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1958-1978

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INMM

NUCLEAR MATERIALS MANAGEMENT

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EDITORIAL

Focus Too Narrow, Goal Too Grand

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

In the good old days nuclear matters were relatively simple to comprehend. Nuclear policies, managed by the AEC and the Joint Congressional Committee, were based on the assumption that nuclear power was important, including the development of breeders, and that problems of reactor safety and disposal of radioactive wastes would be resolved by the continuing R&D, and with experience. The subject of proliferation was also being dealt with, as necessary, through the Atoms for Peace proposal, the IAEA, the nuclear Non-Proliferation Treaty, and other international arrangements.

It is not that policies are changing more frequently, but that all past assumptions and programs are being called into question. Thus the issues raised by nuclear opponents regarding reactor safety and waste disposal focus public attention on problems which nuclear experts had recognized and had been working on. To some degree, AEC programs were less vigorous than they might have been. But also, arriving at a consensus as to what degree of assurance is acceptable is proving to be very difficult with everyone participating.

That proliferation of nuclear weapons might have serious consequences was recognized from the beginning. The Baruch proposals were for a world with no nuclear weapons, and with nuclear energy development under the tight control of an International Atomic Energy Authority. It was not possible to achieve agreement on that drastic proposal. Even had there been agreement, there is considerable doubt whether such an enterprise could have succeeded for long. Anyway, there are now five major nuclear-weapon powers, and The Baruch-Lilienthal proposals are no longer viable.

The U.S. took the initiative in the Atoms-for-Peace proposal of 1953, in the Atoms-for-Peace Conference of 1955, and in proposing and supporting the IAEA. Ireland should get credit for proposing the nuclear Non-Proliferation Treaty (in 1959). After six years, the U.S. adopted the proposal, with strong support from the USSR and the UK. It took some time to persuade the non-nuclear weapon powers that ratifying the NPT and accepting IAEA safeguards was in their best interests, but eventually that came about.

(Continued on Page 17)

Dr. Higinbotham

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INMM Expanding Professional Activities, Services

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

As you are probably already aware, the Institute is expanding its professional activities, functions, and services in the area of nuclear materials management and safeguards on both the domestic and international levels.

With regard to International Safeguards, there is today a widespread awareness and appreciation of the global nature of safeguards and nonproliferation issues — as well as the obvious corollary that such complex international problems are simply not tractable, let alone soluble, through isolated or unilateral action by individual nations. The vital importance of international cooperation, exchange, and mutual understanding has been repeatedly underscored — most recently at the Pacific Basin International Fuel Cycle Conference held in Tokyo, September 25-29, 1978, and the IAEA Symposium on Nuclear Materials Safeguards held in Vienna, October 2-6, 1978. At the Tokyo and Vienna conferences as well as meetings with the Japan Chapter of the INMM and with Japanese colleagues in various nuclear installations and Universities in Japan, it seemed abundantly clear that today's mounting requirements for high-technology safeguards and materials control systems (requirements in terms of both human and financial resources) will, of necessity, require closer international cooperation and increased technical exchange. And this need will be especially great in the development and implementation of advanced safeguards systems for the large, high-throughput fuel cycle facilities of the future. One such area requiring considerable technical development and close international cooperatin is in measurement standards (both consensus and physical standards) as well as calibration and measurement control procedures that will be workable and effective, and at the same time have minimum interference with plant efficiency and productivity.

The Institute is vitally concerned with the issues, the problems, and the practical implementation of effective international (IAEA) safeguards — as well as our own national safeguards system, which together with other state systems, must eventually comprise the essential "building blocks" of an effective international safeguards system. Clearly, the application of IAEA safeguards under the terms of the Nonproliferation Treaty will have considerable impact on the nuclear industry in the United States, as well as elsewhere. The Institute believes that as smooth and rapid a transition as possible to the new IAEA safeguards requirements is in the best overall interest of the nuclear energy option. We further believe that every effort must be made to minimize the associated cost and inconvenience to facility operators as well as intrusion into plant operations and productivity. To address these problems and concerns, and to provide understanding and valuable insight to plant operators, government and corporate management, the Institute is holding a Work-shop on the Impact of IAEA Safeguards on December 7 and 8, 1978 in Washington, DC. The Workshop Committee, headed by **Russ Weber** of NUSAC, has assembled a group of eminently-qualified individuals who have had direct practical experience with IAEA Safeguards. With U.S. Senate ratification of the NPT expected in early 1979, this INMM information meeting will provide an extremely timely and valuable service to INMM members and the nuclear community generally.

Another instance of our expanding professional activities is the Institute's co-sponsorship of the ANS/INMM/NBS Topical Meeting on "Measurement Technology for Safeguards and Material Control" to be held November 27-30, 1979 at Kiawah Island, South Carolina. The program, speakers, and arrangements for this Topical Meeting are now being firmed up and this, too, promises to be a very significant activity in the vital area of safeguards measurement technology — both destructive and nondestructive assay.

Let me turn now to the Membership Interest Questionnaire that an impressive number of you have completed and returned (some 200 by early September). First, let me thank you on behalf of all of us in Institute management, not only for the magnitude of the response, but also for the extremely heartening overall vote of confidence that

Dr. Keepin

INMM News Coverage

Nuclear Peril

It's 'Negligible' Compared To All Other Risks

Nuclear Conference Begins In Cincinnati

CINCINNATI (UPI) – Riding a tide of anti-nuclear power protests, some 400 professionals from more than a half-dozen countries began gathering in Cincinnati today for discussions of the controversial energy source.

Nuclear safeguards...

Nucler energy 'negligible' risk

CINCINNATI (UPI) – Nuclear danger is "negligible" compared with other risks in life today, says the incoming chairman of a nuclear energy safeguards group.

Routine life deadlier than nuclear plants scientist maintains

CINCINNATI (AP) – Normal daily activity is more dangerous to...

Nuclear Fears Unfounded Safety Expert Claims

Nuclear Risk 'Negligible'

Nuclear Danger's Seen 'Negligible'

Cincinnati Hosts Nuclear Talks

CINCINNATI (UPI) – Riding a tide of anti-nuclear power protests, some 400 professionals from more than a half-dozen countries began gathering in Cincinnati today for discussions of the controversial energy source.

Nuclear safeguards, nonproliferation and international nuclear trade headed the topics list for members of the 20-year-old Institute of Nuclear Materials Management.

In a four-day annual meeting, professionals from the United States, Canada, England, Europe, Japan, the Middle East and South Africa are to discuss themes including "Safeguards and Nonproliferation" and "Nuclear Power – The Imperatives Here and Now."

Institute spokesman G. Robert Keepin said the session provides a forum for "timely review and updating of national and international policy, programs, and technical progress in nuclear materials management and physical security."

It also follows in the wake of anti-nuclear power demonstrations scheduled in at least 14 states last weekend. A throng estimated at more than 6,000 collected near the...

"In this technological age, there is always anything that we do, there is always some background of ambient danger and threat to our life. That's just part of living in a technological society in which we live," said Keepin.

DANGER OVERBLOWN

Nuclear Safety Expert Doubts Terrorists Will Make Bombs

By ANDY LIPPMAN
Associated Press Writer

CINCINNATI (AP) – Fears that terrorists may someday use nuclear materials are unfounded, a nuclear safety expert contends.

"The danger of clandestine bombs and the sensational side is much overblown," said G. Robert Keepin, incoming chairman of the Institute of Nuclear Materials Management, which began its annual conference here Tuesday.

"I feel the controls, the security and the safeguards we have in place are stringent enough to assure a high level of assurance against the real possibility of this being an appreciable threat."

Keepin, director of nuclear safeguards programs at the Los Alamos, N.M. Scientific Laboratory, added in an interview Tuesday, "that it isn't as easy to make a bomb as some sensationalists would like you to believe."

"The materials are very difficult to come by," he said.

The danger of an accident resulting from operation of a nuclear reactor "can essentially be ignored" in comparison with other threats of daily life, he said.

"In this technological age, almost anything that we do, there is always some background of ambient danger and threat to our life. That's just part of living in a technological society in which we live," said Keepin.

"If you measure nuclear against the background of the natural risks that you take every day, and the danger from nuclear is absolutely infinitesimal."

As for the touchy issue of storing nuclear wastes, Keepin said "All the waste from nuclear power plants between now and the year 2000 can be stored, properly managed, in a cube 250 feet on a side."

"Now surely in this country we can find geologically isolated locations where that kind of quantity of material can be stored."

Asked why solar energy couldn't replace the need for nuclear energy, Keepin said that while solar energy could do things like heat homes, it was not technically or economically feasible for it supply the large amount of energy needed for cities and factories.

Keepin, 54, director of nuclear safeguards at the Los Alamos, N.M., Scientific Laboratory.

it clearly conveyed. A full report on the results of this "omnibus" questionnaire (including tabulated data plus an analysis of written responses and many excellent suggestions) has been prepared by **Dennis Wilson**. Dennis' report is presented, on behalf of the INMM Executive Committee, elsewhere in this issue and I would not want to steal his thunder. Since we have indicated, however, that direct membership input, as expressed in the questionnaire, would be used for future INMM planning, I want to take up one important topic that bears both on Institute Administration (Item VII in the questionnaire) and on membership participation in Institute activities (Item III in the Questionnaire). There have been recurrent suggestions from various Institute members that our effectiveness as a professional organization could be increased if there were a greater degree of distinction between Institute administrative and technical affiars.

In this same vein, a recent ad-hoc committee on evaluation of Institute management has recommended that as a part of our INMM working organization we form Technical Working Groups, or Committees, that could more directly and effectively represent major pro-

East and West meet in Cincinnati. Bob and Madge Keepin, Yoshio and Toyono Kawashima enjoy themselves at the INMM Reception.

NUCLEONICS WEEK COVERAGE — Lynn Stevens of McGraw-Hill Publications, Chicago, covered the INMM convention for Nucleonics Week. Nate Hurt (left) of Goodyear Atomic Corporation and Warren Donnelly (right) of Congressional Research Service were among the speakers Lynn interviewed during the meeting.

fessional/technical interest areas, as for example:

- Accountancy and Materials Management
- Measurement, Calibration, and SNM Control Systems
- Systems Studies, Statistical Analyses and Evaluations
- Physical Protection and Transportation Safeguards
- International Safeguards: Inspection, Verification, Policy etc.

The Chairman of each Technical Working Group would designate his group members from among those who indicate an interest in actively working and serving in that area. This would provide a mechanism not only for increased member participation but also for better representation of specific interest areas in Institute activities such as meeting planning; Institute-sponsored technical studies, reviews, and special projects; regular "newsletter" columns in the INMM Journal updating relevant new developments in each interest area; participation in the review of technical papers for INMM meetings, etc. Such an innovation would clearly enhance the Institute's professional character, and enable better external communication and more effective INMM interactions on Technical matters throughout the nuclear community.

The INMM Officers and Executive Committee are in concurrence that improvement along these lines is indeed important, and we would hope to have this general concept implemented, in one form or another, well before our next annual meeting; thus, for example, the membership would have an opportunity to meet and talk with the Technical Working Group chairmen at our 20th Annual Meeting in Albuquerque, July 16-19, 1979. In the meantime we solicit (as always) your comments and suggestions on this, or any, Institute matter.

Finally, and most importantly, we extend a warm welcome to our newly appointed standing committee chairmen: **Dennis Bishop** - N-15 Standards; **Roy Cardwell** - Nominating; **John Jaech** - Program; **Sam McDowell** - Awards; **Herman Miller** - Public Information; **Joe Stiegler** - Meeting Arrangements; and **Syl Suda** - Safeguards. Based on the clear mandate in the membership's collective response to the questionnaire, our Public Information Committee now under Herman Miller's very able leadership, will be mounting a determined effort to do a better job in the area of public information, with support as appropriate from the industry.

The newly-established Meeting Arrangements Committee, under Joe Stiegler, is intended to provide the Institute with a standing organization capable of handling the logistics and all non-Program aspects of INMM meetings (Annual Meetings, Topical Meetings, etc). This committee will include a minimum of four subcommittees as follows: (1) Local Arrangements — **Roy Crouch**, Chairman for Albuquerque Meeting, (2) Communications and Publicity — **Tom Gerdis**, Chairman, (3) Registration — **Duane Dunn**, Chairman, and (4) Exhibits and Displays — **John Glancy**, Chairman. This arrangement should have several advantages, including year-to-year continuity, clearer delegation of responsibility/authority areas, increased efficiency, and overall effectiveness in meeting management.

A complete listing of current INMM Standing Committee Chairmen is given below:

Awards:	S. C. T. McDowell, DOE/SS
Certification:	F. Forscher, EMC
Education:	H. L. Toy, BCL
Journal-Technical Ed.:	W. A. Higinbotham, BNL
Journal-Managing Ed:	T. A. Gerdis, KSU
Meeting Arrangements:	J. E. Stiegler, SLA
Local Arrangements:	Roy Crouch, DOE/ALOO (Alb. Mtg.)
Communications, Publicity:	Tom Gerdis, KSU
Registration:	Duane Dunn, RIRF
Exhibits and Displays:	John Glancy, SAI
Membership:	J. W. Lee, Consultant
N-15 Standards:	D. M. Bishop, GE
N-15 Secretary:	D. W. Zeff, B & W
Nominating:	R. G. Cardwell, ORNL
Program:	J. L. Jaech, EXXON
Public Information:	H. Miller, NNC
Safeguards:	S. C. Suda, BNL
Site Selection	R. E. Lang, CHOO

To each of these gentlemen, we extend our congratulations and best wishes for a successful and productive year ahead in the advancement of our Institute and the profession of Nuclear Materials Management generally.

Panelists at the Wednesday afternoon panel discussion (from left) were Herman Dieckamp, President, General Public Utilities; Myron B. Kratzer, Senior Consultant, International Energy Associates, Ltd.; Richard L. Williamson, Jr., U.S. Arms Control and Disarmament Agency; and Dr. Leonard Weiss, Staff Director, Subcommittee on Energy, Nuclear Proliferation Planning, and Federal Services, and for Senate Committee on Governmental Affairs, Washington, D.C.

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Membership Interest In INMM Is High

By Dennis W. Wilson
San Jose, California

About a year ago at an Institute Executive Committee meeting, plans were being made for activities associated with the Institute's twentieth anniversary year. The discussion included the acknowledgement that materials management has come a long way in the past twenty years. The questions that followed flowed readily: Had the Institute maintained its pace with the changes? Had the goals and objectives of the Institute remained valid? Were the needs of the members being met? Was the leadership responsive to the membership? The Executive Committee had its own opinion; but in order to prepare for the coming decade, it was decided to ask members for direction and sustaining of goals and interests.

A rather comprehensive member questionnaire was devised and Institute leadership hoped to receive guidance and direction from a large segment of the membership. Input was specifically requested in areas of member interest and participation, Institute direction, finances, the Journal, the annual meeting, and administration. The questionnaire was distributed in person to members attending the 19th Annual Meeting in Cincinnati, and it was mailed to other members shortly thereafter.

Response to the questionnaire exceeded expectations in that a full third of the membership participated. Assuming there respondents are representative of the Institute as a whole, much was learned about attitudes of the membership. In some areas the response was expected; in others some surprising things were learned. These responses will help Institute leadership formulate future direction, and Institute membership will see results very soon in the form of changed programs and new direction is some areas along with the continuation of many past practices.

In general, the membership believes the Institute is on the right course with correct goals and objectives, and the leadership received a vote of confidence. However, numerous excellent suggestions were received to improve communication and increase participation. A summary of the detailed questionnaire follows.

Membership/Participation

The growth of the Institute is evidenced by the indications that most members (60%) have been in the Institute less than five years. Stability is also shown in the 25% who have been members longer than ten years. The main reasons for belonging to INMM are to keep current in a field of expertise (78%) and to maintain safeguards contacts (76%). Nearly nine out of ten believe the Institute is meeting their needs and interests.

With respect to participation, a clear majority (84%) feels Institute activities can assist in meeting their professional goals, and most (77%) feel there has been sufficient opportunity to participate. However, only about half (53%) actually desire to participate in any active Institute position (committee member, committee chairman, or executive committee member). While a minority (25%) needs employer support for membership, a majority (52%) requires employer support for participation.

There appears to be some uncertainty over what Institute participation can entail. For example, while most members (over 75%) recognize the purpose of ANSI, annual meeting, membership, and safeguards committees, only about half are conversant with the activities of the annual meeting site selection, awards committees. (Just for fun, we included a non-existent "employment committee" on the list, and over one in ten claim to recognize this as a functioning committee. This result only goes to show that horses can't fly—except sometimes!)

Institute Direction

A favorable majority (89%) supports the current Institute purposes as stated in the constitution and believes them still to be valid in today's environment, although a smaller number (81%) feel these objectives are actually being met. The Institute receives credit for doing at least an adequate job in the areas of standards (92%), technical information (89%), and education (73%). However, the frustration of today's nuclear environment is evidenced in the feeling of the majority (63%) that we are doing a poor job in public information.

Notwithstanding the general support of the current efforts, a significant number (39%) believe we should make some changes in direction to accommodate the changing safeguards environment. As if to sound a trump of warning, a surprising number (27%) already feel the Institute is **not** recognized as **the** professional voice in the field of nuclear materials management.

(Continued on Page 62)

Mr. Wilson

Plans for Albuquerque

By G.F. Molen and John L. Jaech
In Order of Presentation Below

When called upon to write the Vice-Chairman's Report for this issue of the Journal, I have to admit that I was mildly shocked. After many active years in the Institute, I find it difficult to accept that I am the Vice-Chairman. It is a humbling experience.

As a result of this humbling influence, I am taking a fresh look at what I've been doing as one of the Institute's leaders. A quick glance at **John Jaech's** Program Committee Report or Dennis Wilson's article on the results of the Members' Interests Questionnaire will show the Institute is a viable, dynamic organization and that its leadership is open to change.

We learned a lot from our meeting in Cincinnati. By many measures of progress, the meeting was a success; but, by some other measures, it was not a complete success. As with all things, we can improve on past performance and we intend to do just that. Our new Program Chairman, John Jaech, is already laying the groundwork for next year's meeting in Albuquerque. Meeting arrangements for the Albuquerque meeting are being handled by our new Meeting Arrangements Committee Chairman, **Joe Stiegler** of Sandia Laboratories.

The Cincinnati meeting presented some new challenges and new opportunities for learning. We hope we have met these challenges and that we're making the most of the opportunities. We learned we could present a keynote speaker via videotape with a reasonable degree of success. We learned that no matter how much planning we do, the speakers must be able to be heard by all parts of the audience. We failed to do that during our panel discussion and we apologize for that inconvenience. That is a challenge that we are still trying to meet. Next year, we expect to improve. We can improve if you continue your support. As **Dennis Wilson** said in his article, "Your comments of today help frame the Institute of tomorrow."

PROGRAM COMMITTEE REPORT

The Program Committee for the 1979 Meeting in Albuquerque includes **Dick Chanda** and **Bill DeMerschman** in addition to the Chairman. This Committee met in July with **Gary Molen**, INMM Vice-Chairman and General Chairman for the Annual meeting, and began to formulate plans for Albuquerque.

As of this writing, plans are tentative, but some key innovations are planned for the upcoming meeting. These are as follows:

1) The Plenary Session on Monday will be limited to the morning with concurrent technical sessions scheduled for Monday afternoon, Tuesday morning, and all day Wednesday.

2) On Tuesday afternoon, the student paper will be followed by an invited papers session on the topic, "Safeguards and Alternative Fuel Cycles" chaired by **Bill DeMerschman**. The Panel format will not be used.

3) **Dick Chanda** is designated Chairman, Contributed Papers. All contributed papers received in accordance with the published guidelines will be reviewed by a committee appointed by Dick.

4) In order to achieve a more balanced selection of topics, the plan is to have several invited papers sessions with the designated session chairmen taking care of invitations for each designated topic. With the exception of the Tuesday afternoon session, the invited papers sessions will be concurrent.

The theme for the 1979 meeting is a timely one, "International Safeguards."

Watch this column in the winter issue for additional meeting developments, and make your plans now to attend the INMM meetings in Albuquerque.

G.F. Molen

J.L. Jaech

J.E. Stiegler

INMM Officers Elected

By V. J. DeVito
INMM Secretary
Goodyear Atomic Corp.
Piketon, Ohio

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 - **Robert Keepin**
For Vice Chairman - **Gary Molen**
John Jaech
For Secretary - **V. J. DeVito**
For Treasurer - **Edward Owings**
For members of the Executive Committee:
Dennis Bishop
Richard Chanda
Herman Miller
Frank O'Hara
Charles Vaughan

In accordance with Article III, Section 5, a ballot was mailed to each of the Institute's 561 members of which 326 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, 1978, are as follows:

Chairman - **Robert Keepin**
Vice Chairman - **Gary Molen**
Secretary - **Vincent DeVito**
Treasurer - **Edward Owings**

* **For Chairman: Edward Young, William Higinbotham, Duane Dunn, Dennis Bishop, Ralph Jones, Dennis Wilson, John Jaech, Gary Molen**
For Secretary: **Harold Foster**
For members at Large (Executive Committee): **William Bartels**

Executive Committee (Members at Large):
William DeMerschman to June 30, 1979
Dennis Wilson to June 30, 1979
Dennis Bishop to June 30, 1980
Frank O'Hara to June 30, 1980
Roy Cardwell - Immediate Past Chairman

A record number of ballots were received this year representing 58% of the membership.

