication, etc. Panelist **R.G. Page** of NRC noted that IAEA safeguards under the President's offer are expected to be implemented in the U.S. by mid 1978; thus U.S. direct participation in, and stake in, international safeguards will continue to grow.

Meanwhile, on the domestic front, the United States is obviously in the throes of an intense national debate over certain nuclear issues, policies and program alternatives—and this is particularly apparent in the high-profile areas of safeguards, non-proliferation and nuclear materials control. One essential component of effective public debate, no less than effective legislative action on Capitol Hill, is factual input from those who know and understand the capabilities and the limitations of modern materials control methods and safeguards systems. We in the INMM must meet this combined technical and "communications challenge" so that our unique and essential technical input can be properly factored into forthcoming nuclear policy and program decisions in the US and internationally—decisions that will, in large measure, shape the energy future of the world.

Through the comprehensive public information and education program being undertaken by our newly formed INMM Public Information Task Force, as well as the Institute's standing committees on Education and Public Information, the Institute and its membership is in a unique position to make a truly effective and timely contribution toward better public, and Congressional, understanding of safeguards issues and implementation realities. This, in a nutshell, is our challenge for the critical year ahead.

INMM Officers Re-elected

By V. J. DeVito
Secretary of INMM

According to Article III, Section 6, of the INMM Bylaws, "The Secretary shall notify each member in good standing of the results of the election by November 15 of each year." This notice in the Journal shall be construed as having fulfilled that obligation.

In accordance with Article III, Section 4, of the INMM Bylaws, the selection of candidates for the elected positions on the Executive Committee (officers and members) was properly received by the Secretary. The Nominating Committee selected the following slate of candidates:

For Chairman — **Roy Cardwell**
For Vice Chairman — **Robert Keepin**
For Secretary — **Vincent DeVito**
For Treasurer — **Robert Curl**

For members of the Executive Committee:

Jimmy Gilbreath
William DeMerschman
Robert Kramer
Dennis Wilson

In accordance with Article III, Section 5, a ballot was mailed to each of the Institute's 495 members of which 242 returned ballots.

There were no petitions for candidates to be added to the ballot; however, there were several write-ins.*

As a result of the balloting, the officers and the members of the Executive Committee for the terms of office beginning July 1, 1977, are as follows:

Chairman — **Roy Cardwell**
Vice Chairman — **Robert Keepin**
Secretary — **Vincent DeVito**
Treasurer — **Robert Curl**

*For Chairman: **Armand Soucy, Vincent DeVito**

For Vice Chairman: **John Jaech, Dennis Wilson, Walter Strohm**

For Executive Committee: **Ralph Jones, Chas. M. Vaughan, Dr. Earl Shibe, Edward R. Young, H. Thomas Yolken, Carl Bennett**

Executive Committee:

Gary Molen to June 30, 1978
John Ladesich to June 30, 1978
William DeMerschman to June 30, 1979
Dennis Wilson to June 30, 1979
Armand Soucy—Immediate Past Chairman

The Executive Committee, on June 28, 1977, approved June 27, 28, and 29, 1978, as the dates for the annual meeting to be held in Cincinnati, Ohio. The annual meeting in Cincinnati will highlight the INMM's twenty year history. The Executive Committee also approved, tentatively, June 19, 20, and 21, 1979, as the dates for the annual meeting to be held either in Santa Fe or Albuquerque, New Mexico.

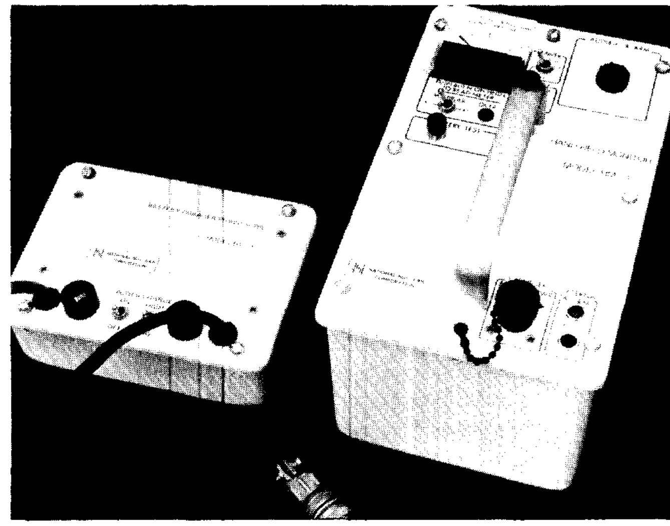
The INMM's dedicated secretary, Vincent J. DeVito (left) of Goodyear Atomic, sat with his charming wife, Jeanne, and Yoshio Kawashima of Japan at the noon luncheon at the 1977 annual meeting of INMM.

NNC Monitor

A portable, high-sensitivity special nuclear materials (uranium and plutonium) monitor is now available from National Nuclear Corporation (NNC), Redwood City, California. The HM-1 was developed for searches at materials-access exits and in other situations where it is necessary to detect the passage of even very small quantities of the radioactive materials employed in nuclear-power and nuclear-weapons applications. It is suitable for searching personnel, packages, and vehicles.

These monitors were developed and tested by the ERDA Los Alamos Scientific Laboratory. National Nuclear Corporation is supplying a large number of these hand-held monitors for use in U.S. ERDA facilities. The NNC unit features low weight (4 lbs.), and one-hand, battery operation. NNC has developed a low ripple battery recharger which allows operation with or without an external power supply. Low current drain for normal operation allows several days' operation between charging.

A unique radiation background-subtraction circuit permits the use of the HM-1 by personnel with little training, even in a noisy and distracting environment. The audible alarm will activate only in the presence of the pre-determined small quantity of special nuclear material.



Hand Held Monitor

LASL Groundbreaking

LOS ALAMOS, N.M.—Groundbreaking ceremonies were conducted August 16, for the initial phase of the 90,000-square-foot, $55-million High Energy Gas Laser Facility at the Los Alamos Scientific Laboratory (LASL).

Guests, including U.S. Sen. **Pete Domenici,** were welcomed and introduced by LASL Director Dr. **Harold M. Agnew.** Speakers included Lt. Gen. **Alfred D. Starbird** (USA Ret.), assistant administrator for National Security, Energy Research and Development Administration (ERDA), Dr. **Lawrence E. Killion,** associate director, ERDA Division of Laser Fusion, and Dr. **Roger B. Perkins,** LASL Laser Research and Technology Division leader and laser fusion program manager.

Construction of the HEGLF is a major step in LASL's program, which was initiated in 1969 with the invention of an efficient laser "pumping" technique that is based upon electron-beam-controlled discharges.

Bleak Official Scorecard

By John L. Jaech, Chairman

The official scorecard for INMM fiscal year 1977 is quite bleak with respect to publication of ANSI approved standards. However, prospects for the coming year are good. As of this writing, there are several standards almost ready for N15 balloting; and it is hoped and expected that by this time next year we will have added a few standards to the impressive list of approved standards.

In order to inform the INMM membership of the current status of proposed standards, and also to give recognition to the various active working groups through mention of the working group chairmen, the following listing of standards under development is provided. Scopes of the proposed standards are not included, but the titles are generally descriptive enough to indicate the subject matter. As each draft standard is submitted for N15 balloting and concurrent ANSI approval, a listing of working group active members will be published in this journal in inadequate but grateful appreciation for the efforts expended.

Subcommittee/ Working Group	Chairman	Standard and Status
INMM-3	John Telford	N15.5 (Revision), "Statistical Terminology and Notation for Nuclear Materials Management." Currently being distributed for peer review as the final step before balloting. N15.29, "Procedures for Correcting Measurement Data for Bias." Detailed outline developed at June 1977 meeting.
INMM-4	Shelly Kops	N15.24, "Standard for the Recordkeeping and Reporting of Licensee Inventory Data." Soon to be distributed for peer review.
INMM-6	Dick Schneider	N15.25, "Standard for Measuring Material in Process Equipment." To be distributed for peer review around September 1.
INMM-7	Bob Sorenson	N15.38, "A Generic Guide for Auditing Nuclear Materials Safeguards Systems." To be distributed for peer review around September 1.
INMM-9	Dennis Bishop	- - - - - - - -
INMM-9.1	Dick Chanda	N15.33, "Categorization of SNM for NDA." To be distributed for peer review around October 20.
INMM-9.2	Tom Atwell	N15.34, "Standardized Containers for NDA." First draft nearing completion.
INMM-9.3	John Glancy	N15.35, "Physical Standards for NDA." To be distributed for peer review in September.
INMM-9.4	Darryl Smith	N15.36, "NDA Measurement Control and Assurance." To be distributed for peer review in December.
INMM-9.5	John Stewart	N15.23, "Guide to Nondestructive Assay of the ^{235}U Content of Low Enriched Uranium Fuel Rods." Undergoing revision in response to negative ballots.
INMM-9.6	Walt Strohm	N15.37, "Automated NDA Data Acquisition and Analysis." Currently being reviewed within INMM-9 and soon to be distributed for peer review.


Jaech

In addition to the above, other subcommittees and working groups held meetings during the INMM annual meeting in Washington, D.C. **Lou Doher,** Chairman of INMM-8 (Calibration Techniques), continues to watchdog, test, and review his Subcommittees' published standards on calibration prior to upcoming revisions. Three of his working groups met for this purpose: INMM-8.1, Mass Calibration, chaired by **John Murrel**; INMM-8.2, Volume Calibration, chaired by **Syl Suda**; and INMM-8.4, Calorimetry Calibration, chaired by **Frank O'Hara. Tom Sellers**, recently appointed chairman of INMM-10, Physical Security, convened his initial reconstituted working group and made good progress. Finally, **Fred Forscher**, chairman of INMM-11, Certification, reported that he intends to begin work soon on a revision of the proposed certification standard that was rejected on the ballot, as reported earlier.

There has been a regrettable tendency on occasion in the past to gear up for standards activity in conjunction with the INMM annual meeting and then to proceed with lesser enthusiasm in the following months. My optimistic outlook is that with so many proposed standards nearing completion, this lack of sustained effort will not generally occur during this coming year. It takes dedicated chairmen to keep working group members motivated; we have such chairmen. To them, and to the active working group members, we owe a vote of thanks for their contributions to this important activity of the INMM.

INMM-3, Statistics (Left to Right) Victor Lowe, Union Carbide Nuclear Division; John Telford (Chairman), GE, Vallecitos Nuclear Center; Roger Moore, USNRC; Merril Hume, Rockwell International; Frank Wimpey, Science Applications, Inc.; Dave Zeff, Babcock and Wilcox; and Dolores McCarthy, United Nuclear Corporation. Not present: Yvonne Ferris, IAEA; Charles Holland, Union Carbide Nuclear Division; Nora Smiviga, Lawrence Livermore Laboratory; and Kirk Stewart, Battelle-Northwest.

ANSI-INMM 9.1, Characterization of Nuclear Materials for NDA. (Left to Right) Fran Haas, Rocky Flats; Al Evans, LASL; Herb Smith, AHRCO; Dick Chanda, Rocky Flats; Ray George, ERDA-ALO; John Gray, AGNS; Will Brown, NRC; and (not pictured Dick Bramblett, IRT).

Forscher's Analysis of Nuclear Safeguards

April 21,1977

TO: The Senate Committee on Energy and Natural Resources

FROM: Warren H. Donnelly, Ph.D. Senior Specialist, Energy

SUBJECT: Analysis of Nuclear Safeguards

Last year, in anticipation of congressional interest in nuclear proliferation and what to do about it, we engaged Dr. **Frederick Forscher** to prepare an analysis of nuclear safeguards. A copy of his report is enclosed for your information. Dr. Forscher sees proliferation of nuclear technology and its relation to our nuclear export policy as a new concern upon the world scene. Control of proliferation represents a classical conflict between U.S. policies of international cooperation on one hand and of free market competition on the other. The four major findings of his report are:

1. **Safeguards are a necessary protective institution of society,** as are institutions for law enforcement, defense, or fire protection. Safeguards would still be needed even were generation of nuclear power to be stopped. Only with the concept of safeguards as an institution, and not merely a technology or a system, or even a major Federal action, can planning for safeguards proceed with assessment of its broad social, industrial, economic and technological impacts.

2. Concerning planning, the United States does not have an integrated safeguards plan nor does it have an appropriate locus for safeguards planning. This lack of a safeguards planning locus is important because the lack of a workable plan can be rectified by feedback adjustment if there is a locus, but the lack of a locus is never self-adjusting and must be corrected from outside the system. For Forscher, the **feedback concept in safeguards planning is very important.**

3. An essential objective of safeguards is to provide **sensitive and timely methods for detecting diversion of nuclear materials.** In this connection, he raises questions about stalled progress in the Safeguards Measurement Assurance Program of the National Bureau of Standards, which was initiated in 1975.

4. Any safeguards institution, whether domestic or worldwide, depends on the competence, expertise and motivation of the individuals in industry and government who are charged with implementing safeguards. The importance to society of accurate measurements and secure protection of special nuclear materials should elevate such activities to a profession, but formal recognition of safeguards as a profession has not begun to emerge. Forscher believes formal **training and licensing or professional certification are prerequisites for safeguards.**

I am sending Forscher's report to you at this time because of the rapidly evolving interest in safeguards as a critical element of non-proliferation measures. His views reflect his long association with nuclear materials management with the nuclear industry and his participation in the **Institute of Nuclear Materials Management.** Consequently, some of his analyses and conclusions might not find agreement among those who are raising questions about nuclear energy and its relation to the further spread of nuclear weapons. Nonetheless, his ideas about safeguards as an institution provide fresh insight into this matter, insight that should be useful.

Dr. Forscher

On INMM Committee

HEDL Safeguards Man Serves Institute

A. William (Bill) DeMerschman is Manager of Safeguards and Materials Management at Westinghouse Hanford Company, with primary responsibility for the institution of safeguards programs for special nuclear materials' control, measurement and accounting.

Westinghouse Hanford Company operates the Hanford Engineering Development Laboratory (HEDL) for the Energy Research and Development Administration at Richland, Washington. HEDL is a national technological center for the fast breeder reactor development, including the 400-megawatt-thermal Fast Flux Test Facility which will test fuels and materials for fast breeder reactors.

Since 1968, DeMerschman has been working on the Fast Flux Test Facility project in managerial positions related to the nuclear fuel development programs.

He began his career in Nuclear Materials Management in 1950 shortly after graduating from Mesa College in Grand Junction, Colorado, with a business administration degree. Several years were spent on the Colorado Plateau in uranium ore procurement and ore concentrate buying for the Atomic Energy Commission.

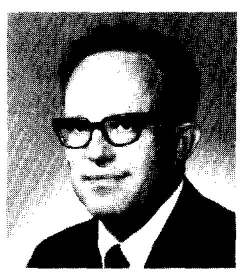
In 1956 he joined Atomics International at Canoga Park, California, where he spent 12 years in nuclear research, development, and manufacturing fields involving reactor fuel. It was during this period that DeMerschman elected to resume his education, and in 1965 he was granted a Juris Doctor degree from Southwestern University in Los Angeles.

"As a result of over 25 years' association with the nuclear industry, I have a strong belief in the efficiency of the nuclear fuel cycle and its importance in the growth of our nation's energy independence," DeMerschman says.

"Safeguarding the nuclear fuel cycle is one of the key issues to development of the industry over the next few years," he adds, "and the challenge will be met."

DeMerschman has been a member of the INMM since 1962. He and his wife Beverly have three daughters: Denice, Melanie and Janine.

DeMerschman



Mr. Tabor

Charles Tabor, G.A.T. G.M.

Charles D. Tabor Jr., 54 , general manager of the Goodyear Atomic Corp., Piketon, Ohio, died July 14, from an apparent heart attack.

He had returned from a visit to the Energy Research and Development Administration (ERDA) at Oak Ridge, Tenn.

A native of Brotherton, Tenn., Tabor received a bachelor of science degree in mechanical engineering from Tennessee Polytechnic Institute in 1944.

Before joining GAT, he was with the U.S. Government Soil Conservation Program, Putnam County, Tenn.; the National Advisory Committee for Aeronautics (now NASA) at Langley Air Force Base, Langley Field, Va.; and Union Carbide Corp., Oak Ridge.

On May 10, 1954, he joined GAT as supervisor of the mass spectrometry department. On April 1, 1957, he became superintendent of the works laboratory and on Feb. 1, 1965, he was promoted to technical division assistant manager.

On the same date two years later he became manager of the technical division.

He was named deputy general manager on Aug. 1, 1967, and became general manager on Oct. 1, 1970, following the death of G.H. Reynolds.

Tabor was a member of the Gallia-Jackson-Meigs County Mental Health and Mental Retardation Board (648 Board), Jackson City Board of Education and a past president of the Ohio School Boards Association.

Advertising Index

Activities This Fiscal Year

By Harley L. Toy, Chairman
INMM Education Committee

(1) Organized and conducted "Selected Topics in Statistical Methods for SNM Control" this spring—successfully received by 23 attendees at the Joint Center for Graduate Study in Richland, Washington, March 28-April 1, 1977. Credit due to the untiring efforts of **John Jaech** and **Bob Sorenson**. See write-up in Spring '77 Journal.

Currently planning to continue the statistics course on a regional basis. Plans call for presenting the course at Battelle's Columbus Laboratories this fall.

(2) The Guard Force Supervisor Course is proceeding for presentation at Oak Ridge this fall. **Roy Cardwell** has spearheaded this effort. Discussions have been held with ERDA and negotiations are continuing. ERDA is presently assessing feedback from their field offices as to attendees. Roy Cardwell will present a status report on current status of the program. Appears ERDA is highly receptive to such a formal course on Guard Supervisor Training.

Toy

(3) Plans are underway for presenting a Calorimeter Measurement Course this fall. Early indications show significant interest and need for such a course. The course outline and content has been worked out by Dr. **Frank O'Hara** of O.S.U. Frank O'Hara advises that the course will probably be conducted at Mound Laboratory. Mound is especially equipped for conducting the course. At this time Frank and I are contacting several ERDA contractors and licensees for potential attendees.

(4) During the year, we have received requests from high schools and college placement offices for information on a career in nuclear materials management. One of the immediate projects of the Education Committee between now and the end of the year will be the preparation of a "Career Brochure in NMM." This may be designed somewhat along the lines of our current INMM Brochure.

(5) We are presently collecting information on courses being offered in NMM. We would hope to function as a clearing house on formal course training. The listing will provide courses available not only in specific NMM but in allied areas such as health-safety.

(6) In the coming months, we hope to pursue thoroughly the concept of training seminars held in conjunction with our annual meetings. **Dick Chanda** has developed this concept and this subject will be discussed in the next issue of the Journal.

Finally, we are reassessing the educational role of INMM in light of recent developments in reprocessing and plutonium operations. It may be necessary to rethink our potential role in providing current, updated training and formal course studies.

In the coming months the Education Committee will be playing a greater role in the INMM Public Information Program. **Dick Parks** and I are meeting with a select group in investigate a program designed to counter current critics of nuclear power.

New Member Total Reaches 106

By James W. Lee, Chairman
INMM Membership Committee

PROGRESS—in the form of the largest number of new members to join INMM during one fiscal year (over 100) is the name of the game the Membership Committee gladly reports in this issue of the JOURNAL. At this writing, ten days before the start of this year's Annual Meeting, a grand total of 106 membership applications have been accepted and acknowledged by the committee.

Much credit is due—and should be given to those active and enthusiastic INMM members who were responsible for this fine record. While the Institute receives a number of unsolicited, self-initiated inquiries every year, our constantly increasing membership each year stems from the continuing success of those interested members who buttonhole their friends and colleagues at every opportunity and who regularly make certain that their new business contacts are made aware of the value of applying for membership in INMM and the resultant benefits to the individual and the nuclear industry. An examination of the list of members who sponsored one or more new applicants this year emphasizes the gratifying realization that a very large part of the INMM membership is actively supporting the continuing effort to obtain qualified new members.

In the spring issue, we tried to list the names of everyone who had sponsored new applicants, or requested the mailing of information to a new prospect, by publishing an HONOR ROLL containing the names of those individuals, a procedure which does not really do justice because it fails to recognize the outstanding effort some members have devoted towards increasing the membership of the Institute.

Yet, so many of our members have contributed so much towards the large increase in membership this year that it would be impossible to single out any one or two persons for proper recognition in this regard.

All of the current officers have sponsored applicants. **BOB KEEPIN** probably leads the group as he never misses an opportunity to extoll the virtues of membership in the INMM, especially among his many overseas contacts.

Across the ocean, more-active INMM sponsors include **GABRIEL HART, HOWARD HUGHES, ALFRED ANDERSON,** past Chairman **JIM LOVETT,** and in the Far East **HIROYOSHI KURIHARI,** and **YOSHIO KAWASHIMA.**

Here, at home Chairman **ROY CARDWELL'S** signature turns up frequently, along with past Chairmen **TOM BOWIE, ARMAND SOUCY** and **RALPH LUMB.** Our active members **EDWARD ECKFELD** and **ROY ROBERTS** also deserve special recognition.

There is a newly-revised INMM brochure and an application form. While you are thinking about this subject stop for a moment and think about your friends and colleagues. Who do you know who also should be a member of INMM? Your working partner? A friend from another company?

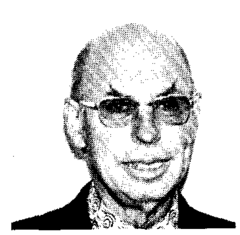
Give INMM a boost!

Talk to that person today. Or, write a short note urging your friend to complete the application. Be certain to mail him your letter with the forms today.

This is one very specific action you can take to provide direct, positive help to your organization with very little demand on your time.

After you pass on this invitation, send your friend's name and address to **James W. Lee,** Chairman INMM Membership Committee, P.O. Box 14336, North Palm Beach, FL 33408, and we will follow up your invitation. Don't be formal. Just write the name and address on a piece of paper, mark it **"INMM Prospect"** and mail it to us.

Keep INMM growing with worthwhile new members!



Mr. Lee

82 New Members

The following individuals have been accepted for INMM membership as of August 16, 1977. To each, the INMM Executive Committee extends its welcome and congratulations.

New members not mentioned in this issue will be listed in the Winter 1977-78 (Vol. VI, No. 4) issue to be sent out in late January or early February.

Frank L. Adelman, Senior Scientist, System Planning Corp., 1500 Wilson Blvd., Arlington, VA. 22209.

Robert G. Affel, Union Carbide Corp., Nuclear Division, P.O.Box X, Bldg. 9766 (5), Oak Ridge, TN. 37830.

Gerald L. Atkinson, 6110 Rayburn Drive, Camp Springs, MD 20031.

Charles N. Beets, Chef de Departement, CEN, CEN-SCK Boeren Tang 200, 2400 MOL, Belgium.

Wendell Belew, Safeguards Chemist, U.S. ERDA, Savannah River Operations, Aiken, S. C. 29801.

Emile A. Bernard, Project Leader, Sandia Laboratories, Division 1756, Albuquerque, NM 87109.

Drayton D. Boozer, Sandia Laboratories, Albuquerque, NM 87115.

Fred P. Brauer, Staff Scientist, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

B. Stephen Carpenter, National Bureau of Standards, Activation Analysis Section, Washington, D.C. 20234.

Leon D. Chapman, Divisions Supervisor, Systems Analysis, Sandia Laboratories, Organization 5741, Albuquerque, NM 87115.

Jack R. Craig, 206 Hargrove Street, Pittsburgh, PA 15226.

Marc Cuypers, Research Chemist, CCR Euratom, 21020 Ispra (VARESE), Italy.

Hassan Aly Dayem, MS 541, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

Everett A. DeVer, Mound Laboratory, Monsanto Research Corp., Miamisburg, OH 45342.

Glen H. Duncan, Accounting Supervisor, Union Carbide Corp., Nuclear Division, P.O. Box P, Oak Ridge, TN 37830.

Dr. Dennis Engi, Technical Staff Member, Sandia Laboratories, Albuquerque, NM 87115.

John F. Fagen, Jr., Manager, Naval and Energy Systems, System Planning Corp., 1500 Wilson Blvd., Arlington, VA 22209.

Herminio Gonzalez-Montes, First Officer-Safeguards Inspector, International Atomic Energy Agency, A-1011, Vienna, Austria.

Robert B. Gustafson, Corporate Security Officer, United Nuclear Corp., 67 Sandy Desert Road, Uncasville, CT 06382.

Dr. **Rudolf Haas,** Administrateur Principal, Commission of the European Communities, Luxembourg, Belgium.

Dr. **E. Arnold Hakkila,** Staff Member, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

Norman Ellsworth Hall, General Electric Co., Vallecitos Nuclear Center, P.O. Box 460, Pleasanton, CA 94566.

Maurice G. Hartman, Senior Research Scientist, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Charles R. Hatcher, Technical Coordinator, IAEA Programs, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

Dr. Milton Heinberg, Nuclear Materials Manager, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

Carl Noel Henry, 2191A-45, Los Alamos, NM 87544.

Deborah D. Hill, U.S. ERDA, Albuquerque Operations Office, P O. Box 5400, Albuquerque, NM 87115.

Dr. **Mitsuho Hirata,** Principal Scientist, Japan Atomic Energy Research Institute, Tokai, Ibaraki, Japan.

Barton M. Hoglund, President, ETA, Inc., 600 Enterprise Drive., Suite 214, Oak Brook, IL 60521.

Koji Ikawa, Senior Scientist, Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, Japan.

Noboru Kaseda. Manager for Planning, Nuclear Material Control Center, Akasaka Park Building 2-3-4, Akasaka, Minato-ku, Japan.

Kenneth L. Kniskern, Yankee Atomic Electric Co., 20 Turnpike Road, Westboro, MA 01581.

Robert K. Kunita, 4234 Lake Ridge Drive, Raleigh, NC 27604.

Dr. **James R. Lemley,** Associate Chemist, Brookhaven National Laboratory, Upton, Long Island, NY 11973.

David Allen Lewis, 812 Magnolia Street, Johnson City, TN 37601.

Mr. **Jean Ley,** CCR Euratom, 21020 Ispra (VARESE), Italy.

Victor W. Lowe Jr., Statistician, Union Carbide Corp., Nuclear Division, Y-12 Plant, P.O. Box Y, Oak Ridge, TN 37830.

John Joseph Ludwig, 379 Pipe Stave Hollow Road, Miller Place, NY 11764.

Carl Ray Lux, U.S. ERDA, Materials Management Division, P.O. Box E, Oak Ridge, TN 37830.

Don Majors, Kerr-McGee Nuclear Corp., Cimarron Facility, P.O. Box 315, Cresent, OK 73028.

Bresesti Marcello, Project Manager, CCR Euratom, 21020 Ispra (VARESE), Italy.

Frank Powell Martin, Chief Inspector, U.S. ERDA Division of Safeguards and Security, Washington, D.C.

Erick L. May, Jr., Safeguards Specialist, U.S. NRC, Washington, D.C.

Thomas L. McDaniel, Supervisor, Radiochemistry, Babcock & Wilcox, P.O. Box 1260, Lynchburg, VA 24505.

Dr. **Thomas I. McSweeney,** Research Engineer, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Catherine S. Morimoto, P.O. Box 5400, Division of Safeguards and Security, U.S. ERDA, Albuquerque, NM 87115.

G. Wayne Morrison, 241 Peterson Road, Concord, TN 37720.

E. L. Musselwhite III, Allied-General Nuclear Services, P.O. Box 847, Barnwell, SC 29812.

Dr. **Vernon W. Myers,** Nuclear Physicist, National Bureau of Standards, Washington, D.C. 20234.

Yoshiaki Ninagawa, Deputy Manager, Power Reactor and Nuclear Fuel Development Corp., 9-13, 1-chome, Akasaka, Minato-ku, Tokyo, Japan.

Hideo Nishimura, Research Scientist, Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, Japan.

Charles Kilbourne Nulsen, Safeguards Systems Analyst, U.S. NRC, Washington, D.C.

Joseph F. Olivier, Nuclear Technologist, U.S. ERDA, Savannah River Operations, Box A, Aiken, SC 29801.