At the Executive Committee meeting in Cincinnati in June annual meeting plans were discussed:

1979 Albuquerque Hilton, **Albuquerque, New Mexico**
July 16-19, 1979
1980 The Breakers - **Palm Beach, Florida**
Week of June 29, 1980
1981 Sheraton Palace - **San Francisco, California**
Date to be determined
1982 **Washington, D.C.** or **Boston, Mass.**
Date to be determined

Mr. DeVito

Tribute to John Jaech, Inputs Requested

By **Dennis M. Bishop**
Chairman N15
General Electric Company
San Jose, California

Under the careful direction of the Institute's newly elected officers and Executive Committee, a number of major Institute organizational changes have recently been completed. As a result of one such change, **John Jaech** has left N15 to take over the Technical Program Committee, the backbone of the Institute's annual meeting and overall technical activity.

Having worked with John on a variety of INMM ACTIVITIES FOR MORE THAN TEN YEARS, WE OF N15 would like to commend the individual contribution and leadership he has brought to N15 over the years, and wish him well on his new INMM assignment.

ANSI standards are best likened to children: 1) They are normally the result of advance planning, 2) extract inordinate resources and emotions to nurture through adolescence, 3) seem doomed to failure on multiple occasion, but 4) somehow live through it all to everyone's benefit. John Jaech has personified the rare combination of creativity and tenacity required to motivate our volunteer organization to consistently parenting high-quality ANSI standards which fit this mold. We of N15 will miss his patient cajoling and quiet but strong leadership.

Under INMM leadership, the N15 Standards Committee has functioned virtually intact for almost ten years to satisfy diverse standards needs in the safeguards area. We can all be proud of this contribution. However, particularly during the past few years, the scope and complexity of safeguards reqruiements have changed significantly. Therefore, it seems appropriate, at such an obvious demarcation point as the introduction of a new chairman, to undertake a brief assessment of N15 scope and ability to keep pace with these changes.

The goal of this review is two-fold: 1) To assure that the N15 organization can continue to address high priority industry-wide **needs** in a timely and coordinated fashion. (Clearly, our individual time economies have little room for **wants** or **wishes**). 2) To establish mechanisms for external review (e.g., NRC, DOE) of N15 topics and priorities before initiating writing group activities. In both cases, review and input from the membership is solicited as the best way to assure that N15 is maximizing its resources to satisfy overall Institute needs. I consider the completion of this reassessment as my highest initial N15 priority and request inputs from the Institute membership (both current N15 contributors and other interested parties) on how to readjust our basic direction and priorities.

For those new to the Institute, and those to date not involved with N15, a few words of description may be of aid. ANSI has defined the following scope for the INMM-N15 organization:

"Standards for the protection, control, and accounting of special materials in all phases of the nuclear fuel cycle, including analytical procedures where necessary and special to this purpose, except the physical protection of special nuclear material within power plants."

In response to this scope N15 has been divided into the following working groups:

Sub-committee	Chairman/ Affiliation	Current Scope
INMM-1	Howard Menke (Westinghouse)	Nuclear Materials Control Systems
INMM-3	Frank Wimpey (SAI)	Statistics
INMM-4	Sheldon Kops (DOE)	Records and Reports
INMM-6	Richard Schneider (Exxon)	Inventory Techniques
INMM-7	Robert J. Sorenson (Battelle)	Audit Techniques
INMM-8	Lou Doher (RI-RFP)	Calibration
INMM-9	Darryl B. Smith (LASL)	Nondestructive Assay
INMM-10	Thomas A. Sellers (Sandia)	Physical Security

Clearly, N15 has been a viable organization with a good track record. The goal of any future changes would in no way involve perturbing ongoing productive activities. However, new emphasis in the safeguards arena

Mr. Bishop

Fuel Storage Rack Measures Poison Content

President Carter's decision to defer the reprocessing of water reactor fuel elements has greatly increased the need for additional spent fuel storage space. Special neutorn absorbing racks have been designed to provide higher storage density in exisiing facilites.

National Nuclear Corporation, Redwood City, Calif., has developed a new method (patent pending) to measure the neutron poison in these racks reliably and quickly. The company's method utilizes a single compact instrument which is passed quickly through the fuel storage cell. During this single quick pass, the neutron poison content of each of the four cell walls is determined.

Using this unique new equipment, National Nuclear Corp. (NNC) is now offering a service to provide rapid and economical measurement of the neutron poison content in these racks. The measurements are made in place in the pool.

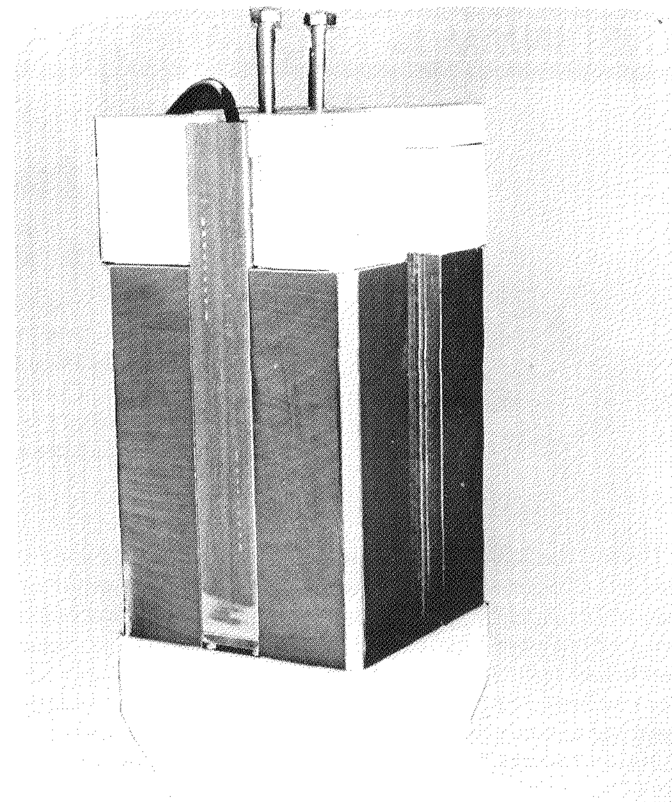
To assure neutron poison content and prevent a possible ceriticality indident due to insufficient neutron absorber, it is advisable to accurately rest these racks in their operating position.

The NNC specialized equipment make these poison measurements very rapidly, assessing hundreds of cells in a short workig period. Since the asmall Californium^{252} neutron source and the four dectetectors are combined in a single diameter "drage probe"drag probe," the equipment is very rugged, accurate and reliable under inplant usage.

For those preferring a dry measurement, NNC also offers a service using an older, conventional technique. A fixtured array is deployed with the neutron source in one cell and the four detectors spatially arrayed in each of the four adjacent cells. While the dry method suffers from being somewhat cumbersome and sensitive to misalignment, it has proven equally effective as the wet method.

Measurements have now been successfully completed at nuclear power plants by both the "wet" and "dry" techniques. Both have given very satisfactory results. For example, both methods are able to distinguish reliably between one and two layers of boronated steel.

In connection with the use of both methods, NNC has assembled an instrument package consisting of four channels, each with its own preamplifier, amplifier and ratemeter. This provides measurement of each of the cell walls.



Mr. Martinez

Rocky Flats Promotes J. L. Martinez

GOLDEN, Colo. — **Jorge L. Martinez** has recently been promoted to manager of the Technical Security Group (TSG) at the Rocky Flats Plant, Rockwell International, Golden. The TSG is part of the Energy Systems Group.

Martinez, who attended his first INMM meeting in 1971 at West Palm Beach, Fla., has been instrumental in the development of personnel doorway monitors, vehicle monitors and surveillance instrumentation for safeguards and security purposes.

He presented a paper co-authored by **G. J. Cunningham** on "Rocky Flats Security and Safeguards Systems Vehicular Gate Monitor" at the 1974 annual meeting in Atlanta, Ga.

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deserves new emphasis within N15. With some minor reorientation and additional scope, we can take better advantage of the available and limited resources and increase the overall INMM technical contribution. Major areas of current safeguards activity which may deserve added consideration in this matrix include:

1) International Safeguards
2) Measurement Controls
3) Documentation Practices
4) Updated Accountability and Materials Control Practices
5) Systems Analysis/Assurance Methods
6) Tamper Safing Practices
7) Transportation

Our overall challenge is clear; to continue our history of high productivity. As in the past, we have no quota. Our only goal is the incisive definition of real needs and the management of our technical expertise to address such needs in a timely fashion.

I look forward to inputs from the membership on this subject, and to working with each of you toward the continued growth of the Institute.

New Members Needed — Quality Only

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

Any reader who doubts the message in the headline of this column has only to cast a look at the story revealed by the figures in the following chart to realize that while INMM membership has grown well in total (now about 600) there is no question at all about the need for all of us to continue to mount a constant drive to enlist qualified new members in the Institute.

The chart shows that the increase in new memberships peaked two years ago, during the 1976-1977 fiscal year. During that year the Institute enrolled almost twice as many new members as it was able to obtain during the following year, 1977-1978, when approved applications for new members dropped from 139 to only 97. The number of government employees and those who work for government contractors applying for membership in the Institute dropped from 61 to 41. In a like vein, the applications from employees of nuclear industries fell from 38 to 28.

As might be expected, given the many cutbacks affecting the nuclear industry during this time frame, Utility employee applications dropped from 7 to 2. And even though the fiscal year 1977-1978 was a period when foreign experts in the nuclear field evidenced an increasing desire to participate in Institute activities, the number of new applications from persons outside the United States dropped from 33 to 25.

Analysis of New INMM Members
1974-75 through 1977-78

Year	Total	Government & Gov. Contrac's	Industry	Utilities	Foriegn
1974-75	82	29	37	10	6
1975-76	76	33	25	4	14
1976-77	139	61	38	7	33
1977-78	97	41	28	2	25

So, the message is very clear. Each and every member of the Institute must continue to look among his friends and colleagues for persons who have the technical knowledge, drive and interest to make an active and viable member of INMM. Although the circumstances and cutbacks of the past two years have limited the number of persons who should be considered for INMM membership, we are not seeking just additional members. The steady, solid growth of INMM since it was founded in 1958 has happened because people in the nuclear field who are sincerely interested in advocating and helping the growth of their profession came forward and applied for membership in INMM. The Institute never has resorted to high-pressure promotional gambits to obtain new members. It has grown and matured because the active, working membership consists of outspoken, knowledgable experts of the nuclear industry who work hard to maintain the professionalism of the many beneficial functions of the Institute.

This is the reason INMM has expanded from a few dedicated individuals, less than 20 in 1958 to almost 600 today.

It is extremely important that this quality of membership be continued during our effort to find new, professionally competent members. Not just everyone should be invited to join INMM simply because it might swell the Institute membership rolls, and add a few dollars to the treasury. INMM, now, is an established, highly-regarded, technical and professional associatiion.

When urging prospects to affiliate with the Institute, we must always seek the individual who represents the quality and intelligence of those who now comprise our fine Association.

We want more members
We need more members.
But we must never compromise quality for numbers.

Do your part to help the Institute find quality members. Send the names of competent, qualified members to your Membership Committee. We will do the rest.

Mr. Lee

You will be interested in knowing at this time that letters from your Membership Committee, have been sent to all non-member registrants at the Cincinnati Annual Meeting. It is our belief that really active persons in the nuclear industry who come to our Annual Meeting and thus have the opportunity to see for themselves what the Institute is doing to advance the professionalism and state of the nuclear field do not have to be sold on joining INMM. Our special dues offer to applicants who submitted membership requests at the Annual Meeting, has so far, produced thirteen new members.

They are: **Anthony Fainberg, Karl E. Goodwin, Don E. Hostetler, James Jacobs, Michael J. Jump, Gary C. Karsteer, James F. Ney, James G. Partlow, Wiliam C. Scotten, Julia M. Smith, Bobby H. Stoutt, James R. Summer and J. Frank Wimpey.**

We try to utilize every INMM activity to publicize the advantages of Institute membership. **Harley Toy**, Chairman of the Education Committee, gives the Membership Committee excellent cooperation and makes INMM brochures and application forms available to everyone who attends the INMM sponsored classes held each year. An individual who will take the time and spend the money to better himself, by attending an INMM sponsored class, obviously is one of the elite group of highly-motivated, active, interested individuals that we are trying to find and to interest in becoming an INMM member.

As always, the real results will come from you and the other members who are reading this appeal for help. The Membership Committee and the Officers and Directors can only do so much. The regular day-to-day contact with INMM prospects takes place in your daily work and correspondence. Help us increase and preserve the quality membership of the Institute. Send us the name of at least one eligible prospect today.

New Members

The following 34 individuals have been accepted for INMM membership as of August 31, 1978. To each, the INMM Executive Committee extends its welcome and congratulations.

New members not mentioned in this issue will be listed in the Winter 1978-1979 (Volume VII, No. 4) issue to be sent out February 1, 1979.

Dr. **Kenneth R. Alver**, Staff Physicist, IRT Corporation, P.O. Box 80817, San Diego, CA 92138.

John E. Barry, Nuclear Fuels Engineer, GULF STATES UTILITIES, P. O. Box 2951, Beaumont, TX 77704.

Dr. **Anthony Feinberg**, Associate Physicist, Brookhaven National Laboratory, Upton, Long Island, NY 11973.

Douglas Roger Fuhrman, Teledyne Isotopes, 50 Van Buren Avenue, Westwood, NJ 07675.

Karl E. Goodwin, Industrial Engineer, National Bureau of Standards, Washington, DC 20234.

Linda J. Heines, Nuclear Materials Control Engineer, United Nuclear Corp. Fuel Recovery Operation, Wood River Junction, RI 02894.

Dr. **Carolyn Delane Heising**, Electric Power Research Institute, P.O. Box 10412, Palo Alto, CA 94023.

Edward R. Herz, Safeguards Specialist, Exxon Nuclear Co., Inc., 2101 Horn Rapids Road, Richland WA 99352.

Donald E. Hostetler, Staff Physicist, DuPont Savannah River Plant, Aiken, SC 29801.

James Jacobs, Department Manager, 1760, Sandia Laboratories, Albuquerque, NM 87115.

Michael J. Jump, Manager, Safeguards Development, Westinghouse, NRD, P.O. Box 355, Pittsburgh, PA 15230.

Gary C. Kersteen, Superintendent, Nuclear Material Control, Combustion Engineering, Inc., 1000 Prospect Hill Road, Windsor, CT 06095.

Mark H. Killinger, Battelle Memorial Institute, Battelle-Human Affairs Research Center, 4000 NE 41st St., Seattle, WA 98105.

Laurent C. Lafond, Nuclear Materials Assistant, United Nuclear Corp., Fuel Recovery Operation, Wood River Junction, RI 02894.

Sudarshan K. Loyalka, University of Missouri, Nuclear Engineering Department, Columbia, MO 65201.

John J. Malanify, Alternate Group Leader, Los Alamos Scientific Laboratory, Q-3, MS 539, Los Alamos, NM 87545.

Louis H. Martin, Manager, Nuclear Fuel, Carolina Power & Light Company, P.O. Box 1551, Raleigh, NC 27602.

H. Donald Moss, Senior Scientist, Westinghouse Electric Corporation, Safeguards Development and Industrial Statistics, P.O. Box 355, Pittsburgh, PA 15230.

James F. Ney, Division Supervisor, Sandia Laboratories, Albuquerque, nm 87185.

Dr. **Nicholas Nicholson**, Staff Member/Physicist, Loa Alamos Scientific Laboratory, MS 562, Los Alamos, NM 87545.

Dr. **James H. Opelka**, Assistant Mathematician, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

James G. Partlow, Chief, Material Control Licensing Bureau, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

William C. Scotten, Staff Engineer, DuPont Savannah River Plant, Aiken, SC 29801.

William R. Severe, Staff Member, Los Alamos Scientific Laboratory, MS 539, Los Alamos, NM 87545.

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

Julia M. Smith, Statistics Associate, Technical Support Organization, Brookhaven National Laboratory, Building 197-C, Upton, Long Island, NY 11973.

Cecil S. Sonnier, Sandia Laboratories, Division 1754, Albuquerque, NM 87185.

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

Bobby H. Stoutt, Section Head, Computer Programming, Union Carbide Corporation, P.O. Box P, MS 65, Oak Ridge, TN 37830.

James R. Sumner, Accountant, Union Carbide Corporation, P.O. Box P, Oak Ridge, TN 37830.

Donald Robert Terry, First Officer, International Atomic Energy Agency, P.O. Box 645, A-1011 Vienna, Austria.

Lynn W. Vaught, Supervisor, Technical Security, Allied-General Nuclear Services, P.O. Box 847, Barnwell, SC 29812.

Jim Haycock Retires

Thomas J. (Jim) Haycock, Jr. resigned his position as Assistant Director for Information Support, Division of Safeguards and Security, October 7, 1978, and retired from government service after 32 years spent in the nuclear safeguards field. Jim, who is considered "Mr. Safeguards" by many in that field began his atomic energy career with Union Carbide at the K-25 plant in Oak Ridge, Tennessee, in October 1945. He joined the Manhattan Engineering District, the predecessor of the Atomic Energy Commission in August 1946, and is one of the few individuals whose continuous service has taken him through the changes from MED to AEC to ERDA and finally, to DOE.

Haycock has been in a position of leadership throughout his nuclear energy career. He organized the safeguards control program for the newly organized AEC Oak Ridge Operations complex in early 1947. This early work was a piece of the foundation for the nationwide nuclear materials safeguards program which began in the latter part of that year. Following the successful competion of this work, Haycock was assigned a similar task for the Commission's work in the nuclear weapons field under the Sante Fe Operations Office at Los Alamos (now the Albuquerque Operations Office), developing safeguards control mechanisms and assuring its effective operation throughout the Commission's nuclear weapons complex. He continued this activity for the nation's weapons activities until the control of completed nuclear weapons was transferred to the DOD. The survey (inspection/assessment) work with organized working papers and reporting format developed and orgaized in AL during that period, was adopted as the accepted model by the entire nuclear complex of field offices and contractors throughout the Commission. Haycock next served the nuclear industry as the U.S. representative for the development of worldwide safeguards program with the International Atomic Energy Agency, at Vienna, Austria. He not only represented the U.S. in this critical work but guided the preparation of the final draft of the original IAEA safeguards plan as Acting Director of the IAEA Safeguards Division bringinig the paper forward to its final approval in June of 1961.

Upon returning to the AEC, in August of 1961, Haycock joined the Division of International Affairs as Chief of the Technical Branch. He continued his work in the inspection field for the Government by making inspections and coordinating activities throughout Europe and the near East with foreign nations having bilateral agreements with the U.S. He is one of the few U.S. personnel who has had the opportunity to inspect the Dammona reactor in Israel. In 1963, he joined the Division of Nucler Materials Security as Assistant Director for Operations. Haycock was the motivating force for the development of the Commission's computerized Nuclear Materials Information System and its successor, the Nuclear Materials Management and Safeguards System (NMMSS), which is the National Central Data Base of nuclear materials information. This system provides the DOE, NRC and other governmental units including Congress, a single coordinated base of accurate, reproducible and factual nuclear materials data. During the past year he has developed and implemented through the use of the NMMSS, a system for tracking foreign nuclear material in the U.S. The concept of fungibility of nuclear materials which he has utilized is a cornerstone that makes the tracking system economically practical. Two papers presented in this issue give detailed descriptions of this final effort Haycock has made for the DOE.

Dr. **J. Frank Wimpey**, Staff Scientist, Science Applications, Inc., 1764 Old Meadow Lane, McLean, VA 22101.

Bill N. Yates, Sandia Laboratories, Kirtland Air Force Base, Albuquerque, NM 87115.

Address Changes

The following 15 changes of address have been received as of August 31, 1978 by the INMM Publications Office (Phone: 913/532-5837) at Kansas State University, 20 Seaton Hall, Manhattan, Kansas 66506 USA.

Emile A. Bernard, Sandia Laboratories, Org. No. 1762, Albuquerque, NM 87185.

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

Masanori Hatchya, Mitsui Engineering & Shipbuilding Co., Ltd., Chiba Laboratory, 1, Tawata Kaigan-Dori, Ichihara, Chiba Pref., 290 JAPAN.

James Russell Lemley, DNE, Bldg. 197C, Brookhaven National Lab., Upton, NY 11973.

Albert J. Moellenbeck, 1 Harmon Plaza, 6th Floor, Secaucus, NJ 07094.

Milad R. Matthias, Box 1276, Burlington, Ont., Canada L7P 359.

Dr. **Roger H. Moore**, 3333 University Blvd., #1211, Kensington, MD 10795.

Ray Mulkin, 54 Lomas Del Excolar, Los Alamos, NM 87544.

Marvin Fred Schnaible, International Atomic Energy Agency, P.O. Box 645, A-1011 Vienna, Austria.

Dr. **G. Dan Smith**, Safeguards Department, International Atomic Energy Agency, P.O. Box 590, A-1011 Vienna, Austria.

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

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

John L. Telford, 12710 Viers Mill Rd #3, Rockville, Md 20853.

C. C. Thomas, Jr., Los Alamos Scientific Laboratory, Q3, MS 539, Los Alamos, NM 87545.

Edwin A. Wiggin, Atomic Industrial Forum, Inc., 7101 Wisconsin Avenue, Washington, DC 20014.

Barbara Marie Wilt, P.O. Box 634, Richland, WA 99352.

Several Courses Planned

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

As reported in the last issue of the Journal, we were considering a one-or two-day statistics seminar for non-statisticians in managerial positions. Well, at this writing we are in final preparations to present the first three-day course, "Introductory Statistics with Applications to Special Nuclear Material Control." Once again, we are most fortunate in obtaining **John Jaech** to present this "introductory course" to be held here at Battelle on October 10, 11, 12, 1978. I am constantly amazed at John who somehow manages to find time to serve the INMM education program. As an example, John was off to England in September to present his "Selected Topics in Statistical Methods for SNM Control." The course was presented at the Barton Grange Hotel in Preston, England on September 28 and 29. The course was presented under INMM auspices.

The Education Committee had the opportunity to meet and discuss activities for the coming year at our Cincinnati Annual Meeting. On board at that meeting were **Jim Patterson**, NRC Region III, **Vince DeVito** of Goodyear Atomic, and Dr. **Frank O'Hara** of Battelle- Columbus. At the meeting, we resolved plans and a method of liaison with NRC and DOE on mutual educational programs. We took action on the preparation of establishing current files on available courses and seminars in the area of nuclear materials management and safeguards. This file on course availability information will be be disseminated to the membership through the Journal. This issue of the Journal will mark the beginning of this service to be carried as a continuing item in the Journal.

During the coming year the Education Committee will be assisted by Dr. **Frank O'Hara**. Chairman **Bob Keepin**, in organizing functional responsibilities for members of the Executive Committee, has assigned oversight responsibility for the Education Committee to Dr. O'Hara, newly-elected member of the Executive Committee. We look forward to working with Frank who brings an educational background to this assignment, having been a member of the faculty of the Nuclear Engineering Department at Ohio State University. This should prove very effective since I have essentially daily contact with Frank here at Battelle.

Your Education Committee urges your support and assistance in defining and selecting courses for the coming year. Your suggestions on course selection will be most welcome. Contact me at Battelle-Columbus with your thoughts and ideas.

Short Courses and Seminars

- "Introductory Statistics with Applications to Special Nuclear Material Control," October 10,11,12, 1978, Battelle's Columbus Laboratories, Columbus, Ohio. Sponsored by INMM. Contact **H. L. Toy**, Columbus, Ohio, Phone 614-424-7791.
- U.S. DOE Safeguards Technology Training Program, Los Alamos Scientific Laboratory 1978 Sessions; "In-Plant Nondestructive Assay Instrumentation," November 27 - December 1, 1978. For further information, contact **Karen Humphrey**, Los Alamos, Phone 505-667-6394, FTS 843-6394.
- "Selected Topics in Statistical Methods for SNM Control," May 7-11, 1979, Battelle's Columbus Laboratories, Columbus, Ohio. Sponsored by INMM. Contact **Lavella Adkins**, Columbus, Ohio, Phone 614-424-4038, FTS 976-4038.

NOTE: In coming issues, the Short Courses and Seminars section will be expanded to include course information in allied fields.

HE WANTS YOU — Harley L. Toy (left), Battelle Columbus Laboratories, gave the "I want you" finger reminiscent of the old Uncle Sam military recruiting posters. Mr. Toy, a Past Chairman of INMM, currently serves as Chairman of the Institute's Education Committee. He is shown visiting with Vincent and Jeanne DeVito of Goodyear Atomic Corp., Piketon, Ohio. Mr. DeVito has served as INMM Secretary for several years.

DOE, NRC Responses

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

With a growing demand for qualified people, there is also the growing need for institutions of higher learning that provide the necessary professional training for nuclear materials specialists. Professional certification and professional training are intimately connected. The certification column (Summer 1978) addressed this issue in the form of a proposal to the nuclear community. Below, we reprint two responses, from NRC and DOE that should be of interest to our readers.

June 15, 1978

Dr. **Fred Forscher**
6580 Beacon Street
Pittsburgh, Pa. 15217

Dear Dr. Forscher:

We are in full agreement with the statement in the opening paragraph of your May 10, 1978 letter. There is no doubt that the effectiveness of safeguards depends on the quality of the people who are developing and implementing safeguards systems and programs. In recognition of this, the NRC is about to publish effective amendments to its regulations to specify requirements and criteria for qualification and training of security personnel. We also have in progress the development of regulations and guides to set forth requirements and critieria for selection and training of key material control and accounting personnel. The latter are expected to be published for comment within the next year. Another report, which is nearing completion, addresses training and qualifying measurement personnel. A draft of ths report was provided to your committee some time ago. In addition, we are about to publish two training manuals to assist licensees in developing training programs for their security personnel.

One step that the NRC has not taken, and does not at this time plan to take, is the certification or licensing of these personnel. We have a study in progress to evaluate the pros and cons of training and certification of security personnel, in particular, armed personnel. On the basis of the results of this study and implementation of the forthcoming guard qualification and training regulation, we will evaluate the need for further action, such as NRC certification or central training facilities. Similar studies undoubtedly will be considered for material control and accounting personnel.

If we can assure qualified persons in safeguards programs by providing criteria and guidance, we do not believe it is necessary to become involved in formal certification programs. A major factor in this respect could be a certification program such as that being considered by the INMM. If professional organizations such as INMM and ASIS provide means to certify the qualifications of personnel in the various disciplines in safeguards it should not be necessary for the government to do so. We are providing guidance for training in several areas, but do not believe it is necessary for the government to provide or fund training programs. Organizations such as the INMM, have been, and we hope will continue to be, quite helpful in this respect by sponsoring training programs in a number of safeguards areas. We also hope that the INMM will continue its efforts in the development of the certification program for safeguards personnel.

We do not believe that it is necessary for one person to have detailed knowledge in the several disciplines encompassed by safeguards. Rather, we believe that persons should be trained and qualified to the extent needed in specific areas to carry out their respective duties.

This has resulted in the efforts noted above. The basic knowlege needed for safeguards is available, as you noted in the academic disciplines now provided in the universities. The specific application of these disciplines to safeguards can better be obtained through such special courses as those the INMM has soponsored, those given at LASL and BMI, or training provided in accordance with NRC guidance such as we are about to publish. These courses can be tailored to the specific disciplines and to the specific applications of those disciplines, i.e., fuel cycle facilities, power reactors, nonpower reactors, etc. With this in mind, we do not see the need for comprehensive "safeguards options" at the university level as you indicated in your letter.

We appreciate the interest of the INMM and the efforts which they have made in the past in providing specialized safeguards training. We will be happy to

Dr. Forscher

Focus Too Narrow, Goal Too Grand

(Continued from Page 1)

The Indian nuclear test in 1974, and orders from a few countries with small nuclear programs for fuel reprocessing plants, suggested to U.S. policy makers, that the IAEA might not be enough. Hence, the freeze on reprocessing in the U.S., the DOE quest for less proliferation-prone nuclear technologies, and the International Nuclear Fuel Cycle Evaluation. This turn of events has precipitated a reevaluation of every nuclear fuel cycle ever thought of, stimulated a frantic search for uranium in every country in the world (which could be a tactical mistake), and created a situation of extreme confusion for anyone who is interested in either energy or proliferation.

There is confusion as to the issues that are being discussed - alternative nuclear fuel cycles, monopolistic control by the nuclear-weapon powers, or by advanced "supplier states," formation of multinational nuclear fuel facilities, or perhaps a moratorium on all nuclear developments pending some remarkable international invention to proscribe proliferation. The instigators of the current international review of nuclear policy are not stupid. But they have raised a host of issues which are entwined with national concerns for security, for reliable energy supplies, for the efficient use of natural resource, for protection of the environment, for the safety of nuclear power, and for the long-term safe disposal of nuclear wastes. All of this on top of a widespread, emotional distrust of things nuclear.

Our particular problem is to keep our eye on the important issues and not to be overwhelmed by the misconceptions or diversions featured in the news, or by the mountains of papers on technical or institutional trivia being generated by NASAP, and by our friends in many nations for INFCE.

As was recognized from the start, the technology of nuclear energy is closely related to that for nuclear weapons. The nuclear arms race is very dangerous for the U.S. and for all of the world. To the extent that it may be possible to separate nuclear power programs from nuclear weapons, that is worth pursuing. But no one is going to invent a nuclear fuel cycle which could not be subverted. Control of nuclear energy for peaceful applications will require the voluntary cooperation of many sovereign nations because they believe it to be in their self interest.

The issues are real, and it is prudent to confront them. They are not new, and they have received consideration before. The trouble with NASAP and INFCE is that the focus is too narrow and the goal is toc grand. If you are concerned about international military security, you should be concerned as to the causes of international conflicts, on the one hand and about nuclear and conventional arms races on the other. If you are concerned about energy, you should consider the present status of and the future propsects for all energy sources, and for the troublesome byproducts of each. NASAP is not likely to lead to any alternative nuclear fuel cycle which would not have been adopted anyway. INFCE may succeed in turning off small reprocessing plants in a few countries which don't need them. More importantly, it may institute continuing international cooperation on preventing the misuse of nuclear technology, by states and by non-state adversaries. But world security can only be achieved by cooperating in solving the basic problems facing humanity: the nuclear arms race, reliable energy supplies, population control, food, intellectual stimulation, and other natural and societal challenges.

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work with your committee and the INMM in further efforts of this type.

Sincerely,
Robert B. Minoque, Director
Office of Standards Development
U.S. NRC

June 27, 1978

Dr. **Frederick Forscher,** Chairman
Certification Committee
Institute of Nuclear Materials Management
6580 Beacon Street
Pittsburgh, Pennsylvania 15217

Dear Fred:

This letter is in reply to your correspondence of May 10, 1978, related to the formal training and recognition of nuclear material specialists.

At present we are working with our DOE Office of Education, Business and Labor Affairs (EBLA) to structure a safeguards course, preferably at an academia.

I want to thank you for your interest in our safeguards program and will be happy to discuss the subject when the opportunity arises.

Should you have questions, please contact **Joseph Goleb** of my staff.

Sincerely,

H. E. Lyon, Director
Office of Safeguards and Security
U.S. DOE

The Silent Society

By Bernard Gessiness
Past Chairman, INMM

Now that our Cincinnati meeting of last June is only a pleasant memory, I can't help but reflect on the high and low points of that busy week's activities. Strangely enough, the most encouraging and most disappointing moments occurred at the same moment in the same place! I am referring to the Institute's annual business meeting on Wednesday, June 28 at 5:00 p.m. It's true the hour was late and everyone was tired after a long, arduous day. Nevertheless, the largest, most enthusaistic crowd ever, perhaps a hundred or more members, streamed into the Grand Ballroom at Stouffer's, seeking to learn what the Institute is doing in its twentieth year of operation. An annual report, prepared by the Chairman, was distributed to the members at the time they registered for the meeting.

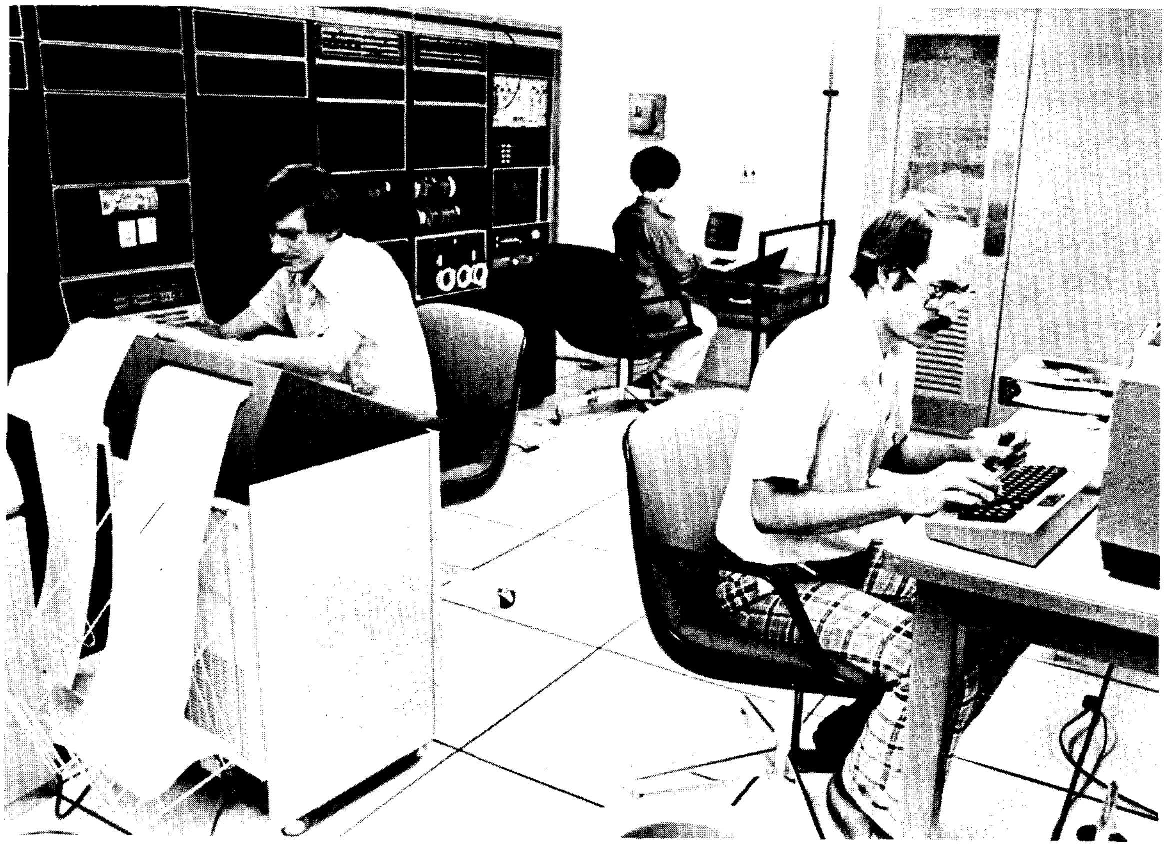
The Chairman called for Old Business; there was none. The Chairman called for New Business; there was none of that either. Utter silence fell upon the society of nuclear materials specialists. The meeting was then adjourned. Everyone shuffled out of the room, wondering why they had come to the annual business meeting.

During the past year, we have witnessed a steady decline in the nuclear industry. From the White House to the dissidents at Seabrook, New Hampshire, from the utility company who cancelled its order for a nuclear power plant to the National Council of Churches, a vote of no confidence in our ability to measure, protect, and control nuclear materials has been registered. Do we as the professionals in this field offer a rebuttal? Do we as a technical society sponsor a resolution, assuring the American public of our competence to manage nuclear materials? Does INMM offer comments to DOE on its new Manual Chapter 6104, Control and Accountability of Nuclear Materials? Does INMM meet regularly with NRC Safeguards and Security staff members to present our views on forthcoming regulations affecting our licensee members? No, only silence reverberates from our meeting hall.

We have dwelt in the back room of anonymity long enough! If we expect to survive as a respected professional society for another twenty years, we must speak out long and loud. We must stand up and be counted. Our annual business meeting should be the high point of our year's activities, where the Institute's public relations and Government liaison programs make us proud of our officer's accomplishments.

It is not too late for the Institutute to experience a renaissance. I call upon the new officers and Executive Committee and especially upon you, the general membership, to end your silence and speak out for nuclear. Let the White House and the New Hampshire hippies know of our expertise; let DOE and NRC know that we are looking after the best interests of their contractors and licensees; let the American public know that there is an Institute of Nuclear Materials Management. Then, next year our annual business meeting will be anything but silent!

Attending the Founders' Luncheon Thursday noon (from letf): Harley Toy, Bernie Gessiness, Ralph Lumb, Roy Cardwell, Shelly Kips, Ed Johnson, Tom Bowie and Paul Morrow.



The NBL computer system processes data from NDA systems, performs numerical calculations, performs statistical analysis of laboratory measurement data and monitors the laboratory measurement quality assurance programs for uranium and plutonium assay

NBL Has Key Role In Measurement Science

During the Manhattan Project days of World War II, wartime security dictated stringent secrecy concerning nuclear energy. The U.S. Army had "a passion for clamping down security on anything that could relate to fission – even as far as common knowledge atomic theory: one officer wanted the periodic table declared top secret!" recalls **Clement J. Rodden,** who directed New Brunswick Laboratory (NBL) from 1949 to 1960

Now it is the international controversy over nuclear non-proliferation that urges great care in the handling of nuclear materials. And NBL, now under the direction of **Carleton D. Bingham,** plays a key role in the measurment science necessary to nuclear materials control.

As reported in the Winter Journal issue, NBL, the U.S. Department of Energy (DOE) nuclear materials safeguards measurement laboratory, has completed its relocation from New Brunswick, New Jersey, to new $4.3 million facilities on the site of DOE's Argonne National Laboratory, 25 miles southwest of Chicago, Illinois.

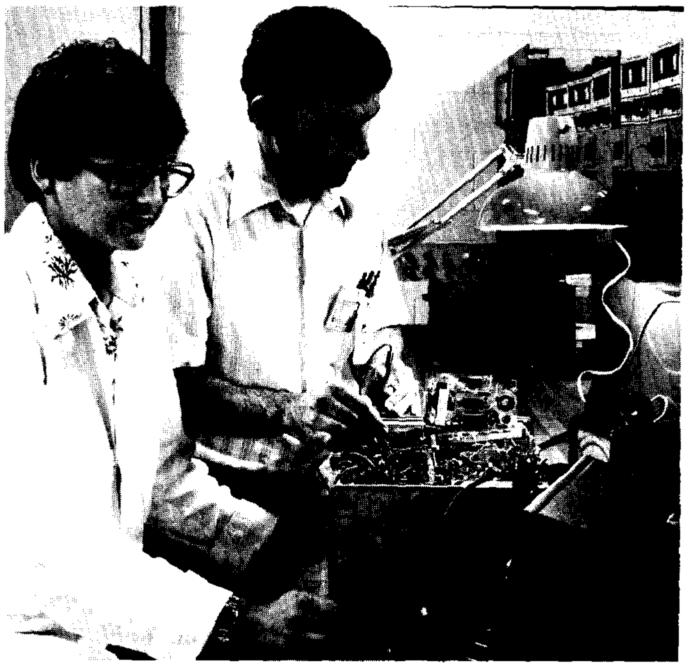
The accompanying photos show the sophisticated equipment and techniques applied to NBL's work. NBL is supported by DOE and U.S. Nuclear Regulatory Commission. Its 28-year history is replete with examples of contribution to nuclear materials measurement science. Reference materials for the calibration and testing of measurement methods have been developed and made available to the nuclear industry. Reliable measurement technology for uranium, plutonium, boron and thorium has been developed and passed on to the nuclear community. Evaluation of measurement methods and routine measurement performance is an on-going operation which provides technical credence to safeguards statements regarding uncertainties in inventory differences attributable to measurement science.