Takeshi Osabe, Japan Nuclear Fuel Co., Ltd., 907, Uchikawashhinden, Yokosuak-shi, Kanagawa-ken, Japan Postal No. 239.

Sanda Onnen, Dr. Ing., Nuclear Research Center, 7500 Karlsruhe, Postfach 3640, Germany.

Thaddeus Pasternak, Staff Scientist, Science Applications, Inc., 1200 Prospect Street, La Jolla, CA 92038.

Dr. **Alan Edward Proctor,** NDA Laboratory Manager, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

Robert Lee Rinne, 2737 Canyon Creek, San Ramon, CA 94583.

Charles Thomas Roche, 2231 North Bissell Street, No. 1E, Chicago, IL 60614

Dr. **James R. Roney** (The Franklin Institute of Philadelphia, Pa.), 152 Grover Avenue, Princeton, NJ 08540.

Joseph Sapir, Los Alamos Scientific Laboratory, Los Alamos, NM 87545.

Robert L. Shepard, Safeguards Operational Analyst, U.S. NRC, MS 430-SS, Washington, DC 20555.

Frederick Lewis Sherman, 17 Hillsdale Drive, Cranston, RI 02920.

R. Dee Sherrill, Research Chemist, Babcock & Wilcox, Lynchburg Research Center, P.O. Box 1260, Lynchburg, VA 24505.

Takaaki Shibata, Safeguards Engineer, Power Reactor and Nuclear Fuel Development Corp., 1-9-13, Akasaka, Minatoku, Tokyo, Japan.

Loren E. Shuler, Standards Engineer, Rockwell International, Atomics International, Division, Rocky Flats Plant, P.O. Box 464, Golden, CO 80401.

Donald Ellsworth Six, Manager, Safeguards and Security Branch, EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, ID 83401.

Wilkins R. Smith, 656 Herndon Parkway, Herndon, VA 22070.

John P. Stewart, Senior Engineer-Quality Systems, General Electric Co., P.O. Box 780, Wilmington, NC 28401.

Robert V. Studley, Staff Engineer, Savannah River Operations, Aiken, SC 29801

Hugh Gregory Sturman, British Nuclear Fuels Limited, Head Office, Risley, Warrington WA3 6AS, England.

Eizo Sugimoto, Manager for Operation, Nuclear Material Control Center, Akasaka Park Bldg. 2-3-4, Akasaka, Minato-ku, Tokyo.

David B. Talan, 25 Santiago Street, Providence, RI 02907.

W. Bruce Taylor, 4831 Willett Parkway, Chevy Chase, MD 20015.

Larry H. Taylor, Supervisor of Technology, Rockwell Hanford Operations, Richland, WA 99352,

Mary Alice Thom, 400 Monte Vista Avenue, Idaho Falls, ID 83401.

Takao Tsuboya, Chief Engineer, Power Reactor and Nuclear Fuel Development Corp., 1-9-13, Akasaka, Minato-ku, Tokyo, Japan.

Dr.**Kunihiko Uematsu**, Manager, Fuels and Materials, Power Reactor and Fuel Development Corp., 1-9-13, Akasaka, Minato-ku, Tokyo, Japan.

Dr.**James D. Williams**, Division Supervisor, Intrusion, Sandia Laboratories, Division 1739, Albuquerque, NM 87115.

Eiji Yagi, Deputy General Manager, Mitsubishi Metal Corp., 5-2, Ohte-machi-1, Chiyoda-ku, Tokyo, 100 Japan.

Barbara Marie Wilt, 1876 Fowler Street, Apt. 309, P.O. Box 634, Richland, WA 99352.

Dr. **Neil R. Zack**, Senior Chemist, Allied Chemical Corp., 550-2nd Street, CPP 602, Idaho Falls, ID 83401.

Address Change

The following changes of address have been received as of August 16, 1977, by the INMM Publications Office at Kansas State University, Manhattan.

C. H. Sathrum, Project Engineer, Sargent & Lundy Engineers, 55 East Monroe Street, Chicago, IL 60603.

William J. Shelley, P.O. Box 25861, Oklahoma City, OK 73125.

Russell E. Weber, 19064 Montgomery Village Avenue, Gaithersburg, MD 20760.

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BOOK REVIEWS

"The Last Chance," by William Epstein,
The Free Press, Division of MacMillan Publishing Co.,
New York, 1976.

By Eugene V. Weinstock
Brookhaven National Laboratory

This is a nagging, sometimes repetitious, often engrossing book that should be of great value to those interested in nuclear arms control and disarmament. In painstaking detail, **William Epstein,** who, until his retirement in 1973, was the Director of the Disarmament Division of the United Nations Secretariat and who has participated in many important arms control negotiations and conferences since 1950, traces the history of attempts to control the atom, from the Three-Power Declaration by the U.S., the U.K., and Canada in 1945, to the NPT Review Conference thirty years later (which the author regards as a failure). Both his professional career at the U.N. and his Canadian origins give his book a unique perspective that Americans should find interesting and instructive.

Subtitled "Nuclear Proliferation and Arms Control," the book takes its main title from the author's belief (shared by many) that, with the Indian explosion of a nuclear device in 1974, we are at the brink of uncontrolled nuclear proliferation, that one more accession to the nuclear club will cause the collapse of what he calls the non-proliferation regime, and that, therefore, the world has one last chance to control the spread of nuclear weapons.

A large part of the book is concerned with the history of the Non-Proliferation Treaty and the aftermath of its adoption, although other important arms control treaties, such as the Treaty for the Prohibition of Nuclear Weapons in Latin America (the Treaty of Tlatelolco), are also covered. From the vantage point of his involvement as a U.N. representative he was in a position to observe and try to understand all sides in the negotiations leading up to the NPT—the weapons states and non-weapons states, the U.S. and U.S.S.R. and their respective allies, and the non-aligned states. The fears and misgivings of the non-weapons states are given particular prominence.

Out of this account and that of the subsequent events emerges the major theme of this book—that the responsibility for the present shaky state of the non-proliferation regime can be laid squarely at the door of the weapons states, principally the U.S. and the U.S.S.R. By and large, the non-weapons parties to the NPT have kept their part of the bargain, but almost without exception the weapons parties have failed to fulfill the obligations they undertook as a **quid pro quo** to the non-weapons parties for foreswearing nuclear weapons. These are embodied mainly in Articles IV, V, and VI of the treaty.

Article IV calls for contributing to the development of the peaceful applications of nuclear energy in the non-weapons states, particularly in the developing areas of the world. So far, the amount of aid going to these countries for the development of what they most desire, nuclear power, has been pitifully small. Article V calls for the benefits of peaceful nuclear explosions (whatever they may be—the U.S., which once was enthusiastic about their potential, has since soured on them) to be provided to the non-weapons states at a reasonable cost and under the auspices of an appropriate international body, for the establishment of which negotiations were to be undertaken "as soon as possible after the Treaty enters into force." No such body has ever been established and no such negotiations have ever taken place. Perhaps most important of all, Article VI and the preamble to the Treaty obligate the weapons parties to pursue negotiations "in good faith" (strange language to put into a treaty, one would have assumed that good faith would have been implicit) leading to a cessation of the nuclear arms race and to nuclear disarmament and a treaty on general disarmament "at an early date." In Epstein's view, the agreements that have resulted from these negotiations have largely made a mockery out of stopping the arms race. Thus, "each successive SALT agreement has raised the numerical ceiling for nuclear weapons and . . . has imposed no qualitative or technological limitations on offensive weapons." The Threshold Test Ban Treaty of 1974 permitted the U.S. and the U.S.S.R. to conduct an unlimited number of underground tests of any desired size until March 31, 1976, and thereafter restricted the size of a single blast to 150,000 tores of TNT equivalent—in practical terms, hardly any limitation at all, since very few of the previous tests had been larger.

The behavior of the weapons powers since the adoption of the NPT, although it might not have been in the spirit of that treaty, was very much in the spirit of what had preceded it: thus, for example, after the signing of the Partial Test Ban Treaty in 1963 the rate of testing in the U.S. and in the U.S.S.R. **increased** by 60 and 33%, respectively.

The failure of the weapons states to live up to their commitments has led to a growing disillusionment among the non-weapons states, particularly in the developing countries, many of whom "consider that they have been misled or duped by the nuclear powers"—a dangerous situation for the weapons states, who have the most to lose by a failure of the NPT.

Epstein admits that strict fulfillment of their commitments under the NPT by the weapons states might

Weinstock

not of itself prevent proliferation; however, he feels that it is a necessary condition.

Not content with mere criticism, the author offers recommendations—thirty-some-odd of them—for strengthening the NPT. These range from security assurances by the nuclear powers to the non-nuclear powers to provisions for periodic conferences to review progress in achieving the goals of the treaty. Some of the recommendations, like the one urging scientists to stop working on military research and development, are probably Utopian, but most are eminently sensible. They are also mostly political or institutional in nature, in contrast to the mostly technical approach of the present Administration, with its preoccupation with alternate fuel cycles.

In sum, this book is an excellent contribution to the current intense debate on nuclear proliferation and how to prevent it.

Nuclear Power, Issues and Choices
(The Ford-MITRE Study)
Ballinger, 1977

By W. A. Higinbothom
Brookhaven National Laboratory

Candidate **Jimmy Carter's** first detailed policy statement called for a moratorium on the purchase or sale of enrichment and reprocessing facilities (N. Y. Times, May 13, 1976). A report prepared by Panheuristics for the Arms Control and Disarmament Agency, "Moving Toward Life in a Nuclear Armed Crowd," made a similar proposal at about the same time. The reasoning was that proliferation of nuclear facilities involving high enriched uranium or separated plutonium would permit a number of nations to be in a position on short notice, to become significant nuclear powers. The Ford Foundation study, administered by MITRE, is the best available explanation of this issue.

The Ford-MITRE study was initiated only shortly before the Carter statement. An earnest effort was made to select competent experts who were not publicly committed either pro or con nuclear power. Like the authors of the Panheuristics paper, most of them have been associated with arms control studies for many years. The Ford-MITRE report was presented to President Carter a few days before he presented his nuclear policy to the public on April 21. Although the present Carter program is not identical with that proposed in "Nuclear Power, Issues and Choices," it is clear that several key people have contributed to both. **Albert Carmesdale, Abraham Chayes** and **Paul Doty,** of Harvard, contributed to the first Carter position paper and participated in the Ford study. **Joseph Nye** and **Harold Brown** participated in the study and now hold key positions in the Carter Administration on nuclear policy. Consequently, the Ford-MITRE study deserves special attention.

Although the study stemmed from concern about proliferation, it addressed the energy problem in general and considered the role of nuclear power within that general framework. Considering the resources of gas and oil, the study concluded that oil production will peak at around 2,000. There is a lot of coal in the U. S. and in some other countries. Coal utilization will have to be expanded, starting now. Nuclear power will be needed during the next 50 years, but not breeders. This is based on the conclusion that there will be adequate supplies of uranium to fuel LWR's and HWR's for that period of time without breeding. Sometime around 2025 a new energy source probably will be needed. This could be breeders or fusion, or solar. Since that is a long time off, there is no urgency to develop reprocessing and breeders. On the other hand, some work on breeders should continue as insurance.

The prospects for alternative energy fuel cycles were assessed. While there will be economically attractive applications of solar and geothermal power, they are not likely to appreciably reduce the need for nuclear and fossil generated electricity until well into the next century.

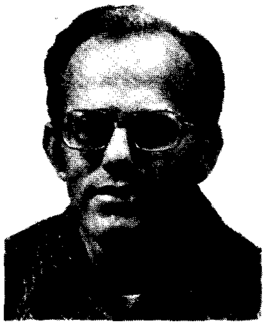
The environmental impacts of nuclear and fossil fuels are compared. Even if the Rasmussen estimates for reactor reliability are very optimistic and the hazards of domestic diversion and sabotage are considered, the social costs of nuclear and coal are comparable. Safe disposal of radioactive wastes needs more emphasis, but it can be achieved. Expanding combustion of fossil fuels conceivably might upset the global heat balance, due to production of CO_2. It is too soon to assess this problem, but it could call for drastic action sometime in the future.

There are chapters on health effects, environmental impacts, reactor safety, reprocessing, enrichment and breeders. The U. S. should encourage other "reliable" nations to supply enrichment services, so that other nations will have a choice of suppliers. The U. S. breeder development program is criticized as being hasty and ill-planned, especially the CRBR.

The subject of incentives for nations to achieve nuclear weapons is treated only superficially. The main point is that reprocessing and breeders are not urgent and that a moratorium would be desirable on behalf of world security.

It would take careful study of the issues in several fields to refute the conclusions of this report. The CIA study which President Carter quoted, and an M.I.T. study released on May 16, paint a much grimmer picture of future costs and availability of oil. The latter, "Energy: Global Prospects 1895-2000" (McGraw-Hill), suggests that the price of oil could double sometime between 1983 and 1987, creating a strain for the advanced countries and tragedy for developing countries. Even though Pu-recycle might only reduce a nation's imports by 20%, that could seem very significant in terms of balance of trade. Nations will understandably try to achieve assured fuel supplies insofar as that is possible. As the authors of "Nuclear Power, Issues and Choices" recognize, the U. S. cannot unilaterally do much to slow down proliferation. It can adjust its own programs and try to persuade other nations to cooperate.

The President asks us to take a hard look at our nuclear policies. We can start by reading this challenging book—**William A. Higinbotham.**



Sapir

Special Thanks To Joe Sapir

As most people who speak to him can quickly detect, **Joe Sapir** was born and reared in New York City.

Mr. Sapir received a B.S. degree in mechanical engineering from New York University in 1957 and the M.S. degree in nuclear engineering from MIT in 1959. He and his wife Fannie, also a New Yorker, came to New Mexico in 1962 for a change of scenery and to experience a different environment. Their three children (Amy, 12, Marcie, 9, and Mark, 7) are all native New Mexicans. The family enjoys the outdoor activities in Los Alamos and the environs such as camping, hiking, and skiing.

At LASL, Mr. Sapir worked on Project ROVER (nuclear propulsion) primarily in the critical assemblies group until 1973. His specialties were reactor physics and enginneering. In June, 1973, the Sapirs moved back east for a two-year assignment at the U.S. NRC. He was a project engineer in the Division of Operating Reactors.

After coming back to LASL in 1975, he joined the safeguards program, working directly for **Bob Keepin,** INMM Vice Chairman. His duties are quite varied. He responds to inquiries and assessment requests, compiles the Safeguards progress report, and has management responsibilities for the safeguards SNM inventory. In addition, he is involved in several technical projects associated with calibration standards and safeguarding critical assemblies.

The job of serving as local arrangements chairman for the 1977 meeting in Washington, D.C., was very new to him particularly since he had never attended an INMM meeting.

"It turned out to be quite interesting and enjoyable. One of the most enjoyable and rewarding aspects was meeting the people associated with INMM. It was indeed a pleasure working with them," he commented.

Mr. Sapir's most anxious moment at the meeting came when people were lining up for the luncheon. In an attempt to save some money, he had estimated that there would be a significant number of no-shows and had the hotel set up fewer seats than the total number of tickets sold. He was of course quite worried that he had miscalculated and that there wouldn't be enough seats. The crowd waiting outside looked immense. But things turned out okay as his calculations proved to be accurate.

The journal of INMM expresses its thanks to Mr. Sapir for a task well handled. Without a doubt, the membership is grateful to the Joe Sapirs who pitch in when an assignment comes and work so diligently and effectively.

INTERVIEWS WITH ATTENDEES AT 1977 ANNUAL MEETING

Compiled by Tom Gerdis, Editor
Nuclear Materials Management
Journal of INMM

Walter G. Martin is the chief of safeguards branch, Philadelphia office, U.S. NRC. He was Technical Program Chairman of the 1967 (Washington, D.C.) and 1968 annual meetings of INMM. He then served as Exhibits Chairman for the 1969 and 1971 meetings. Martin, who resides in Marlboro, N.J., was a member of the INMM Executive Committee during 1970 and 1971.

O'Hara

Gessiness

Dr. **Frank A. O'Hara,** Assistant Professor of Nuclear Engineering at Ohio State University, Columbus, has been asked by the INMM Executive Committee to head an Ad Hoc Committee on Student Awards. Frank together with Dr. **William A. Higinbotham** of BNL and **Bernard Gessiness** of National Lead of Ohio (Cincinnati) will consider the establishment of an annual paper-project competition with appropriate recognition provided by the Institute.

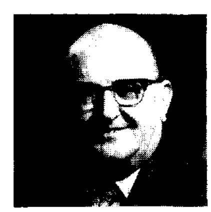
Ella Werner, Washington, D.C., the lovely "Grand Lady of INMM," spent an enjoyable few minutes visiting with J. W. Nave, Jr., at the Chairman Roy Cardwell's official reception during the 1977 annual meeting. J.W. Nave, Sr., of ORNL, was the Official Photographer for the meeting and was responsible for most of the photos in this issue.

J. W. Nave of the Metals and Ceramics Division of ORNL served as Official Photographer for the 1977 annual meeting of INMM. He was ably assisted at the convention by his handsome 7-year-old son, tow-headed J. W. Jr.

Special thanks is due **Raymond E. Lang** of the U.S. ERDA Operations Office at Chicago. In addition to his duties as Site Selection Chairman for the Institute, Ray handled most of the arrangements for a post-convention trip to colonial Williamsburg, Va., the weekend of July 2-3. The two-day visit included pre-arranged tours and a special Saturday evening dinner.

Dr. **Martin S. Zucker** of BNL works with the U.S. NRC Inspection Division as an Advisor and a Consultant. Lately, he has also been doing considerable work with IAEA Division of Development in implementing the Presidential Gift-in-Kind Program. The program supplies the IAEA with the latest developments in NDA equipment. He has been an INMM member for eight years; he attended his first annual meeting in 1970 at Gatlinburg, Tenn.

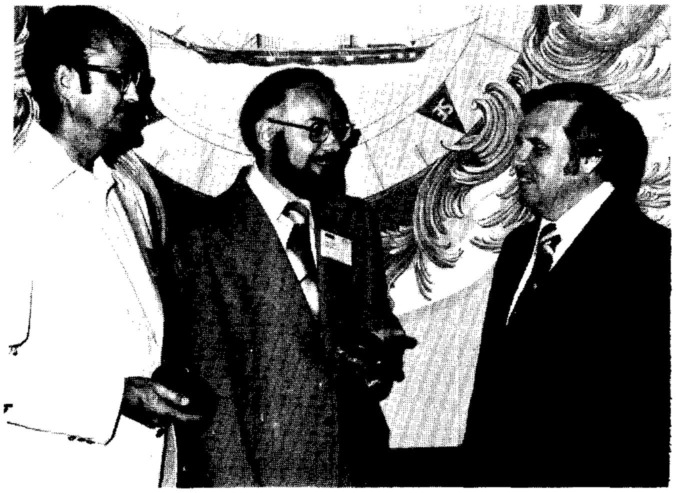
Indusi



Austin

Harvey C. Austin is the Accountability Representative at ORNL. Harvey is completing his 26th year in the management of nuclear materials. He attended his first INMM meeting in 1963 at Buffalo, N.Y. That particular meeting included a post-convention trip to Niagara Falls with a dinner at the famed Seagren Towers revolving restaurant.

Dr. **Joseph P. Indusi** is with the Technical Support Organization for Nuclear Safeguards at BNL. He is the BNL Project Coordinator for the International Safeguards Project Office, a part of the U.S. support program to IAEA Safegurads. Indusi's primary involvement has been activities in support of the IAEA Safeguards Information System In addition, other efforts include studies concerned with methodologies for the safeguarding of nuclear power plants.



Special INMM Desk Paperweights were presented at the annual meeting to Ralph J. Jones (left) of the NRC and John L. Jaech (center) of Exxon Nuclear for their service on the Institute's Executive Committee. The presenter of the honors was none other than ORNL's Roy Cardwell, INMM chairman.

John L. Telford is the Chairman of INMM-3 Statistics Subcommittee. A member of INMM since 1974, Telford is associated with the Vallecitos Nuclear Center of GE. He is involved in advanced safeguards systems and coördinates statistical efforts. These efforts include nuclear materials accountability required for a licensee and the statistical aspects of the integrated control system for the Coprecal Process (Coprecipitation and Calcination). He holds an M.S. degree in Statistics from Southern Methodist University, Dallas.

Ralph J. Jones, Damascus, Md., completed a one-year term on the INMM Executive Committee on June 30. Jones is a former INMM Treasurer and headed a special Future Plans Study. The Kansas State University graduate attended his first INMM annual meeting in Pittsburgh, Pa., in 1964. Jones is Chief of the Materials Protection Standards Branch of the U.S. NRC, Washington, D.C.

Lynn K. Hurst is the new President of NATCO, Vienna, Va. Nuclear Audit and Testing Co. is a subsidiary of E. R. Johnson & Associates, Washington, D.C. He was formerly vice president of NATCO. He joined E. R. Johnson in 1972 after being associated with the Argonne (Ill.) National Laboratory beginning in 1949. See elsewhere in this issue for an article announcing Mr. Hurst's appointment as President of NATCO.

Homer M. Faust is the Accountability Representative at Battelle (Ohio) Columbus Laboratories. He has been with Battelle nearly 28 years. He is involved in materials management and safeguards at Battele. Faust has been a member of INMM for 18 years and is a Certified Nuclear Materials Manager.

William T. Dickenson is Head of the Material Accountability Section for DuPont, Savannah River. A native of Newport News, Va., Dickenson has been with DuPont for 24 years at Savannah. He was a reactor operator for 16 years, in budget preparation for 7 years, and a year ago moved to Accountability. He recently joined INMM and served on the Registration Committee at the 1977 annual meeting.

Sheldon Kops is the Chief of the Materials Management and Safeguards Branch of the Chicago Operations Office, ERDA. He was the Institute's first

Faust

Gatti

Treasurer and has been active on the INMM Executive Committee for 17 years. He is currently Chairman of the INMM-4 Standard Subcommittee on Accounting Records and Reports.

Dick Parks, Jim Roney, and Frank O'Hara

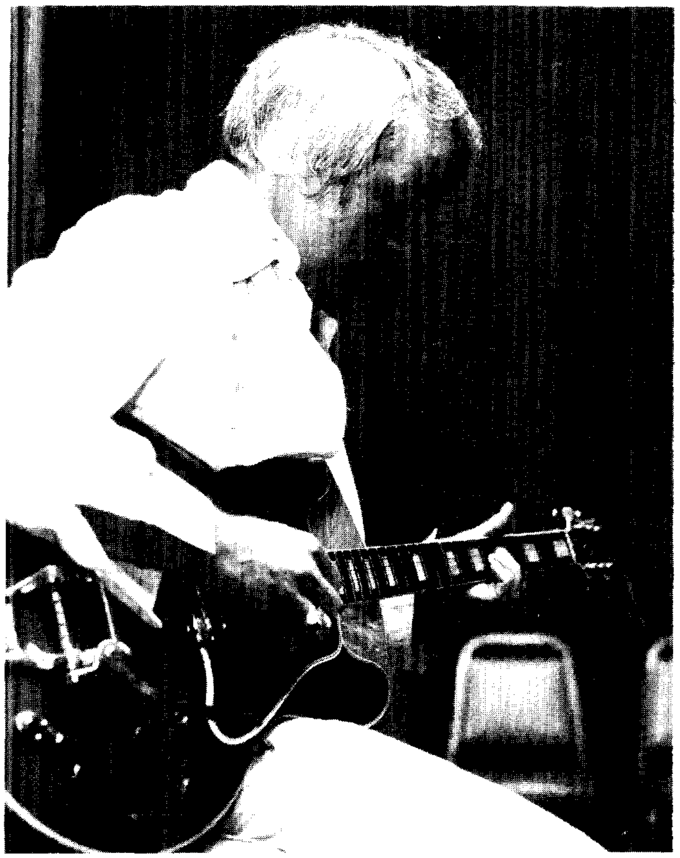
Dr. **James R. Roney** is Director of Systems Science at the Franklin Institute, Philadelphia, Pa. He is participating in safeguards related studies for Brookhaven National Laboratory and U.S. NRC. He has a special interest in the sociology in the public acceptance or lack of acceptance of nuclear power. He is serving on the INMM Task Force on Public Information (a special action group) which met at the annual meeting.

Dr. **Tsahi Gozani** is Chief Corporate Scientist for Science Application, Inc., (SAI), Palo Alto, Calif. Gozani is in the charge of the SAI experimental program relating to the energy and nuclear fields. He is completing his 10th year in safeguards related work, mostly in the development of NDA systems,. He has presented a technical paper at all but two annual meetings of INMM since 1969. Gozani is currently working on development of an on-line NDA for coal composition. This uses the technology used in nuclear NDA.

Daniel C. Allen is a Methods Analyst in Nuclear Materials Management at the Atomics International Division of Rockwell International, Canoga Park, Calif. He is involved in material control, inventory control and safeguards. Allen has been in the industry for 12 years, a member of INMM for 9 years, and is a Certified Nuclear Materials Manager. He was formerly with United Nuclear Corp., New Haven, Conn., as Nuclear Materials Manager.

Billy Joe Campbell, Oak Ridge, Tenn., was the musical entertainment at the Chairman's Tennessee Type Reception at the 1977 annual meeting. Campbell, a guitarist, is with the U.S. ERDA Oak Ridge Operations Office. The reception on Tuesday evening, June 27, was cohosted by INMM and the George Dickel Tennessee Distillery.

A native of Newnan, Ga., **Wilkins R. Smith** attended his third INMM meeting. He previously attended in 1971



Billy Joe Campbell of Oak Ridge, Tenn., provided the special entertainment at the Chairman's Reception with his vocal and instrumental renditions. Special thanks from the Journal staff to Billy.

and 1974. He is Manager of Quality Programs Division for NUSAC, Inc., McLean, Va. He handles fuel quality assurance, UF_6 confirmation, and material control programs. A graduate of Georgia Tech, he formerly was with United Nuclear Corp., Naval Products Division, New Haven, Conn., and Combustion Engineering, Inc., Windsor, Conn. He is currently residing in Herndon, Va.

Lewis F. Casabona, a resident of Fairfield, N.J., is the Manager of Mass Spectrometry Services for Teledyne Isotopes, Westwood, N.J., near New York City. In his position, Lew is responsible for all the analytical programs pertaining to the nuclear fuel cycle. Teledyne Isotopes is a service laboratory performing isotopic analysis for the nuclear industry. Casabona, in his 14th year with Teledyne, has been an INMM member for 9 years and since 1969 has attended all INMM annual meetings. He has a B.S. degree in Chemistry from Fairleigh Dickinson University, Teaneck, N.J.

Dr. **Ronald A. Harlan,** Boulder, Colo., is a Research Specialist in NDA and Calibrations of NDA in the Instrumentation and Statistical Systems Group at Rockwell International, Rocky Flats Plant. He decides requirements of the instrumentation and plans calibration experiments. Harlan, who received a Ph.D. in Nuclear Chemistry in 1963 at Florida State University, Tallahassee, advises on the need for and construction of physical standards for calibrations. He serves on the INMM-9.3 Subcommittee on Physical Standards. He joined INMM in 1974 at the Atlanta annual meeting. Harlan gave a paper in 1971 at West Palm Beach, Fla., and in 1975 at New Orleans and this year. At Rocky Flats the past seven years, he was previously with Idaho Nuclear Corp., Idaho Falls, and served as an Assistant Professor of Chemistry at the University of Arkansas, Fayetteville.

The Local Arrangements Chairman for the 1978 meeting will be **Bernard Gessiness,** Nuclear Materials Representative and Materials Management Coordinator at National Lead Company of Ohio at Fernald near Cincinnati. He recently celebrated 25 years of service at NLO. He is a past Chairman of INMM (1968-1970), Vice Chairman (1966-1968), Technical Program Chairman (1966), and Local Arrangements Chairman for the 1965 annual meeting of INMM held in Cincinnati. His duties at NLO include serving as Official Contact with U.S. ERDA Oak Ridge Operations Office and all ERDA contractors. NLO makes uranium metal for use for the New Production Reactor (NPR), Richland, Wash., and for the reactors at DuPont Savannah River Plant, Aiken, S.C. NLO also supplies cascade feed for Union Carbide Nuclear, Paducah, Ky., and for Goodyear Atomic Corp., Portsmouth, Ohio. NLO, for many years, has been the chief recipient of low-enriched uranium and thorium scrap returned to ERDA facilities for recovery.