NBL also administers the Safeguards Analytical Laboratory Evaluation (SALE) program, which is to serve

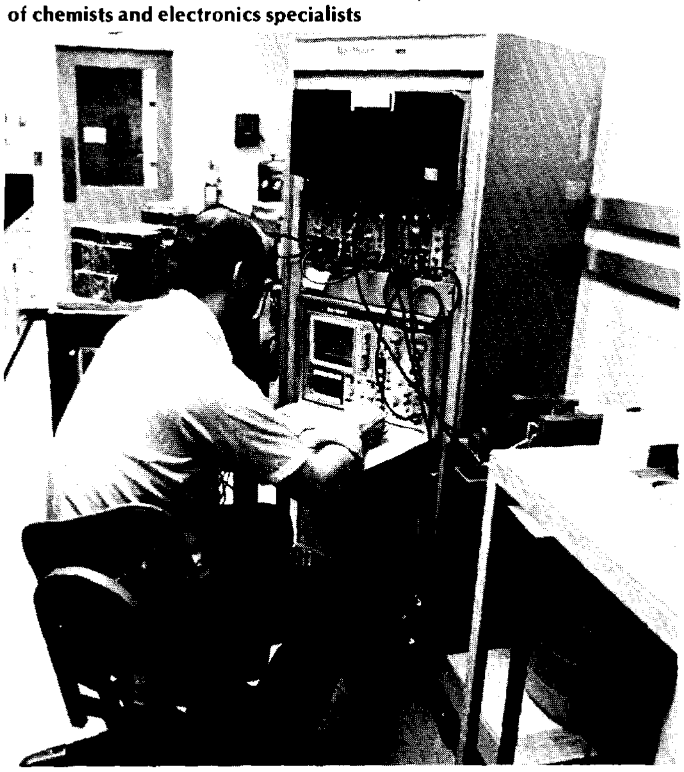
C.D. Bingham

as a framework for a national materials measurement assurance program. In May, NBL hosted the third biennial SALE program meeting, involving about 60 participants from the United States, Belgium, Finland, the Federal Republic of Germany, Japan, the Netherlands, and the United Kingdom.

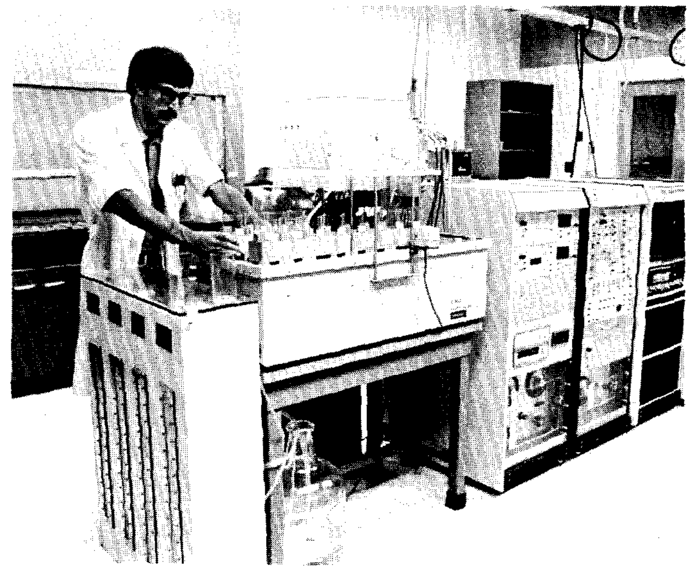
At that SALE meeting, information exchange, rather than secrecy, was the order of the day. The current international safeguards effort seeks to develop and distribute measurement science information, such as that developed by NBL, to assure consistent, accurate methods of nuclear materials management throughout the world.



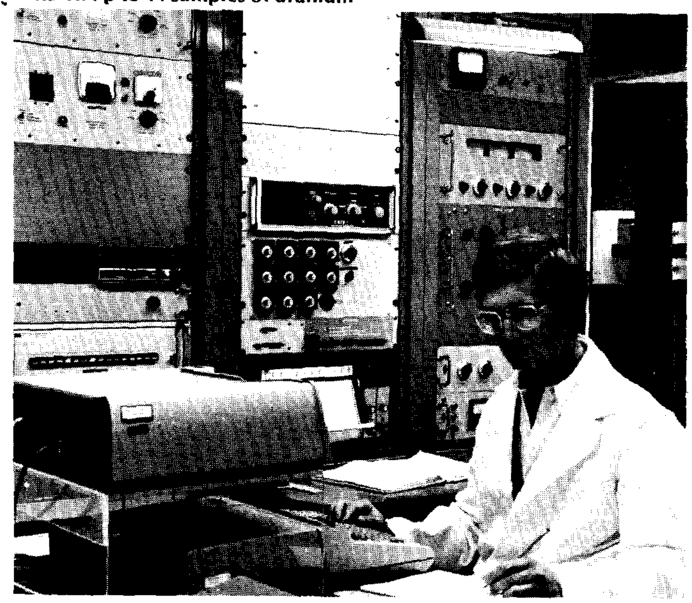
Automation of instrumental measurement systems combines the talents of chemists and electronics specialists



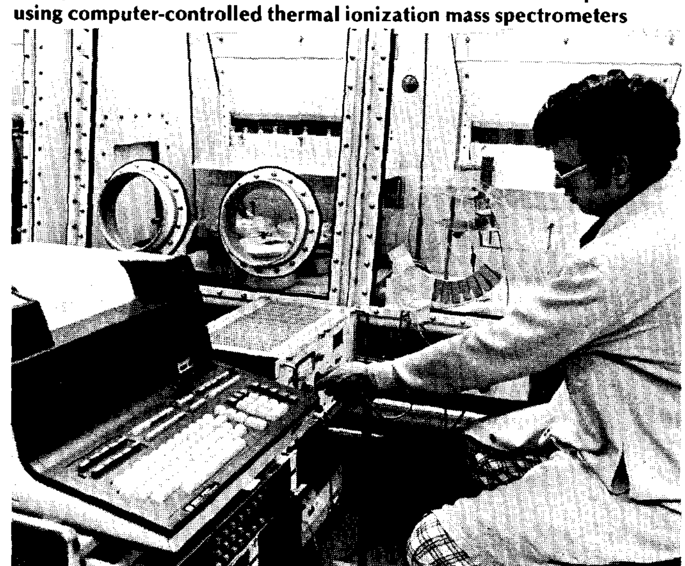
Uranium content of calcined ash samples is measured by nondestructive assay (NDA) using passive gamma-ray methods



A computer-controlled automatic titration system utilizing constant-current coulometric generation of vanadyl ion can analyze and report data on up to 44 samples of uranium



Isotopic abundance measurements on nuclear materials are performed using computer-controlled thermal ionization mass spectrometers



Plutonium content is determined using a computerized controlled-potential coulometry system

BOOK REVIEW

THE WHITE-COLLAR CHALLENGE TO NUCLEAR SAFEGUARDS, Herbert Edelhertz and Marilyn Walsh, Lexington Books, D.C. Heath & Company, Lexington, Mass., 1978.

By John N. O'Brien
Brookhaven National Laboratory

The safeguarding of special nuclear material and establishing assurance against sabotage of power reactors has recently taken on an urgency unprecedented in the hisotry of industrial regulation. The Nuclear Regulatory Commission (NRC) has the formidable task of regulating nuclear safeguards in an atmostphere of controversy and confusion concerning threats and consequences which defies our traditional methods of regulatory decision-making. *The White-Collar Challenge to Nuclear Safeguards* is a study which will add considerably to the constellation of knowledge from which NRC must work in designing a comprehensive approach to safeguards regulation.

Authors Herbert Edelhertz and Marilyn Walsh had the task of starting, quite literally, from scratch in assessing the whitecollar threat to the commercial nuclear energy industry. The first obstacle to be faced by the authors was the inapplicability of empirical analysis relied upon so heavily in other contexts of nuclear regulation. The dependence of both the probability of failure and the consequences on deliberate human action combined with the questionable availability of basic data concerning the effectiveness of specific safeguards systems dilutes the value of such analysis.

Instead, the study exhaustively examines the concept of white-collar crime in a descriptive fashion, aiming to pinpoint potential safeguards vulnerabilities rather than ferretting out problem areas in current regulations. The approach taken is to integrate the body of knowledge developed in the area of white-collar crime with nuclear regulation. While this approach provides a framework for regulators to discuss and scrutinize the white-collar crime problem, it misses points which would be apparent to those actively engaged in ongoing safeguards research. For instance, particular vulnerabilities of nuclear facilities to criminal activities by management personnel in those facilities are not specifically examined in this study so that the application of principles and concepts developed in the study is left to the reader.

The approach of the book is, first, to describe generally the accepted definitions and background of white-collar crime as it is understood today. The operating characteristics of the white-collar criminal are discussed in detail using recent studies on the general topic to form an integrated and workable concept of white-collar crime. Then the book sets out to develop, through general scenarios, the concept of crime in the nuclear energy industry. The motivations and opportunities for nuclear theft are examined, but only in a general way. Finally, the general aspects of nuclear safeguards regulation which may be applicable to coping with the threat of white-collar crime are scrutinized to reveal how safeguards research should be shaped to deal most efficiently with the problem.

The study does make several very important but generally overlooked points. First, the existence of a market for illicitly obtained nuclear materials may foster an impetus for nuclear white-collar crime which does not exist currently. The authors maintain that increased worldwide proliferation of nuclear energy along with increasing constraints on legitimate markets will undoubtedly foster such a market. Secondly, safeguards threats have, up to now, received selective attention in an arbitrary manner. In fact, there is a strong basis for suggesting that current safeguards regulation is off base, considering past experience. Much attention is given to the overt or terrorist threat to nuclear facilities and materials while covert threats receive relatively little regulatory attention. However, no armed adversary assault has occurred to date and it is not possible to state with complete confidence how likely and/or imminent such an assault may be. While the same argument can be made concerning white-collar crime, it is important to note that no no one can state with complete confidence that a white-collar adversary action has not taken place to date.

This book is an invaluable starting point for regulatory research aimed at protecting against white-collar crime in the commercial nuclear energy industry. It is successful in its objective of delivering an overview of white-collar crime and how that knowledge may be applicable to nuclear crime. It is not a book which will bring light to the problem in a direct regulatory or management oriented approach. This book is valuable to those initiating regulatory research in this urgent and important area of nuclear safeguards and has merit on that basis. It must be borne in mind by the safeguards professional that the book is not meant to suggest safeguards measures but rather to construct a workable framework for examining this difficult problem through the discipline of white-collar crime research.

John O'Brien (left) and Jerry Cadwell are with the Technical Support Organization for Nuclear Safeguards at Brookhaven National Laboratory. Both have been published in recent issues of NUCLEAR MATERIALS MANAGEMENT. O'Brien and Cadwell attended their first INMM annual meeting in 1978.

Chapter Offers to Assist INMM Members

By Dr. Yoshio Kawashima, Chairman
Japan Chapter
Institute of Nuclear Materials Management
Tokyo, Japan

Mr. **Roy G. Cardwell**, Immediate Past Chairman of INMM, visited Japan in April. He presented a charter to authorize the Japan Chapter on April 11. Mr. Cardwell was kind enough to bring INMM badges to all members of the Japan Chapter and INMM table appointments and medals tothe officers and the chapter members. We will treasure these invaluable gifts as a constant reminder of the sincere good wishes of INMM.

Mr. Cardwell also gave a lecture entitled, "The relation of INMM to the International Nuclear Industry," which was well accepted by the audiences. His lecture clearly pointed out the important role of INMM in international nuclear materials management. The party followed and active social exchanges took place between Mr. and Mrs. Cardwell and the chapter members.

The election of officers and four members of the Executive Committee took place and was approved at the annual meeting of the chapter on June 8. The following officers and members will serve for two years:

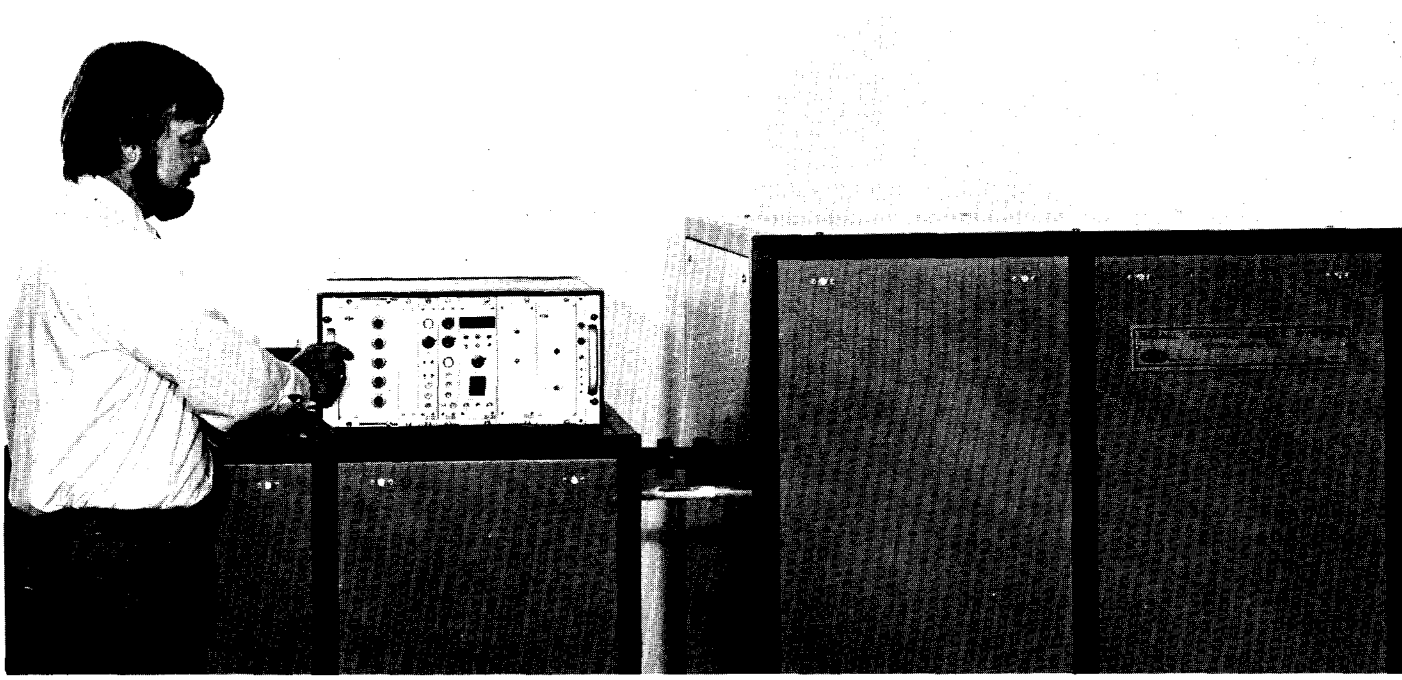
Chairman . . . . **Yoshio Kawashima**
Vice Chairman . . . . **Ryohei Kiyose**
Secretary . . . . **Mitsuho Hirata**
Treasurer . . . . **Reinosuke Hara**
Member . . . . **Ryukichi Imai**
Member . . . . **Hiroyoshi Kurihara**
Member . . . . **Kentaro Nakajima**
Member . . . . **Haruo Natsume**

At the annual meeting, future activities of the Japan Chapter were discussed. Emphasis was on international relationships.

It was noted that five members of the Japan Chapter participated in the 19th annual INMM meeting this past June 27-29 in Cincinnati, Ohio including Chairman Kawashima and Vice Chairman Kiyose.

In late August, plans were being made for the visit of Dr. **G. Robert Keepin**, INMM Chairman. The chapter extended a cordial welcome to the visit in September.

The Japan Chapter is willing to extend any assistance to the INMM members who visit Japan, and appreciates any advance information of such visits.



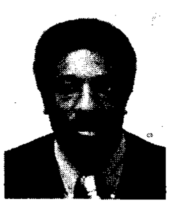
IRT ASSAY SYSTEM — A new data sheet describing the Model SSAS-100 Small Sample Assay System from IRT Corp., San Diego, Calif., has just been completed and is available on request. Designed primarily for the type of analyses required in UO_2 fuel plants, the SSAS-100 is capable of accurately determining the fissile content of samples with volumes up to 7 cm^3. It operates on the principle of neutron activation analysis and has the feature being rapid, nondestructive and specific to fissile material without requiring a separate isotopic analysis. Contact: W. M. Hawkins, Jr., IRT Corp., P. O. Box 80817, San Diego CA 92138. Pictured above is Dr. Richard Bramblett of IRT, an INMM member.

Reports from Members At 1978 Annual Meeting

Compiled by Thomas A. Gerdis, Editor
Nuclear Materials Management
Manhattan, Kansas

Etoy Alford is currently assigned to the Personnel Programs Division as Manager, Personnel Programs System. In this position, he is responsible for development of all personnel systems, programs, systems/programs integration, and related procedures affecting employees of the Washington Public Power Supply System (WPPSS). Prior to his present position BM Etit was Fuel Project Engineer assigned to the Fuel Supply section. Responsibilities included writing the Fuel Quality Program Manual and developing criteria for establishing the WPPSS nuclear materials accountability and safeguards program. Before joining WPPSS, Etoy was Nuclear Materials Safeguards Specialist for Battelle Northwest Laboratories. He has been an INMM member for five years.

Roy B. Crouch is Deputy Director Safeguards and Security for the Albuquerque Operations Office of U.S. DOE. He has been a member of the Institute for twenty years. Roy is in charge of local arrangements for next year's Institute meeting in Albuquerque, New Mexico.

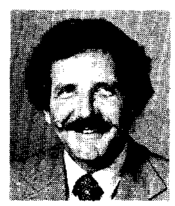

Alford


Crouch

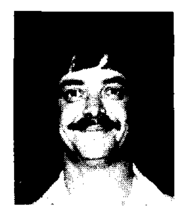

Kull

Dr. Larry Kull is a Vice President of Science Applications, Inc., in San Diego, California, where he currently serves as manager for a group of engineers and technologists who have performed safeguards systems analyses. He continues to be directly involved with several projects in the safeguards area including performance evaluation methods, IAEA inspection systems, and power plant protection strategies. He attended his first INMM meeting in 1971 and has missed only one since.

Larry E. Wheeler is the Accountability Representative at the Oak Ridge Gaseous Diffusion Plant. Larry has completed 10 years in the management of nuclear materials.


Wheeler


Rushton


Gilbreath

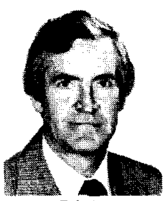
Dr. James E. Rushton is the Safeguards Task Leader for the Advanced Fuel Recycle Program at ORNL. He is currently involved in assessments of safeguards systems for breeder fuel recycle facilities. Jim is a member of N15 Writing Group 9.2. He has also worked on development of NDA instruments for 233 U-Th fuels.

Dr. Anthony Fainberg works with the Technical Support Organization for Nuclear Safeguards at BNL. In this capacity, he has worked with the US NRC in safeguarding nuclear materials at fabrication facilities and in safeguarding nuclear power plants, specializing in hardware assessment.

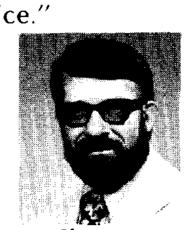
Jimmy D. Gilbreath (B.S., Nuclear Engineering, Mississippi State University, 1970) is employed by the Tennessee Valley Authority in nuclear materials management and nuclear fuel quality assurance. He has been a guest lecturer at Argonne National Laboratory and has co-authored a paper for **Nuclear Materials Management.** He has been a member of INMM since 1974.

Allen R. Diehl is the Nuclear Materials Technical *Control Administrator and alternate Accountability* Representative for the National Lead Company of Ohio, Cincinnati. Allen is completing his 25th year in the management of nuclear materials. He became an INMM member in 1960. He served on INMM's subcommittee "Standard Color Code for SS Materials" during 1965-1966 and subcommittee chairman of ANSI N15.8, Calibration Techniques, during 1970-1971. He has attended seven of the Institute's annual meetings and several of the INMM and DOE sponsored specialized programs.

Henry H. McClanahan is the Manager, Nuclear Materials Control, at Babcock & Wilcox, Naval Nuclear Fuel Division. His responsibility covers head in phase of production, nuclear safety and all NRC licensing activities, along with physical control and accountability of SNM. He is a co-author of ANSI Standard N15.5, "Nuclear Materials Control Systems for Fuel Fabrication Facilities (A Guide to Practice)." He is also a co-holder of several patents pertaining to the manufacture of nuclear fuels. Henry's secondary functions involve chairman of the corporate-wide Nuclear Materials Control Committee and chairman of the NNFD Nuclear Licensing Board. He has been an INMM member since 1970. He attended the first safeguards training program held at Argonne in 1968. He presented his first paper to the INMM at the West Palm Beach meeting on "Practical Applications of a Non-Destructive Uranium Assay Device."


Diehl

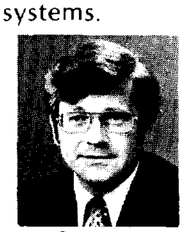

McClanahan


Chapman

Dr. Leon D. Chapman is the Supervisor of the Safeguards Methodology Development Divison at Sandia Laboratories. He is the project manager for the development of modeling techniques for the evaluation, design, and inspection of both facility and in-transit safeguards systems under sponsorship by the U.S. NRC Office of Nuclear Regulatory Research. DOE has utilized part of the safeguards methodology in assessing their facilities. In addition, other efforts have included studies concerned with the modeling of national energy systems, nuclear fuel cycles, and environmental systems.


Myre


Rosser


Sorenson

John P. Rosser is the Manager of Marketing for United Nuclear Corporation's Fuel Recovery Operation in Wood River Junction, Rhode Island. While a newcomer to the INMM, Jack has participated in the growth of the nuclear industry since 1959 when he joined the staff of the Mallinckrodt Chemical Works plant at Hematite, Missouri. This plant was the first privately owned plant to process enriched uranium in the United States.

Robert I. Sorenson is a Senior Research Scientist *with the Material Safeguards Group at Battelle in* Richland, Wash. He is Battelle's Laboratory Coordinator for the International Safeguards Project Office (ISPO), a part of the U.S. Support program to the IAEA. Sorenson has been involved in safeguards inspection strategies and assessment evaluations for both the DOE and NRC. He is chairman of the INMM-7 Subcommittee, Audit Techniques. Currently Sorenson is working a Nonproliferation Alternative Systems Assessment Program (NASAP) for the DOE.

W.C. Myre was recently appointed Director, Nuclear Security Systems at Sandia Laboratories, Albuquerque. In this position, he has responsibility for Sandia's Physical Protection Programs sponsored by the DOE, DOD and NRC. Although Bill has been involved in surveillance and containment instrumentation development since 1966, the recent INMM annual meeting was his first.

Donald E. Six is Manager of Safeguards and Security Branch for EG&G Idaho and has been a member of the INMM for two years. Although only recently involved with nuclear materials management and safeguards, he has many years experience with the AEC and AEC contractors in the Water Reactor Safety Program. He has also served on the staff of the advisory Committee on Reactor Safeguards. Six has been impressed with the goals, functions and organization of the Institute and looks forward to putting his experience gained in ANS topical meeting arrangements to work in assisting with Institute business and meetings. He was recently asked to serve on INMM-10 and attended his first committee meeting in Cincinnati.

Tony Prudich is the Manager of Production Planning and SS Representative for United Nuclear Industries, Inc., Richland, Wash. He is completing about 28 years in Nuclear Materials Management for three different companies. The Section which he manages is presently engaged in Nuclear Materials Management, Nuclear Materials Accountability, Production Planning, and Safeguards. He attended is first INMM meeting in 1965.


Six

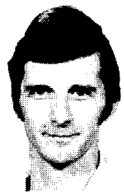

Griggs


Prudich

James R. Griggs is a Nuclear Materials Control Engineer for Goodyear Atomic Corporation. His current responsibilities include the design of the DYMCAS Computer Based Nuclear Materials Control System at the Portsmouth (Ohio) Uranium Enrichment Facility. A member of the Institute for three years, Jim is active with the INMM-ANSI Standards Committee dealing with Nondestructive assay techniques. This year's meeting was the first one attended by Jim.

Ronald W. Brandenburg has been a member of the Nondestructive Assay Group at ANL for eleven years, and has attended ten INMM meetings, missing only Atlanta. His projects here included an automated system for the gamma assay of large numbers of EBR-II and ZPPR fuel elements. He is now serving on INMM 9.6, the committee which is writing the ANSI Guide to the Automation of Nondestructive Assay for Nuclear Material Control.

Kuklinski



Brandenburg

George B. Kuklinski is the Alternate SS Representative at Rockwell Hanford Operations. He is completing his 27th year in the management of nuclear materials and has been a Certified Nuclear Materials Manager since February, 1968. He attended his first INMM meeting in 1962 at St. Louis and served on the Registration Committee at the recent meeting in Cincinatti.

Dr. **John R. Powers** resigned as Chairperson of the INMM-10 Writing Group on accepting a position in the Department of Energy as Director of R&D Strategy Studies. The Writing Group is preparing a Standard Definition of Terms for Physical Protection (N15: 40). Ms. **Blyth Jones** has assumed responsibility as Acting Chairperson.

Frank Voss is Superintendent of the Works Laboratory at Goodyear Atomic Corporation. He has been involved with the development and improvement of methods for the chemical and isotopic analysis of Safeguards Materials for over 25 years. Frank has been an INMM member for 13 years.

Fehlau

Voss

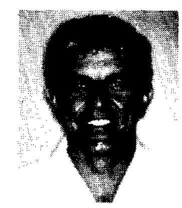
Paul E. Fehlau is with Safeguards Group Q-2 at the Los Alamos Scientific Laboratory. He has been working on research, development, and evaluation of SNM monitors for personnel, packages, and vehicles for both domestic and international application for many years. He also participates in the development and training use of instrumentation for the LASL component of DOE's Nuclear Emergency Search Team.

Chairman **Roy Cardwell** is completing nine years of active involvement with INMM in Cincinnati. Roy, who has been with ORNL since he graduated from the University of Tennessee, began his INMM career as Chairman of the Institute's first attempt at an exhibits program for the 1969 Annual Meeting in Las Vegas. "I was as proud of those three exhibits as I would have been of 300" he said, adding that he was pleased that the program has been continuous since that time. Current active plans? "To try to be a good Executive Committee member for two years, keep my mouth shut most of the time, and let the new officers do their job the way they see it best."

Dr. **Ryohei Kiyose**, Professor of Nuclear Chemical Engineering, Department of Nuclear Engineering, University of Tokyo, helped organize the Japan Chapter of INMM. He is now the Vice Chairman of that chapter. Dr. Kiyose has attended the past three INMM annual meetings. He and fellow members of the chapter enjoyed the recent visit of INMM Chairman **G. Robert Keepin** September 25-29. Dr. Keepin presented a paper, "Nuclear Safeguards Implementation in the Nuclear Fuel Cycle" at the Second Pacific Basin Conference on Nuclear Power in Tokyo during the visit to the Japan Chapter.

Cardwell

Kiyose



Klein

David C. Klein is the Chief of the Nuclear Materials Management Branch, Safeguards and Security Division, Albuquerque, DOE. He has been a member of INMM for seven years and attended his first meeting in San Diego. The branch is developing an automated 741 system utilizing electronic communications for data transmission (SACNET) to be used by contractors within the weapons complex. In addition, the branch is responsible for the AL Nuclear Materials Management Program and the monitoring of the NMMSS data flow.

Cecil S. Sonnier, Sandia Laboratories, has been Project Engineer for a number of the Laboratory's Physical Protection projects sponsored by DOE/SS, an activity spanning the past four years. In recent months, Sonnier has worked at the International Safeguards Project Office (ISPO) at Brookhaven National Laboratory. This past September, Sonnier became Liaison Officer at the U.S. Mission to the IAEA in Vienna, Austria for a period of six to nine months. This position is a principal focal point between the IAEA and the U.S. Technical Assistance Support Program to IAEA Safeguards managed by ISPO/BNL. Sonnier joined the INMM this past June and looks forward to active participation in the Institute upon his return from Vienna.

Sonnier

Trahey

Nancy M. Trahey is with the U.S. DOE New Brunswick Laboratory, Argonne, Ill. As Chief of the Standards and Reference Materials Section, she is responsible for the preparation and certification of reference materials used world-wide to calibrate nuclear instrumentation systems and to evaluate nuclear measurement methods. An INMM member for four years, she has attended the last three annual meetings and co-authored a paper presented at the Washington, D.C. meeting in 1977. Currently, she is serving on the INMM 9.3 subcommittee on Physical Standards. Nancy was formerly associated with the Atomics International Division of Rockwell International in Canoga Park, Calif., before joining NBL in 1971.

Jerome (Jerry) W. Handshuh is responsible for the Nuclear Materials Accountability for Southern California Edison Company with which he has been located since 1971. Formerly, he worked in accountability with the Hanford facilities at Richland, Wash. He received the INMM Certified Nuclear Materials Manager Certificate in May, 1971. He participated in the writing of ANSI Standard N15.8 and is presently participating in the writing of ANSI N14.19.

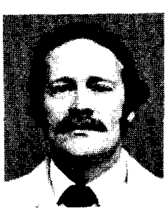
Dr. **Ralph F. Lumb**, President of NUSAC, Inc., has been actively involved in Nuclear Materials Management for over 25 years. He is currently active with NUSAC in all phases of safeguards — physical protection, material control, and material accounting. He is quite optimistic about the future of the INMM and endorses more responsive and timely action of the Institute on current safeguards problems.

Harvey E. Lyon is the Director of the Office of Safeguards and Security within the Department of Energy. He has been a member of the INMM for two years and active in the annual meetings since joining the Department of Energy (formerly the Energy Research and Development Administration) in 1975.


Lyon


Handshuh


Lumb


Tipton


Green


Patterson

W. Hord Tipton has worked for the Union Carbide Nuclear Division at Oak Ridge, Tenn., as an Engineer in the Chemical Services Department at Y-12 for seven years. During this period, he has served as the Department representative for Nuclear Materials Management. He also supervises the Department Accounting and Budgeting, Special Production, and Special Processing sections. He served with **S. C. Suda** of Brookhaven National Laboratory as a member of ANSI INMM N15-8.2. Mr. Tipton assisted with the development of the Dynamic Materials Control and Accounting System (DYMCAS) for the Y-12 Plant. He is currently responsible for the selection and procurement of NDA equipment to be used with DYMCAS. He earned his M.S. degree in Engineering Administration from the University of Tennessee.

James P. Patterson recently completed 10 years of Federal service as a chemist in two regional offices—Berkeley, California (1969-1972) and Chicago, Illinois (1972 to the Present). He previously was with Argonne National Laboratory for over 11 years. Jim was awarded Certificate No. 75 as the last Certified Nuclear Materials Manager designated by INMM in June, 1974. He is presently active on two INMM committees: Education and Membership.

Leon Green is Head of the International Safeguards Project Office at BNL. The office has a responsibility for technical management of the U.S. Program of Technical Assistance to IAEA safeguards (POTAS). The program is now in its second year of assistance to the safeguards activities of the International Atomic Energy Agency. Green was formerly with the Technical Support Organization at Brookhaven and has been a member of INMM for nine years.

Roger H. Moore is Chief of the Applied Statistics Branch (ASB) in the Office of Management and Program Analysis in the U.S. Nuclear Regulatory Commission. The ASB's mission is to provide timely, independent support to NRC management and staff by applying statistical theory and methods to regulatory issues. Thus, in addition to nuclear materials management problems, such topics as reactor steam generators, fuel behavior, siting, ecological effects, and safety questions occupy ASB staff and serve to illustrate the applicability and need for statistical work throughout the nucler power community.

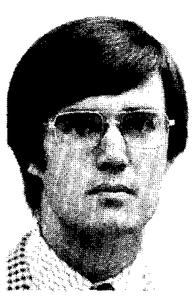
John L. Jaech, beginning his ninth year as Consultant in Statistics with Exxon Nuclear, has stepped down as N-15 Standards Chairman, ending a four-year stint in that position. He has been named Program Chairman for the 1979 INMM annual meeting July 16-19 in Albuquerque and Los Alamos, New Mexico. John's INMM-sponsored course, "Selected Topics in Statistical Methods for SNM Control," given several times in past years, is being supplemented by a three-day introductory course which was given in Columbus October 10-12, 1978.


Jaech


Weinstock

Dr. **Eugene V. Weinstock** is a physicist and has been a member of the Technical Support Organization for Nuclear Safeguards at Brookhaven National Laboratory since 1969. In that capacity, he has participated in studies for DOE and NRC of fuel cycle safeguards, possible improvements in domestic safeguards regulations, spiking of nuclear materials, the international transportation of SNM, and, most recently, the production of weapons-grade nuclear material in clandestine facilities. His current duties include membership in the Safeguards Core Group appointed by the Office of Safeguards and Security for the International Fuel Cycle Evaluation (INFCE). An INMM member since 1970, Weinstock serves as Book Review Editor of *Nuclear Materials Management*.

Dennis M. Bishop, General Electric Company, San Jose, Calif., has recently been elected to the INMM Executive Committee. He will also assume responsibility for the ANSI INMM N15 Standards Committee. Dennis was recently promoted to senior fuel program manager with the Fuel Department at G.E.


Bishop


Shea

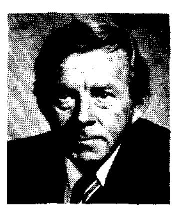
Dr. **Thomas E. (Tom) Shea** is with the systems studies section of the IAEA Department of Safeguards. He is assisting in the development of a system of technical criteria for the application of international safeguards and formulating positions for Agency negotiations with various countries. Tom indicates that he most enjoys the interface between international politics and safeguards technology, an interface which requires one to keep a firm eye on goals while maintaining the utmost flexibility in selecting the technical means through which those goals might be achieved. He enjoys the gemutlich Viennese life and hopes to see an INMM chapter formed there.

Ms. **Barbara (Barbi) Wilt** is a physical scientist with the DOE Richland Operations Office, in the Safeguards and Security Division, Safeguards Branch. Her primary involvement is with reviewing, monitoring, and statistically evaluating Hanford contractor inventory differences, shipments and receipts, participation in interlaboratory analytical/NDA comparability exchange programs, and NDA verification of inventory holdings. She attended her first INMM meeting at Seattle in 1976.

J. Frank Wimpey is with Science Applications, Inc. in the Energy Technology Services Division, McLean, Virginia. He is project manager for the division's nuclear materials safeguard studies. Dr. Wimpey's primary activities have been in support of domestic and international safeguard systems analyses. He has been a member of the ANSI-INMM Subcommittee-3 (Statistics) and at the Cincinnati meeting was selected as chairman of the subcommittee. Prior to his work with SAI in McLean, he was with SAI's La Jolla, CA office and the General Atomic Company.


Reilly


Ney


Toy

Doug Reilly was on his way to LASL after spending the last two years at the Joint Research Centre of the Commission of the European Communities in Ispra, Italy. At LASL, he will continue development of NDA techniques particularly in the area of technique evaluation and standardization. He has been an INMM member for seven years, has frequently presented papers at the annual meeting and in the Journal, and presently serves on INMM 9.3, subcommittee on physical standards. Doug has a Ph.D. in Physics from Case-Western Reserve.

James F. Ney is supervisor of the Systems Studies and Engineering Division at Sandia Laboratories, Albuquerque, N. Mex. This division is responsible for system studies to develop concepts for international safeguards at nuclear facilities and the development of unattended containment and surveillance instrumentation. He is the Sandia project coordinator for the U.S. Program for Technical Assistance to IAEA Safeguards. Under this program, a new high security seal and an unattended TV surveillance system have been developed and are being evaluated by the IAEA.


Studley


Ellingsen


Kawashima

Yoshio Kawashima is Executive Director of the Nuclear Materials Control Center, which serves as the safeguards organization of Japan. He is also Chairman of the Japan Chapter of the INMM. Hé is chairman of the Committee on Physical Protection of the Japan Atomic Energy Commission.

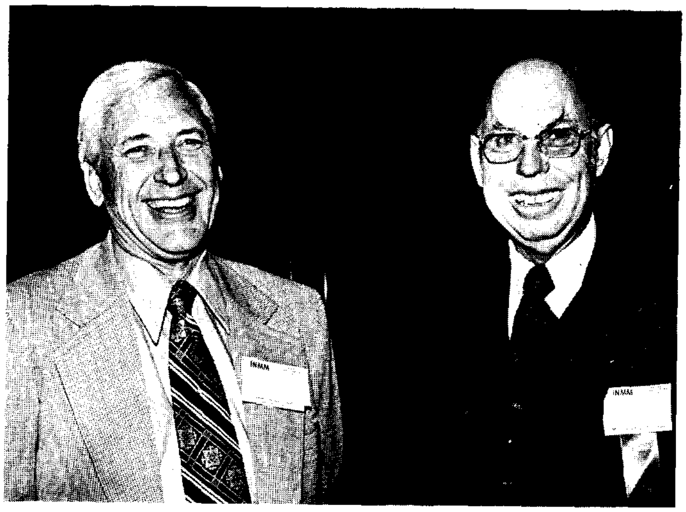
John C. Schleter is with the Center for Radiation Research at the National Bureau of Standards. He is Project Leader of the Nuclear Materials Safeguards Studies Group. He and his group have been primarily involved in developing Diversion Path Analysis. This methodology provides a tool for evaluating an operating plant's material control and material accounting systems to determine vulnerabilities to diversion by an insider using stealth and/or deceit.

John E. Ellingsen is Assistant Advisor (Safeguards) to the UK Department of Energy in London, and is involved in the implementation of both Euratom and IAEA Safeguards in the United Kingdom. He has worked in the nuclear materials management and Safeguards field since 1968, initially with the United Kingdom Atomic Energy Authority, where he carried out studies on safeguards problems in all types of nuclear facilities.

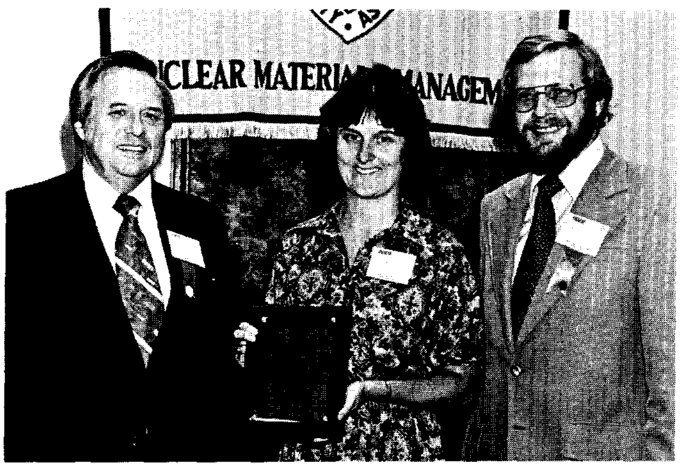
R. V. Studley, was employed by DuPont in the nuclear industry at Savannah River Plant beginning in 1955. He was involved in electronic design and instrument development for reactor monitoring and safety systems for 14 years. He also supervised the Equipment Engineering Department Digital Systems Development and Process Computer Programming groups. He was appointed Staff Engineer two years ago to assess NDA requirements for SRP processes and to implement measurements with suitable instrumentation.

Harley L. Toy, NRC/DOE Compliance Coordinator at Battelle's Columbus Laboratories has been active in INMM activities since it's inception. Currently serves as Chairman of the Education Committee.

INMM Annual Meeting Has Excellent 357 Attendance



For years Chuck Mayer (left) and Jim Lee of Tri-State Motor Transit, Co., Joplin, Mo., have been strong supporters of INMM. In recent years, Jim has served as Chairman of the INMM Membership Committee. Tri-State has provided portfolios for attendees at recent annual meetings.

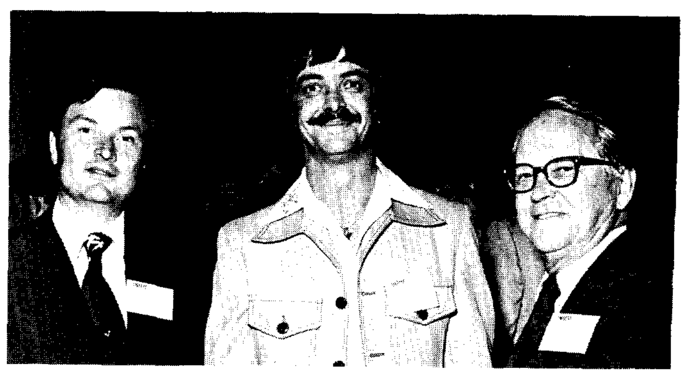


Dr. Carolyn Heising (center), formerly of EPRI and now of MIT, is the recipient of the first annual INMM Student Paper Award. Her paper is "Analyzing the Reprocessing Decision: Plutonium Recycle and Nuclear Proliferation." She received a check for $500, a plaque (presented by Roy Cardwell and Frank O'Hara), and travel expenses to the annual meeting. Dr. O'Hara chaired the committee which selected the winning paper.

Syl Suda (center) of Brookhaven National Laboratory is Chairman of the INMM Safeguards Committee. Mr. Suda is shown visited with Tom McSweeney and Bob Sorenson (right) of Battelle Northwest.

ANNUAL MEETING RECEPTION LINE — At the Chairman's Reception Monday evening, Convention Photographer George Mayhew of Cincinnati posed a photo of the attractive couples in the reception line (from left): Vincent and Jeanne DeVito, Waverly, Ohio; Roy and Barbara Cardwell, Oak Ridge, Tenn.; Bob and Madge Keepin, Los Alamos, N. Mex.; and Bernie and Naomi Gessiness, Cincinnati.

Members of the Technical Program Committee for the 1978 Annual Meeting in Cincinnati, Ohio, were (from left) Tom Collopy, United Nuclear Corp., Uncasville, Conn.; Gary Molen, Chairman, Allied-General Nuclear Services, Barnwell, S.C.; and Dr. Richard Chanda, Rockwell-Rocky Flats, Golden, Colo.



THE T.V.A. THREESOME — Three representatives of T.V.A. safeguards (from left) — Bob Thompson, Jimmy Gilbreath and O. P. Pitts — took part in the 1978 Annual Meeting. Mr. Pitts attended his last annual meeting this past June.