On September 22, **Jack A. Buck** will begin his 20th year with Nuclear Fuel Services, Inc., Erwin, Tenn. Since 1968, he has been the Accountability Representative. Prior to that, he did cost estimating. He has a B.S. degree in Business from East Tennessee State University, Johnson City. A World War II veteran, he served in Italy with the 10th Mountain Division. As Accountability Representative, he maintains all ledger controls, is in charge of all nuclear shipping, receiving and warehousing. He has been an INMM member for the past nine years.

A familiar name in INMM circles is **Barry D. Devine** who is now a radiological engineer with the Materials Transportation Bureau, U.S. Department of Transportation, Washington, D.C. Barry, who was with Argonne (Ill.) National Laboratory for many years, joined DOT in 1972 and is primarily concerned with safe transportation of radioactive materials. No longer an INMM member, he attended the annual meeting to see old friends in the business. At the 1968 INMM annual meeting in Chicago, Barry and Lynn K. Hurst (then of ANL and now of NATCO) worked closely on meeting arrangements. "We at DOT are working on the implementation of the IAEA transportation regulations in the United States and the incorporation of the IAEA approach into the U.S. regulations," Devine commented. He thought that this implementation effort would be of interest to INMM members and other readers of this publication.

On July 1 **A.W. (Bill) DeMerschman** began a two-year term on the INMM Executive Committee. Bill is Manager of Safeguards and Materials Management at HEDL at Hanford, Wash. In this capacity, he is responsible for FFTF core materials and radiation test materials. Bill was Local Arrangements Chairman for the 1976 INMM annual meeting at Seattle. In addition, this past year he has been looking into INMM legal affairs. He has been actively involved in the Institute since the first annual meeting in 1960 at Columbus, Ohio. "Our group at HEDL is involved in scoping and installing advanced accounting techniques which will be utilized the High Performance Fuel Laboratory. The laboratory will be constructed in the next four years as a demonstration plant for fast reactor fuel fabrication," Bill noted.

Dr. **Walter W. Strohm** of Mound Laboratory, Miamisburg, Ohio, has been a member of the INMM since 1973 when he attended the San Diego meeting. He attended his first INMM meeting in 1970 at Gatlinburg, Tenn. Strohm is a Project Leader for Safeguards at Mound. In this capacity, he is involved in safeguards development projects for U.S. ERDA and U.S. NRC. Strohm is chairman of INMM-9.6 Subcommittee on Automation of NDA and chairman of the ERDA Half-Life Evaluation Committee. The ERDA effort is a multi-laboratory effort to resolve current discrepancies in plutonium half-life values. Other labs involved ANL, LLL, LASL, Mound, NBS, and Rocky Flats. Mound's Safeguards Program is concerned with the development of the Controllable Unit Methodology for Diversion Detection, automated measurements systems, and measurements.

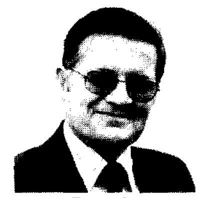
The Grand Lady of INMM, **Ella C. Werner**, who edited some early editions of **The INMM Newsletter** (no longer published) now resides at 4740 Connecticut Avenue, N.W., Washington, D.C. 20008. For many years, she was with the former U.S. AEC as a Nuclear Materials Manager for the Division of Raw Materials and the AEC Washington Office. She was responsible for all records and reports for raw materials from the Belgian Congo, Port Hope, Ontario, Canada, and the Colorado Plateau. She was with the AEC for 13 years. Her background was in accounting but was helped by the fact that three of her brothers were mining engineers. Miss Werner attended the 1977 meeting to see many old friends in INMM and in the field of nuclear materials management.

Dr. **Orval E. Jones** of Sandia Laboratories, Albuquerque, where he is Director of Nuclear Security Systems, served as Chairman of the Physical Protection Systems and Studies Session at the 1977 meeting. At Sandia, he is responsible for the development of physical protection systems for U.S. ERDA applications. This includes conceptual designs for future facilities at one of the spectrum and hardware evaluation at the other. He has been in safeguards activity for about three years and joined the INMM a year ago. "In a relatively short span of several years, I believe the safeguards program has made remarkable advances in evolving a structured, logical approach to the problem. We're now in a position to efficiently solve safeguards needs," Jones noted.

Mose Baston has been employed for the past 20 years at Monsanto Research Corp., Mound Laboratory, Miamisburg, Ohio. He holds a degree, B.S. in Industrial Chemistry from the University of Kentucky, Lexington. For the past eight years, he has been in Data Processing and is now a Project Leader in charge of nuclear applications. Prior to this, he worked as a chemist and a supervisor in nuclear development at Mound Laboratory. Mose has attended four INMM annual meetings and is interested in surveying the interest in establishment of an INMM Committee on Data Processing Application.

Marshall L. Pendergrass, a member of INMM for three years, attended his second annual meeting in 1977. He is associated with Arkansas Power and Light Co., Little Rock, as Manager of Nuclear Fuel. He is responsible for the out of core and in core fuel management functions the utility's two nuclear plants at Russellville. He earned a B.S. in electrical engineering at the University of Arkansas, Fayetteville, and the M.S. in nuclear engineering at the University of New Mexico, Albuquerque. While at UNM, he worked part-time at Sandia Laboratories in Area V Reactor Operations as an operator-in-trainging and in flux-map experiments. He has served on the INMM Safeguards Committee.

Saalborn



Denning

Gary N. Denning, among the first to join INMM, is Manager of Safeguards and Security at Allied Chemical Corp., Idaho Falls. "We operate the Idaho Chemical Processing Plant, a facility chartered to recover 20% and above enriched uranium. It is all irradiated fuel," he noted. Denning has been in accountablility, nuclear materials management, and safeguards since 1954, all at Idaho Falls. The facility is located at the Idaho National Engineering Laboratory about 50 miles from Idaho Falls. "All the old-timers in the business were at the founding meeting. Shelly Kops got me into the safeguards business and into the Institute. That was one of those temporary things 22 years ago; and I'm still in it," Denning said in an interview at the INMM annual meeting.

Otto E. Saalborn is Manager of the Nuclear Division of the Management Consulting Service of Burns International Security Services, Inc., Briarcliff, N. Y. "We provide consulting services to utilities for preparing security plans, writing security implementation procedures, doing special security studies, preparing specifications for electronic security systems, and offering training programs for guard forces in compliance with U.S. NRC regulations," he commented. "We will also do security audits for the operating nuclear power plants which assure compliance with 10 CFR," Saalborn added. Otto joined the INMM two years ago and attended his first annual meeting this year.

Raymond L. Jackson, formerly of Battelle Columbus Laboratories, is now with the U.S. NRC in the Division of Nuclear Safety and Safeguards. He edited **The INMM Newsletter** for six years immediately prior to the founding of this Journal, served as Local Arrangements Chairman for a number of years. He resides at 2538 Avon Lane, Falls Church, Va. 22043. At Battelle, he was the Nuclear Materials Management Representative.

Thomas B. (Tom) Bowie, West Hartford, Conn., is Chairman of the INMM Awards Committee. Tom is with Combustion Engineering, Inc., Windsor, Conn., as Manager of Nuclear Materials and Security. A graduate of Central Connecticut College, New Britain, he has a M.A. degree from New York University. He is a charter member if INMM, a past Chairman (1960-1962) of the Institute, and served on the Executive Committee (1974-1976).

Victor W. Lowe, Jr., formerly of Yakima, Wash., has joined Union Carbide Y-12 Plant as a Statistician June 15. He had been with LASL in the Statistical Services Group. He has been a member of INMM for three years, has attended three annual meetings, and is a member of INMM-3 Standard Subcommittee on Statistics.

David W. Zeff, native of Oshkosh, Wis., is Administrator of Licensing and Control for the Commercial

Nuclear Fuel Plant, Babcock & Wilcox, Lynchburg, Va. David is responsible for plant's NMC records system. Other responsibilities include preparation and submittal of plans in response to NRC, state and local requirements. He joined the INMM in 1974, serves on the INMM-3 Standards Subcommittee on Statistics, and participated in the writing of the special INMM report on Assessment of Domestic Safeguards for Low-Enriched Uranium. David received a B.S. degree in Physics from the University of Wisconsin, Oshkosh, and an M.S. in Industrial Administration from Purdue University, West Lafayette, Ind.

Dr. **Richard N. Chanda** is Manager of Instrumentation and Statistical Systems R&D at Rocky Flats. The group is involved in the development of NDA, physical security and process instrumentation, and statistical support in experimental design, sampling plans and data analysis and evaluation. He has been there for seven years. He was formerly in R&D at Idaho Nuclear Corp. where he was involved in alpha and-gamma-ray spectroscopy studies in the heavy elements. A Bonneville, Ore. native, he received his education at Willamette University, Salem, Ore., and the University of California, Berkeley, where he received his Ph. D. in 1963 in Nuclear Chemistry. He joined INMM in 1972, chairs INMM-9.1 Standard Task Force on Characterization of Materials subject to NDA, and served on the Technical Program Committee for the 1977 annual meeting.

Dr. **Douglas Reilly,** who grew up in Newark, N.J., is a visiting scientist at the Joint Research Center of EURATOM at Ispra, Italy. He is working in the nuclear safeguards program in their gamma spectroscopy section. The major problems of interest are on plutonium isotopic composition measurements, development of safeguards training program, and technical advice of the Euratom Safeguards Inspectorate. He will be at Ispra for another year and return to LASL next June. Doug has been an INMM member for at least five years and has given papers at annual meetings. Doug received his Ph.D. in 1970 in physics from Case Institute of Technology at Cleveland, Ohio.

Larry Musselwhite, formerly of Erwin, Tenn., is now with Allied General Nuclear Services, Barnwell, S.C. He joined AGNS last November after spending about 18 months with Nuclear Fuel Services as security supervisor. For the previous six years, Larry was with Babcock &

It's off to Vienna for a two-year assignment for Bob and Kitty Curl and their children of Argonne West. Bob served faithfully as INMM's Treasurer the past two years and will be working at the I.A.E.A.

Congressman John J. Duncan (R.-Tennessee), in attendence at the annual meeting, discusses some of the activities with Vice Chairman G. Robert Keepin of LASL.

Wilcox, Naval Nuclear Fuel Division, Lynchburg, Va., as the Division Security Officer. Larry joined INMM in 1974 and the 1977 annual meeting was the first one he was able to attend. He earned a B.A. degree at The Citadel, Charleston, S.C. and taken additional education in law enforcement activities.

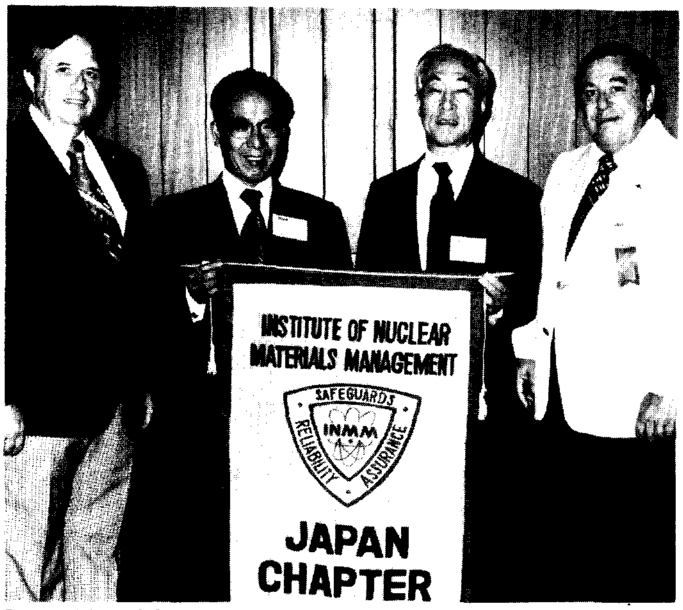
Gozani

Ricci

Rudy Gatti is Product Manager of Nuclear Instruments for Canberra Industries, Meriden, Conn., was an exhibitor at the 1977 meeting. Others from Canberra working with Rudy were Dr. **Larry East** and **Robert Sargis** 1977 marked the fourth year Rudy has attended the annual meeting and his firm has had exhibits at the past three meetings. Gatti is mainly reponsible for the instrumentation for the total fuel cycle market. NIM modules, special computerized systems, and environmental instruments are among the product lines produced and marketed from the Connecticut plant, main office for Canberra. He holds two degrees in electrical engineering: B.E.E., City University of New York, and M.S.E.E., University of Bridgeport, and a M.B.A., also at UB. He completed the course requirements for the Ph.D. in EE at Yale University.

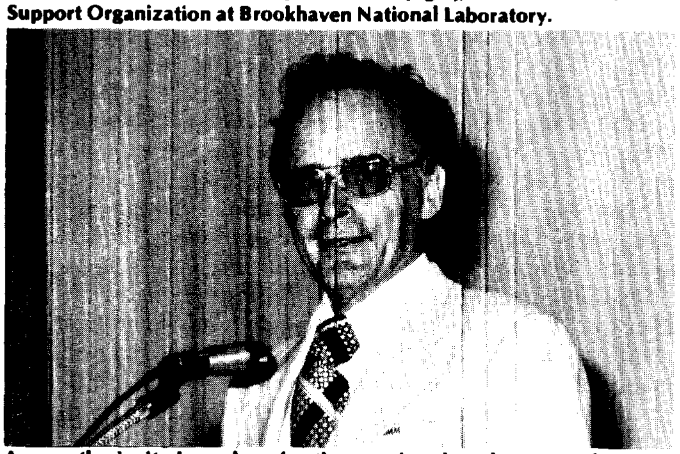
Part of the reason Intex, Inc., Chevy Chase, Md., had an exhibit at the 1977 meeting was to relate directly to people in the industry concerning the use of, application and capabilities of metal detectors, with respect to security requirements for nuclear facilities. According to Dr. **Roy J. Ricci,** "we were interested in showing the most advanced technology as relates to pilferage control and weapons detection. We've made a breakthrough in the past six months. We're quite anxious to show our product's ability to discriminate in the detection of desired objects, such as a weapon, against the background of normally carried metals. I found here that most people concerned with the personnel screening requirements and controlled access very much appreciated the exposure to our new technology." He joined the Institute a year ago.

INMM Annual Meeting Has Record 457 Attendance



Recognition of the first INMM chapter, organized by members in Japan, came at the annual meeting. Chapter representatives were on hand to receive the Official INMM Chapter Banner from Roy Cardwell (left), chairman, and Vince DeVito (right), secretary. Japan chapter officers (from left): Ryohei Kiyose and Yoshio Kawashima.

Obviously enjoying a friendly conversation at the Chairman's Reception were Vic Lowe of ORNL and Jack Cusack (right), head of the Technical Support Organization at Brookhaven National Laboratory.

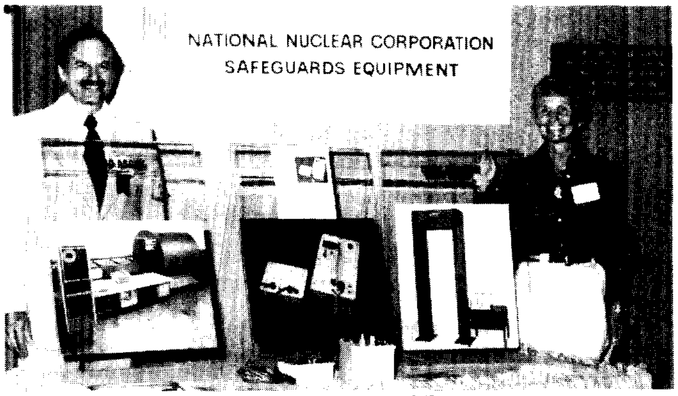


Among the invited speakers for the opening day plenary sessions was Dr. Warren Donnelly of Congressional Research Service, Washington, D.C. Dr. Donnelly has been a special friend to INMM in recent years.

Without a doubt, the excellent work of the Registration Committee played a very important role in the success of the 1977 meeting which had in excees of 450 registrants, largest in INMM history. This fine group of men who served so efficiently was headed by Ed Owings (seated, second from left) of ORNL, new treasurer of INMM.

George F. Boyd, president of Tri-State Motor Transport Co., Joplin, Mo., proudly displays the INMM's 1977 Industry Recognition Award. Tom Bowie (right), INMM awards chairman, presented the award. Roy G. Cardwell, INMM chairman, is at the left.

Following the Thursday noon luncheon, (from left) Roy Cardwell, Ella Werner, and Craig Hosmer posed for this photo. Mr. Hosmer was the luncheon speaker. Miss Werner was a special invited guest at the head table.



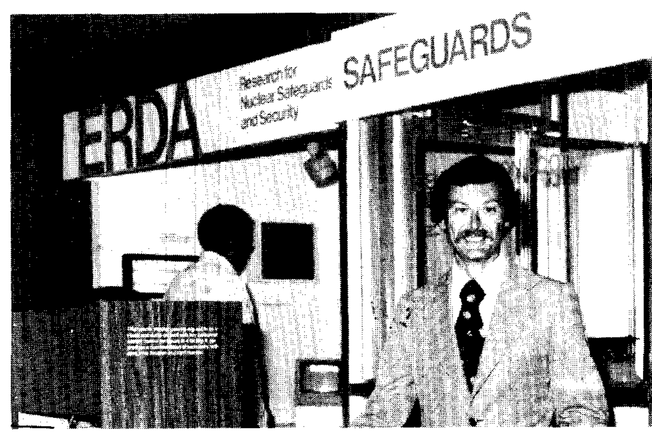
National Nuclear Exhibit
Herman Miller, Exhibits Chairman

Sentry Doorway Monitor

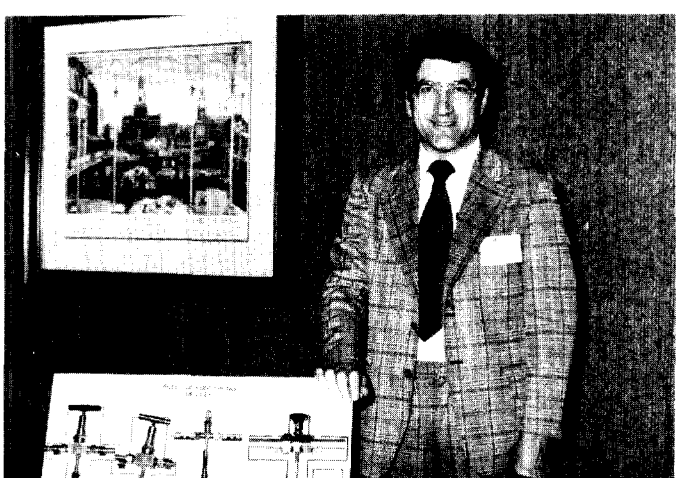
Impossible Electronics

Barnes Engineering

Canberra Industries



U.S. ERDA



Westinghouse

Omni Spectra

Joseph F. Nye

Robert W. Fri

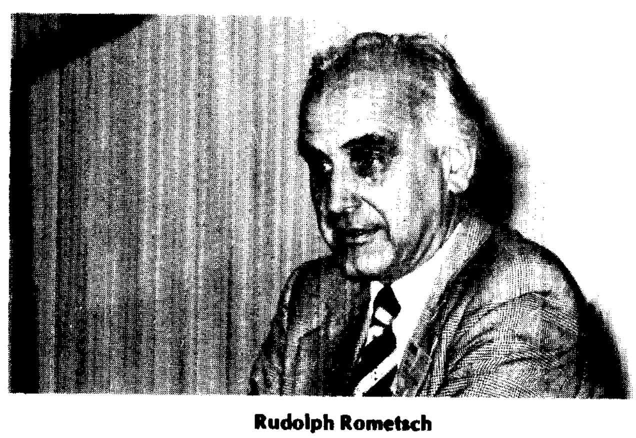
L. J. Colby

Hon. Mike McCormack

Richard T. Kennedy

Harvey E. Lyon

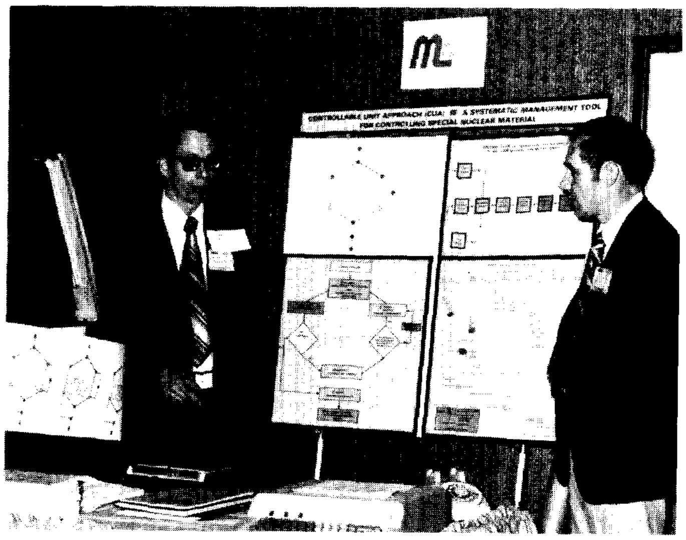
Craig Hosmer



Rudolph Rometsch

Officers and wives (from left) Vincent and Jeanne DeVito, Secretary; Roy and Barbara Cardwell, Chairman; Madge and Bob Keepin, Vice Chairman; and Kitty and Bob Curl, Treasurer. Since the annual meeting, Ed Owings has succeeded Mr. Curl as Treasurer.

Enjoying the Chairman's Reception were (from left) John Ladesich of Southern Cal Edison, his visiting guest, and Jan and Armand Soucy of Yankee Atomic. Mr. Ladesich and Mr. Soucy are members of the INMM Executive Committee. Soucy is immediate past chairman of the Institute.



Mound Laboratory Exhibit

Tom Gerdis and Mr. and Mrs. Ray George

Charles Bean and Jeanne DeVito

Margaret Musselwhite and Patty Clarke

WEAPONS NATIONS CREATING CLIMATE FOR PROLIFERATION

William Epstein, past Chairman of the Disarmament Division of the U.N. Secretariat, gave the third in a series of seminars on nuclear safeguards and proliferation sponsored by the Technical Support Organization at Brookhaven National Laboratory, on May 31st.

In his talk, entitled "Ways of Curbing Nuclear Proliferation," Mr. Epstein, who divides his time between the University of Victoria and the United Nations Institute for Training and Research, and is the author of the recent book, "The Last Chance: Nuclear Proliferation and Arms Control," warned that nuclear weapons are proliferating now at a greater rate than at any time since the discovery of nuclear energy. At the start of the first SALT talks in 1972 the U.S. had enough bombs to wipe out every Russian city with a population of more than 100,000 thirty-six times over, and the U.S.S.R. could do the same to comparable American cities ten or twelve times over. Now, after five years of talks on limiting strategic nuclear weapons, the "overkill" factors are approximately 50 and 20, respectively.

Not only have the SALT agreements allowed the number of weapons to grow, but they have not curbed their qualitative improvement, so that the weapons become increasingly more expensive, sophisticated, and lethal.

As the arms race continues, it increases the danger of war by inadvertence, through misinterpretation of orders or escalation of local conflicts. If present trends continue, a nuclear war by the end of the century seems a certainty.

The danger of "horizontal proliferation"—the spread of nuclear weapons to countries not now having them—is also increasing. At present it is estimated that there are nine countries which could acquire nuclear weapons within one or two years of the decision to do so, eight which could acquire them within five years, and twenty-two which could acquire them within ten years. Most countries choosing to "go" nuclear would probably have only a few bombs. These would confer only a first-strike capability, which could tempt a country into a preemptive attack through fear of the other country attacking first.

Professor Epstein does not consider IAEA safeguards to be the answer. These, he feels, have the same effect as locks on the doors and windows of a house, which mainly deter or inhibit normally honest persons who might otherwise be tempted to steal, but which are ineffective against determined burglars or thieves. Countries can deliberately hamper IAEA inspectors, who have less authority than bank auditors.

If a country decides to go nuclear, under present circumstances it can do so legally simply by withdrawing from the Nuclear Non-Proliferation Treaty. Non-parties to the Treaty are not bound at all by it, and can always test a weapon under the guise of "peaceful nuclear explosions," a technology that for many years was promoted by the U.S. and the U.S.S.R.

Sanctions available to the IAEA for violations of safeguards agreements or the NPT include suspension of membership or the cutting off of aid by the organization, but neither of these is apt to be very significant. The violation can also be reported to the Security Council of the U.N., but China, which in the past has supported the right of any nation to acquire nuclear weapons, would be unlikely to vote for sanctions.

The NPT is basically a bargain between the nuclear and the non-nuclear states. In the initial draft offered by the nuclear states the bargain was very one-sided: the non-nuclear states agreed not to acquire nuclear weapons and the nuclear states agreed not to give them any. At the insistence of the non-nuclear states, however, certain **quid pro quos** were written into the Treaty. Article IV calls for the parties to facilitate the fullest possible exchange of information on the peaceful uses of nuclear energy and for contributions for the further development of the applications of nuclear energy in the non-weapons states, particulary in the developing non-weapons states. Article V calls upon the weapons states to make available to the non-weapons states the benefits of peaceful nuclear explosions at the lowest possible cost, and for the establishment of an appropriate international agency to monitor and supervise such explosions. Article IV urges the weapons states to negotiate towards the curbing of the nuclear arms race, and towards nuclear and general disarmament.

So far, the 102 parties to the Treaty have lived up to their part of the bargain, but the weapons powers have not. The amount of assistance rendered developing countries has been miniscule compared with the cost of a single power reactor, no steps have been taken to set up the international agency to control peaceful nuclear explosions and, far form curbing the nuclear arms race, the weapons states have institutionalized and intensified it.

This failure of the weapons states to carry out their commitments under the NPT may have dire effects on proliferation. Most of the countries that have not joined the NPT are outside the nuclear umbrellas of either the U.S. or the U.S.S.R. and have serious problems of security. They include Pakistan, Israel, South Africa, Taiwan, and Korea. Two of the industrialized countries—Sweden and Switzerland—have traditional positions of neutrality and therefore can depend only on themselves for protection.

The course followed by India is a dangerous omen for the future. Originally she asked for nuclear disarmament, to no avail. Then she asked for guarantees of the security of non-weapons states by the weapons states, but was refused. At that point she began to talk of the benefits of peaceful nuclear explosions, and eventually exploded a device ostensibly for this purpose. In doing so, she broke no agreements or treaties (she is a member of IAEA but not a party to the NPT, and peaceful nuclear explosions are not forbidden to members of the IAEA).

The importance of the Indian explosion is that it demonstrated that even a poor developing country could develop nuclear explosives and might not suffer severe consequences as a result. The U.S. has finally agreed to send new enriched fuel for the Indian power reactors; the U.S.S.R. has, since the explosion, supplied them with 250 tons of heavy water. Only the Canadians, outraged by what they consider Indian deception, have cut off all nuclear assistance. Meanwhile, France and Germany have offered to sell reprocessing plants to non-parties to the NPT.

Epstein characterized the **London Suppliers Club** as "an arrogant little group of nations attempting to dictate to the rest of the world." They should invite user nations—especially potential proliferators—to join in the talks, and drop the secrecy surrounding the negotiations, since in his experience secrecy is often used to conceal lack of progress.

To encourage non-profilferation, a different climate must be created by the weapons states. At the least, they should:

(1) Promise not to use nuclear weapons against non-weapons states (so far the U.S., in particular, has refused).

(2) Stop all further testing of nuclear weapons (the Partial Test Ban Treaty prohibits all but underground tests and limits these to 150 kilotons per blast and 1.5 megatons for a series of tests; since the Treaty came into force the weapons states have tested at a higher annual rate than before).