Mr. David W. Leigh, Director of Health and Safety, Nuclear Division, NL Industries, Inc., *Wilmington, Del.*

Dr. Warren H. Donnelly, Senior Specialist (Energy), Congressional Research Service, U.S. Library of Congress.

Dr. Leonard Weiss, Staff Director, Subcommittee on Energy, Nuclear Proliferation Planning, and Federal Services, and for Senate Committee on Governmental Affairs.

Mr. Nathan Hurt, General Manager, Goodyear Atomic Corporation, Piketon, Ohio

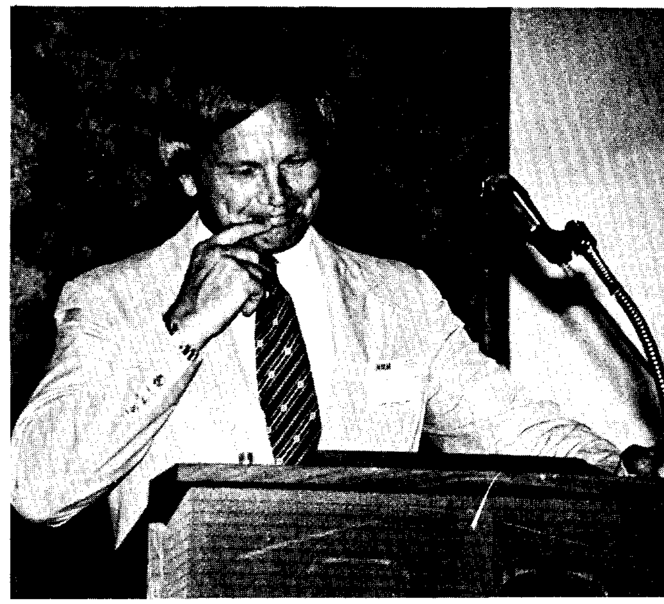
Dr. Philip Farley, Deputy Special Representative for Nonproliferation Matters, U.S. Department of State.

Dr. Joseph R. Dietrich, Past President, American Nuclear Society, who is with Combustion Engineering, Inc., Windsor, Conn.

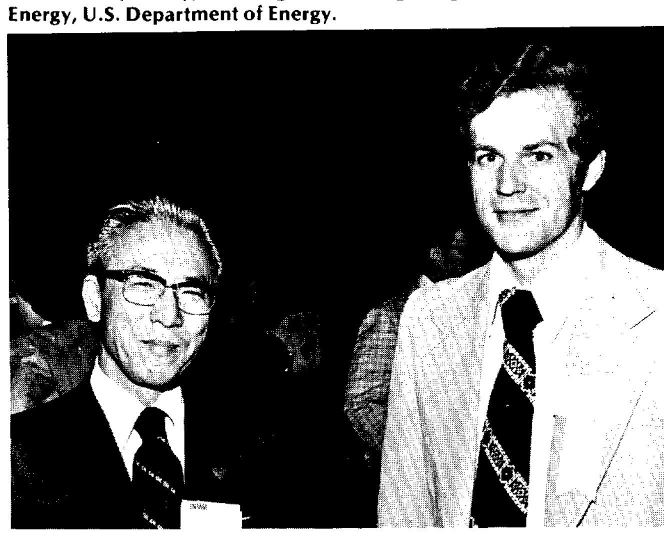
Admiral Harvey E. Lyon, Director, Office of Safeguards and Security, U.S. Department of Energy.

Mr. John Conway, Executive Assistant to the Chairman, Consolidated Edison Company, New York, N.Y.

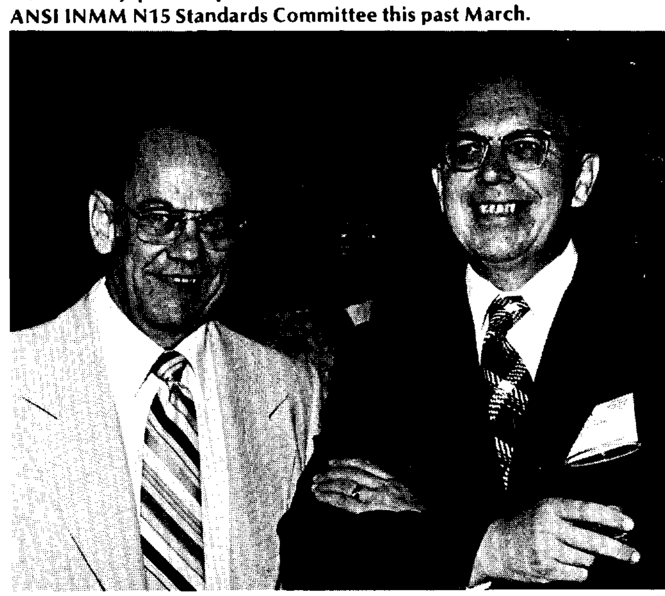
Ann MacLachlan, Managing Editor of Energy Daily, Washington, D.C., was moderator of the Wednesday afternoon panel discussion, "Nuclear Power — The Imperatives Here and Now." She substituted for Llewellyn King, Editor of publication.



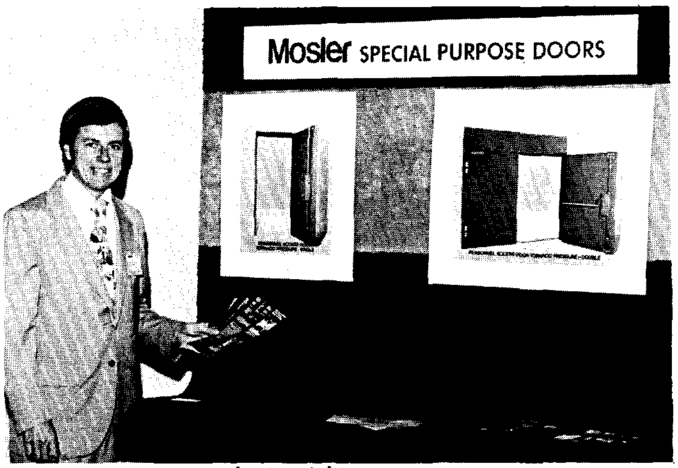
Dr. G. W. (Woody) Cunningham, Acting Program Director, Nuclear Energy, U.S. Department of Energy.



Prof. Ryohei Kiyose of the University of Tokyo is shown with David W. Zeff of Babcock and Wilcox, Lynchburg, Va. Prof. Kiyose is Vice Chairman of the Japan Chapter of INMM. Mr. Zeff became Secretary of the ANSI INMM N15 Standards Committee this past March.



Cal Solem (left) of the U.S. NRC visited with Invited Speaker Frantisek Klik of IAEA during the Chairman's Reception. Mr. Solem formerly served with the IAEA in Vienna.

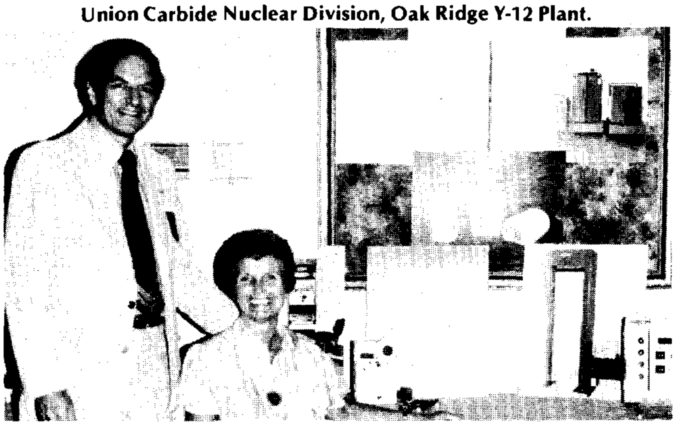


Mosler Special Purpose Doors.

Ludlum Measurements.

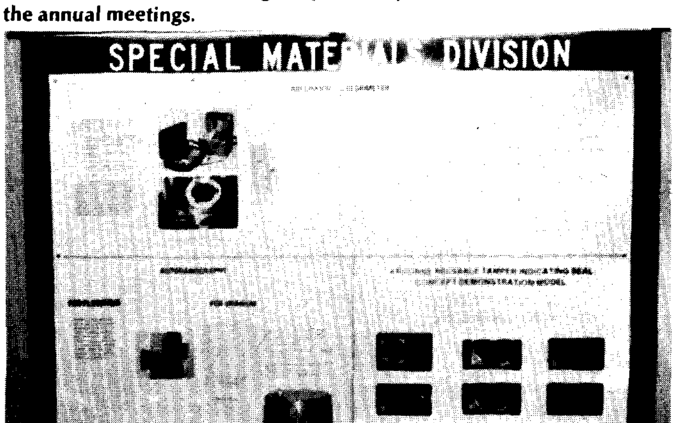
Union Carbide Nuclear Division, Oak Ridge Y-12 Plant.

Harshaw Chemical Company.



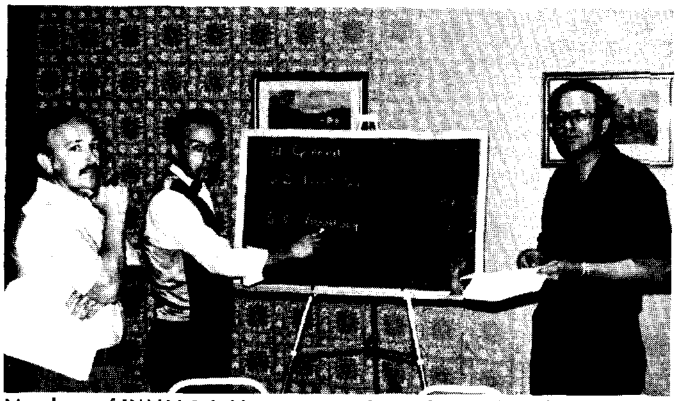
Herman and Joanne Miller of National Nuclear Corporation, Redwood City, Calif. Mr. Miller is the new Chairman of the INMM Public Information Committee after serving the past two years as Exhibits Chairman for the annual meetings.

Mound Laboratory of Monsanto Research Corp., Miamisburg, Ohio.



Air Chamber Calorimeter, Special Materials Division, Argonne National Laboratory.

Chuck Demos (left) of the U.S. NRC had two exhibits at the 1978 Annual Meeting. He is enjoying a festive moment at the Chairman's Reception with Richard Grammann, also of the NRC.



Members of INMM 9.4, Measurement Controls, are (from left), Bob McCord, Westinghouse-Hanford; Darryl Smith, LASL; and Richard Grammann, NRC.

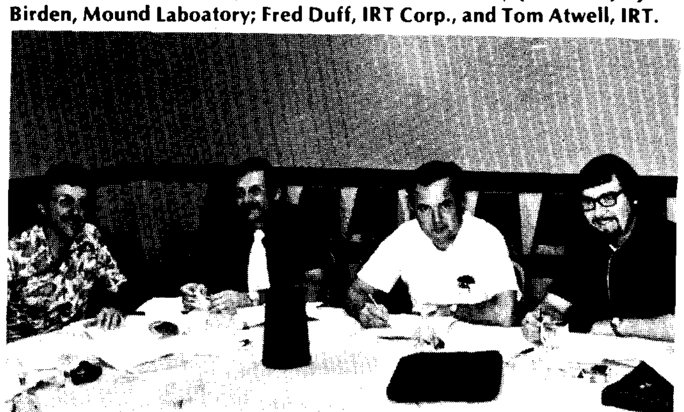
Members of INMM 10, Physical Security, are (from left)–Jim Prell, NRC; Sam McDowell, DOE; Al Winblad, Sandia; Ed Kurtz, GE-Pleasanton; John Powers, IEAL; Herb Dixon, Office of Secretary of Defense; Blythe Jones, IAEL; E. L. Musselwhite, AGNS; and Don Moss, Westinghouse.

Members of INMM 3, Statistics, are (from left)–Merril Hume, Rocky Flats; David Zeff, Babcock & Wilcox (Secretary of N15 Standards); Richard Mensing, LLL; Vic Lowe, Y-12 ORNL; John Telford, NRC; Roger Moore, NRC; Gery Tietjen, LASL; Delores McCarthy, UNC; and Frank Wimpey, SAI-McLean.

Members of INMM 9.6, Automation, are (from left)–Larry East, Canberra; Nick Roberts, LLL; Phil Ting, NRC; Walt Strohm, Mound Laboratory; Norm Hall, GE; and Ron Brandenburg, ANL.

Members of INMM 9.3, Physical Standards, are (standing, from left)–John Glancy, SAI; Bill Rodenburg, Mound Laboratory; Tom McDaniel, Babock & Wilcox; and Ron Harlan, Rocky Flats. Seated are (from left)–Bill Reed, NBS; Nancy Trahey, NBL; and Steve Carpenter, NBS.

Members of INMM 9.2, Container Standardization, (from left)– John Birden, Mound Laboatory; Fred Duff, IRT Corp., and Tom Atwell, IRT.



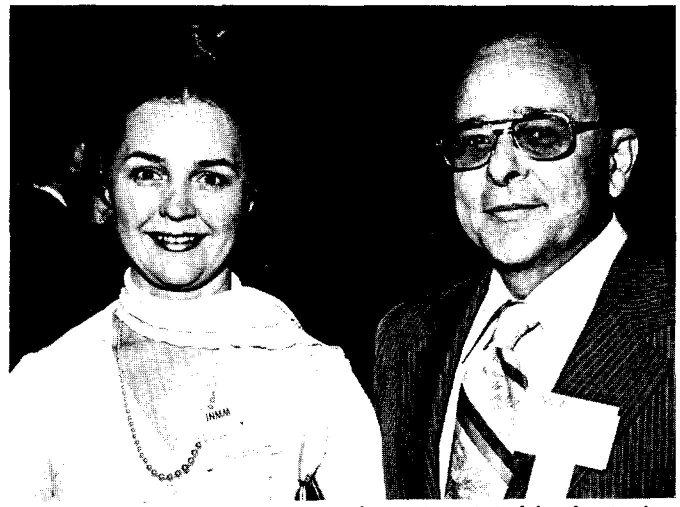
Members of INMM 9.1, Material Categorization, are (from left)–Dick Chanda and Fran Haas, Rocky Flats; Al Evans, LASL; and Herb Smith, Rockwell-Hanford.

Members of INMM 7, Audit Techniques, are (from left)–Bob Sorenson, Battelle Northwest; Dean James, GE; Tom McSweeney, Battelle Northwest; Bob Kramer, Northern Indiana Public Service; Cal Solem, NRC; and Shelly Kops, DOE-Chicago.

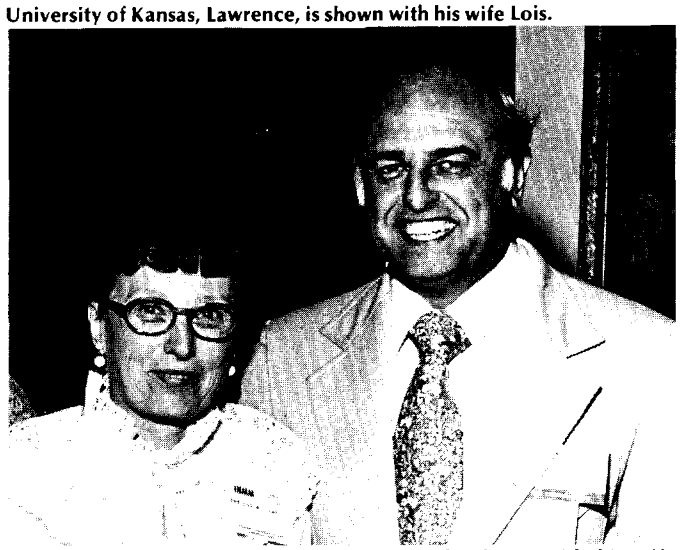
Yoshio and Toyono Kawashima of Tokyo, Japan, were among those attending the Chairman's Reception. The Kawashimas hosted R.G. Cardwell and G.R. Keepin of the INMM Executive Committee during recent visits to Japan.

SERVICE AWARD TO JAECH — John L. Jaech (left), Staff Consultant in Statistics at Exxon Nuclear Co., Richland, Wash., was honored at the 1978 meeting for his many contributions to the Institute including standards, education, and writing for the Journal. He is pictured with is wife Delores at the reception.

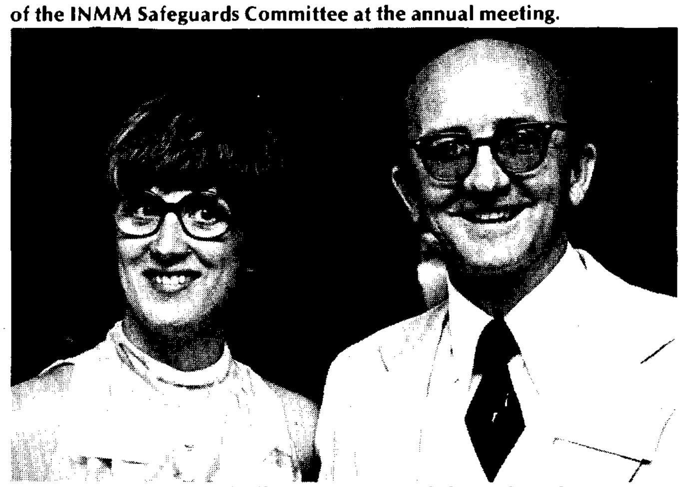
Regular attenders at recent INMM meeting have been Lewis and Pat Casabona of Teledyne Isotopes, Westwood, N. J.



THANKS TO WALTER STROHM — The Institute is indebted to Walter Strohm of Mound Laboratory, Miamisburg, Ohio, for his efforts in transcribing some of the presentations in the morning plenary session so they could be printed in the INMM Proceedings of the 1978 meeting. Mr. Strohm who received at least some of his advanced education at the University of Kansas, Lawrence, is shown with his wife Lois.



LUNCHEON SPEAKER — Dr. Ralph F. Lumb, shown with his wife Phyllis, gave the Institute paper, "INMM—20 Years of Service," during the awards luncheon Thursday noon. Dr. Lumb, President of NUSAC, Inc., McLean, Va., took part in the Founder's Luncheon and the meeting of the INMM Safeguards Committee at the annual meeting.



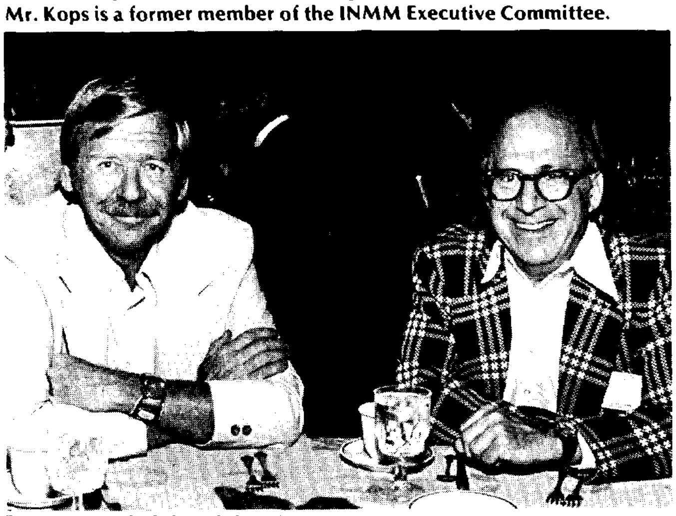
THE GARY MOLENS of Aiken, S.C., enjoyed themselves thoroughly at the 1978 meeting. Gary has been elected INMM Vice Chairman for this year after two years as Chairman of the Technical Program Committee. Mr. Molen is Manager of Nuclear Materials Safeguards at AGNS, Barnwell, S.C. His wife Sara has been an active participant in the annual meeting ladies' programs in recent years.

The G. B. Kuklinskis of Rockwell Hanford took part in the annual meeting. Mr. Kuklinski served on the INMM Registration Committee at Cincinnati.

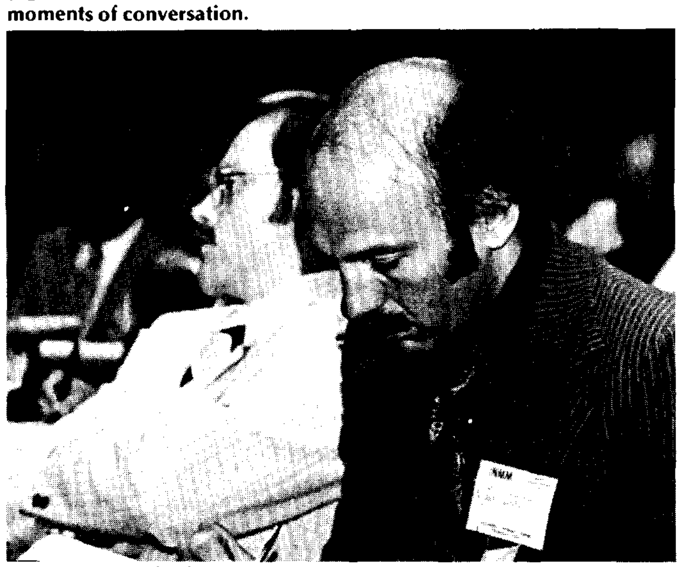
Russ Weber, recently retired from U.S. DOE, is now with NUSAC, Inc., McLean, Va. Russ, and his wife, Phyllis, were in attendance at the 1978 Annual Meeting. Russ is coordinating the December 7-8 INMM Workshop on the Impact of IAEA Safeguards in the U.S. at the Washington Hilton in Washington, D.C.

Ed Young (left) of Rockwell-Rocky Flats, Golden, Colo., visited with Sheldon Kops of the U.S. DOE Chicago Operations Office, Argonne, Ill. Mr. Kops is a former member of the INMM Executive Committee.

Mr. and Mrs. Roger Moore (left) of the U.S. NRC and Edward Kurtz (right) of General Electric, Pleasanton, Calif., enjoyed some pleasant moments of conversation.



Roy B. Crouch (left), of the Albuquerque Operations Office of the U.S. DOE, is serving as Local Arrangements Chairman for the 1979 Annual Meeting next July 16-19 in Albuquerque at the Hilton Hotel. Leon Green (right) is Head of the International Safeguards Project Office at Brookhaven National Laboratory, Upton, N.Y.



Dr. Tom Atwell of IRT Corp., San Diego, Calif., took notes during technical sessions at the annual meeting. Dr. Atwell, formerly of LASL, is active in ANSI INMM N-15 Standards activities.

Taking advantage of the opportunity provided by the social event to renew old acquaintances are (from left): Robert Tharp, formerly Acting Director of DOE's Division of Safeguards and Security, now Chief of Plant Security for Union Carbide's K-25 facility at ORNL; Harvey E. Lyon, Director of DOE's Office of Safeguards and Security; Dipak Gupta, Head of the Safeguards Project at the FRG's Karlsruhe Nuclear Research Center; and William Hagis of DOE's Office of International Security Affairs.

Richard A. Alto was honored at the 1978 annual meeting for his outstanding service as Secretary of the ANSI INMM N-15 Standards Committee. Mr. Alto was unable to attend the 1978 meeting where his plaque was presented. Accepting it on his behalf was David W. Zeff (left), new Secretary of N15. Alto and Zeff are with Babcock & Wilcox, Lynchburg, Va. Roy Cardwell presented the plaque to Zeff.

Delores McCarthy of United Nuclear Corp., Uncasville, Conn., visited with Tom Gerdis of Kansas State University, Manhattan. Ms. McCarthy has been active in the INMM standards program related to statistics. Mr. Gerdis is Editor of the INMM journal at K-State where he serves as News Editor for the College of Engineering.

Immediate Past INMM Chairman Roy G. Cardwell (left) of ORNL presented INMM Founder's Plaques at the annual meeting during the Founder's Luncheon to Shelly Kops (center) of the DOE Chicago Operations Office and Paul Morrow (right) of the NRC Directorate of Licensing.

CANBERRA REPRESENTATIVES — Among representatives of Canberra Industries, Meriden, Conn., at the 1978 Annual Meeting were Rudy Gatti (left) and Don Taylor. Canberra has been an active participant in recent INMM meetings as an exhibitor of instrumentation.

Dr. T. Douglas Reilly (right) has recently returned to Los Alamos Scientific Laboratory after a couple of years at ISPRA (Italy). He visited with Herman Miller, President of National Nuclear Corp., Redwood City, Calif., at the annual meeting. After two years as Exhibits Chairman for annual meetings, Mr. Miller has been designated the new Chairman of the INMM Public Information Committee.

Raymond E. Lang, Chairman of the INMM Annual Meeting Site Selection Committee, is shown with his two children. Mr. Lang is with the Chicago Operations Office of U.S. DOE.

Enjoying a joke together at Roy Cardwell's Chairman's Suite at the annual meeting were Harley L. Toy (left) of Battelle Columbus Laboratories and Professor Ryohei Kiyose of the University of Tokyo's Department of Nuclear Engineering.

The Ron Tschieggs of Westinghouse-Pittsburgh visited briefly with Armand R. Soucy (right), Assistant Treasurer, Yankee Atomic Electric Co., Westboro, Mass. Mr. Soucy, a past INMM Chairman, completed a two-year term on the INMM Executive Committee this past June 30. Ron Tschiegg has been active in the INMM for several years including helping to write the recent INMM Special Report on Low-Enriched Uranium.

At the Chairman's Reception, Bob Keepin (center) gets off a funny one to two good lookin' friends from Tennessee — Roy and Barbara Cardwell.

The Goodyear Atomic contingent (from left) of Jim Griggs, Ken Baldwin, Bill Schultz, Frank Voss and John Murrell enjoy the Chairman's Reception at the 1978 annual meeting in Cincinnati.

Billy Joe Campbell of the Oak Ridge Operations Office of U.S. DOE provided the musical entertainment at the Chairman's Reception. He is pictured with is wife who accompanied him to the 19th INMM meeting. Billy is an outstanding entertainer. He also performed at the 1977 INMM meeting in Washington, D.C.

Dr. Ralph F. Lumb (left) of NUSAC and Thomas B. Bowie (right) of Combustion Engineering were given special recognition at the annual meeting as the only two Founders of the Institute who later served as Chairman of the organization. Special plaques were presented by Roy G. Cardwell, Immediate Past Chairman, at the Awards Luncheon.

Gary C. Kersteen (left) of Combustion Engineering, Windsor, Conn., who presented a paper on his firm's fuel accountability and control system at the annual meeting, enjoyed some conversation with Chuck Mayer, Vice President, Nuclear Division, Tri-State Motor Transit Co., Joplin, Mo.

ENJOYING THE INMM AWARDS LUNCHEON (from left) were David L. Dye, Boeing Computer Services, Bellevue, Wash.; James P. Patterson, U.S. NRC Region III, Glen Ellyn, Ill.; and Jay Durst, U.S. NRC, Washington, D.C.

Bill DeMerschman, Ryohei Kiyose, Akihiko Kitano, and Madge Keepin visiting at the Chairman's Reception.

Kenneth C. Duffy (left), Manager of Nuclear Materials at General Atomic Co., San Diego, Calif., visited with Dr. J. Frank Wimpey of Science Applications, Inc., McLean, Va., at the Chairman's Reception Monday evening at Stouffer's in Cincinnati.

John Ladesich (left) of Southern California Edison Co., Rosemead, Calif., served on the INMM Executive Committee for the past two years. He was recognized for his service with a special INMM momento by Roy G. Cardwell, Immediate Past Chairman of INMM, at the Thursday noon Awards Luncheon.

Billy Joe Campbell, vocalist and guitarist, provided the special entertainment during the Chairman's Reception for the second straight year. Billy with the U.S. DOE Oak Ridge Operations Office.

Enjoying a particularly happy moment together with Immediate Past Chairman Roy Cardwell (left) of ORNL were Ray and Martha Jackson of the U.S. NRC. Ray, formerly of Battelle Columbus Laboratories, was Editor of The INMM Newsletter which was the official Institute organ until April 1972 when the first issue of this Journal was published.

John Mangusi (left) of Transnuclear, Inc., White Plains, N.Y., voices a point firmly with Chuck Demos of the U.S. Nuclear Regulatory Commission who displayed two excellent SNM transportation firms during the annual meeting.

BUSY REGISTRATION TABLE — Duane Dunne of Rockwell International's Rocky Flats Plant, Golden, Colo., was in charge of the registration activities at the 1978 meeting. Activity was quite hectic. The work load was handled efficiently by a dedicated registration committee.

Members of the INMM Executive Committee (FY 78) in attendance at the annual meeting Founders' Luncheon (from left): John Ladesich, Gary Molen, Dennis Wilson, Bill DeMerschman, Roy Cardwell, Bob Keepin, Ed Owings and Vince DeVito.

Fourth in a Series

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

Editor's Note–This is the fourth in a series of listings of titles and abstracts of recent safeguards R&D publications and reports from agencies and R&D laboratories. It has been compiled by Science Applications, Inc., La Jolla, California. In order, the first three listings were from Los Alamos Scientific Laboratory, Los Alamos, New Mexico; Mound Laboratory, Monsanto Research Corp., Miamisburg, Ohio; and Argonne (Ill.) National Laboratory. The Winter issue will have a similar listing from Sandia Laboratories, Albuquerque, New Mexico. If your agency or R&D Laboratory is interested in being included in this series, please contact Dr. William A. Higinbotham, Brookhaven National Laboratory (516-354-2908 or FTS 664-2908/2924), Upton, Long Island NY 11973.

1) S. Donelson, P. Melling, T. Pasternak and W. Hagen; *Management of Safeguard System Functions During Maintenance Operations,* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 139-148. The Engineered Safeguards System (ESS) to protect advanced nuclear fuel cycles against internal and external threats from terrorists and others has been under development since early 1976. An important role of the ESS is the detection and prevention of the covert activities which may result in theft of SNM or sabotage. This role is fulfilled by the implementation of effective closed-loop controls through access control elements and operational control elements. The methodology for the development of requirements for the safeguards elements, called Operational Control Analysis, and its applicability to less structured activities, such as maintenance, is described.

2) H. Kendrick, L. Kull, J. NiCastro, F. Wimpey, D. Rundquist and P. Melling; *Technology Transfer Proliferation and Safeguards,* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 205-211.

3) F. Wimpey and J. Glancy, *International Safeguards Inspection Approach for Plutonium Recycle Facilities,* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 231-237. This paper presents the results of studies that were directed toward quantifying the effort necessary to inspect plutonium recycle facilities. The cross-over sampling method is used to develop inspection plans for reprocessing and recycle fuel fabrication facilities. These sampling plans are then used to estimate the manpower requirements of the inspectorate. Practical constraints, such as scheduling of shipments, verification of in-process inventory, measurement techniques, etc., are discussed.

4) L. Kull, L. Harris, Jr. and J. Glancy; *A Method for Evaluating the Effectiveness of a Facility Safeguards System,* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 292-301. A method is under development for evaluating the performance of a nuclear facility safeguards system for defeating attempts of theft or sabotage. The most important challenge of the work lies in defining a framework which is complete, in the sense that it considers all items known to be important in such an assessment. The method consists of a series of analytical techniques which determine a figure-of-merit for the system capability to prevent an adversary from achieving his objective. Results from the use of a preliminary version of the method indicate it has practical value for use in safeguards design, licensing and policy applications.

5) L. Harris, Jr., C. Rindfleisch and B. G. Hartenau; *Estimation of the Outcome of Overt Adversary Actions Using Simulation,* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 356-363. A batched, aggregate, network simulation method for estimating the outcome of overt adversary actions is under development. Aggregate models are used to represent delay mechanisms and engagements. The engagement model includes disengagement criteria. The network includes multiple action lines for adversary, guard, and off-site response forces. Simulation results include the material containment probability and time distributions for material containment by the guard and/or off-site response forces and for material removal by an adversary force. A simulation example is given.

6) Tsahi Gozani, *An Evaluation of Hold-Up Measurement* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 424-433. The purpose of this work is to assess the importance of holdup determination in nuclear fuel cycle facilities and to discuss the present status and future development of holdup measurements. It is shown that the measurement uncertainty of holdup contributes significantly to LEMUF in the mixed oxide fuel fabrication plant. In other cases like the reprocessing plant, the contribution is insignificant. The nuclear material signatures available for holdup measurements are reviewed. The possibility of using

the more penetrating gamma rays emitted by traces of fission products such as Zr95-Nb95 and Rh106-Ru106 is suggested. A variety of recent holdup measurements indicate that systematic errors between 20% to 50% are attainable. The lower values are obtained under more favorable conditions. For many applications the higher error is acceptable and can be easily achieved even in the present industrial environment.

7) J.E. Glancy, R. Polichar, C. Stone, T. Gozani and A. Unione, *Evaluating the Vulnerability and Detection Probability of Detection Mechanisms,* INMM, Nuclear Materials Management, **VI**, No. III, Fall 1977, p. 601-610. This paper describes a procedural framework for evaluating the performance of instruments, equipment, watchmen and procedures designed to detect covert adversary actions that could lead to theft of nuclear material or sabotage of nuclear facilities. The evaluation of these detection mechanisms produces figures-of-merit, similar to detection probabilities, that are compiled into a data base used in a total safeguards system performance evaluation. The detection mechanism data base is generated by independently evaluating each mechanism against a defined threat (number of insiders and outsiders) and under defined initial conditions (plant operating state, mechanism operating state, and adversary state). The threat is divided into adversaries with and without access to the mechanism via operation, maintenance or circumventing the mechanism so that it is completely prevented from functioning effectively and a probability analysis that assumes the mechanism is functioning correctly and the adversary is in the "field-of-view".

8) T. Gozani, *Safeguards Systems for Nuclear Facilities,* Washington Meeting of the American Physical Society, April 24, 1978. The general objective of nuclear material safeguards is to protect the public against the unacceptable risks of death, injury, or property damage produced by malevolent use of nuclear materials or sabotage of nuclear facilities. The safeguards system acts as a barrier between the adversary and his intended goal. The magnitude of this barrier is directly related to the safeguards system's performance. The three main ingredients of safeguards technology, have evolved over the last decade: materials handling, materials measurement, and materials accounting. Each of these areas require personnel assignments and procedures which are subject to human error, and hardware whose design and utilization may require knowledge of neutron physics. The success of a safeguards system depends critically on the proper combination of "people" and "hardware". The advancements in safeguards hardware for all types of nuclear fuel cycle facilities are remarkable. One of the areas in which progress is most noticable is the development of nondestructive assay (NDA) and of nuclear materials detection. The physics principles underlying instrumentation have been covered extensively and the state of art of NDA is discussed in the next paper. An outstanding example of a powerful nuclear technique and its proper incorporation within an integrated safeguards system is provided by Portal Monitors. These monitors are highly sensitive devices which unobtrusively detect the passage of plutonium, for example, via the radiations it emits. The basic sensitivity of the monitors can be calculated on the basis of physical laws, but the monitor's detection capability greatly depends on adversary tactics. One can apply various physical laws to each assumed tactic and determine the probability of nuclear material detection in one or multiple passage scenarios. Such an analysis shows that the probability of covert removal of a substantial amount of nuclear material, either in a few large thefts or many small thefts in nuclear facilities with properly placed portal monitors is very small. This and other safeguards techniques can indeed provide reasonable assurance of the adequacy of an integrated safeguards system.

9) L.A. Kull, J.E. Glancy and L. Harris, Jr., *The Performance of Safeguards Technology-Hardware, People, Systems,* ANS Transactions, **27**, 1977, p. 177.

10) G.M. Borgonovi, J.E. Hammelman and C.L. Miller, *Dynamic Process Model of a Plutonium Oxalate Precipitator,* ANS Transactions, **28**, 1978, p. 374.

11) Tsahi Gozani, *Evaluation and Vulnerability Analysis of Portal Monitors,* ANS Monitors, ANS Transactions, **28**, 1978, p. 376.

1) **T. Pasternak, J. Walkush, E. Chen, P. Melling, S. Donelson and R. Higgins;** *Preliminary Operations Control Analysis for an Engineered Safeguards System, Volumes I and II,* SAI-77-530-LJ, January 29, 1977. Operations Control Analysis (OCA) has been developed as a tool for the design and analysis of the closed-loop safeguards controls which join together parts of an Integrated Safeguards System (ISS). Volume I provides an introduction to the content and purpose of OCA's, including a discussion of the role of OCA's in the ISS concept and a description of OCA formats and classifications. Volume II contains OCA's for a generic mixed oxide fuel fabrication facility.

2) S. Donelson, W. Hagan, J. Hammelman, P. Melling, T. Pasternak and F. Wimpey, *Supplementary Concept for Baseline Reprocessing Plant,* SAI-77-669-LJ, May 29, 1977. The report provides concept descriptions for a baseline reprocessing plant and updated a 1976-concept description authored by Sandia Laboratories. These baseline descriptions provide a framework for identifying those generic design and operating features of a spent fuel reprocessing plant which impact the safeguarding of plutonium.

3) S. Donelson, J. Glancy, T. Gozani, B. Hartenau, J. Maly, F. Wimpey (Volume 2); T. Gozani, J. Maly (Volume 3), *A Study of Nuclear Material Accounting, Volumes 2 and 3,* NUREG-0290, June 1977. This report contains a technical evaluation of present-day periodic nuclear material accounting systems ability to provide adequate assurance that SNM is safeguarded. Volume 2 focuses on three aspects of accounting: (1) sensitivity to detect theft as determined by measurement accuracy, measurement plan, and batch size; (2) the predictability of the

material-unaccounted-for (MUF) in terms of measurement error, losses and gains; (3) the vulnerability of accounting to tampering that would cover-up theft. Volume 3 presents a survey of measurement methods and reports on accuracies, precisions and vulnerability to tampering to induce a bias or inflate the variance.

H. Donnelly, R. Fullwood, J. Glancy, T. Gozani, L. Harris, B. Hartenau, H. Kendrick, L. Kull, P. Melling, J. Nicastro, R. Polichar, C. Rindfleisch, D. Rundquist, E. Simpson, C. Stone and A. Unione; *VISA - A Method for Evaluating the Performance of Integrated Safeguards Systems at Nuclear Facilities, Volumes I and II*, SAI-77-590-LJ, June 30, 1977. This report describes a method that was developed to evaluate safeguards systems at nuclear facilities. The method, called VISA (Vulnerability of Integrated Safeguards Analysis), defines a framework that is complete in the sense that it logically considers all items known to be important in assessing vulnerability. The present version of the method can be described from several aspects: (1) it determines a quantitative figure of merit for a safeguards system capability to prevent an adversary from achieving his objectives; (2) the adversary action sequence (AAS) is divided into a number of separate segments for analysis, each segment defined by an intermediate adversary objective; (3) each AAS segment consists of many paths that are analyzed for covert and overt modes of adversary operation; and (4) the work is performed in three sections: input preparation, analysis, and assessment of results. The method can be used to evaluate safeguards systems for different facilities, for different threats (outsiders, insiders, both), for different targets (theft and sabotage) and for different adversary action modes (covert, overt, both). It has been applied to a model mixed oxide fuel fabrication facility and results indicate that future uses for design, licensing, inspection and policy planning are practical. Also, the method is applicable to evaluation of security systems for any type of facility.

5) W. Hagan, H. Kramer, T. Pasternak, J. Schmid and J. Walkush, *Description of Theft and Sabotage Targets in the MOFF*, SAI-77-775-LJ, August 5, 1977. Safeguards concerns for theft and sabotage targets are identified and analyzed for a representative, safeguarded, mixed oxide fuel fabrication facility (MOFF). This facility is modeled after process line descriptions and layouts proposed for the Westinghouse recycle fuels plant, but has been modified by adding a conceptualized engineered safeguards system (ESS). The safeguards include a closed-loop control system employing automatic monitors, procedures, and correlation criteria. The ESS was developed and evaluated using an SAI-developed process step analysis methodology called "operations control analysis" (OCA).

6) J. Schmid, T. Pasternak, J. Walkush, E. Chen, S. Donelson, B. Hagan and P. Melling; *Operations Control Analysis for a Mixed Oxide Fuel Fabrication Facility*, SAI-77-871-LJ, October 4, 1977. This report contains a brief introduction to the objectives of operations control analysis, its overall role in the development of an engineered safeguards system, and the details of the classifications and format used for operations control analyses (OCA's). A representative facility is defined based on the proposed Westinghouse Recycle Fuels Plant. The facility is divided into protection zones and a format for operations control analysis of the model facility is presented. Adversary sequence fault trees are constructed for selected zones. The complete set of OCA's for the MOFF and adversary sequence fault trees for the selected zones are described.

7) D. Kaul and E. Sachs, *Adversary Actions in the Nuclear Power Fuel Cycles: Volume I. Reference Events and Their Consequences, and Volume II. Assessment of Methodology for Consequence Estimation*, SAI-121-612-7803 (Volume I), SAI-121-612-7802 (Volume II), October 1977 Volume I), March 1977 (Volume II). Volume I presents preliminary calculations of consequences of several nuclear material dispersion scenarios including stolen materials, sabotage of nuclear reactors, sabotage of fuel reprocessing and fuel fabrication facilities and sabotage of fuel storage and transportation vehicles. The source terms including radioactivity and chemical and physical form and the dispersal mechanisms are being analyzed to determine the consequences to the health and safety of the public. Volume II presents a description and assessment of methodologies for estimating consequences. A third volume will soon be published and will report on the consequences calculated using the selected methodology.