(3) Freeze the technology of nuclear weapons at the present state of development.

(4) Reduce the number of nuclear weapons drastically; in particular, ban land-based and bomber-based intercontinental missiles altogether, and reduce submarine-based missiles to 10% of their present number.

(5) Negotiate towards general disarmament.

If these things are not done, the non-weapons states will conclude that the nuclear powers are not seriously interested in arms control or disarmament, and will adopt all the arguments that the weapons states now use to justify their retention of nuclear weapons to justify, in turn, the acquiring of such weapons by the present non-weapons states. Summary of talk based on notes taken by E. V. Weinstock.

On INMM Executive Committee

Recognition to Dennis W. Wilson

CRYSTAL CITY, Va.—The Institute of Nuclear Materials Management presented its 1977 Individual Recognition Award to **Dennis W. Wilson,** San Jose, Calif., during the Institute's 18th annual meeting June 29-July 1 at Stouffer's National Center Hotel near Washington, D.C.

Wilson was honored for chairing and coordinating the nationally acclaimed INMM special study evaluating the criteria for governing low-enriched uranium: "Assessment of Domestic Safeguards for Low-Enriched Uranium."

The 1962 graduate of the University of Utah is manager of Nuclear Materials Safeguards Systems for the Nuclear Division of General Electric Co., San Jose.

Chairman of the INMM Safeguards Committee, Wilson is only the second Institute member to receive the organization's recognition award. The 1976 award went to **Louis Doher** of Rockwell International's Rocky Flats Division at Golden, Colo.

INMM is an international organization of nearly 500 members responsible for working in governmental, industrial and academic institutions where nuclear materials are used.

Wilson completed his B.S. degree in Chemical Engineering at Utah. At GE-San Jose, Wilson's duties are to define safeguards systems used throughout GE's Nuclear Division for nuclear materials.

A 1957 graduate of Jordan High School, Salt Lake City, he and his wife JoAnn reside in San Jose. They have three children.

Roy Cardwell and D. W. Wilson

FURTHER UPGRADING OF PROTECTIVE MEASURES FOR NUCLEAR MATERIALS PROPOSED BY NRC

Extensive changes in requirements for protecting strategic quantities of highly enriched uranium and plutonium were proposed today by the Nuclear Regulatory Commission. This action is part of the Commission's plan, announced last January, to conduct a rulemaking proceeding to establish upgraded interim safeguards requirements and to propose longer term upgrading actions.

The new upgrading program would affect companies licensed to fabricate nuclear fuel and conduct scrap recovery operations, and organizations which transport the materials. The proposed requirements would not apply to nuclear power plants. Regulations significantly upgrading physical security at these plants were adopted by the Commission earlier this year.

The proposals would further strengthen NRC requirements in effect since late 1973 for fuel cycle facilities and transportation activities, and supplemented over the last year by conditions added to individual NRC licenses.

In a related action today, the NRC also proposed new criteria for the training, qualification and equipping of security personnel.

Earlier this year, the Commission proposed requirements to provide for background checks and NRC clearances for licensee personnel having access to or control over special nuclear material, and the development of licensee contingency plans outlining specific actions for handling an attempted theft or sabotage.

The changes proposed today are part of an over-all effort to upgrade protection on a systematic basis. Last January, in denying a petition of the National Resources Defense Council seeking safeguards improvements on an emergency basis, the Commission said staff studies indicated a need for "a systematic and integrated increase in safeguards protection implemented on an expedited, but not emergency basis. Such an orderly enhancement of safeguards effectiveness has indeed been in progress since March (1976). . . ."

Changes being proposed today include general performance requirements to protect against the following:

(1) a determined violent external assault, by stealth, or deceptive actions by a small group which is well trained (including military training and skills) and dedicated; these persons could have the assistance of a knowledgeable insider and be armed with automatic weapons equipped with silencers; they also could have incapacitating agents and explosives to gain entry or otherwise destroy plant or transport integrity and to operate as two or more teams;

(2) acts of theft or sabotage by an insider, including an employee; and

(3) a conspiracy of insiders or employees in any position.

Also included are basic performance capabilities that reflect the inherent differences in protecting nuclear materials at fixed facilities and during transportation.

Performance capabilities for facilities are proposed to assure that only authorized personnel, materials and vehicles are admitted to areas housing strategic nuclear materials and to other areas designated as protected or vital areas; to provide controls on movement or placement of nuclear materials; and to assure that any breach or attempted breach of security is detected and a response is made.

More detailed measures for various aspects of security plans, such as the security organization, communications and alarm systems, barriers, detection systems, access controls and response plans also are included in the proposed regulations.

Proposed new requirements for protecting strategic quantities of highly enriched uranium and plutonium in transit involve the number of armed escorts, frequency of communications, types of vehicles and containers, route information and reporting of shipments.

Basic safeguards performance capabilities would be required for transportation activities to assure that the physical security system is capable of restricting access and activity in the vicinity of a shipment and of preventing unauthorized access to or removal of nuclear material from the carrier.

New testing and maintenance programs also are proposed to assure the continuing operation and effectiveness of security systems for fixed sites and transportation.

Based on preliminary NRC staff estimates, the initial cost to the nuclear industry for the proposed upgrading could be about $2.8 million, with annual total costs in the order of $6.8 million.

There are 11 nuclear fuel cycle facilities subject to NRC physical security requirements. They are located in California, Connecticut, Massachusetts, Pennsylvania, Rhode Island, Tennessee, Virginia and Washington. Three firms have approved security plans to transport highly enriched uranium and plutonium which would have to be changed to meet the proposed physical security requirements.

The proposed amendments, to Part 73 of NRC regulations, appear in the July 5 Federal Register. Persons wishing to comment should submit their comments to the Secretaty of the Commission, Nuclear Regulatory Commission, Washington, D.C. 20555, Attention:

Docketing and Service Section within 45 days of publication in the Federal Register.

PROPOSED UPGRADING OF PHYSICAL PROTECTION OF NUCLEAR MATERIALS AND FACILITIES

In early 1976, the NRC staff began a series of assessments of the adequacy of existing safeguards to protect nuclear fuel cycle facilities from attempts to steal highly enriched uranium and plutonium. These assessments led to a general upgrading of physical protection requirements in effect since 1973 by application of conditions to individual NRC licenses. Among the changes were additional guards, improved communications, improved alarm systems, better search and surveillance procedures, formalized procedures for support from local law enforcement agencies, and strengthened controls over access to nuclear materials.

Also last year, a joint Nuclear Regulatory Commission-Energy Research and Development Administration task force was organized to develop a plan for improving controls over, and protection of, strategic quantities of special nuclear materials. The task force report was released publicly last February. The proposed changes now being made in safeguards regulations are based, in part, on these efforts.

Proposed rules already have been published that would (1) require licensees to develop contingency plans for responding to attempted sabotage of a nuclear facility or theft of nuclear materials; (2) upgrade training and qualifications of security personnel in the nuclear industry; and (3) require background checks and NRC clearances for certain nuclear industry workers.

The amendments now being proposed describe basic performance capabilities for fuel cycle facilities (not power plants) and transportation activities. Basic differences inherent in protecting material at facilities and in transportation are defined. Also included are more precise measures for systems within a physical security plan. Common to both fixed sites and transportation are the following systems: authorization controls, access and removal controls, barriers, detection systems, security organization, response plans, communications, and test and maintenance procedures to assure continuing effectiveness of the safeguards program.

The proposed rule is performance oriented to provide licensees with flexibility in meeting its provisions. Licensees would have the option of employing safeguards measures different from those in the rule, provided the proposed substitute measures meet the basic performance requirements.

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* Strategic quantities of special nuclear materials are defined as (a) two kilograms of plutonium or U-233 or (b) five kilograms of uranium enriched to more than 20% in the U-235 isotope or (c) a combination of these materials. These quantities are established at a level substantially below that required for the manufacture of nuclear explosives.

Physical Protection in Transit

The proposed regulations describe the systems and subsystems required in physical security plans to meet the following performance capabilities during transportation:

(1) restrict access to, and activity in, the vicinity of transports;

(2) prevent unauthorized attempts to gain entry or introduce materials into, and the unauthorized removal of, strategic special nuclear materials from transports; and,

(3) provide a response capability.

The major elements of security plans are detailed. They cover planning and scheduling of shipments; the structure of the security organization, including guard training, qualifications and equipment; procedures for responding to emergency situations; actions required in transferring or storing shipments and for shipping the materials by various modes—road, rail, air and sea; procedures and controls for access to vehicles and materials; and test and maintenance programs to assure that elements of the plans are properly functioning.

Shipments by road either would be in specially designed, penetration-resistant vehicles capable of being immobilized in an emergency, or in armored cars. In both cases, there would be nine armed escorts accompanying the shipment. If an armored car is used, three bullet-resisting escort vehicles would accompany the shipment. Two escort vehicles would be required for shipments in the specially designed trucks. All shipments would be over primary highways, not secondary roads, without intermediate stops except for refueling, rest or emergencies or to transfer the shipment. Cargo and escort vehicles would maintain continuous two-way communications and have continuous communications capability with a control center. There would be a back-up communications system. Calls to the licensee's control center would be required at least every half hour. During any stops the nine guards would be available immediately and the shipment would be under continuous surveillance.

Shipments by air, including imports and exports, would be accompanied by three armed guards. At least nine armed escorts would be available at any scheduled refueling stops in the United States. Two escorts would keep the shipment under surveillance at all times. On overseas shipments, the escorts would be capable of conversing in a common language with the captain of the aircraft.

Shipments by rail would be escorted by nine armed escorts in the shipment car or an escort car next to it. At least two escorts would keep the shipment car under continuous surveillance. Continuous communications between the shipment and control center would be maintained and there would be a back-up communications system. Every half-hour the control center would be contacted on the status and position of the shipment.

Shipments by sea would be on container ships only. Containers with nuclear materials would be used exclusively for that purpose. All shipments would be escorted by three armed guards. They would be capable of conversing with the ship's captain in a common language. Ship-to-shore communications would be available and a contact would be made every six hours between the ship and an on-shore contact.

Physical Protection at Fixed Sites

The following are performance capabilities that physical security programs at fuel cycle facilities would be required to meet:

(1) admit only authorized personnel and materials into material access areas and vital areas;

(2) permit only authorized activities and conditions within protected areas, material access areas, and vital areas;

(3) permit only authorized placement and movement of strategic special nuclear material within the material access area;

(4) permit removal of only authorized and confirmed forms and amounts of strategic special nuclear material from material access areas; and

(5) detect and respond to unauthorized penetrations of the protected area to prevent theft of stragetic special nuclear material.

As with the proposed requirements for physical protection in transit, the major elements of security planning for fixed sites are detailed.

Vital and material access areas would be located so that access requires passage through at least two physical barriers. Isolation zones, with illumination, would be adjacent to the barrier at the perimeter of a protected area and be large enough to permit observation of activities on either side of that barrier.

A numbered picture badge identification system would be used and badges would be coded to indicate whether an individual has access to vital or material access areas. All points of personnel and vehicle access to protected, vital and material access areas would be controlled and all individuals and vehicles passing into protected areas would be searched.

Alarm systems would immediately detect penetration or attempted penetration into a protected area, or the isolation zone. Emergency exits would be alarmed. Unoccupied vital and material access areas would be locked and protected by alarms that would detect entry, exit or any movement of anyone in those areas. Duress alarms would be provided at all manned access control points in the protected areas, at security patrol and guard stations, and in alarm stations. There would be two continuously manned alarm stations designed so that a single act could not remove the capabilities of both stations. All alarms would be operable from independent power sources in the event normal power was lost. Alarm devices would have tamper-indicating and self-checking systems.

Security personnel would be required to have the capability of maintaining continuous communications with both alarm stations. The alarm stations would have both conventional telephone and radio or microwave systems to communicate with off-site law enforcement officials. These systems would have an independent power source to back-up normal power.

Tests and inspections would be conducted during design, installation, and operation of the alarm and communications systems, physical barriers and other security-related devices and equipment. The systems would be subject to a maintenance program to assure continued operation and effectiveness.

COMPANIES HAVING NUCLEAR REGULATORY COMMISSION LICENSES THAT POSSESS STRATEGIC QUANTITIES OF SPECIAL NUCLEAR MATERIAL

Companies	Operations
1. Atomics International	Canoga Park, CA
2. Babcock and Wilcox	Apollo, PA
(Nuclear Materials Division	Parks Township, PA
Babcock and Wilcox	Lynchburg, VA
(Naval Nuclear Fuel Division)	
3. Exxon Nuclear Company	Richland, WA
4. General Atomic Company	San Diego, CA
5. General Electric Company	Vallecitos, CA
6. Nuclear Fuel Services	Erwin, TN
7. Texas Instruments	Attleboro, MA
8. United Nuclear Corporation	Uncasville, CT
(Naval products Division)	
United Nuclear Corporation	Wood River Junction, RI
(Fuel Recovery Operation)	
9. Westinghouse	Cheswick, PA

COMPANIES HOLDING NRC—APPROVED TRANSPORTATION PLANS FOR SHIPMENTS OF STRATEGIC QUANTITIES OF SPECIAL NUCLEAR MATERIAL

1. Tri-State Motor Transit, Joplin, Mo
2. Transnuclear, Inc., White Plains, NY
3. Edlow International Company, Washington, DC

NRC Proposes Requirements To Upgrade Security Personnel

The quality and performance ot security personnel at commercial nuclear facilities and in the transportation of highly enriched uranium and plutonium would be significantly upgraded under regulations proposed by the Nuclear Regulatory Commission.

If adopted, the regulations would require security personnel to meet minimum criteria for fitness, training, qualification and annual requalification. These general criteria are being published for public comment as part of the proposed regulations.

The general criteria describe physical and mental requirements for employment; the types and scope of training, including requirements in the use of semiautomatic handguns and rifles and shotguns; and the types of equipment to be available to security personnel at the facilities and escorting shipments.

In addition to meeting minimum physical and mental requirements, security personnel would be required to undergo a physical fitness test every 12 months. They also would be required to requalify with weapons and undergo at least five days of advance training every 12 months.

Basic and advance training courses, and weapons training and qualification, would involve up to 172 hours of instruction and testing. Courses in basic and advance training would cover such subjects as introduction to law, adversary threat, fixed site and transportation security, use of security equipment, escort and patrol techniques, response force operations, alarm station operations and security force skills. Tactical exercises also would be included.

A proposed 60-hour course on use of weapons would require each individual to demonstrate ability with certain weapons under specified conditions, including at night.

The NRC staff estimates that the initial cost of the guard force upgrading would be about $2.5 million, with annual costs approaching $1 million. Already proposed are regulations that would require security personnel and others in the nuclear industry to undergo background checks and obtain clearances from the NRC.

The amendments now being proposed, and those which would require clearances, are based in part on a joint Nuclear Regulatory Commission—Energy Research and Development Administration task force report on actions for improving the controls and protection of nuclear materials at NRC-licensed fuel cycle facilities. Actions recommended by the task force included upgrading of guards. An unclassified version of the report was published earlier this year.

In a report last year to Congress on the need for and feasibility of a federal guard force for commercial nuclear facilities, the NRC had concluded that private guards "properly qualified, trained and certified" by the NRC can provide a level of effectiveness comparable to federal guards.

The proposed amendments, including the general criteria for security personnel, are to part 73 of NRC regulations. They are published in the July 5, 1977 Federal Register. Persons wishing to comment should do so by writing the Secretary of the Commission, Nuclear Regulatory Commission, Washington, D.C. 20555 within 45 days of publication in the Federal Register.

LOS ALAMOS NATIONAL ENVIRONMENTAL RESEARCH PARK (NERP)

LOS ALAMOS, N.M.—The Los Alamos (N.M.) National Environmental Research Park (NERP), a 27,500-acre outdoor laboratory, was dedicated on August 16 in ceremonies, to which the public was invited, at the Occupational Health Laboratory at the Los Alamos Scientific Laboratory (LASL).

Dr. **Harold Agnew**, LASL Director, led the program and list of speakers, including U.S. Senator **Pete Domenici** (R-N.M.) and Dr. **Jeff Swinebroad**, Manager for Environmental Programs, of the U.S. Energy Research and Development Administration's (ERDA) Division of Biomedical and Environmental Research. State officials from the Rocky Mountain region, university administrators and faculty, representatives of regional institutions and industries, and employees of the ERDA and LASL also participated.

Persons attending the ceremony visited environmental science displays and demonstrations, and were encouraged to drive through portions of the NERP lands, which encompass the entire ERDA reservation in Los Alamos.

Salzburg Report: SAFEGUARDS

By **G. Robert Keepin**
Los Alamos Scientific Laboratory

All previous indications had pointed toward the IAEA Salzburg conference being an especially timely and important international meeting on the urgent topic of nuclear energy and its fuel cycle—and certainly from the standpoint of safeguards, Salzburg did indeed live up to all expectations. On opening day, the pivotal issues of nonproliferation and safeguards were clearly the driving force behind the highly controversial new U.S. nuclear energy policy that had been elaborated for heads of foreign delegations by **Joseph Nye** of State and **Robert Fri** of ERDA. There was initially considerable confusion, open criticism, and generally negative reaction to the U.S. policy of deferring commercial reprocessing and plutonium recycle in the United States and calling on other nations to do the same in return for assured fuel supplies, to be secured through future cooperative arrangements between seller and buyer nations. Many delegates from various nations expressed the opinion that deferral or denial of reprocessing had little bearing on the problem of nuclear weapons proliferation inasmuch as reprocessing technology is readily available to any country determined to acquire it, and that in any case commercial reprocessing facilities are by no means the most economical or practical vehicles for obtaining weapons-usable fissile materials.

During the course of the conference something of a consensus seemed to emerge on the need for a strong international and cooperative approach to the problem of assured fuel supply and fuel cycle services—all under effective international (IAEA) safeguards. This in turn seemed to engender growing support for the general concept of an International Fuel Cycle Evaluation Program, which was proposed, as a part of the U.S. policy package, to be open to all interested countries. Thus, after considerable initial skepticism, there seemed to be growing interest on the part of many delegates at Salzburg in the Carter proposal of a multinational effort to examine a number of urgent problems associated with current functioning (or malfunctioning) of the fuel cycle, such as reliable international fuel supply, storage and ultimate disposition of spent fuel, evaluation of alternative fuel cycles, including future-generation reactors (e.g., advanced reactors and breeder/converter options), and institutional as well as technical arrangements for reducing proliferation risks.

General support for multinational and/or regional nuclear fuel centers and the internationalization of reprocessing and spent-fuel storage under effective IAEA safeguards was expressed by delegates from many nations, including both Western and Communist countries. The idea of regional enrichment and reprocessing plants being established under IAEA auspices or even outright "ownership" was also discussed by some delegates. In any case, it seemed clear that the Salzburg conference carried the international theme rather consistently throughout all safeguards and related fuel cycle sessions.

The mutual benefits of close coordination between IAEA safeguards and effective national safeguards systems—which are an essential component of effective international safeguards—were stressed in an Agency position paper presented by IAEA's **R. Rometsch.** The unique seven-nation Euratom safeguards system and its relationship to IAEA under NPT as a regional system of control was presented by Euratom officials as an unprecedented example of the practical application of supranational safeguards.

In the same general vein, the necessity for an international approach to safeguards and its importance to the worldwide expansion of nuclear trade was elaborated by **R. Imai** of Japan, who also pointed out that the mounting demands of high-technology safeguards R & D (in terms of both financial and human resources) will of necessity require closer cooperation and in creased international technical exchange on advanced safeguards technology and control systems in the future.

The cooperation between ERDA and the NRC in the development and independent assessment of safeguards in the United States was stressed in a review paper by **R. T. Kennedy** of the NRC and **H. E. Lyon** of ERDA. Both the U.S. paper and a similar review by **I. D. Morokhov** of the USSR emphasized the importance of international safeguards for achieving nuclear nonproliferation goals.

The IAEA reported studies now under way on regional fuel cycle centers, noting that under the provisions of the Agency's statute, Article XII, A.5, there is provision for the deposit of special nuclear material with the IAEA. This, it was suggested, might offer an effective means of preventing the accumulation of large national plutonium stocks, and thereby conceivably contribute to the prevention, rather than just the deterrence, of proliferation. Any proposed procedure for implementation of such a scheme would clearly require extensive consultation between governments and eventually formal approval by the IAEA board of governors.

It may be noted here that in the United States there now appears to be increasing congressional and Administration interest in this approach to the allocation and distribution of guaranteed fuel supplies for recipient countries. In recent testimony before the Senate Foreign Relations Committee, **Joseph Nye** listed "international arrangements, such as an international fuel bank," as part of the U.S. approach to a fuel assurance program.

Continuous feedback and technical collaboration between the facilities being safeguarded and the safeguards community—both the inspectorate and the developers of new technology—is vital to meet the growing demands for increasingly stringent and timely safeguards. The highly interactive roles between safeguarders and the "safeguarded" was developed by **A. Anderson** of the United Kingdom, who also highlighted areas of technical collaboration where special emphasis should be placed in the future (e.g., technology development, inspector training, systems demonstration, and evaluation of overall safeguards system effectiveness).

An entire session at Salzburg was devoted to the rapidly expanding area of safeguards technology, including the development and application of safeguards techniques as well as their in-plant implementation and performance evaluation in various types of fuel cycle facilities. Indicative of the widespread interest and effort in safeguards R&D, advances in instrumentation development and experience with safeguards measurement systems were reported from Italy, Japan, USSR, Euratom, Federal Republic of Germany, France, Czechoslovakia, Canada, the IAEA, and the United States. The wide-ranging types of nondestructive assay (NDA) instruments and techniques discussed included passive and active neutron assay methods for various plutonium materials, high-resolution gamma ray spectroscopy for bulk feed and product as well as scrap and waste assay, and various gamma ray correlation instruments for spent-fuel burnup and Pu/U fissile material ratio determination.

In general, state-of-the-art NDA methods now seem capable of providing assay accuracies in the range of a few percent for many typical process materials. For well-characterized material, such as quality-controlled feed and product, the accuracy of NDA may approach 1 percent or even 0.5 percent, depending on the composition and homogeneity of the sample, signal attenuation effects, interfering gamma or neutron "signatures," etc. In the case of poorly characterized materials, such as heterogeneous solid wastes, the accuracy of measurement may be 20 percent, 30 percent, or even larger, depending on the composition, form, and container geometry of the nuclear material to be measured—but in many cases NDA provides far better accuracy than meaningless chemical analysis of a nonrepresentative sample.

It is both noteworthy and significant that the importance of direct physical *measurement* as the basis of any effective system of accountability and control of nuclear material was noted by every speaker in the safeguards technical session at the conference.

In addition to NDA measurement instrumentation, considerable attention was given to recent advances in physical protection technology, including surveillance, seals and containment systems, personnel identification techniques, item-counting instruments, portal monitors, radiation detection equipment, reactor power monitors, secure data links, and transport systems. The importance of redundancy in safeguards, security, and surveillance systems was stressed in a joint IAEA-AECL paper on safeguarding CANDU-type on-line-refueling reactors.

It was clearly evident at Salzburg (as at other recent international safeguards meetings) that the main thrust of in-plant safeguards technology today is toward automated material measurement and control systems incorporating "on-line," nondestructive assay instruments and interactive automated data-processing equipment to provide detailed, accurate in-plant materials accountability and inventory data on essentially a "real-time" basis. Such systems were described at Salzburg by safeguards experts from Japan, Germany, the United States, and Euratom.

The over-all capability for automated material measurement, process control, criticality safety, accountability and safeguards clearly affords the plant operator important operational advantages, and this is sometimes viewed with concern by safeguards authorities, who feel this additional knowledge and operational control in the hands of the plant operator could place the safeguards inspector at a relative disadvantage. It was noted in this connection that the safeguards inspector would be provided with the same complete real-time knowledge of material disposition and control throughout the plant. Moreover, techniques and procedures are being developed to enable the inspector to carry out necessary independent calibration and verification functions on various assay instruments, material flows, process operations, etc. Also in the large, remotely controlled and automated fuel cycle facilities envisaged for the future, there would be minimal access to in-process material (e.g. plutonium) by anyone, including plant operators, and this strict containment feature is expected to provide a very important added measure of protection against theft or diversion of SNM. Furthermore, full-time resident inspection is anticipated in the large-scale regional fuel cycle plants envisaged for the future, thus permitting the inspector to gain maximum understanding and familiarity with plant operations.

In response to questions put by delegates from various countries on the future availability of advanced material control systems technology and in-plant experience—specifically, the U.S. DYMAC (DYnamic MAterials Control) system being developed and demonstrated at ERDA's Los Alamos Scientific Laboratory—it was indicated that the nondestructive assay instruments, interactive computer system technology, and experience gained with real-time material accountancy would be made available to the IAEA and member states who share U.S. nonproliferation objectives as a part of the over-all U.S. program of technical support for strengthening international safeguards.

In a round table discussion of the effectiveness of safeguards, IAEA's R. Rometsch defined international

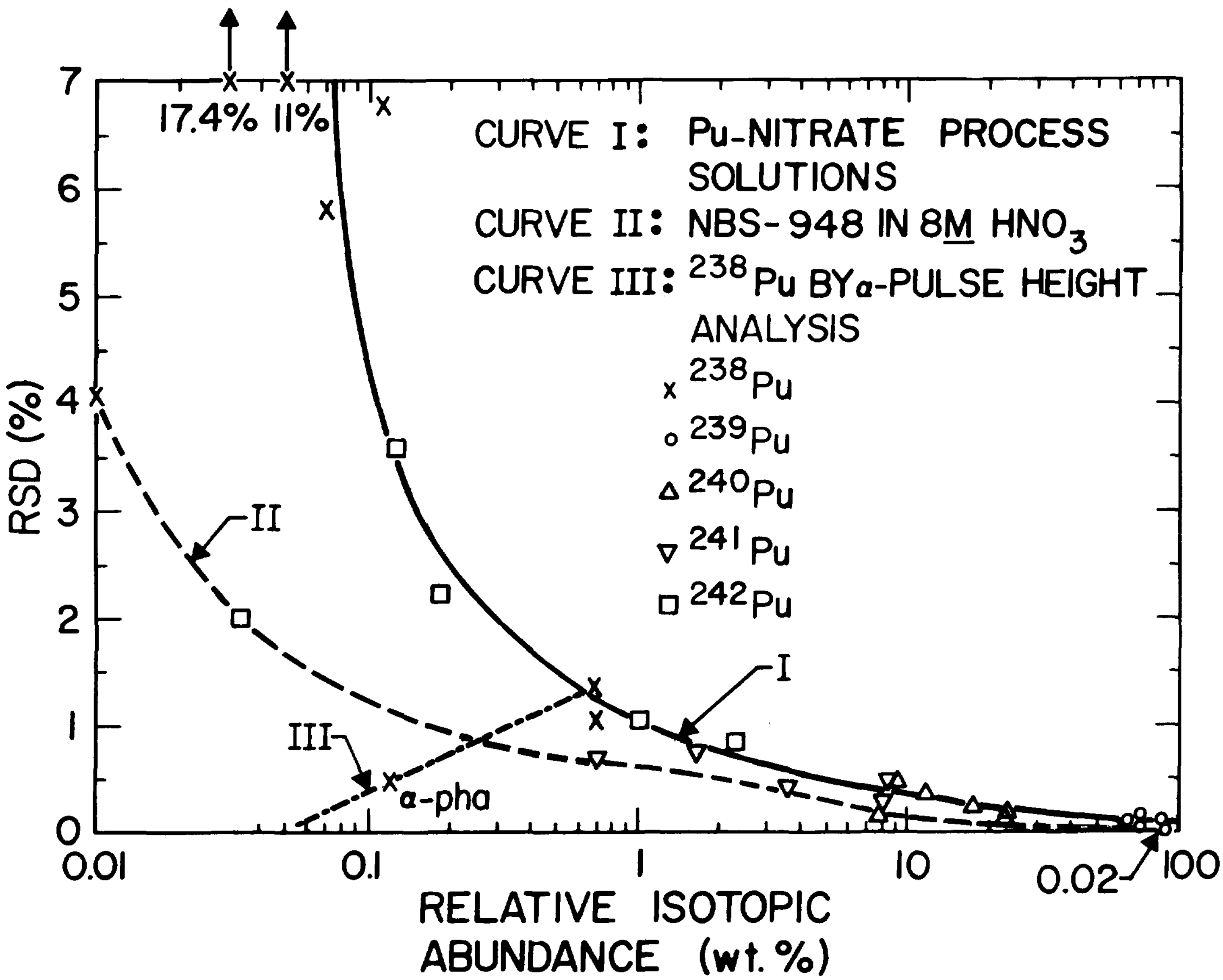

Fig. 1. Precision of plutonium isotopic measurement.

(IAEA) safeguards, stressing that the Agency's safeguards system is based on the individual state (national) systems of accountancy and materials control, and that the IAEA, under the terms of its safeguards mandate, must independently verify the effectiveness of each member state's safeguards system. It was pointed out that with new, large-scale fuel cycle facilities of the future, incorporating sophisticated real-time systems of materials accountancy and control, such as the U.S. DYMAC system or similar systems to be implemented in other countries, it will be essential that the IAEA acquire commensurately increased sophistication and technical capabilities in its own inspection and verification functions. Clearly, much depends on a truly effective IAEA safeguards inspectorate and worldwide inspection/verification system.

The practical goal in modern safeguards measurement and control technology was indicated as material control on a "near real time" basis at a level of the order of 1 percent or better, based on closing material balances around individual batches or "unit processes" rather than total plant throughput. Meaningful evaluation of safeguards effectiveness in various types of fuel cycle facilities must be based on plant-specific data, including detailed infromation on plant material compositions, process flows, etc., for a specific reference plant design. The older, very general safeguards systems designs for "generic" facilities are no longer useful for today's sophisticated diversion detection algorithms and plant simulation models that can generate detailed quantitative assessments of MBA-specific detection and false alarm probabilities as well as other incisive safeguards system effectiveness parameters.

In addition to the safeguarding of plutonium recovered from spent fuel at the "back end" of the fuel cycle, it was emphasized at Salzburg that it is similarly important to implement effective safeguards at the "front end" of the fuel cycle—specifically in present and future enrichment facilities of various (and "proliferating") types that could be used to separate not only U-235 but also U-233 (for example, from the proposed "denatured" fuel comprised of U-233 mixed with U-238). Several delegates, among them **Bertrand**

Goldschmidt of France, felt that the front end of the fuel cycle is "more dangerous" than the back end, and that development of advanced enrichment processes—such as centrifuge, laser isotope separation, and other new isotope separation technologies—may in the future constitute a greater contribution to nuclear proliferation than reprocessing.

Andre Giraud of France announced at the conference a new uranium enrichment process based on chemical exchange, which "practically forbids the production of weapon-grade enriched uranium." While no technical details of the process were revealed, Giraud expressed French interest in discussing with other governments the conditions under which the new enrichment process could be further developed and demonstrated on an international basis.

At Salzburg there seemed to be a general concensus among safeguards experts from around the world that a cooperative international approach must be taken toward the further development and implementation of effective safeguards throughout the *complete* fuel cycle including enrichment, fuel fabrication, reactors, and spent-fuel disposition (whether fuel storage or future reprocessing in internationally safeguarded regional or multinational facilities). In general, this can be viewed as in keeping with the spirit and thrust of the U.S. proposal for an international fuel cycle evaluation program aimed at assessment of various fuel cycle alternatives, with particular emphasis given to nonproliferation considerations throughout the full range of *complete* fuel cycles to be evaluated—i.e., front end, back end, and everything in between.

In contrast to the somewhat confused and divisive atmosphere that seemed to prevail at the beginning of the Salzburg conference, there appeared during the course of the conference and subsequently to be an emerging spirit of cautious optimism that the proposed international fuel cycle evaluation effort can provide both a vehicle, and something of an international rallying point, for all who seek a common positive and constructive approach to strengthening the prospects for worldwide nuclear power while decreasing the growing risk of nuclear proliferation.

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Roy Cardwell and George F. Boyd

INMM Industry Award To Tri-State

CRYSTAL CITY, Va.—The Institute of Nuclear Materials Management, at its 18th annual meeting at Stouffer's National Center Hotel near Washington, D.C., presented its 1977 Industry Recognition Award to Tri-State Motor Transit Co., Joplin, Mo.

Tri-State was honored "as one of the major contributors to the growth of the nuclear industry. Their expertise in nuclear material transportation is acclaimed by government and industry,"noted **Thomas B. Bowie,** West Hartford, Conn., in announcing the award.

Bowie cited Tri-State as a "major contributor to individual and combined government/industry committees, conferences, seminars, assignments, instrumental in the developing of guidelines and regulations which have resulted in this country's outstanding nuclear material transportation record."

George F. Boyd, chairman-president of Tri-State, accepted the award on behalf of the Joplin Firm.

New NUSAC Senior Technical Associate

Elting

Dr. **Ralph F. Lumb,** President of NUSAC, Inc., McLean, Va. announced on August 8 the appointment of **Philip E. Elting** as Senior Technical Associate in the company's Security Programs Division. Elting's responsibilities will include the design of electrical and electronic systems concepts.

Elting comes to NUSAC from Duke Power Company where his experience included responsibility for systems interface design for the power plant monitoring computer, the nuclear security system, CCTV and other monitoring systems. He later became Supervisor of the Security Systems Design Group with design responsibility for Oconee Station. Subsequently, Elting was placed in charge of developing security philosophy and for coordinating and managing security operations for all the company's power generating stations.

NUSAC's Security Programs Division provides a wide range of industrial security planning and support to the nuclear power generation industry to assure compliance with current and anticipated regulatory requirements. NUSAC also provides program assistance in such areas as special nuclear materials safeguards, and quality assurance audits of fuel materials and hardware.

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

Summary of Safeguards in the U.K.

By A. S. Adamson
U. K. Atomic Energy Authority

Operators in the United Kingdom seldom undertake any Research and Development whose sole purpose is the improvement of safeguards*, despite which the Nuclear Materials Accounting Control Team of the UKAEA compile an annual report listing effort which is deemed to be relevant to safeguards. Since safeguards benefits are not specified in the aims of the programs it follows that the attribution," relevant to safeguards" is open to interpretation and also that the items selected have to be identified in the programs of work of a number of organizations who have undertaken the programs for commercial or managerial reasons.

In the sections which follow are items which have been extracted from the annual progress report for 1976. The information is presented in outline only but those who have received personal copies of the report have found this consolidated listing useful and it has been decided to present it, with a minimum of editing to the readership of the INMM Journal.

ASSAY TECHNIQUES

(i) Destructive

1. X-ray fluorescence has been applied to the determination of uranium in ore concentrates and the determination of Pu/U ratios in fuel fabrication feed solutions. The application to ore concentrates is now used routinely while the feasibility of the Pu/U ratio determination has been confirmed and evaluation will continue.

2. A method to determine uranium in effluents by solution fluorimetry, has been put into routine use and can be applied to samples ranging from 0.01-100ug/ml.

3. Development has continued on the determination of plutonium and uranium using controlled potential coulometry. A technique, using a platinum or gold working electrode, has been tested for the determination of Pu/U ratios and work has started on an improvement to the coulometric determination of uranium, based on the oxidation of U^{IV} to U^{VI}. Results are promising and further investigation is planned.

4. An automatic controlled potential coulometer has been supplied to the IAEA and ancillary equipment is being provided to IAEA specification.

5. The argentic oxidation and subsequent reduction method for the determination of plutonium is being improved to overcome interference from certain fission products and to allow easier application to reprocessing plant input solutions.

(ii) Non-destructive

(a) Passive Radiometric Measurement Methods

Gamma Spectrometry

6. There has been an increased application of NaI measurements to the determination of enrichment of low enriched uranium in drums of powder and in fuel elements. On drums of UO_2 the coefficient of variation is limited by the counting time (50 sec) and varies from approximately 7% on depleted uranium to approximately 2% on 3% enriched uranium. The accuracy achieved is approximately ± 2%.

7. Rogue pellet detectors have been developed to scan fuel pins containing oxide pellets. A GeLi detector is used for pins containing mixed Pu, UO_2. NaI detectors are used to examine complete pins of low enriched UO_2 but the process is too slow to be used to detect single rogue pellets (but see para. 16).

8. An efficient and rapid technique to measure the plutonium in drums of soft waste has been developed. This entails the use of two NaI detectors placed near the top and bottom of the drum. An absorber whose thickness varies with vertical position is placed between the detectors and the drum. The varying absorber thickness smooths the relationship between the height of the plutonium source in the drum and the observed count rate while rotating the drum smooths the effect of differences in radial position.

9. Segmented gamma scanners with transmission correction have been developed for the assay of plutonium in waste when the matrix can not confidently be defined as soft. For areas where the plutonium has no possibility of fission products contamination and has a well known isotopic composition, NaI detectors will be used. Where these criteria do not apply a high resolution detector system will be used. Both systems have been manufactured and prototypes are in operation. It is

* It should be noted that in the United Kingdom, safeguards does not include physical security. This paper consequently does not contain any references to this topic.

hoped to extend the capability of the high resolution system to measure U-235 and Pu-241.

10. There are plans to measure the ratios of various fission products as a check on the duration of cooling time of irradiated oxide fuel. The experimental rig has been built but measurements will not be made until late 1977.

11. Some work on the determination of isotopic composition of plutonium by high resolution gamma spectrometry has been performed. Promising results have been obtained on small samples when the fission product activity is less than 1 mCi/g Pu. This work has recently been reported in AERE-R8737.

Combined γ and neutron methods.

12. Combined γ and neutron methods have been tested to measure plutonium in heavy, low *B*γ, waste material, including scrap equipment. The purpose of the measurements is principally to enable adherence to safety regulations and calibration is carried out against plutonium metal of low Pu-240 content.

Neutron Methods

13. Evaluation of the Birkoff (VDC) and Bohnel (shift register) circuits has continued. A report (AERE-R8303) is now being written and will be issued shortly. In general, the conclusion is that the Birkoff system has better precision at low count rates and that the Bohnel system has a larger dynamic range and better precision at high count rates.

14. Various systems have been considered to analyze pulse-time correlation and equipment has been built and tested. Recent proposals have widened the scope of this work and no decisions have been taken on the preferred system.

15. Equipment has been constructed and measurements made to determine UF_6 in large pieces of plant equipment. The technique depends on the detection of neutrons from α,n reactions and was carried out in collaboration with the IAEA. This has recently been reported in AERE-R8652.

(b) Active Radiometric Techniques

16. A rogue pellet detector based on irradiation from a Cf-252 source followed by measurement of gammas using a NaI detector, has been constructed for the examination of low enriched UO_2 pellets in fuel elements. Preliminary trials have been completed and evaluation will continue.

17. Neutron transmission and interrogation measurements combined with high resolution gamma spectroscopy, have been made on unirradiated fuel bundles in order to determine the fissile content of inner pins. Results so far are satisfactory and it is hoped to continue this work.

18. The development of a neutron transmission technique to measure the U-235 content of U/A1 hollow cylindrical tubes (inserts) has been completed. The equipment is now installed and calibration by reference to destructive analysis is in progress. The technique is expected to be applied as the routine analytical method in the near future.

(c) Non-radiometric techniques

19. An ultrasonic method has been developed for the on-line measurement of heavy metal concentration in solvent in reprocessing plants. Further developments, e.g. to measure the concentration in solvent and aqueous phases of a mixer settler box, are in progress.

20. A flow through ion-selective electrode has been developed for the determination of uranium in plant solutions. This is less affected by the simultaneous presence of phosphate and fluoride than were previous electrodes.

(d) Associated data processing

21. Micro processors have been applied increasingly to systems processing analytical data or controlling instrumentation. Hardware and software development aids have been introduced to facilitate their design and construction and to meet the increasing demand for micro processors.

22. Further studies have been undertaken to define a mathematical function which will give a good fit to the degraded Gaussian peaks typically obtained by gamma spectrometry, particularly at high count rates. The formulae are being tested on the spectra provided by the IAEA for the G1 laboratory intercomparison experiment.

DETECTOR AND SOURCE DEVELOPMENT AND FLUX MONITORS

23. There has been a small amount of developments on improving silicon diffused junction detectors for soft X-ray and α detection. These are used as "hot-spot" monitors in high radiation backgrounds and have been found robust and convenient. They have not yet been applied to the measurement of plutonium other than in the context of monitoring for contamination.

24. Some work has been contracted to Universities to study CdTe and HgI_2 detectors. Promising results have been obtained and reports are in course of publication.

25. Work has continued on the development and production of neutron sources for special applications, e.g. for use in very high temperatures or high pressure environments. Following the decision to cease manufacture of low energy (less than 1 Mev) neutron sources containing lithium hydride, there has been some effort devoted to the investigation of alternative sources. This work is continuing, but pressure of other commitments is likely to curtail effort during 1977.

27. Investigations have continued into the use of niobium as a fast neutron fluence monitor using the n,n' reaction which yields Nb^{93m}. The fast flux profiles obtained from the long wire monitors, although only indicative of relative flux, provide very useful confirmatory evidence of the neutron distribution in reactor channels and may have applications in verification of reactor operating history. Work is continuing on the design of a multiple foil package for neutron energy spectrum evaluation including its use at temperatures up to 400°C.

IRRADIATED FUEL ELEMENT COUNTER

28. A device, designed to count irradiated fuel elements discharged from a reactor has been tested. This work carried out in collaboration with the IAEA, has utilized both CdS detectors and Geiger tubes. To date the reliability of the former has been disappointing, but the Geiger tubes have been satisfactory.

SYSTEMS ANALYSIS, STATISTICS AND COMPUTING

29. Studies have been inaugurated to establish a quantitative link between specifications and analytical schedules and methods. These will continue in 1977.

30. A number of computer programmes designed to handle the nuclear materials accountancy have been brought into use and will replace the existing manual control systems. It is expected that several of the programmes will be able to produce the routine returns to Euratom in the format which will be required by the new regulations.

EPILOGUE

An epilogue seems more appropriate than a conclusion to this presentation. As has already been explained, the information is gleaned from a number of organizations in the UK. Requests for further information should be directed in the first instance to the author.

Book Review

Radiation Protection Guide

A Guide to Radiation Protection-J. Craig Robertson (Department of Physics, Dundee College of Technology, Dundee Scotland) John Wiley & Sons, New York, (1976), (86 pages).

A Guide to Radiation Protection is intended for those without scientific training who have some need to understand the basic principles, for example: firemen, policemen and industrial technicians. It is very difficult to provide suitable instructional materials for this "in between level," which on one hand do not overwhelm the reader with scientific terminology and detail, or on the other do not condescendingly oversimplify the subject matter. While the author has obviously endeavored to steer a middle course in this short text, scientifically literate readers will find his approach overly-elementary and unsatisfactorily non-quantative.

After a brief consideration of biological effects and the nature of radioactivity, the working information presented includes radioactive materials, types of sources, shielding, radiation units, detection and measurement and legislation (principally U.K.). Most of the basic working concepts of radiation protection, such as the principal types of ionizing radiation, of the curie, the roentgen, the rad, the rem, and quality factors, of open and sealed sources, of half thickness and half lives are introduced clearly and accurately. The principal rules in radiation protection, time, shielding and distance are mentioned and portable detection devices indicated.

While all of this is very worthwhile, there is a minimum of mathematics and not a single equation in the book. Thus, the reader being introduced to the subject for the first time would find in it many useful "cookbook" rules. His or her knowledge would be insufficient to work independently with radioactive substances or sources, except under the supervision of a well qualified radiation specialist. Reviewed by Andrew P. Hull, Brookhaven National Laboratory, Safety & Environmental Protection Division, Building 535, Upton, New York 11973, (516) 345-4210.

Measurement Reliability For Nuclear Material Assay . . .

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ABSTRACT

A summary of a recent report describing the reliability of nuclear material assay is presented. Analytical chemistry, calorimetry, and nondestructive nuclear methods are discussed. Ranges of accuracy and precision encountered in the assay of nuclear material are given.

Introduction

A recent report[1] describing the reliability of nuclear material assay is summarized below. In addition to discussing classical destructive analysis, the report is intended to be a source book for reliability data relevant to nondestructive assay (NDA) measurements. Comparing data from any plant with data given in the report permits evaluation of an assay system's performance. The data would also be invaluable in designing any facility handling or processing nuclear material. Simulation studies using accuracy and precision data given here can predict how well safeguards and accountability systems detect diversion of nuclear materials in a given process or at an entire plant.

Generic types of materials are discussed (including feed, product, scrap, and waste), but not all materials encountered in the various fuel cycles are considered. A basic premise of the report is that only typical reliability data should be presented, because the limits of reliability must be determined on a plant-by-plant basis by means of a comprehensive measurement-control program. Reliability can range from the best that can be achieved under optimum conditions, to routinely obtainable values, to poor results caused by careless procedures or inadequate control. Consequently, the report gives ranges of values to be used in assessing total system reliability.

Measurement reliability data is summarized in three tables taken from Ref. 1. The main report contains detailed data from a wide variety of both destructive and non-destructive measurements. Also included is an extensive bibliography of the sources from which the data were taken.

The reliability data pertaining to analytical chemistry measurement were derived from procedure manuals, ANSI-ASTM standards, and interlaboratory exchange programs. The data illustrate both the optimum performance attainable with a given measurement technique and the deviation from optimum that is frequently observed in a production environment.

The major source of reliability data for NDA measurements is a large collection of comparisons of NDA measurements with sampling/chemical assay, calorimetric assay, and known (fabricated) standards. The collection illustrates particularly well the present state of NDA measurement of scrap and waste materials using synthetically prepared standards.

Tables I-III provide values of the mean and range for the precision and bias observed for a given type of measurement. Where available, a summary of interlaboratory comparison data is also included.

Development of Measurement Methods

The evolution of a method of measurement has many stages. Development begins with initial measurement theory—the recognition of a signature. After initial testing, the first studies attempt to identify the parameters that influence measurement, the interferences, the limits of applicability, and the standards required. When applicable standards already exist, the method can be tested against them. It can also be tested against other proven methods if such exist. Samples are then circulated among laboratories to test methods and standards for consistency. Standard procedures are documented and physical standards are developed. These are made available through recognized standards agencies such as the National Bureau of Standards (NBS) and the International Atomic Energy Agency. Quality-control programs are developed within individual laboratories. Sample exchange programs may be set up to monitor measurement performance on a routine basis. Even after widespread application of the method, continuing measurement research refines procedures and standards and evaluates new methods.

Status of Analytical Chemistry Assay

Analytical chemistry measurements of product- and feed-grade materials have evolved as outlined above. Standard uranium and plutonium samples are available from NBS for calibration purposes in the determination of elemental concentration using titrimetry and coulometry and for isotopic determinations using mass spectrometry.

Standard measurement procedures have been issued through the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) for the assay of product-grade uranium and plutonium metals, oxides, and nitrate solutions. ASTM-ANSI standard procedures also exist for UF_6, UF_4, and mixed-oxide materials. A comprehensive source of measurement methods[2] (detailed procedures) was published in 1963 and revised[3] in 1972. Both editions describe methods for sample preparation and for the analysis of certain scrap, waste, and product-grade materials.

Numerous domestic and foreign round robins and sample-exchange programs were initiated in the mid-1960s and some are still being conducted. In general, they demonstrate the range of measurement reliability that occurs in practice. The results of some laboratories consistently deviate from the average. Round robins have frequently improved performance in such laboratories by pointing out deficiencies in measurement methods and procedures.

Most chemical methods require considerable operator skill and care to achieve reliable results. Because of information exchange, analytical chemistry measurements have become highly developed and well documented. The definition and control of measurement accuracy have permitted reasonable agreement to be achieved concerning the use and appropriateness of reference materials and standard procedures.

Status of Nondestructive Assay

Nondestructive assay measurement is of more recent origin than chemical analysis. Most NDA methods have been developed within the last ten years, many within the last five. Developed independently at various laboratories, they are inadequately standardized and documented. Most NDA methods require special physical standards, yet there is no set procedure for producing or procuring them.

NDA methods are currently used to assay product materials such as fuel rods, oxide powders, and process solutions. These methods are similar to analytical chemistry techniques in that standards for powder and solution measurements can be constructed quite readily from (or calibrated against) standard reference samples. For measurement of waste and scrap, where NDA is the major technique, more representative standards are required, and fabrication methods are still under development.

Very few sample-exchange programs using NDA methods have been undertaken. There are no common standards upon which to base comparisons. Data describing the accuracy and precision presently attainable with these methods are based on measurements of synthetic counting standards or on comparisons with analytical chemistry determinations.

With the exception of calorimetry, no NDA standard procedures have been written, although some are now under development. NDA methods have reached the stage of development at which consideration should be given to the implementation of common physical standards, standard procedures, and interlaboratory exchange programs so that measurement reliability can be better defined and controlled. These considerations would also provide impetus for much-needed container standardization. Benefits from such administrative and organizational improvements are as important as those to be derived from further technical experimentation and development.

Feed and Product Material Measurement

Product and feed materials include uranium and plutonium liquids, powders, pellets, and fuel rods. Most product quality control and accountability programs now use a sampling plan in conjunction with analytical chemistry methods. With few exceptions (e.g., plutonium calorimetry), nondestructive measurements have not demonstrated the accuracy and precision attainable with analytical chemistry. Because feed and product constitute the largest part of a plant's inventory, the most reliable measurements are required for their determination. A drawback of sampling is that it does not test the entire inventory. Nondestructive measurements are being added to accountability systems to facilitate measurement of the entire product inventory. A common use of NDA has been in quality control and accountability of product fuel rods.

Analytical chemistry methods are usually applied to relatively pure materials, especially process feed and product. Uranium and plutonium concentrations are determined by coulometry or a variety of titration methods. Isotopic concentrations of ^{235}U and ^{239}Pu are determined by mass spectrometry. Under optimum conditions, uranium and plutonium concentration measurements have a precision of 0.1% or better. In routine analysis this precision may be worse by a factor of two or more. Calibrations are usually performed using a standard derived from NBS standard reference material, and thus should have no significant bias.

Plutonium calorimetry involves the measurement of heat generated by the radioactive decay of plutonium and americium. All but a negligible portion of the decay energy is transformed into heat when the decay particles (alpha, beta, and low-energy gamma) are absorbed by the sample and calorimeter walls. The heat generated by a plutonium sample can be measured very accurately by calorimetry. The heat determination can be traced to primary NBS electrical standards, thereby obviating the need for accurate plutonium standards.

The plutonium isotopic composition and ^{241}Am content must be known or determined if the amount of plutonium is to be inferred from the measured heat. Uncertainties in composition are usually the largest errors in the measurement. There are also uncertainties in specific powers, heat determination, heat distribution, and heat produced by interfering reactions such as radiolysis.

Product Plutonium

Table I summarizes the data for plutonium product material (solutions, oxide powder and pellets, and fuel rods) for both total plutonium content and ^{239}Pu concentration. For titration analyses the optimum precision is much better than the mean from laboratory exchange programs. The analytical chemistry measurements are bias-free in the optimum case, where careful calibration against a standard should exist, but this may not be the case for routine assays. Chemistry measurements should easily give a precision of 0.3% and a bias of 0.2%.

Calorimetry measurements should be very accurate for the assay of well-characterized plutonium. The heat determination should have a precision of 0.25%, and the uncertainty in the specific power of the sample may introduce a bias of only 0.1-0.2%. For low-burnup plutonium (94% ^{239}Pu by weight), precisions of 0.08-0.3% have been obtained, while for spent LWR fuel (containing 62% ^{239}Pu) precisions are 0.3-1.0%. In summary, precisions of 0.3-1.0% and biases of 0.1-0.2% can be expected for calorimetry measurements.

The data shown in Table I for fuel rods are routinely obtained for fast-breeder fuel rods with a ^{252}Cf scan system. Plutonium rods and plates have been routinely assayed at Argonne National Laboratory with computer-controlled gamma-scan systems.

Figure 1 shows the precision of mass spectroscopic determinations of istopic abundance. Although the figure shows plutonium data, it applies as well to uranium. The upper curve represents a worst case (process solution) and the lower curve is optimum (NBS standard).

Product Uranium

Table II summarizes the data for uranium product assays, both for total uranium content and for ^{235}U concentration. Chemical measurements should easily yield a precision of 0.2% and a bias of 0.05%. LWR fuel rods are routinely assayed by ^{252}Cf scan with the reliability shown in the table. Routine uranium solution assays (some in-line) have precisions of 0.25% and biases of 0.1%. Bulk and small-sample uranium active-assay systems are capable of biases of 0.1% or less.

Scrap Measurement

Scrap consists of process residues that have economically recoverable quantities of special nuclear material (SNM). The SNM content in scrap ranges from that contained in reject product material to that of very dirty residues (less than 10% SNM by weight). Scrap is usually placed in smaller containers than waste and is usually denser and more homogeneous. Scrap materials are often difficult to sample, causing the results of analytical chemistry measurements to be suspect. Consequently, it is difficult to define the actual SNM content of scrap to be used as a standard for testing a new technique. In some cases, the best procedure is to use results from synthetically prepared standards.

Reject product and feed, the most common form of scrap, is assayed (with similar reliability) by the same methods as are product materials (refer to Tabel III). Calorimetry is a reliable technique for plutonium scrap assay. Reject product calorimetric assays have precisions of 0.3-1% and biases of 0.1-0.2%. For dirty scrap materials, the isotopic composition is more difficult to determine, so that the observed precisions are 3% and the biases are 2%.

Analytical chemistry assays of hard-scrap materials are as reliable as are product measurements. However, for well-blended dirty scrap, sampling errors may still be 2-3%, and larger errors can result from poor blending.

Gamma-ray assays of dirty plutonium scrap have optimum precisions of 2% for low-attenuation materials such as incinerator ash. For more attenuating materials the precision is as poor as 10%. Biases of 2% have been observed, but smaller biases could probably be achieved.

Neutron-coincidence techniques are useful for the assay of plutonium scrap. For reject materials the accuracy is limited by the determination of the isotopic composition and is predicted to be 0.1-0.5% in the optimum cases. Actual measurements indicate a bias of 1% or worse. For dirty scrap materials, precisions range from 3% for homogeneous to 8% for very heterogeneous materials, with biases of less than 1%.

Uranium scrap can be assayed with gamma-ray techniques. Precisions of 2% are observed for high-transmission materials. Biases are smaller for uranium (0.5-1%) than for plutonium because of the availability of better standards.

Active NDA techniques are used for both plutonium and uranium scrap. Passive techniques are, however, simpler and more reliable for plutonium. For reject uranium product and feed active techniques have given precisions of 1% and biases of 0.5%.

Waste Measurement

Waste is residue that does not contain economically recoverable SNM. It is usually less dense and more heterogeneous, and is stored in larger containers than scrap. The largest category of waste consists of hydrogeneous, combustible, and low-SNM-content materials such as paper, wipes, plastic, glassware, and other disposables. Wastes also include contaminated equipment, tools, and higher density materials that are difficult to assay. In contrast, low-level liquid waste streams, usually carrying insignificant amounts of SNM, are relatively easy to measure.

Typically, only 0.25-2% of plant throughput or inventory is waste, so that relatively large waste measurement errors are tolerable because of their minimal impact on LEMUF (limit of error of material unaccounted for). Common practice is to use 120- to 200-liter drums for waste storage and transportation. This large drum size and the fact that the drum contents can vary greatly makes assay difficult. When possible, it is desirable to incinerate large volumes of combustible wastes because the ash occupies a much smaller volume and is more reliably assayed. Bulk waste is often placed into smaller packages and assayed before final loading in the drums. This makes accounting easier and more reliable, as suggested in NRC guides 5.11 and 5.47. Small-package assay, however,is often impractical and drum measurement reliability can be adequate for accountability purposes. Waste is usally not amenable to analytical chemistry methods (except for low-level solutions), and, as a result, nondestructive techniques have been widely used (and abused). There is much latitude for error with this type of material, and measurement reliability is difficult to determine.

Gamma-ray and neutron-coincidence systems are used for plutonium waste assay (refer to Table III). The precision of bulk waste measurement is 10-13% and the bias is 1-5%. Measurement of small waste packages is more reliable, yielding precisions of 3% and biases of 1-2%. Gamma-ray assay systems should always include transmission measurements to avoid large biases. Also,

TABLE I

RELIABILITY OF PLUTONIUM PRODUCT AND FEED ASSAYS

		Precision (RSD,%)			Bias (%)			Interlaboratory Deviation (%)	
Material	Method	Optimum	Mean	Range	Optimum	Mean	Range	Mean	Range
TOTAL PLUTONIUM									
Nitrate solution	Titration	0.04	0.29	0.07-0.6	0	0.16	0.1-0.2	0.35	0.13-0.67
	Gamma spectroscopy	0.5	----	---------	0.2	----	--------	----	---------
Oxide	Titration	0.04	0.15	0.04-0.6	0	0.25	0.0-0.35	0.26	0.07-0.48
	Calorimetry	0.25	----	0.26-0.95	0.1	0.16	--------	----	---------
Mixed oxide	Coulometry	0.04	0.14	---------	---	----	--------	0.07	---------
Fuel rods	^{252}Cf scan	0.8	----	---------	0.1	----	--------	----	---------
Fuel plates	Gamma spectroscopy	0.5	----	---------	0.1	----	--------	----	---------
^{239}Pu CONCENTRATION									
Nitrate solution	Mass spectroscopy	0.02	0.09	0.01-0.13	0	0.01	0.0-0.08	0.05	0.03-0.1
	Gamma spectroscopy	0.2		---------	0	0.01	--------	----	--------
Oxide	Mass spectroscopy	0.02		0.01-0.16	0	0.08	0.06-0.19	0.09	--------

TABLE II

RELIABILITY OF URANIUM PRODUCT AND FEED ASSAYS

Material	Method	Precision (RSD, %)			Bias (%)			Interlaboratory Deviation (%)	
		Optimum	Mean	Range	Optimum	Mean	Range	Mean	Range
TOTAL URANIUM									
Nitrate solution	Titration	0.02	0.15	0.03-0.78	0	0.06	0.004-0.29	0.09	0.02-0.2
	Gamma spectroscopy	0.5	----	---------	1.0	----	----------	----	--------
Oxide	Titration	0.02	0.16	0.02-1.4	0	0.03	0.01-0.66	0.05	0.03-0.09
	Gamma (and neutron bulk amounts)	2	----	---------	1.0	----	---------	----	---------
	Active assay	0.5	1.0	0.5-2.0	0	1.0	---------	----	---------
Fluoride	Titration	0.02	0.08	---------	----	----	---------	0.18	---------
Mixed oxide	Coulometry	-----	0.27	---------	----	----	---------	0.03	---------
Fuel rods	^{252}Cf scan	1.0	----	---------	0.25	----	---------	----	---------
^{235}U CONCENTRATION									
Nitrate	Mass spectroscopy	0.014	0.14	0.03-0.48	0	0.01	0.001-0.29	0.07	---------
Fluoride	Mass spectroscopy	0.014	0.18	---------	----	----	---------	0.16	---------
Oxide	Mass spectroscopy	0.014	0.25	0.01-2.0	0	0.07	0.02-0.45	0.16	---------
Fuel rods	Gamma spectroscopy	0.5	----	---------	0.1	----	---------	----	---------

representative standards are required if reliable assays of waste are to be attained.

Conclusion

It is believed that the data of Ref. 1 present an accurate view of the status of nuclear measurement reliability as of January, 1977. However, the field of nuclear material safeguards and control is quite dynamic and will undoubtedly provide increasingly reliable techniques for the assay of nuclear materials. In particular, continuous improvements can be expected in NDA methods with respect to standard procedures and physical calibration standards. The next several years should also give rise to NDA laboratory exchange programs comparable to those of analytical chemistry assay.

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TABLE III

SCRAP AND WASTE MEASUREMENT RELIABILITY

Material	Method	Precision (RSD, %)	Bias (%)
SCRAP			
Plutonium reject product	Chemical assay	0.3	0.1
	Calorimetry	0.3-1.0	0.1-0.2
	Neutron coincidence	3.0	1.0
Plutonium dirty scrap	Chemical assay	2-3	1.0
	Calorimetry	3	2
	Gamma (T[a] 0.1)	2	2
	Gamma (T 0.0001)	2-10	2-5
	Neutron coincidence	3-10	1
	Active assay	8	0.5-2.5
Uranium reject product	Chemical assay	0.2	0.05
	Active assay	1.0	0.1-0.5
Uranium dirty scrap	Gamma (T 0.1)	2	1
	Gamma (T 0.0001)	2-10	2
WASTE			
Large volume of plutonium waste	Gamma	10-13	5
	Gamma (without transmission correction)	20	10-20
	Neutron coincidence	10	5
Small can of plutonium waste	Gamma	3	1-2
Large volume of low density uranium wate	Gamma	10	5-10
Small can of uranium waste	Gamma	5	2

[a] T is the gamma transmission coefficient.

Measurements and Standards For Nuclear Safeguards

By Craig Hosmer, President
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Editor's Note: This was a speech given by Mr. Hosmer at the noon luncheon Thursday, June 30, at the 18th INMM Annual Meeting at the Stouffer's National Center Inn, Arlington, Virginia.

One of the issues constraining the full exploitation of nuclear energy to meet the world's energy needs is widespread concern over the adequacy of institutions and methodology for safeguarding the public against malevolent acts involving fissionable material. Malevolent acts encompass the concepts of proliferation, sabotage and theft for terroristic purposes. Safeguards embrace all activities involving control, measurement, protection and security of the nuclear fuel cycle. **President Carter** seems to find present safeguards practices and institutions inadequate. As a consequence, he has called for indefinite postponement of the commercialization of breeder reactors and of reprocessing spent nuclear fuel. There may or may not be another explanation for his action.

In any event, this rejection by the President of plutonium on the grounds that the world is not yet equipped to handle it safely has enormous consequences. By the year 2000 it would put out of reach the energy equivalent of six years' current free world petroleum production. This energy potential would lie idle as unburned U235 and plutonium locked in unreprocessed spent fuel elements. The President's ban also locks away other potential energy equivalents which I shall detail later.

It is obvious that a forebearance of this magnitude will prove financially precarious and physically discomforting to United States citizens, but in many nations of the world it can make the vital difference between life and death to millions of people. Therefore a matter of considerable priority has to be the upgrading of safeguards technology and institutions to world-wide levels preceived to be acceptable so that these energy resources can be made available in the U.S.

The problem has several facets, but central to most of them is a need for accurate and reliable measurements of highly enriched uranium and plutonium at all steps in the nuclear fuel cycle. At present this capability for standard measurements that are internationally acceptable with unquestioned confidence is not available in some cases, or in other cases not available at a level necessary to ensure the consistency and adequacy of the measurement system for safeguards purposes.

The National Bureau of Standards has long been recognized as an independent, unbiased laboratory possessing international trust and confidence throughout its 75 year history. It has proposed a modest, $3 million per year program to establish universal measurements and standards for safeguarding nuclear material. To date the program has received only limited funding through allocations of money by the Energy Research and Development Agency and the Nuclear Regulatory Commission. The Office of Management and Budget has not yet seen fit to approve the program for regular budgeting via NBS's parent agency, the Department of Commerce.

As a result, the program is not only underfunded, but such money as it gets it receives from sources that may be seen by some in the U.S. and overseas as placing a cloud upon the objectivity of this program.

Although neither the present Administration nor the predecessor Ford Administration saw fit to remedy this situation, I am pleased to report that the Congress soon may do so. Considering the prevailing high level of concern over nuclear weapons proliferation it is high time. I have received letters from several congressmen and senators telling me that they intend to move to introduce the necessary amendment to any nuclear exports bill that moves, whether it is one of the Congressional versions or the Administration's bill.

So much for the good news. I would now like to dole out the bad news in somewhat more leisurely portions—and maybe range a bit wider in reporting what has been happening in Washington this year, of nuclear interest, with the new 95th Congress and the new Carter regime. In this I would prefer to be omnipotent and oracular—but by force of circumstances I must be vague and obfuscatory.

But in any event, what Mr. Carter asks—and what he eventually gets from Congress by way of energy legislation are starting to look like two very different things. After Congress works its will, we could end up with a facade of conservation measures that don't save much, but won't disturb complacent voters very much either. There will be plenty of coal just so long as no one disturbs the landscape to dig it or involves the air in burning it. We will have all the nuclear power that Ralph Nader allows Congress to give us. There will be no new taxes or price boosts on oil and gas—instead we will cut down on their use by patriotism, persuasion and prayer. Soft technologies will abound. R&D on exotic energy sources will be endless. A lot of our energy will be sought from wind mills and captured from the hot air in political speeches. If that doesn't do it, as a last resort we may even turn to the awesome power of the peaceful peanut.

So there you have it—a blueprint for the upcoming transition from our energy intensive industrial society today to its successor, tomorrow's lean, mean and pristine sleeping bag society.

On the other hand, Jimmy Carter may get born again and decide that our energy situation demands production as well as conservation measures. That would be something to see. I tried to get Gerry Ford to go that route when he first assumed the Presidency. But his advisors convinced him he would have to go public with a lot of bad news and end up like the Greek messenger—with his head on a platter. But Gerry Ford had only two years to go to an election. Jimmy Carter has four. Carter could get away with it politically given that amount of recovery time.

For that reason, my organization, the American Nuclear Energy Council, has a deep interest in President Carter's plans for nuclear power. We have devoted a lot of resources to getting a fix on them. We have talked to people in key administration energy jobs, to congressmen and senators who will control energy legislation, and to astute Washington old-timers. No one can say what thoughts are inside a President's head, but all these contacts boil down to educated speculation along the following lines:

First, I think in his mind Mr. Carter has separated nuclear power into its plutonium and its non-plutonium aspects. Anything that has to do with plutonium and proliferation is between him and the National Security Council, the State Department, and ACDA. Everything else is between Jimmy Carter and **Jimmy Schlesinger.** Carter is the active boss on both sides of this watershed. Where NSC, et al and Schlesinger rub together the wrong way he listens to both—or reads what they put in a memo—and makes a decision quickly.

On the political side, President Carter has major debts to **Ralph Nader** and others of that ilk who oppose what they call the "plutonium economy." Lately, in order to get at plutonium, these types have blown up a firestorm over nuclear weapons proliferation. Earlier they tried to stigmatize plutonium with the hot spot theory, but got nowhere. Then they failed again with accusations about its supposed "deadly toxicity." No one believed them. Even with the National Council of Churches of Christ they got no place trying to declare element number 94 to be "immoral." But now, at last, they have managed to trigger emotions and fears over possible illicit diversion of the stuff to spread nuclear weapons amongst unstable nations, terrorists, and even the mafia. They roll back their eyes to the whites, throw up their hands and mumble about armageddon being "only a screwdriver away." They do this whenever the subject of plutonium comes up—and they bring it up a lot. It is all a little silly. But never-the-less it goes on and we must contend with it.

Now during his campaign Jimmy Carter talked a lot about atomic power being a "last resort." But when pinned down about that he merely said he meant that it would be used to measure and to fill the remaining energy gap after other energy sources make their contributions. He even declared that the gap to be filled this way by nuclear power is "substantial."

So you see—he's got a political puzzler. It is how to preserve the nuclear option and at the same time get people like Nader off his back. And that's quite a problem. Probably deep down in his heart he strongly suspects that there will not be enough uranium and that there is no way eventually to avoid reprocessing and using breeders. But there is darn little he can do about that right now. Maybe if the National Bureau of Standards already had the fullblown measurements and standards for nuclear safeguards program I mentioned earlier, the situation would be much better as of now.

The President is being very tough. Deferral of the breeder and moratorium on reprocessing are by no means inconsequential. The bruhaha it kicked up both here and overseas is ample testimony to that. I hope it wasn't accidental, but was exactly what Carter wanted in order to give emphasis to the **carrot** he offered in the form of guaranteeing delivery of nuclear fuel to other countries and the **stick** he waves about plutonium and proliferation.

I hope that President Carter is not serious about throwing away enormous energy reserves worth billions of dollars, which is exactly what any permanent forebearance of breeders and reprocessing would involve. Here is an example: it would put out of reach a United States energy resource that could fuel the Nation for 165 years at our present rate of energy use. Its energy potential roughly equals that of all U.S. coal resources still in the ground. This resource is some 200,000 tons of depleted uranium tailings left over after enriched uranium was extracted from it to make fuel for nuclear power plants and the weapons program. Realizing their energy potential would require that they be used in breeder reactors. Eventually at least 70% of the material would be transmuted into plutonium and used as nuclear fuel. Calculations by Dr. **C.S. Winters** of the Union Carbide Corporation predict their total power yield in this mannner at some 11,500 quads of thermal energy. By comparison, today the U.S. uses only about 70 quads per year from all energy sources, including petroleum, coal, uranium and hydropower. On this basis, these tailings equate to potential energy of 13,300 quads estimated by ERDA for all yet-to-be-mined U.S. coal. Taken with yet-to-be-mined U.S. uranium—around 1.76 million tons—Dr. Winters says they represent 78,000 quads, or 1,280 years of energy for the U.S. at the rate we now use it.

But President Carter's deferral of reprocessing and breeders certainly raises this issue: *Does the danger he wants to contain really warrant the sacrifices called for by his program to manage it?*

Other countries almost universally have answered that question in the negative. There is no doubt in my mind that there are much less costly and much more effective anti-proliferation alternatives. I don't see how we can afford the energy loss, or the surrender of hundreds of billions of dollars, or the gross human suffering that would be its consequence. I refuse to believe that such folly is President Carter's ultimate intention.

My guess is that the man figures: (a) that plutonium is a real problem but a manageable problem, (b) that, in the end, plutonium will prove irreplaceable for meeting our own and the world's energy needs, (c) that the proliferation spectre is the principal obstacle standing in the way of instituting a worldwide, safeguarded plutonium economy, (d) that this obstacle may be removable by proliferation control measures which would accompany internationalization of key segments of the nuclear fuel cycle, and (e) that effective international controls are conditions precedent to destigmatizing reprocessing and breeders here on the U.S. domestic front.

In addition, Mr. Carter may have in mind that, however serious is the view that ultimately there are not sufficient uranium reserves to fuel an expanded light water economy, that the pinch will not take place right away. It is two or three or more decades down the road. We have enough fuel for a few years ahead. Thus, there is time left to deal with the uranium problem after current fears and emotions about the plutonium and proliferation are laid to rest. When that is done, the country can talk about reprocessing and breeders again.

I hope that is what the President has in mind and that his strategy is to whipsaw the international community into taking up the plutonium problem now—and taking it up seriously. His domestic restraint on breeding and reprocessing are to underline how seriously he believes the need is to start building the appropriate institutional structures now—structures to police plutonium's real and imagined perils in order to get the proliferation monkey off our backs.

It is my judgment that his cage rattling has worked and the international community is now ready to do whatever is necessary—impose such disciplines as are appropriate—to bring world order, safety and security to the back end of the fuel cycle. The iron is now hot and the President should strike it by indicating the outlines of whatever structure he believes will accomplish all that. The rest of the world awaits his pleasure. If he delays too long the iron will cool. It will take a long time to reheat it.

Let us assume that what I have just said bears some resemblance to what actually is in the President's mind, that he takes timely action, and the international community stops wringing its hands, and agrees to agree on filling in the details of the structure Carter outlines. The question then becomes: How long will it be until reprocessing and breeders get a clean bill of health because necessary governmental and intergovernmental structures to control plutonium are defined in place and functioning? In short, how long should nuclear utilities—or whoever is eventually responsible for it—be planning to store spent fuel? How long will they have to wait before they can start recovering **unburned** U235 and plutonium from fuel and burn the stuff?

You will need three to five years to just get a **consensus** on detail among suppliers, recipients, governments, affected companies, and miscellaneous hangers-on. This would amount to the blue print for the structure and financing of internationally sponsored and safeguarded regional reprocessing, and waste disposal centers. Active leadership by Sigvard Eklund & Company could shrink that leadtime somewhat. Next there's the problem of clearing away the usual underbrush of political science—siting, licensing criteria, agreements for cooperation, hiring, ordering, etc. etc. There is a lot of that to do before you can start building anything these days. After that you can get on with the lengthy process of actually building it. It is not like the good old days when God created the entire earth in six days and rested on the seventh.

I would hope that Barnwell could be thrown into the international pot on this one, along with existing or proposed facilities in Europe, Japan, Brazil and elsewhere. Even so, I suppose that it would be unrealistic to think that you could put into being a viable, safeguarded international reprocessing and waste disposal structure in much less than 10 to 15 years. On the average you would probably be storing spent fuel elements for longer than that.

There are many who believe that reprocessing should be delayed for safeguards reasons until the uranium and plutonium in spent elements is actually needed for immediate fabrication into new ones. They buttress this belief with the economic argument that it is cheaper to store spent fuel than it is to store recovered material since holding charges on reprocessing costs must be added to it. With this in mind, there should be no economic penalty for rather large investments in spent fuel storage facilities, whether they are made by governments, the utilities, specialized companies, or the international structure itself.

In closing I would like to say that the President's an-*nointment* of light water reactors as the chosen instrument for nuclear power has not, by itself set off a wave of orders. LWR's enjoy about the same popularity with U.S. nuclear utility executives as Typhoid Mary, In order to restart reactor orders—which must be done if the country is to close its looming energy gap—nuclear utilities must hear soothing specifics about raw material availability, about enriching capacity availability, about the dilemma at the back end of the fuel cycle, and about cutting down licensing obstacles and delays. Those are all additional items to the international issue I have been belaboring. They have to do with perceiving that nuclear reactors are a viable source of power. They are controversial things that kick up Congressional tempers and delays. So, I guess we will just have to wait awhile longer for the next thrilling chapter of this ever fascinating saga of President Jimmy Carter, the U.S. Congress, light water reactors, breeders, reprocessing, plutonium, proliferation and international cooperation and controls.

ACCOUNTING FOR THE UNCERTAINTY IN A STANDARD VALUE

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Introduction

This paper deals with the general topic of estimating biases, making bias corrections, and expressing the uncertainty in a result for which the bias correction may or may not have been applied. Earlier papers in this general topic area are referenced, [1] to [10]. This present paper includes the additional effect of the uncertainty in the value assigned the standard used to estimate the bias. The principle of maximum likelihood is used to provide the estimates of the parameters. The uncertainty in a reported result is expressed by the mean square error.

Notation

In the problem setup, a known standard (i.e., one having an assigned value for the characteristic of interest) is measured repeatedly to provide an estimate of the bias or systematic error. The data from this experiment, along with model assumptions, are used to establish the need for bias correcting a given measured result and, whether or not the result is corrected for bias, to provide a statement of uncertainty for the reported result.

The notation is as follows:

x_i = i^{th} measurement on the standard; $i=1,2,\ldots,n$

μ_o = value assigned the standard

μ_t = true but unknown value for the standard

η = bias in value assigned the standard

y_j = measured result on a production item j

y_j' = reported result on production item j

T_j = true value for this item j

θ_1 = bias in each x_i measurement

θ_2 = bias in y_i measurement

ε_i = random error in x_i measurement

ε_j = random error in y_j measurement

Models and Assumptions

The assumed models are as follows:

$$x_i = \mu_t + \theta_1 + \varepsilon_i \quad (1)$$

$$\mu_o = \mu_t + \eta$$

$$x_i = \mu_o + \theta_1 - \eta + \varepsilon_i \quad (2)$$

$$y_j = T_j + \theta_2 + \varepsilon_j \quad (3)$$

Three different cases are considered, depending upon the assumptions and also upon whether or not y_j is corrected for bias. The cases are detailed below. In all instances it is assumed that ε_i and ε_j are normally and independently distributed with zero mean and variance σ_ε^2. It is also assumed that η, the bias in the value assigned the standard, is normally distributed with zero mean and variance σ_η^2.

On this latter point, it may be that the uncertainty associated with the standard is expressed by a bound on the absolute value of the bias, i.e., $|\eta|<\eta_o$ with "high" probability. It is assumed that η_o may be expressed in terms of σ_η^2. The development in this paper requires that η be more likely to be close to zero than to η_o, such that the normality assumption is satisfied, and that the "high" probability be expressed in more quantative terms such that σ_η^2 can be expressed as $c\eta_o{}^2$ If "high" means about 0.95, then $\sigma_\eta^2=0.25\eta_o{}^2$; if a probability of 0.99 is intended, then $\sigma_\eta^2=0.15\eta_o{}^2$, etc.

The cases under consideration are as follows:

Case A: $\theta_1=\theta_2=\theta$ and y_j is corrected for bias.

Case B: $\theta_1=\theta_2=\theta$ but y_j is not corrected for bias.

Case C: $\theta_1\neq\theta_2$ but both are random variables, normally and independently distributed with zero mean and variance σ_θ^2. Under case C, it is clearly inappropriate to correct y_j for bias. The purpose of measuring the standard is to obtain an estimate of σ_θ^2.

For Cases A and B, the expected value of x_i is $(\mu_o + \theta)$ while for Case C, it is simply μ_o. The variance of x_i is $(\sigma_\eta^2 + \sigma_\varepsilon^2)$ for Cases A and B and is $(\sigma_\theta^2 + \sigma_\eta^2 + \sigma_\varepsilon^2)$ for Case C. Finally, for Cases A and B, the covariance between x_i and x_k is σ_η^2 while for Case C it is $(\sigma_\theta^2 + \sigma_\eta^2)$.

Estimation of Parameters

For Case A, the problem is to estimate θ in order to make the bias correction. For Case B, it will be necessary to have an estimate of θ^2. For Case C, σ_θ^2 must be estimated. In all cases, σ_ε^2 must also be estimated.

The principle of maximum likelihood is used to estimate the parameters [1]. With this principle, the estimate of θ^2 is the square of the estimate of θ.

The joint likelihood of $(x_1, x_2, \ldots, x_n)$ for Cases A and B is of the form:

$$\left[f(x_1, x_2, \ldots, x_n) = \frac{1}{(\sqrt{2\pi})^n}\sqrt{|\sigma^{ij}|}\,\exp\left[-\frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\sigma^{ij}(x_i-\mu_0-\theta)(x_j-\mu_0-\theta)\right]\right]$$

when σ^{ij} is the (i, j) element in the matrix that is the inverse of the variance - covariance matrix, and where $|\sigma^{ij}|$ is the determinant of that inverse matrix. It can be shown that

$$\sigma^{ij} = \frac{(n-1)\,\sigma_\eta^2 + \sigma_\varepsilon^2}{\sigma_\varepsilon^2(n\sigma_\eta^2+\sigma_\varepsilon^2)} \qquad \text{for } i = j$$

$$= \frac{-\sigma_\eta^2}{\sigma_\varepsilon^2(n\sigma_\eta^2+\sigma_\varepsilon^2)} \qquad \text{for } i \neq j$$

and that $$|\sigma^{ij}| = \left[(\sigma_\varepsilon^2)^{n-1}\,(n\sigma_\eta^2+\sigma_\varepsilon^2)\right]^{-1}$$

The logarithm of the joint likelihood function is to be maximized with respect to θ and σ_ε^2. Ignoring the constant term, the $\ln$ likelihood is

$$L = -0.5(n-1)\ln\sigma_\varepsilon^2 - 0.5\ln(n\sigma_\eta^2+\sigma_\varepsilon^2) - 0.5\,\frac{\left[(n-1)\sigma_\eta^2+\sigma_\varepsilon^2\right]\sum_{i=1}^{n}(x_i-\mu_0-\theta)^2}{\sigma_\varepsilon^2(n\sigma_\eta^2+\sigma_\varepsilon^2)}$$

$$+\frac{0.5\,\sigma_\eta^2\sum_{i=1}^{n}\sum_{j\neq i}^{n}(x_i-\mu_0-\theta)(x_j-\mu_0-\theta)}{\sigma_\varepsilon^2(n\sigma_\eta^2+\sigma_\varepsilon^2)} \qquad (4)$$

where there are n(n-1) terms in the double summation.

The partial derivatives of L are taken with respect to θ and σ_ε^2, equated to zero, and solved simultaneously to obtain the maximum likelihood estimates.

$$\frac{\partial L}{\partial\theta} = \frac{\left[(n-1)\sigma_\eta^2+\sigma_\varepsilon^2\right]\sum_{i=1}^{n}(x_i-\mu_0-\theta)}{\sigma_\varepsilon^2(n\sigma_\eta^2+\sigma_\varepsilon^2)} - \frac{\sigma_\eta^2(n-1)\sum_{i=1}^{n}(x_i-\mu_0-\theta)}{\sigma_\varepsilon^2(n\sigma_\eta^2+\sigma_\varepsilon^2)} = 0$$

from which $$\hat{\theta} = (\bar{x} - \mu_0) \qquad (5)$$

is the maximum likelihood estimate of θ. Therefore, $(\bar{x} - \mu_0)^2$ is the maximum likelihood estimate of θ^2

Next,

$$\frac{\partial L}{\partial\sigma_\varepsilon^2} = -\frac{0.5(n-1)}{\sigma_\varepsilon^2} - \frac{0.5}{(n\sigma_\eta^2+\sigma_\varepsilon^2)} + \frac{0.5\left[\sigma_\varepsilon^4+2(n-1)\sigma_\varepsilon^2\sigma_\eta^2+n(n-1)\sigma_\eta^4\right]\sum_{i=1}^{n}(x_i-\bar{x})^2}{\sigma_\varepsilon^4(n\sigma_\eta^2+\sigma_\varepsilon^2)^2}$$

$$-\frac{0.5\,\sigma_\eta^2(n\sigma_\eta^2+2\sigma_\varepsilon^2)\sum_{i=1}^{n}\sum_{j\neq i}(x_i-\bar{x})(x_j-\bar{x})}{\sigma_\varepsilon^4(n\sigma_\eta^2+\sigma_\varepsilon^2)^2} = 0$$

Replace the double sum in the last term by its equivalent,

$$-\sum_{i=1}^{n}(x_i-\bar{x})^2,$$

multiply both sides of the equation by $-2\sigma_\varepsilon^4(n\sigma_\eta^2+\sigma_\varepsilon^2)^2$, and collect like terms.

$$\left[n\sigma_\varepsilon^2 - \sum_{i=1}^{n}(x_i-\bar{x})^2\right](n\sigma_\eta^2+\sigma_\varepsilon^2) - n\sigma_\varepsilon^2\sigma_\eta^2 = 0 \qquad (6)$$

The value for σ_η^2 is known; n is the sample size,

$$\sum_{i=1}^{n}(x_i-\bar{x})^2$$

is observed. Therefore, the above equation is a quadratic in σ_ε^2 and can easily be solved to provide the maximum likelihood estimate. Note that when $\sigma_\eta^2 = 0$, i.e., when the standard is known without error, then the maximum likelihood estimate of σ_ε^2 is simply $\Sigma(x_i-\bar{x})^2/n$. Also, as $\sigma_\eta^2 \rightarrow \infty$, the estimate of σ_ε^2 approaches $\Sigma(x_i-\bar{x})^2/(n-1)$, the usual unbiased estimate of a random error variance.

Next, consider the $\ln$ likelihood function for Case C. Here, the problem is to estimate σ_θ^2 and σ_ε^2. Let $\theta = 0$ in (4), and replace σ_η^2 by σ_α^2, where $\sigma_\alpha^2 = \sigma_\theta^2 + \sigma_\eta^2$. The estimate of σ_θ^2 will be $\sigma_\alpha^2 - \sigma_\eta^2$, where σ_η^2 is known.

$$-2L = (n-1)\ln\sigma_\varepsilon^2 + \ln(n\sigma_\alpha^2+\sigma_\varepsilon^2) + \frac{\left[(n-1)\sigma_\alpha^2+\sigma_\varepsilon^2\right]\sum_{i=1}^{n}(x_i-\mu_0)^2}{\sigma_\varepsilon^2(n\sigma_\alpha^2+\sigma_\varepsilon^2)}$$

$$-\frac{\sigma_\alpha^2\sum_{i=1}^{n}\sum_{j\neq i}(x_i-\mu_0)(x_j-\mu_0)}{\sigma_\varepsilon^2(n\sigma_\alpha^2+\sigma_\varepsilon^2)} \qquad (7)$$

$$\frac{-2\partial L}{\partial\sigma_\alpha^2} = \frac{n}{(n\sigma_\alpha^2+\sigma_\varepsilon^2)} - \frac{\sum_{i=1}^{n}(x_i-\mu_0)^2}{(n\sigma_\alpha^2+\sigma_\varepsilon^2)^2} - \frac{\sum_{i=1}^{n}\sum_{j\neq i}(x_i-\mu_0)(x_j-\mu_0)}{(n\sigma_\alpha^2+\sigma_\varepsilon^2)^2} = 0$$

Noting that the sum of the numerators for the last two terms is simply

$$\left[\sum_{i=1}^{n}(x_i-\mu_0)\right]^2,$$

the solution for σ_α^2 is

$$\hat{\sigma}_\alpha^2 = (\bar{x}-\mu_0)^2 - \sigma_\varepsilon^2/n \qquad (8)$$

The estimate of σ_ε^2 is found next.

$$\frac{-2\partial L}{\partial\sigma_\varepsilon^2} = \frac{(n-1)}{\sigma_\varepsilon^2} + \frac{1}{(n\sigma_\alpha^2+\sigma_\varepsilon^2)} - \frac{\left[\sigma_\varepsilon^4+2(n-1)\sigma_\alpha^2\sigma_\varepsilon^2+n(n-1)\sigma_\alpha^4\right]\sum_{i=1}^{n}(x_i-\mu_0)^2}{\sigma_\varepsilon^4(n\sigma_\alpha^2+\sigma_\varepsilon^2)^2}$$

$$+\frac{\sigma_\alpha^2(n\sigma_\alpha^2+2\sigma_\varepsilon^2)\sum_{i=1}^{n}\sum_{j\neq i}(x_i-\mu_0)(x_j-\mu_0)}{\sigma_\varepsilon^4(n\sigma_\alpha^2+\sigma_\varepsilon^2)^2}=0$$

Upon replacing σ_α^2 by its estimate in (8), and solving for σ_ε^2, this reduces to the simple expression:

$$\hat{\sigma}_\varepsilon^2=\frac{\sum(x_i-\mu_0)^2-n(\bar{x}-\mu_0)^2}{(n-1)}$$

or, equivalently,

$$\hat{\sigma}_\varepsilon^2=\frac{\sum(x_i-\bar{x})^2}{(n-1)} \qquad (9)$$

Uncertainty in Reported Result

Case A: $\theta_1 = \theta_2 = \theta$ and the result is corrected for bias. The reported result is, from (5)

$$y_j' = y_j - (\bar{x}-\mu_0)$$
$$= T_j + \theta + \varepsilon_j - \mu_0 - \theta + \eta - \bar{\varepsilon} + \mu_0$$
$$= T_j + \eta - \bar{\varepsilon} + \varepsilon_j$$
$$E(y_j') = T_j \quad \text{, unbiased}$$
$$Var(y_j') = \sigma_\eta^2 + \sigma_\varepsilon^2/n + \sigma_\varepsilon^2$$
$$MSE(y_j') = \sigma_\eta^2 + \sigma_\varepsilon^2/n + \sigma_\varepsilon^2 \qquad (10)$$

σ_η^2 is given, while σ_ε^2 is estimated using (6). The first two terms in (10) comprise the systematic error and the last term is the random error.

Case B: $\theta_1 = \theta_2 = \theta$ but the result is not corrected for bias. The reported result is

$$y_j' = y_j = T_j + \theta + \varepsilon_j$$
$$E(y_j') = T_j + \theta, \text{ biased by the amount } \theta$$
$$Var(y_j') = \sigma_\varepsilon^2$$
$$MSE(y_j') = E(y_j' - T_j)^2$$
$$= \theta^2 + \sigma_\varepsilon^2 \qquad (11)$$

Note that the uncertainty in the standard does not affect the MSE directly, except as it has a slight effect on the estimate of σ_ε^2. In evaluating MSE(y_j'), θ^2 is replaced by its maximum likelihood estimate $(\bar{x}-\mu_0)^2$, and σ_ε^2 is estimated using (6) or the simpler limiting expression, $\Sigma(x_i-x)^2/(n-1)$. The quantity $(\bar{x}-\mu_0)^2$ comprises the systematic error, and $\hat{\sigma}_\varepsilon^2$ the random error.

It is pointed out that although $(\bar{x}-\mu_0)^2$ is the maximum likelihood estimate of θ^2, it is not unbiased, i.e., its expected value is not θ^2. However, the unbiased estimate of θ^2 is not necessarily a better estimate than the maximum likelihood estimate. For a discussion of this point, see [6].

Case C: $\theta_1 \neq \theta_2$, but both are normally and independently distributed with zero mean and variance σ_θ^2. It would be inappropriate to correct for bias in this instance.

$$y_j' = y_j = T_j + \theta_2 + \varepsilon_j$$
$$E(y_j') = T_j \quad \text{, unbiased}$$
$$Var(y_j') = \sigma_\theta^2 + \sigma_\varepsilon^2$$
$$MSE(y_j') = \sigma_\theta^2 + \sigma_\varepsilon^2 \qquad (12)$$

In evaluating MSE(y_j'), σ_ε^2 is the solution to (9) and σ_θ^2 is replaced by its maximum likelihood estimate derived from (8):

$$\hat{\sigma}_\theta^2 = (\bar{x}-\mu_0)^2 - \sigma_\eta^2 - \sigma_\varepsilon^2/n \qquad (13)$$

where, in evaluating (13), $\bar{x}$ is observed, μ_0 and σ_η^2 are known, and σ_ε^2 is replaced by its maximum likelihood estimate.

Example

A plutonium standard has an assigned value of 22.12% Pu. Its uncertainty is given by a standard deviation of 0.04% Pu. Twelve analyses are made on the standard, yielding the following data:

22.12	22.16	22.06
22.06	22.09	22.08
22.16	22.13	22.05
22.07	22.08	22.06

A measurement of percent plutonium is then made on a production pellet. Find the mean square error of the reported percent plutonium for this pellet assuming:

(A) Its bias is the same as that for measurements made on the standard, and the reported result is corrected for bias.

(B) Same as (A), but the result is not corrected for bias.

(C) Its bias is not the same as that for measurements on the standard, but the standard measurements are used to estimate the variance of the distribution of biases from which the bias associated with the production pellet was drawn.

Consider each case individually. For all cases,

$n = 12$ $\quad \mu_0 = 22.12$ $\quad \bar{x} = 22.09333...$

$\Sigma(x_i-\bar{x})^2 = 0.017067$ $\quad (\bar{x}-\mu_0)^2 = 0.0007111...$

$\sigma_\eta^2 = 0.0016$ $\quad \Sigma(x_i-\mu_0)^2 = 0.0256$

Case (A): Use (6) to find the MLE of σ_ε^2.

$$(12\sigma_\varepsilon^2-0.017067)(0.0192+\sigma_\varepsilon^2) = 0$$

which gives $\hat{\sigma}_\varepsilon^2 = 0.001541$

Use (10) to find the mean square error of a reported result

$$MSE(y_j') = 0.0016 + 0.001541/12 + 0.001541$$
$$= 0.003269$$
$$\sqrt{MSE(y_j')} = 0.0572 \text{ \% Pu}$$

Case (B): As with Case (A), the MLE of σ_ε^2 is 0.001541. The MLE of θ^2 is

$$(\bar{x}-\mu_0)^2 = 0.0007111.$$

Then, from (11),

$$MSE(y_j') = 0.000711 + 0.001541 = 0.002252$$
$$\sqrt{MSE(y_j')} = 0.0475 \text{ \% Pu}$$

If the size of the mean square error in the reported result were the sole criterion for deciding whether or not to make the bias correction, then the correction would not be made in this instance since 0.0475 < 0.0572.

Case (C): In this case, σ_ε^2 is the solution in (9).

$$\hat{\sigma}_\varepsilon^2 = \frac{0.017067}{11} = 0.001552$$

$\hat{\sigma}_\theta^2$ is given by (13).

$$\hat{\sigma}_\theta^2 = 0.0007111 - 0.0016 - 0.001552/12$$
$$= -0.001018$$
$$= 0 \text{ (systematic error is estimated to be zero)}$$

Then, from (12),

$$MSE(y_j') = 0 + 0.001552$$

$$\sqrt{MSE(y_j')} = 0.0394 \text{ \% Pu}$$

Suppose now that the uncertainty in the standard is described by $\sigma_2 = 0.01\%$ Pu rather than 0.04% Pu. Then what are the results for the three cases?

Case (A): To find the MLE of σ_ε^2, use (6)

$$(12\sigma_\varepsilon^2 - 0.017067)\,(0.0012 + \sigma_\varepsilon^2) - 0.0012\sigma_\varepsilon^2 = 0$$

which gives $\hat{\sigma}_\varepsilon^2 = 0.001477$

from (10),

$$MSE(y_j') = 0.0001 + 0.001477/12 + 0.001477 = 0.001700$$

$$\sqrt{MSE(y_j')} = 0.0412 \text{ \% Pu (Compared with 0.0572)}$$

Case (B): From (11),

$$MSE(y_j') = 0.0007111 + 0.001477 = 0.02188$$

$\sqrt{MSE(y_j')} = 0.0468$ % Pu (compared with 0.0475) larger than the $MSE(y_j')$ if the bias correction were made.

Case (C): From (13),

$$\hat{\sigma}_\theta^2 = 0.0007111 - 0.0001 - 0.001552/12 = 0.0004818$$

From (12),

$$MSE(y_j') = 0.0004818 + 0.001552 = 0.002034$$

$$\sqrt{MSE(y_j')} = 0.0451 \text{ \% Pu (compared with 0.0394)}$$

Summary

If the assumption is made that the bias associated with a given standard may be regarded as a random variable, normally distributed with zero mean and variance σ_η^2, if unknown parameters are estimated by the principle of maximum likelihood, and if the uncertainty in a reported result is expressed by the mean square error, then this uncertainty depends on the assumptions made about the model and on the action taken with respect to making or not making a bias correction.

Three cases are considered. In Cases A and B, the bias associated with an observed result is identically the same as that associated with measurements made on a standard to establish this bias. In Case A, the observed result is corrected for the estimated bias but in Case B it is not. In Case C, the two biases in question are not identically the same, but both are drawn at random from the normal distribution with mean zero and unknown variance σ_ε^2.

Letting $\bar{x}$ be the average of the n measurements $x_i (i=1,2\ldots,n)$ performed on the standard and μ_0 be the assigned value of the standard, the estimated mean square errors of the reported result, y_j', are as follows:

Case A: $MSE(y_j') = \sigma_\eta^2 + \hat{\sigma}_\varepsilon^2(1 + 1/n)$

Case B: $MSE(y_j') = (\bar{x}-\mu_0)^2 + \hat{\sigma}_\varepsilon^2$

Case C: $MSE(y_j') = (\bar{x}-\mu_0)^2 - \sigma_\eta^2 + \hat{\sigma}_\varepsilon^2(1-1/n)$

For Cases A and B, $\hat{\sigma}_\varepsilon^2$ is estimated as the solution to equation (6) For Case C, $\hat{\sigma}_\varepsilon^2$ is given by equation (9).

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THE U.S. ERDA SAFEGUARDS TECHNOLOGY TRAINING PROGRAM

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Los Alamos, NM 87545

The timely transfer of newly developed safeguards technology to the nuclear community is essential to provide guidance for upgrading current safeguards procedures and planning for safeguarding the increasing quantities of commercial nuclear fuels. One efficient method for technology transfer is the U.S. ERDA Safeguards Technology Training Program, the evolution of which is shown in Fig. 1. The training program began in 1973 when the U.S. Atomic Energy Commission authorized the Los Alamos Scientific Laboratory (LASL) Safeguards Program to conduct a course on the fundamentals of nondestructive assay (NDA) of special nuclear materials (SNM). Initially, the enrollment was limited to AEC inspectors, but in 1974 was extended to include government contractor personnel and later was opened to the entire national and international safeguards communities. The annual program curriculum now consists of four one-week courses, three of which are concerned with NDA techniques and instrumentation and one that presents an overview of integrated safeguards systems. Participants in the training courses routinely include representatives of U.S. ERDA, U.S. NRC, the national laboratories, private industry, and the IAEA.

The three NDA courses are designed as a series that will allow the participants to proceed from simple fundamental principles to state-of-the-art instrumentation. The courses are laboratory and instrumentation oriented , with lectures covering basic theory, instrument operation, and potential problem areas. Laboratory groups are small (3 to 5 persons), with each group having its own instrumentation. The LASL instructors interact closely with the attendees, not only on the course work, but also in sharing experiences gained in field-implementation of NDA techniques. Course manuals have been written that serve both as textbooks and as general reference sources.

The first two courses in this series, Fundamentals of Nondestructive Assay Using Portable Instrumentation and Gamma-Ray Spectroscopy for Nuclear Material Accountability, have been described in detail in earlier issues or this journal.[1,2]. The first is an introduction to the principles and techniques employed in passive gamma-ray and neutron assay of fissionable material, and the second familiarizes the students with the powerful techniques available for NDA of SNM using high resolution gamma-ray detectors.

The third course in the instrumentation series, In-Plant Nondestructive Assay Instrumentation, is a study of four automated, computer-controlled instruments that are presently being incorporated into the safeguards systems of a number of nuclear facilities. Again, the focus is on the use of the instrument in the laboratory with lectures to provide a sound understanding of generic instrument types.

The four instruments, the segmented gamma-ray scanner (SGS), the uranium solution assay system (USAS), the neutron well coincidence counter, and the random driver, employ a variety of fundamental active and passive NDA techniques. The SGS is designed to perform passive, transmission corrected gamma-ray assays of the uranium, plutonium, and americium content in low density solids. The USAS incorporates both transmission corrected gamma-ray assasy methods and absorption-edge densitometry, an active gamma-ray technique, to determine uranium concentrations in solutions. The neutron well coincidence counter is a passive system that detects spontaneous fission neutrons from plutonium samples. The random driver measures the sample fissile content by inducing fission events with an external random neutron source and detecting the correlated fission neutrons in coincidence.

The laboratory exercises and the assay equipment used in these courses are revised and updated each year in a manner that reflects the changing interests of the course attendees and the advances in instrumentation technology.

The newest course, Intergrated Safeguards Systems—Concepts and Implementation, was introduced into the training program curriculum during the week of March 21, 1977. The course, conducted by individuals from both the LASL and Sandia Laboratories safeguards programs, presented an overview of real-time dynamic materials accounting and control concepts and the techniques for their incorporation into practical safeguards plants through a series of lectures, demonstrations, and tours of LASL facilities. As an example of the implementation of an automated measurement and accounting system, the DYMAC system currently being installed in the new LASL plutonium facility was

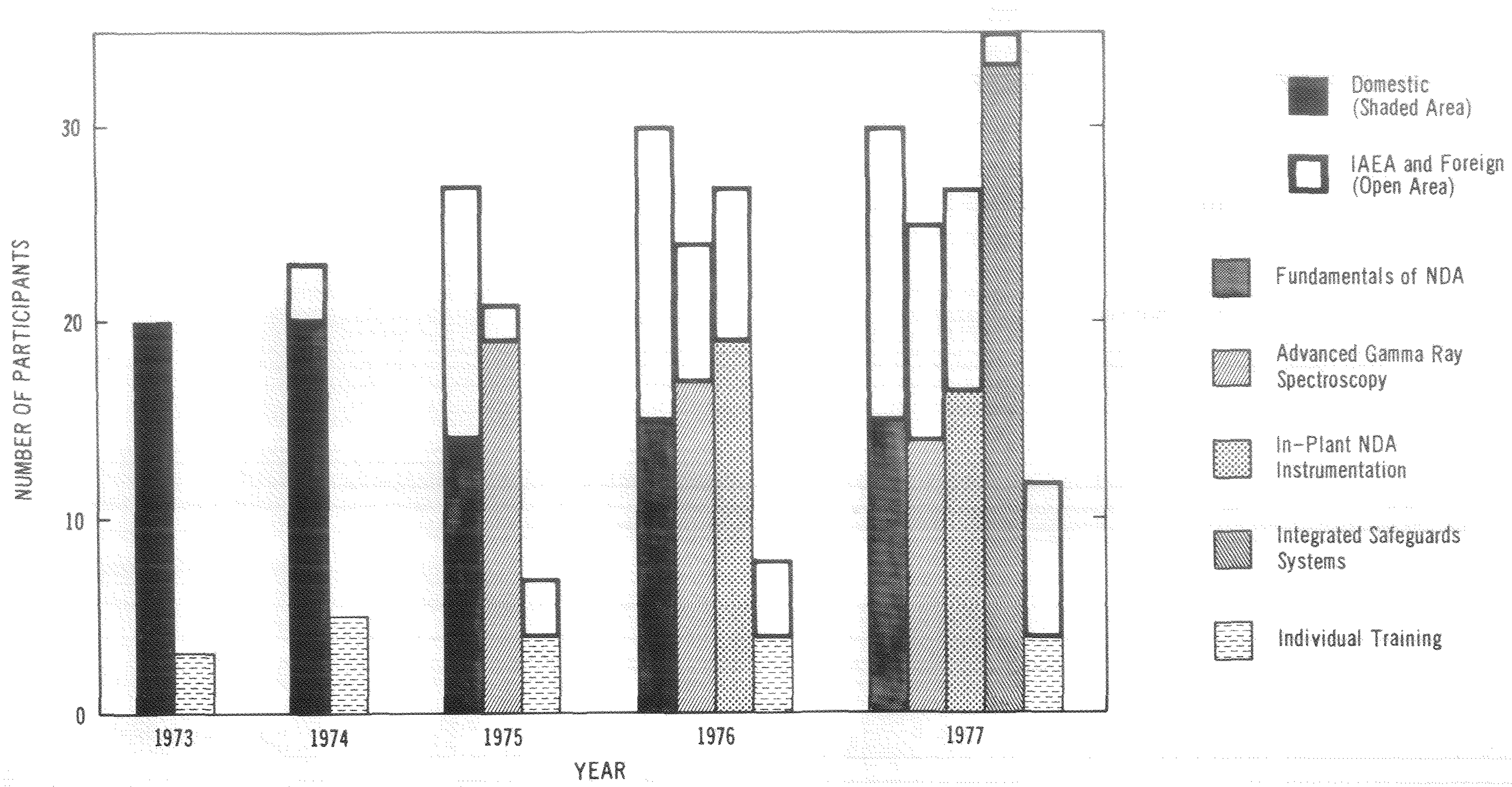

Fig. 1 A histogram of the number of participants in the U.S. ERDA Safeguards Technology Training Program courses (domestic and IAEA-Foreign) vs the calendar year. The enrollment in the three NDA instrumentation courses is limited to thirty by the available facilities. The 1977 Fundamentals and In-Plant NDA enrollment figures are projections.

Fig. 2

TITLE	SPEAKER & AFFILIATION
Integrated Safeguards Systems—An Overview	D. D. Cobb, LASL, Q-4
Conceptual Design of Coordinated Safeguards Systems—An Example	J. P. Shipley, LASL, Q-4
Design and Analysis Methodology for Physical Protection	N. M. Cravens, Sandia Labs
A Review of Available NDA Techniques and Instrumentation	T. R. Canada, LASL, Q-1
Conventional Analytical Chemistry and Nuclear Accountability	E. A. Hakkila, LASL, Q-4
Error Propogation and Measurement Control	W. R. Severe, LASL, Q-3
Material Accountability—Modeling, Simulation, and Evaluation	D. B. Smith, LASL, Q-4
Real-Time Data Base Management Hardware and Software	R. F. Ford, LASL, Q-3
A Review of Available Physical Security Techniques and Equipment	J. D. Williams, Sandia Labs
Perimeter Safeguards and Emergency Search Capabilities	C.N. Henry, LASL, Q-2
Experiences with Real-Time Nuclear Material Control Systems	R. H. Augustson, LASL, Q-3

Fig. 2 A list of the speakers and lecture topics presented during the March 22-24, 1977 Integrated Safeguards Systems course.

described. The broad range of lecture topics, a list of which is given in Fig. 2, included the conceptual design of coordinated safeguards systems, perimeter safeguards and emergency search capabilities, and experience with real-time nuclear material control. Another important topic included in this course was the use of computer modeling and simulation of process flows and measurements to guide the design of safeguards systems for future nuclear facilities, as well as to aid in safeguards performance evaluations of existing facilities.

Figures 3-8 are photographs, taken during each of the four courses, portraying some of the typical training session activities. The participants' interest in learning and exchanging ideas on measurement and control of nuclear materials—their common bond—does not preclude some levity as seen in Fig. 7. Many have attended more than one of the courses, often marking their return with refreshing ideas and practical experience that influence the direction of future courses.

The growth in the scope of the courses offered in the training program and the number of participants attending has been dramatic since the program's inception in 1973 (see Fig. 1). During the past year, 114 individuals, over 25% of whom are foreign nationals employed by either the IAEA or their respective governments, attended the four courses. The continued vitality of this program is ample testimony to its important role in the transfer of safeguards technology to the nuclear community.

Two courses will be offered in the Fall of 1977; the Fundamentals course October 17-21 and the In-Plant NDA Instrumentation course December 5-9, 1977. For further general information, write: DOE Safeguards Technology Training Program, Q-DO/SG, MS 550, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, New Mexico 87545.

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Fig. 3 From the left, E. D. Marshall (ERDA ORO) and Harley Toy (Battelle, Columbus Laboratories) enjoy a little refreshment during a break in the Integrated Safeguards Systems sessions.

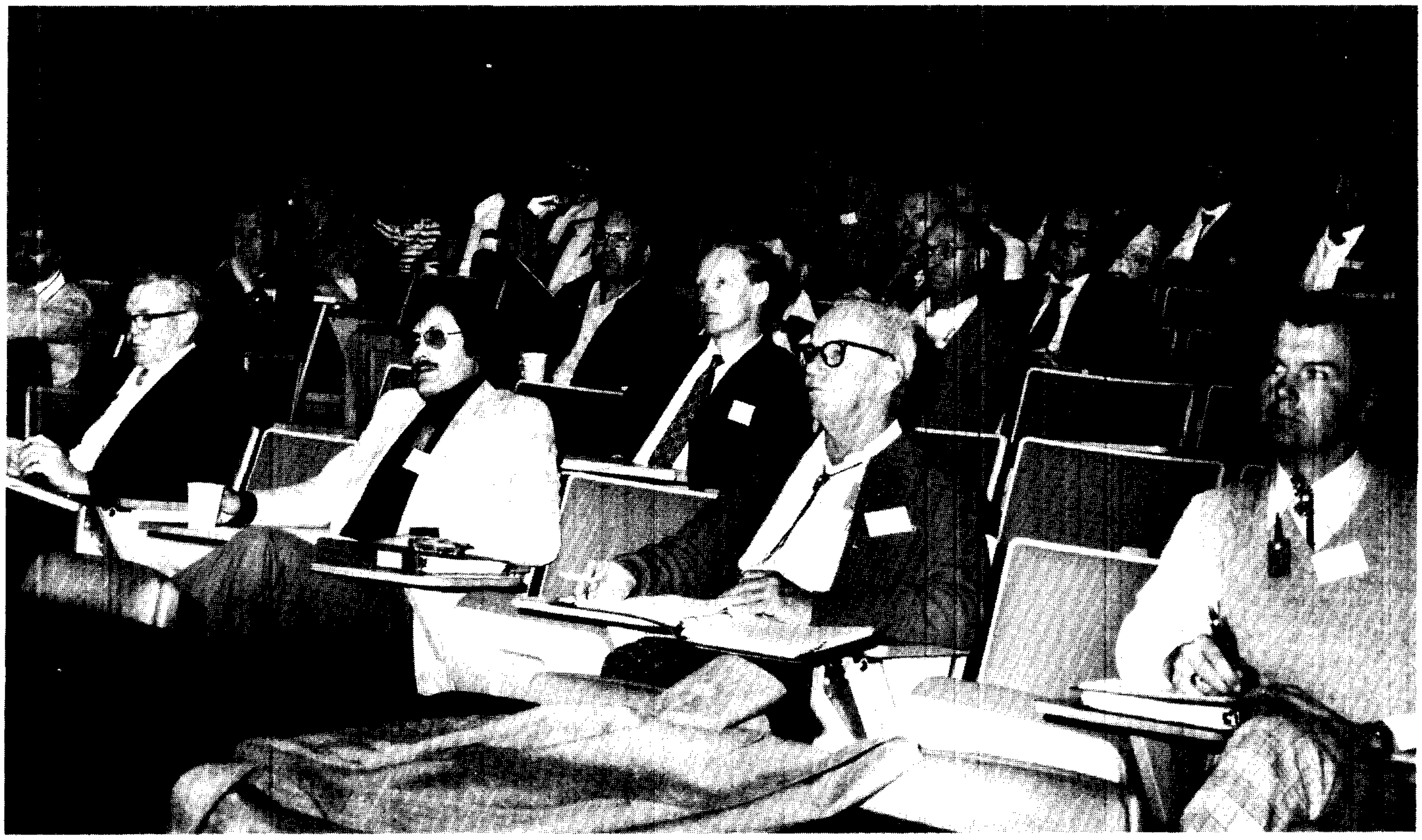

Fig. 4 A partial view of the auditiorium during a session of the Integrated Safeguards Systems course.

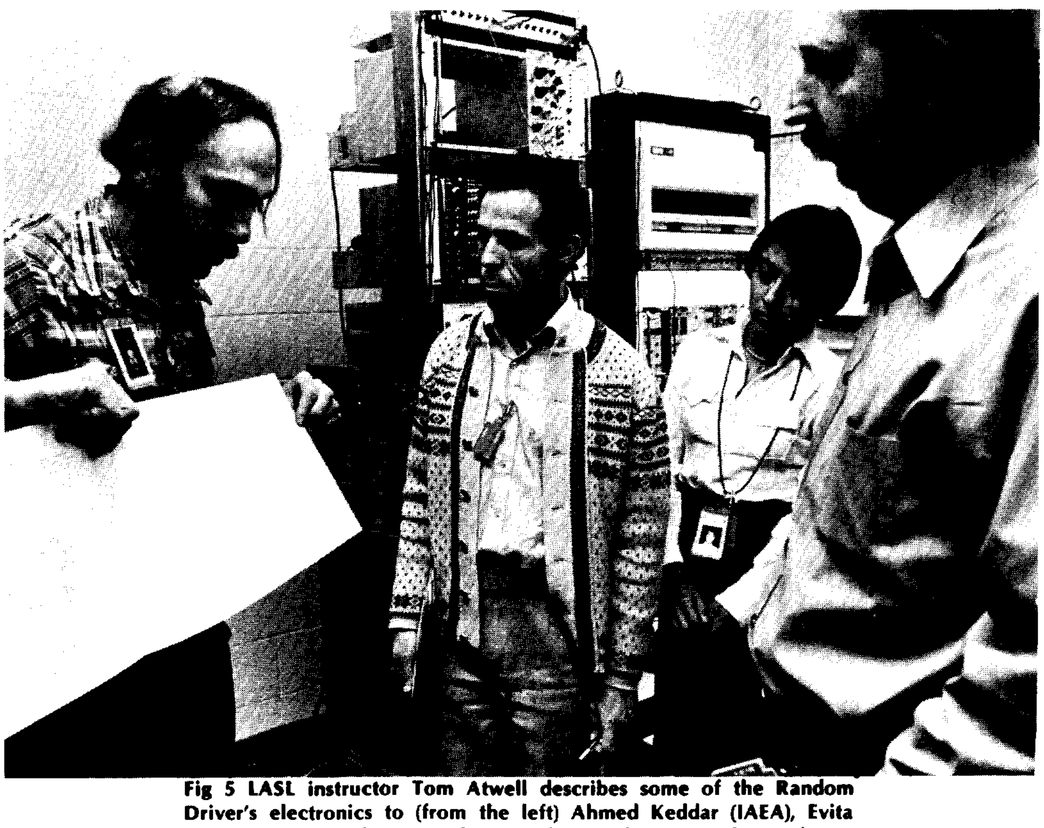

Fig 5 LASL instructor Tom Atwell describes some of the Random Driver's electronics to (from the left) Ahmed Keddar (IAEA), Evita Medina (LASL), and Ron Hawkins (Nuclear Fuel Services) during the In-Plant NDA Instrumentation course (December 6-10, 1976).

Fig. 6 Phil Ting (NRC, Washington, D.C.) talks to the SGS computer during the In-Plant course. Observing are (from the left) Sin-Tao Hsue (LASL instructor), Joe Sapir (LASL), and Cathy Morimoto (ERDA, ALOO).

Fig. 7 The dry wit of LASL instructor Norbert Ensslin (with donut) lightens an Advance Gamma-Ray Spectroscopy (May 2-6, 1977) course coffee break for fellow instructor Mike Baker (right) and two IAEA participants (from the left) Alberto Lumetti and Neil Harms.

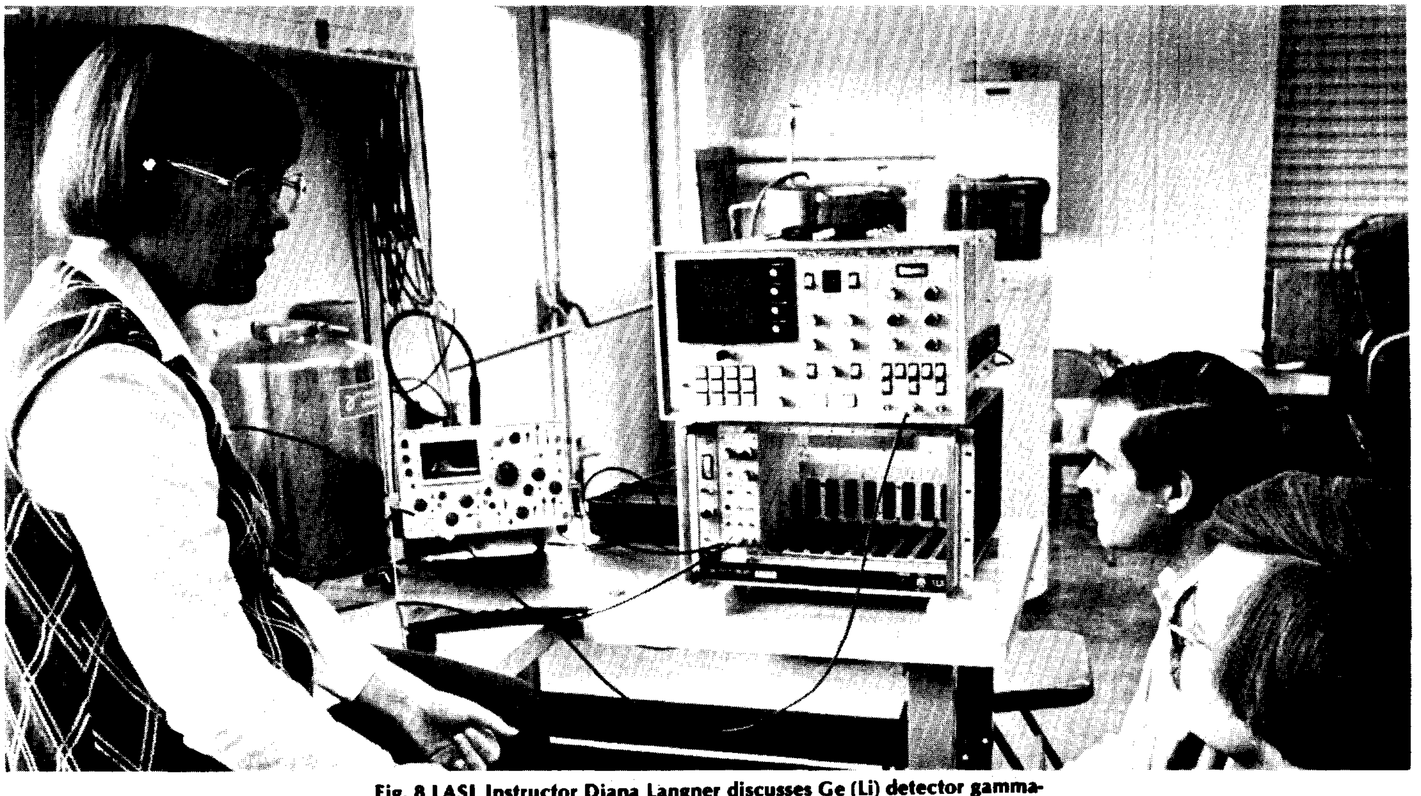

Fig. 8 LASL Instructor Diana Langner discusses Ge (Li) detector gamma-ray spectra with a lab group including Calvin Dellegaard (IAEA) and James Blaylock (NRC, Washingtion, D.C.) during the Fundamentals of NDA course (November 1-5, 1976).

Breeder Reactors

In New York

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ROBERT MacNEIL: Good evening. We nearly didn't get on the air here in New York tonight because of the massive power failure that paralyzed this city for more than twelve hours. It was a sobering reminder of the fragility of our civilization, and how vulnerable it is to technological breakdowns. The blackout was an accident, but there are those who believe mankind is quite capable of deliberately creating technological disaster of far greater magnitude, given the right circumstances. That concern is at the heart of a fight President Carter's now having with the Congress and several European allies. The issue is how to prevent new developments in peaceful uses of nuclear energy from causing a further spread of nuclear weapons. To that end, Mr. Carter wants to stop France and West Germany from selling the new technology to Pakistan and Brazil. They have refused. Mr. Carter discussed the issue with West German Chancellor **Helmut Schmidt** in talks which ended today; they agreed to disagree. Mr. Carter also wants to stop development of the Clinch River Breeder Reactor at Oak Ridge, Tennessee—now Congress is resisting that. So we have the curious spectacle of the President's own Democratic Congress siding with several foreign countries against him. Tonight we examine what Mr. Carter's concerns are and why they seem to be falling on deaf ears. Jim?

JIM LEHRER: Robin, a substance called plutonium is at the core of President Carter's objections to both the Brazilian plant and the Clinch River project. Plutonium is one of those magic products of a technological age that scares some, delights others. In simple terms, it is the man-made by-product of splitting uranium atoms in a nuclear reactor. It can be extracted through reprocessing, as is to be done at the Brazil facility or brought out in a more pure form in a nuclear reactor designed specifically for that purpose. That's the so-called "breeder reactor" 'a la Clinch River. Plutonium is highly radioactive and can be used as a nuclear fuel itself, both for peaceful energy, or for destructive bombs. And it's the emphasis each side puts on those two possibilities that joins the argument. President Carter and others emphasize the explosive possibilities and cite the dangers of plutonium-based nuclear systems. The other side emphasizes the peaceful uses—that plutonium is a virtually inexhaustible source of energy. It's an argument that has both international and domestic fallout and a lot of cross-fertilization back and forth. President Carter has called on all nations, including the Soviet Union, to renounce plutonium as a reactor fuel, and his decision to defer the development of the Clinch River Project was to set the example. This put him at odds with Japan and most of Western Europe,which have already started down the plutonium-making road. But there's a real possibility at this point that Congress won't even let him set that example. Robin?

MacNEIL: So far, the Congress doesn't see things the President's way. On Monday, the Senate voted to keep the Clinch River Project alive, only to delay it one year. In a few days, the House takes up a similar measure which has already passed key tests in committee. The man who often explains the President's nuclear policy to Congress and the world is Dr. **Joseph S. Nye.** A former President of Government at Harvard, Dr. Nye is now Deputy to the Undersecretary of State for Security Assistance, Science and Technology. Dr. Nye, has all this opposition from Congress and our allies softened Mr. Carter's position on plutonium-fueled breeder reactors?

JOSEPH NYE: No, I don't believe that the President has really changed his mind on this. His view is that we have a fundamental dilemma here—a dilemma that we want to go ahead with nuclear energy—we need nuclear energy—but that we have to keep a safe distance between the uses of nuclear energy for commercial purposes and its possible misuse for military purposes. That's really the heart of the President's policy. He wants to avoid getting into a premature use of plutonium until we know how to make it as safe as the kind of nuclear energy we have now.

MacNEIL: Well does the Administration seriously expect—for instance, France and West Germany to abandon the technology in which they're somewhat advanced, and which means so much to them in terms of getting independence from OPEC oil?

NYE: I don't think that we would expect the other countries to abandon this technology. In the larger sense of the word, the image that's sometimes used about the genie being out of the bottle is correct. The question is, are there ways to control it? Or if you want to switch to the horse being out of the barn, are there ways to put a saddle and a bridle on it? What we're hoping to do with these countries is to persuade them to develop this technology at a slower pace, because we think that it can be developed at a slower pace, and in a fashion that can be controlled so that it can't be misused. So I would suspect that many countries will continue with their independent decisions to go ahead. What we're trying to do is to persuade them to go ahead in a safer more careful way at a slower pace.

MacNEIL: As we—as Mr. Carter wants to do here because he is funding some experimental plants. He just objects to the commercial development at the Clinch River plant.

NYE: That's right. I think one of the problems we've had in explaining this policy is that it often gets oversimplified. We have, in fact, in our budget, the Administration's proposed budget, 483 million dollars for breeder reactors. That's a lot of money, in fact, it's more than the European countries are spending. But what we view is that this should be a long-run, carefully-structured base program which will, if we go into a breeder reactor, go into it in a way which is the safest way possible, and that we shouldn't get involved in a commercial competition in a commercial race at this time.

MacNEIL: Hasn't the Senate action, to some extent, undercut the Administration's position? I mean, if that goes ahead, and the House backs it up as some people believe it will, isn't it going to be very difficult to ask other countries **not** to do what our country is in fact going ahead and doing?

NYE: Well, there're grounds for us to make our own decision in any case, but I would say the Senate action was something of a stand-off. The President had recommended a figure of 33 million dollars for the Clinch River breeder reactor as a way of terminating or winding up the project. Some Senators have proposed a figure of 150 million for going ahead and beginning the next stage of work on that reactor and the final vote came out in the range of 70 million dollars which was essentially a way of marking time for a year rather than going in either direction—in that sense, it was something of a compromise. Obviously, it's not a compromise with which the Administration is happy, but it is, I think, essentially what I said, a year's marking time. You read the debate; I think the indication is that the construction won't start during the next year, and the funds won't be used for construction.

MacNEIL: You told a Senate committee recently, I noticed, "We may well enter the plutonium economy someday." If that's a possibility, why abandon its commercial development now?

NYE: Well, our view is that we don't know exactly when we'll be entering into a plutonium economy, and if the timing is a bit further off in the future than is sometimes expected, it may be that there are other alternatives which are superior to plutonium. One possibility is that we may be able to extend the type of nuclear energy we have now using uranium. Another is that we may be able to use thorium, a similar fuel to uranium; there are some differences but you can extend the lifetime of the type of reserves which we have for, some people estimate, a hundred or two hundred years. There are other developments in the area of solar and similar-type energy sources that they may find with twenty, thirty years to work on them. Our feeling is that we should not be rushing into plutonium in an early stage 'cause we have the time to afford to look carefully at these alternatives, and if we find that these alternatives are not there, and that we have to go into plutonium, we should have designed the facilities in such a way that we've gone into it in the safest possible way.

MacNEIL: Thank you, Dr. Nye. Jim?

LEHRER: The House is scheduled to vote on the Clinch River Project in a few days, and one of its champions is Congressman **Mike McCormack**, Democrat from the state of Washington. A former nuclear research scientist, Congressman McCormack represents a district that has an experimental nuclear facility that is widely regarded as the forerunner of the Clinch River Project. The Congressman is a member of the House Committee on Science and Technology as well as the special ad hoc Committee on Energy. Congressman, are we ready to enter a plutonium economy, in your opinon?

Rep. MIKE McCORMACK: We've been in a plutonium economy for about thirty years, Jim. We started mass producing plutonium during the Second World War and were quickly followed by England, France, and Russia, and now by China. We have already produced over three hundred **tons** of plutonium, and it's scattered all over the world in weapons, and in laboratories, and in research facilities, and everyone of our nuclear power plants in the world today is running partially on plutonium that is being produced in these conventional plants during the operation of the reactor. So we're long since **in** a plutonium economy. Now, let me just say as far as the breeder is concerned, we believe that the go/no-go date for commercialization of the breeder in this country is probably about 1990. By that time we must be able to make a decision. Now the Clinch River plant has been advertised as a commercial plant; in reality, it is not. It is an engineering test bed in which we test, first of all, breeding the fuel; second of all, the size of the equipment; third of all, producing energy, which is pretty much a routine operation; it's part of the breeder.

LEHRER: *It has some private money in it though, doesn't it?*

McCORMACK: It has private money to support it, yes, but we would still have to build one more facility to test out whether or not we could actually go commercial; nobody pretends that the Clinch River test is a commercial test.

LEHRER: Do you buy the President's basic argument that plutonium reactors **could** encourage the further spread of nuclear weapons?

McCORMACK: No, I think it's silly. As a matter of fact, every nuclear power plant in this country—every light water plant, every conventional nuclear power plant produces plutonium. The average new nuclear power plant going down the line produces **three times** as much plutonium as the Clinch River plant will produce. And to hint that the Clinch River plant by itself constitutes some kind of unique threat to proliferation is simply not realistic.

LEHRER: Don't want to get too technical, but I think we need to explain that that plutonium has to come out through a reprocessing process.

McCORMACK: Yes, in both cases the formula of the plutonium is exactly the same in a breeder or in a conventional nuclear power plant. You put fuel elements in; you take fuel elements out. The breeder doesn't squeeze metallic plutonium out someplace; you have to take the fuel elements away to a reprocessing plant in either case.

LEHRER: Ummhmm. Well, Secretary Nye used the word "rush" several times in answer to the questions about going into the next stage whether it's Clinch River, whether it's the dealings with the allies or whatever. Do you feel that we're in a "rush" state?

McCORMACK: Well, the President keeps telling us we're having an energy crisis. I've been telling the country this for five or six years now that we're coming into an energy crisis. We're spending 40 billion dollars a year for oil. We have a massive trade deficit—I believe the largest in our history. We're running out of domestic supplies, petroleum and natural gas in which our entire economic stability, our employment, our national strength, everything depends. I think it **is** a crisis, and I think we **must** get to new sources of energy as quickly as we can. If we do everything that we can, and in every form of energy—oil, gas, coal, all the exotic techniques/technologies such as solar energy, geothermal energy, and nuclear energy, and are spectacularly successful in our conservation programs, we'll still have a very difficult time closing the gap between supply and demand for energy, upon which our entire Western industrialized civilization depends. So the breeder is an essential part, but our target date is still being able to commercialize by 1990, and that means going ahead with our engineering demonstration programs now.

LEHRER: Does the compromise approval—call it whatever we want—by the Senate and now the possibility of the same thing happening in the House—does that represent Congress telling the President that they think he's dead wrong on this?

McCORMACK: No question about it. I disagree with Mr. Nye's perspective on this, that it was a stand-off. It was a clear repudiation of the Administration's position. The 33 million dollars the Administration wanted had one purpose and one purpose only, and that was to close down the Clinch River plant—totally close it down and stop it. The 75 million was to continue the ongoing project, but not start construction for a year.

LEHRER: All right. Thank you, Congressman. Another Congressional expert on nuclear proliferation problems is **Jerry Levinson**; he is the Council and Staff Director of the Subcommittee on Foreign Economic Policy which has been in the center of study in the breeder reactor question in relation to our allies. He's sitting in tonight on behalf of Senator **Frank Church**, Democrat of Idaho, the man who engineered that Clinch River Bill in the Senate. Mr. Levinson, how should our allies read what Congress is doing to the President on the breeder reactor?

JEROME LEVINSON: I think they should read it as essentially being consistent with what the Administration has itself sought to achieve with the allies. That is to say, as we understand it, the Administration has sought to convince the Europeans and the Japanese to enter into a study of the international fuel cycle. The Europeans and the Japanese have set three conditions for going ahead with that study. First, that it be completely open-minded with respect to all aspects of the nuclear cycle, specifically including the breeder and plutonium; second, that ongoing programs not be delayed or stopped during the time of the study. That the study, in other words, not be used as an excuse to set aside the ongoing programs dealing with the breeder or anything else; and three, that each country is free to choose its own route once the study is over and is not bound by any majority vote. So what the Senate has essentially done is to say that consistent with what you've agreed with the Europeans are to be the terms of reference for this study, we are not foreclosing the breeder option, we are keeping it open, which is precisely what the Administration has agreed with the Europeans should be the terms of reference for the study.

LEHRER: Well then, it's not then accurate to interpret the Senate's action and possibly the House action as literally pulling the rug out from under the President on this that he's been saying, his promise that we will set the example by Clinch River, etc.

LEVINSON: Well, I think that the problem arises because there is, I think, a confusion as to what has been and what is the Administration's position. I was interested to hear Mr. Nye's articulation tonight. For instance, in reading a recent **New York Times** editorial, it says that the Administration is seeking through bilateral negotiations and an international review to discourage the use of plutonium by other nations. Now, it's my understanding, and I think it's Senator Church's understanding, as well, that the Administration has **agreed** with the Europeans—that that is **not** the purpose: to discourage the use of plutonium through these international studies, but it's to be open-minded with respect to plutonium as well as any other cycle. So I think that what the Senate has done is perfectly consistent with what Mr. Nye has articulated tonight is the Administration's policy, but the Administration's policy has been **represented** to be discouraging other nations from pursuing the plutonium. Now the Europeans **specifically** rejected the first terms of reference proposed by the U.S. for the study because they felt it was biased against the plutonium breeder. So if you characterize the Administration's policy as an open-minded review, I think it's perfectly consistent. If you characterize the Administration's position as an attempt to persuade others to forego the plutonium cycle, then of course, there's a difference.

LEHRER: Well, hasn't that been the Administration's position? I mean, Mr. Nye just said so again. I mean, the policy has been to persuade nations to forego the use of plutonium. Right? Is there any question about that?

LEVINSON: Well, I think you just said that that is not the policy. The policy is possibly to persuade them to slow down but I think . . .

LEHRER: Oh, slow down, right.

LEVINSON: Well, I think if that's the case, it misreads the urgency the Europeans and the Japanese feel and I think that what you have to try and do is see the problem as they see the problem. For them, afterall, they are 90 per cent dependent upon imported oil—Japan and France, for example. Where does that oil come from? Primarily from the Middle East, from the Persian Gulf, Saudi Arabia and Iran. Who controls that oil? Not only Saudi Arabia, but it's marketed through four American oil companies: Exxon, Texaco, Mobil, and Socal in the case of Saudia Arabia. What we are in effect saying to them is that you should leave yourself dependent upon the OPEC cartel and the American companies that market the Saudia oil; additionally, leave yourself dependent upon the United States, Canada, and Australia for enriched uranium. So, in effect, what we're saying to the Europeans and to the Japanese is continue your dependence upon one depletable resource, uranium; substitute one depletable resource uranium for another depletable resource, oil; continue your dependence upon external sources. Of course for them, that's an intolerable situation, so they are going as fast as they can to achieve some measure of limited independence, and what they see is that the breeder is the faster route to that limited degree of independence that they can achieve.

LEHRER: Mr. Levinson, thank you. Robin?

MacNEIL: Yes, let's pursue this. Dr. Nye, how do you respond to this? Is our position open-minded, or are we still trying to discourage the development of plutonium breeder reactors?

NYE: It doesn't have to be an either/or. I think the position is open-minded in the sense that we believe that these issues deserve proper study, that they deserve scientific study, that we're trying to get technical experts together. The President has called as the centerpiece of his approach on this internationally, has called for an international nuclear fuel cycle evaluation, getting thirty countries who approached us to work together to see how you can make the next generation of nuclear energy as safe as the current generation of nuclear energy.

MacNEIL: Let me put a little scenario to you and ask you whether it's right. The President came in in April and said, "We want to stop plutonium ourselves. We'd like to get the others to stop it, too." The only conditions he could get them to agree to this study of things was if it were open-minded. And now he has to say it's open-minded. Is there not some truth in that scenario?

NYE: Well, I think from my view, it's been open-minded from the start. My view is that if you're going to have a serious study, if you're going to have other countries take it seriously, you're going to have to look at their alternatives.

MacNEIL: Sure.

NYE: It's also true that we are trying to discourage, but there's a difference between discouraging persuasion, and discouraging through coercion, as a number of people in the Congress have suggested, not those who are here tonight, but there are others.

MacNEIL: Well, if it's open-minded, why are we prejudging it by stopping the Clinch River development ourselves? Why are we saying, in effect, we've made up our own minds if this is an open-minded study?

NYE: I think the answer to that is because we believe that the Clinch River project specifically is not one that we need nationally as a country. **Jim Schlesinger,** the President's Energy Advisor has testified to this, as has **Robert Fri,** the head of our Energy Research and Development Administration. The point is that we do believe that we should have a breeder reactor program. We are going ahead, as I said, with a larger breeder reactor program than the European countries are. But the view that we have is that the Clinch River breeder reactor was designed to show or to lead ERDA, the Energy Research and Development Administration to be able to reach a decision on commercialization by 1986 for date of commercialization in the mid-nineties, as Mr. McCormack said. Our view is that that date is too early; we don't need that for our own national energy needs, and at the same time that we believe that others may not need it either, there are other alternatives that we think ought to be investigated. There are ways of extending the life of the kind of reactors we have now which use uranium—eg. improving the burn-up of uranium in those reactors.

MacNEIL: For us, because we have lots of uranium.

NYE: For us, but also the same technology will work for others. We're also trying to investigate ways to increase fuel assurances for countries and uranium supply. Investigate that in this international evaluation program and see just how much resources there are there—what technology can extend those resources—what are the possibilities for so-called advanced converter reactors which could be visualized as a generation of technology in between the kind we have now and the breeder reactor which could buy you something in the range of a hundred years by some estimates.

MacNEIL: I see.

NYE: Radkowsky, who was the reactor engineer for the Naval reactor program, for example, suggested that thorium reactors, advanced convertors in thorium, could buy us a hundred or two hundred years. Now this is just one example, it may not turn out. But the point is in the evaluation which we're trying to carry out with other countries, we think we ought to look seriously on what are the reserves of uranium, of thorium; what are the engineering devices that can be used in the relation to the kinds of reactors we have now to stretch out their lifetime, and that there is enough time for us to do this.

MacNEIL: Congressman McCormack, how do you view the Administration position now after this explanation?

McCORMACK: Well, I must say that I disagree with much that Mr. Nye has said. I believe it's very significantly its rationalization for a pre-considered position. That position, which nobody's able to understand who really is involved in this question overseas or in any foreign country or in the United States is why we should stop our program now. It's one thing to say we have a breeder program and how we're spending a lot of money on it, and this is true on the basic program, the basic research and development. The point is that we've been on this program for twenty years now, and the program has taken us to a point now of undertaking these demonstration plants to understand the engineering that must be undertaken, and must be understood before we can commercialize. And to say we have a program but not be able to undertake this engineering, and have a program that will not get us where we have to be when we have to be there doesn't really constitute a program at all. And for one to say that perhaps we can go to a thorium cycle or something else is simply to try to confuse the issue. The fact is the thorium cycle requires a breeder; a thorium program **is** a breeder. Thorium is not fissile material, we have to breed it into a fissile material, and we have to reprocess it, and there is uranium present in all cases and plutonium is produced in all cases. So this is just a smokescreen. The fact is that the thorium program is a breeder program, and the thorium program produces plutonium. So any safeguards that would work for the thorium program would also work for the uranium-plutonium program that we already have so near—fifteen years away from the viability for commercialization.

MacNEIL: Well, let's pursue that safeguards angle. Jim?

LEHRER: Yeah, let's talk about safeguards. That's really one of the real knots of the problem from your-standpoint, is it not, Secretary Nye? So my question is this: are the safeguards now in place able to prevent the use of plutonium being converted into possible destructive purposes?

NYE: We think the safeguards that exist now work fine for the kinds of reactors that we have now. Mike McCormack is right when he says plutonium has existed since 1945, but it's locked up in spent fuel rods from the kinds of reactors we have now, along with a lot of very radioactive materials. It's less than one per cent of the spent fuel that comes out, and this comes out in such a radioactive form that you need heavy shielding to be able to handle it for up to a hundred years after you take it out of the reactor. So that plutonium exists, but it's pretty well locked up in a safe form unless you reprocess it. Now when you reprocess it, when you take it out in pure form, then it is accessible to being made into a bomb. Now the key aspect of safeguards—they're like a burglar alarm; they have to ring with enough time to do something about it, to get your diplomacy in shape to do something about it. Now with plutonium as compared to the spent fuel from uranium, that burglar alarm may go off with the inspectors going into a plant and saying, "Hey, they stole something," or "This stuff's missing," but it doesn't go off with enough time between when they give the notice and when you can do something about it before they've been able to make it into an explosion. So the key point is that we have to find ways to keep the same distance in terms of time, invisibility, and costliness between the commercial uses of the fissile material, whether it be uranium or plutonium, and its military misuse. That's what we're trying to get at.

LEHRER: Mr. Levinson, how do you feel about the safeguards for plutonium? I mean, are they adequate?

LEVINSON: Well, I think that everyone agrees that you're going to have to evolve a system of safeguards. What Senator Church has suggested is that you've got an institutional structure which is in place, that is to say, the International Atomic Energy Agency, and there are Nuclear Proliferation Treaty Committments on the part of the participants . . .

LEHRER: That's part of the U.N., right?

LEVINSON: Yes.

LEHRER: Right.

LEVINSON: And that we should build upon this. We have a London Suppliers Club, which is the major suppliers of nuclear materials which have met and have agreed among themselves on guidelines through which they will or will not sell advanced technology, what's called the sensitive technologies, to other countries without implementing very stringent safeguards. The Germans argue that the safeguards that have been agreed with the Brazilians are the most stringent that have ever been placed anywhere. Whether or not they're adequate by themselves is not clear, but what Senator Church and Congressman McCormack have been trying to emphasize is let's build upon this structure, go forward with it because—but recognize the reality that these countries which are so energy-import dependent are going to go ahead, and not delude ourselves that they're going to abandon their existing energy programs.

LEHRER: Thirty seconds. Congressman, do you feel the safeguards are adequate? Are you not concerned about that?

McCORMACK: There's no threat of nuclear weapons from a breeder program that doesn't already exist from our light-water reactors. What I have been trying to persuade the President to establish is control over reprocessing. The rest of the nations of the world want to establish an international program for control over reprocessing. That's where the only threat of proliferation exists—not in the breeder reactors, not in the light-water conventional reactors, but in the reprocessing plants. And we can have about six of those around the world under control of IAEA, and this is what we're trying to do.

LEHRER: We're in control of time. Thank you. Robin?

MacNEIL: Thank you all very much. Good night, Jim.

LEHRER: Good night, Robin.

MacNEIL: That's all for tonight. For tomorrow night, we're watching several stories, including the New York power disaster, the North Korean killing of three Americans by shooting down their helicopter, and Mr. Carter's plans to reorganize the executive branch of government. I'm Robert MacNeil, good night.

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Editor's Note: Vol, 1, No. 3, Vol. II, No. 3, Vol. III, No. 3, Vol. IV, No. 3, and Vol. V, 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.

Manufacturing Journal Available

Fuel shortages, labor costs, scrap losses, hazardous materiel, worker safety, new inventions, and easier fabrication are only some of the many manufacturing topics treated by a new Army publication, the U.S. Army ManTech Journal. Information on new Army batch production techniques to surmount problems related to such topics is now available to the general public thru this comprehensive new magazine.

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