8) C. S. Sonnier, M. N. Cravens (Sandia); and W. F. Lindsay, W. P. Melling, and T. Pasternak (SAI contributors), SAND 77-1953 (Sandia Document), 1977. Preliminary concepts for detecting national diversion of LWR spent fuel during storage, handling, and transportation are presented. Principal emphasis is placed on means to achieve timely detection by an international authority.

9) C. S. Sonnier, J. W. Mayer (Sandia); and T. Pasternak, T. Kuh, W. Lindsay, A. Hawkins, P. Reardon and P. Melling (SAI contributors), *Baseline Descriptions for LWR Spent Fuel Storage, Handling and Transportation*, SAND 77-1953 (Sandia Document). Baseline descriptions of facilities for storage and handling of spent fuel, as well as descriptions of spent fuel land and water transportation modes are provided. Storage and handling facilities include LWR reactor pools, away-from-reactor-storage basins, dry surface storage units, reprocessing-facility interim storage pools, and deep geologic storage.

10) P. Lobner, W. Horton, J. Mahn and J. Schmid, *Reactor Plant Safeguards - An Evaluation of Sabotage Concerns in a Pressurized Water Reactor Plant, Volumes 1 and 2*, SAI-78-612A-LJ (Volume 1), SAI-78-612B-LJ (Volume 2), March 31, 1978. This report characterizes a typical, modern PWR plant and the vital plant systems. Potential sabotage targets are identified by means of fault-tree analysis. The sabotage modes and locations of each target are identified.

11) J. Glancy, J. Nicastro, W. Woolson and A. El- Bassioni, *Analysis of Nuclear Fuel Facility Safeguards Against Threats Involving Insider Collusion,* SAI-78-547-LJ, April 3, 1978. One of the prime concerns related to the safeguarding of nuclear material and equipment is the vulnerability to a conspiracy among employees of the nuclear facility, especially members of the security force. This report contains an analysis of the issues involved in employee collusion and reports on the ways that work rules can be structured and integrated into facility design and operation to reduce collusion opportunities. A method has been developed that yields the set of event sequences leading to nuclear theft or sabotage that are most susceptible to collusion and the groups of employees who pose the most serious security threat. This analysis method has been automated using the computer code, MAIT (Matrix Analysis Insider Threat). An operating facility has been analyzed and safeguards upgrades were recommended to determine adequacy relative to a proposed regulation on internal conspiracy at nuclear facilities.

12) L. Kull, L. Harris, P. Lobner (One Insider), L. Kull, L. Harris and A. El-Bassioni (Two Insiders), *Protection of Nuclear Power Plants Against Sabotage by An Insider, Protection of Nuclear Power Plants Against Sabotage by Two Insiders,* SAI-77-868-LJ, SAI-77, 965-LJ, October 1977 (one insider), May 1978 (two insiders). New NRC safeguards regulations for protecting nuclear power plants against sabotage were published in early 1977. These regulations include the performance requirement that protection be provided against sabotage by an insider in any position. These reports contain an evaluation of the effectiveness and impact of different sets of access control and surveillance measures for detecting an insider's sabotage attempt. Effectiveness is evaluated for adversary tactics of force, stealth and deceit. Impacts are examined in terms of costs, safety and employee morale. An example security procedure for implementing a selected set of access control and surveillance measures is presented. Similar consideration is given to the two-insider threat.

INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

WORKSHOP ON THE IMPACT OF IAEA SAFEGUARDS
DECEMBER 7 and 8, 1978
THE WASHINGTON HILTON, WASHINGTON, D.C.

The INMM is constantly endeavoring to keep its membership and the industry aware and informed of significant developments in the nuclear field. To that end it is sponsoring a day-and-a-half Workshop on the potential impact on the U.S. nuclear industry of IAEA (International Atomic Energy Agency) Safeguards, under the terms of the Nuclear Non-Proliferation Treaty.

The Workshop will be held at the Washington Hilton on December 7 and 8, 1978 and the Institute will host a reception/mixer for those who arrive Wednesday evening, December 6, and provide a luncheon Thursday, December 7.

The agenda will include knowledgeable speakers from the IAEA, Government, and industry; including "those who have been there." We have set a nominal $55.00 registration fee for the Workshop and urge you attend this introduction to what may be expected to be a new way of life for those of us concerned with nuclear materials management and safeguards.

For further information, contact **Russell E. Weber**, NUSAC, Inc., 7926 Jones Branch Drive, McLean, Virginia 22102 or phone (703) 893-6004.

Safeguards Implementation In the Nuclear Fuel Cycle

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Abstract

The role of modern safeguards technology in implementing effective national and international safeguards is described. Some of the major programmatic activities in the United States Department of Energy Safeguards R & D program are reviewed and documented including safeguards systems design, process simulation and effectiveness evaluation, and safeguards technology development, test, evaluation and in-plant implementation. The availability of newly-developed nondestructive assay technology, together with in-line process instrumentation, automatic item identification and verification equipment, as well as modern computerized data analysis and data base management technology, has led to a whole new generation of "dynamic" materials accounting/control systems. A number of these systems that are currently under development both in the United States and in other countries are briefly described and documented. It is shown that proper implementation of dynamic materials accounting/control can provide greatly-enhanced detection sensitivity for nuclear material diversion in various types of nuclear facilities. Recent developments in nuclear materials measurement technology and nondestructive assay instrumentation are reviewed from the standpoint of domestic safeguards in various fuel cycle facilities, as well as international (IAEA) safeguards inspection and independent verification.

I. INTRODUCTION

Recent nuclear power projections of various nations[1] conservatively indicate that some half-a-million megawatts of nuclear electric generating capacity will be commissioned around the world within the next ten years. To fuel this nuclear capacity will require the production of more than 75,000 tons of natural uranium annually, some 55 million SWU to enrich it, and more than 12,000 tons of fuel will have to go through fabrication and some form of spent fuel disposition (e.g., storage, reprocessing, or some combination of these).

The challenge of how to strengthen and foster the worldwide growth of nuclear power while at the same time decreasing the accompanying risks of nuclear diversion, proliferation, etc., is being addressed by the International Fuel Cycle Evaluation (INFCE) Program and related fuel cycle studies presently underway in a number of countries. Whatever the results of INFCE, it seems clear that world nuclear power demands will, in the near future, require high-throughput process facilities to support any of several alternative fuel cycles (or "mix" of fuel cycles) that are selected for implementation in various countries. And, since very large quantities of strategic nuclear materials will be involved, nuclear safeguards considerations are becoming a major factor in the selection of process and facility design/construction alternatives. Today's trend toward tightening regulations and increasingly stringent safeguards — in both the overall international (IAEA) system, and the various component State (national) systems — further underscores the necessity for nuclear safeguards criteria to be fully incorporated at an early stage in the design of future fuel cycle facilities or centers - be they national, regional, and/or international.

In the nuclear energy area particularly, the vital importance of international cooperation, exchange, and understanding — as exemplified by this biennial series of Pacific Basin Fuel Cycle Conferences - has been stressed by many leaders throughout the world nuclear community[1,2,3]. Specifically in the field of nuclear safeguards it has been repeatedly emphasized[4-8] that today's mounting demands for high-technology safeguards systems (demands in terms of both financial and human resources) will, of necessity, require closer international cooperation and increased technical exchange in the design, test, and evaluation of advanced safeguards technology and control systems.

II. IAEA INTERNATIONAL SAFEGUARDS AND NATIONAL SAFEGUARDS SYSTEMS

At the 21st Session of the General Conference of the International Atomic Energy Agency, the Director General of the Agency, Dr. Sigvard Eklund[9], in his opening remarks on safeguards and nonproliferation, noted that the IAEA is itself a product of man's awareness of the dichotomous nature of nuclear energy — i.e., it can contribute significantly to the fulfillment of vital economic and social goals through almost unbounded production of energy, or alternatively, it can also porvide the source of unprecedented destruction capability. Eklund further observed that "safeguards (in the sense of international measures to detect and thereby deter the diversion and misuse of nuclear materials) remain the central element of any combination of measures taken against nuclear proliferation; their existence has been shown to be a primary condition for international commerce and cooperation in the nuclear field. . . . International interest in the potential effectiveness of safeguards continues to increase, . . .and intensive development work will be essential to make safeguards both more credible and more cost effective. . . . I need hardly mention that the support we are receiving from member states is absolutely essential for these programs."

Effective national safeguards systems are indeed essential components of effective international (IAEA) safeguards, which are in turn essential to the widespread growth and acceptability of nuclear power, and the concomitant worldwide expansion of nuclear trade. At the IAEA Salzburg Conference on Nuclear Power and its Fuel Cycle[1], leading IAEA officials stressed that notwithstanding the requirements for improved national and multi-national systems of nuclear materials accountancy and control, the *sine qua non* of effective international safeguards is independent verification by the IAEA of compliance with the provisions of safeguards agreements concluded pursuant to the NPT and to the Statute of the IAEA. It was further emphasized that this independent verification is the basis of the IAEA safeguards system and this responsibility cannot be transferred to any other authorities.

The importance of continued technical developments and full-fuel-cycle safeguards implementation both in member states and internationally by the IAEA has also been stressed by Eklund (among many others) at Salzburg[1] and elsewhere[9,10], along with specific reference to the role of integrated material accountancy systems, "real time" materials control systems, containment and surveillance methods, and modeling techniques for evaluating the effectiveness of modern safeguards systems. In various member states of the IAEA a growing number of safeguards development, test and evaluation programs are underway, and more are planned. As one component part of this overall effort to enhance both national and international safeguards, we shall review here some representative major programmatic activities in the United States in the areas of safeguards system design, technology development, test, evaluation and in-plant implementation.

III. DESIGN OF INTEGRATED SAFEGUARDS SYSTEMS

In the United States, as a part of the U.S. Department of Energy, Safeguards and Security R&D program[11,12], conceptual designs of integrated safeguards and materials management systems have been developed and evaluated for the major components of the back end of the LWR fuel cycle[13,14]. These designs and safeguards performance criteria are being used as the reference designs in the evaluation of similar facilities in alternative fuel cycles, presently under study in INFCE and related programs. These designs incorporate state-of-the-art materials accounting systems that can be closely integrated[15] with advanced physical protection systems[16-19] to provide overall facility safeguards effectiveness and minimum interference with plant operation, efficiency, and throughput.

To date, conceptual designs of materials management and accountability systems (MMAS) have been completed for a LWR fuel fabrication plant[20], a nitrate-to-oxide conversion plant[21], a large scale chemical separations facility[22] and a nuclear criticality facility[23]. Fuel storage and waste management facilities are also under study. Each materials accounting system design is based on a specific reference facility[24-26] so that realistic and quantitative conclusions can be reached.

IV. CONVENTIONAL MATERIALS ACCOUNTING

In conventional safeguards practice, the accountability of nuclear materials within a facility and the detection of unauthorized removals have relied, almost exclusively, on discrete-item counting and material-balance accounting following periodic shutdown, cleanout, and physical inventory. The classical material balance is usually drawn around the entire facility or a major portion of the process, and is formed by adding all measured receipts to the initial measured inventory and subtracting all measured removals from the final measured inventory. During routine production, material control is vested largely in administrative and process controls, augmented by secure storage for discrete items, sealed containers, etc.

Although periodic shut down-cleanout operations will always have an important role (e.g., in"rezeroing" MUF), this procedure alone as employed in the past clearly has inherent limitations in sensitivity and timeliness. Sensitivity is limited by measurement uncertainties that might obscure the diversion of relatively large quantities of SNM in a large-throughput plant. Timeliness is limited by the practical difficulties, the expense, and hence the infrequency, of process shutdown, cleanout, and physical inventory; i.e., a loss of material could remain undiscovered until the next physical inventory is taken.

V. DYNAMIC MATERIALS ACCOUNTING/CONTROL

Recently developed nondestructive assay (NDA) technology, state-of-the-art conventional measurement methods and special in-plant sensors, combined with supportive computer and data-base management technology have provided the necessary technical basis for much more effective methods of safeguarding nuclear facilities. It has been demonstrated for example, that considerably greater sensitivity and timeliness in SNM control can be achieved by subdividing a nuclear facility into discrete accounting envelopes, called unit processes, around which individual balances can be drawn[27,28]. A unit process can be one or more chemical or physical processes, and is chosen on the basis of process logic, residence time of material within the unit process, and the ability to perform quantitative measurements and draw a material balance. Thus, by subdividing a facility into unit processes and measuring all material flows across unit process boundaries, the location and movement of SNM throughout the plant can be localized both in space and time. Material balances drawn around such unit processes are called "dynamic" material balances to distinguish them from conventional balances drawn after a shutdown, cleanout, and physical inventory. As is the case with any material balance based on physical measurements, balances cannot be closed completely (i.e., MUF = 0 precisely); this is partly due, of course, to ever-present measurement uncertainties, but also because some in-process holdup and minor sidestreams are customarily (and generally for good reason) measured less frequently than major materials transfers [15,28,29]. Such perturbations are normally handled quite adequately by using plant operational experience or "historical" data to interpret trends in holdup, minor sidestreams, etc., with these data being updated when the appropriate holdup and sidestream measurements are made. In some processes, the added control obtained by measuring small sidestreams of material may be negligible, and may not justify the difficulty and expense of making the measurements. Such judgements must, of course, be made on an individual process basis, taking into account "graded safeguards" considerations of the strategic value and safeguards vulnerability of the material, which will depend on its location and form within the process and within the fuel cycle.[13] Graded safeguards considerations are clearly important in the selection of unit processes and associated key measurement points.

Implementation of dynamic or "near real time" materials measurement and control requires the rapid, quantitative measurement of nuclear materials locally (e.g., in-line or at-line) at each unit process. Modern nondestructive assay techniques are quite well suited to rapid, direct in-line measurement, and NDA instruments are being developed, adapted and applied to process measurement requirements in several different ways: (1) as the primary measurement technique at a unit-process boundary, (2) as part of a complementary set consisting of timely, or even "continuous," NDA measurements that may be updated by periodic analytical chemistry assay, (e.g., in conjunction with shutdown and cleanout, as appropriate) and (3) to assay or verify the contents of discrete items such as sealed containers, fabricated pieces, finished components, etc. (where the nondestructive feature of the assay is particularly advantageous).

As may be inferred from the foregoing, current trends in nuclear safeguards technology[8] place increasing emphasis on timely measurement and analysis of materials accounting data of constantly improved quality. The availability of more and better input data underscores the need for an organized framework of techniques to ensure efficient and complete extraction of information concerning possible diversion of SNM. The discipline of decision analysis[30] which combines techniques from estimation theory, decision theory, and systems analysis, provides such a framework, and is well suited for statistical treatment of the imperfect material-balance data that become available sequentially in time. The goals of decision analysis are (1) detection of the event(s) that SNM has been diverted, (2) estimation of the amount(s) diverted†, and (3) determination of the significance of the estimates. Augmented by computer display and pattern-recognition techniques such as the Cusum plot and the alarm-sequence chart, decision analysis can be used to reduce errors caused by subjective data evaluation and to condense large collections of data to a smaller set of more descriptive statistics. The use of these powerful, formalized techniques make the decision process more timely and efficient as well as more consistent and objective[31].

The availability of advanced NDA measurement technology, together with in-line process instrumentation, automatic item identification and verification equipment, as well as modern computerized data analysis and data base management technology, has led to a whole new generation of dynamic materials accounting/control systems that are currently in various stages of development. The degree of complexity of the different systems ranges from simple computerized accounting systems (e.g. for discrete item control) to complete deployment of each of the advanced technologies noted above. Some of the more sophisticated materials control and accounting systems being developed are summarized and documented in Table I.

In the United States, the DYMAC* program[27,47-50] at the Los Alamos Plutonium Processing Facility represents one of the most extensive R&D efforts to integrate advanced NDA technology with automated data- processing methods and to fully evaluate practical in- plant operation of dynamic materials accounting and control on a detailed unit-process basis. A number of NDA measurement systems are being developed, or adapted from existing designs, commercially available equipment, etc., for in-line DYMAC applications in the new plutonium processing facility at TA-55, LASL. These include (See Table I).

(1) a plutonium solution assay system (PUSAS) for measuring Pu concentrations over the range 0.1-20 g/L;

(2) a specialized thermal neutron coincidence counter (TNC) for measuring residues from various recovery processes;

(3) a fast neutron coincidence system for NDA of heterogeneous materials having high (α,n) backgrounds;

(4) high resolution gamma spectrometry for isotopic verification;

(5) product verification stations; and

(6) a variety of digital readout weighing devices.

Design philosophy on NDA instruments used for in-line plutonium assay has been to keep delicate parts of the instrument (e.g., detector and electronics) outside gloveboxes whenever possible. In designing or adapting instruments for glovebox use, careful consideration was given to the frequently cumbersome and awkward nature of having to work through gloves. By focusing attention on the specific functional use of the instrument and working closely with process operators during instrument development, it was possible to maximize operational convenience while minimizing required operator time for making the assay. DYMAC in-plant experience to date[49] has demonstrated that process operators are receptive to entering material transactions at interactive computer terminals in the process area, provided the time and number of entries necessary to complete a transaction are reasonable. In order to streamline the transactions for process areas and specialize them to reduce the amount of information the operator must enter, a

*DYMAC is the acronym for Dynamic Materials Control, or equivalently, for Dynamic Materials Accounting.

TABLE I
SOME DYNAMIC MATERIALS ACCOUNTING SYSTEMS

Facility, Location, Function	System Name	System Functions and Comments	Reference*
General Electric Wilmington, North Carolina; UF_6 conversion to fuel-bundle assembly	INMACS	Material Inventory Control System. Diversion detection, information quality, loss localization, system management and control. NDA used.	32, 33
General Electric Vallecitos, California; Pu fuel-development laboratory for LMFBR	GERTA	Material distribution, diversion detection. Primarily automated record-keeping; no NDA at this time.	34
Mound Laboratory Miamisburg, Ohio; MOX fuel fabrication	CUA	Controllable Unit Accounting. Conceptual system for accounting, diversion detection. No NDA used.	35, 36
Combustion Engineering Windsor, Connecticut; Nuclear fuel manufacturing	FACS	Fuel Accounting and Control System. Timely and accurate reporting on SNM status and flow; no NDA as yet.	37
AECL Chalk River, Canada; Fuel materials development and fabrication	INMACS	Integrated Nuclear Material Accounting and Control System. On-line material accounting, data base mgmt.; no NDA as yet.	38
Y-12 Plant Oak Ridge, Tennessee; Enriched uranium processing facility	DYMCAS	Accountability, diversion detection, physical inventory, NDA verification. Incorporates on-line or keyboard verification of weights.	39, 40
Rocky Flats Plant Golden, Colorado; Pu processing facility	NMC COMSAC	Accountability, criticality control, NDA calibration, NDA measurements.	41, 42
Karlsruhe Research Center Karlsruhe, F.R.G.; Research, processing, handling, storage facilities	— —	Generalized SNM accounting and data handling system for variety of SNM processing, handling functions.	43
ARHCO Richland, Washington; Storage and processing facility	— —	Accountability, process monitoring, laboratory bookkeeping, monitoring and control of storage locations.	44
PNC Tokai-mura, Japan; MOX fuel fabrication	PINC	Plutonium Inventory Control system using on-line NDA sensors and computerized inventory, process control.	45
AGNS Barnwell, South Carolina; Fuel reprocessing plant	AGMAC	Laboratory data system and materials accounting and control system. Some process monitoring.	46
LASL Los Alamos, New Mexico; Pu processing	DYMAC	Accountability, in-plant NDA instrumentation; computerized near-real-time inventory control; data-base management, unit process SNM localization.	47-50

*Indicated individual references are given in "Safeguards Implementation in the Nuclear Fuel Cycle," G. R. Keepin, Proceedings, Pacific Basin Conference on Nuclear Power Development and the Fuel Cycle, Tokyo, Japan, Sept. 25-29, 1978.

flexible "packet software" approach was developed that enables appropriate changes to be readily programmed for any specialized process transaction.

Figure 1 shows the location of DYMAC instruments and terminals in the plutonium recycle wing of the Los Alamos plutonium facility (TA-55). An integral part of the DYMAC system is a rigorous standards and measurement control program[49,50] that assures the accuracy of the assay data. The program provides quantitative limits-of-error information and ensures that the individual instruments function properly by periodically checking their precision and calibration accuracy.

The basic structure of the DYMAC information handling system is shown in Figure 2. The NDA instruments and interactive terminals in each unit process area transmit the status of SNM in the various stages of production to a central computer system which acts as the central data manager for DYMAC. In the computer (cf. Fig. 2), the data base management subsystem accepts and verifies incoming data, updates inventory records immediately, and organizes the data into files for efficient retrieval of specific information. The real time materials accountability (control) subsystem draws on the data base for continuous status monitoring of SNM within the facility. A measurement control program periodically checks instrument performance; control

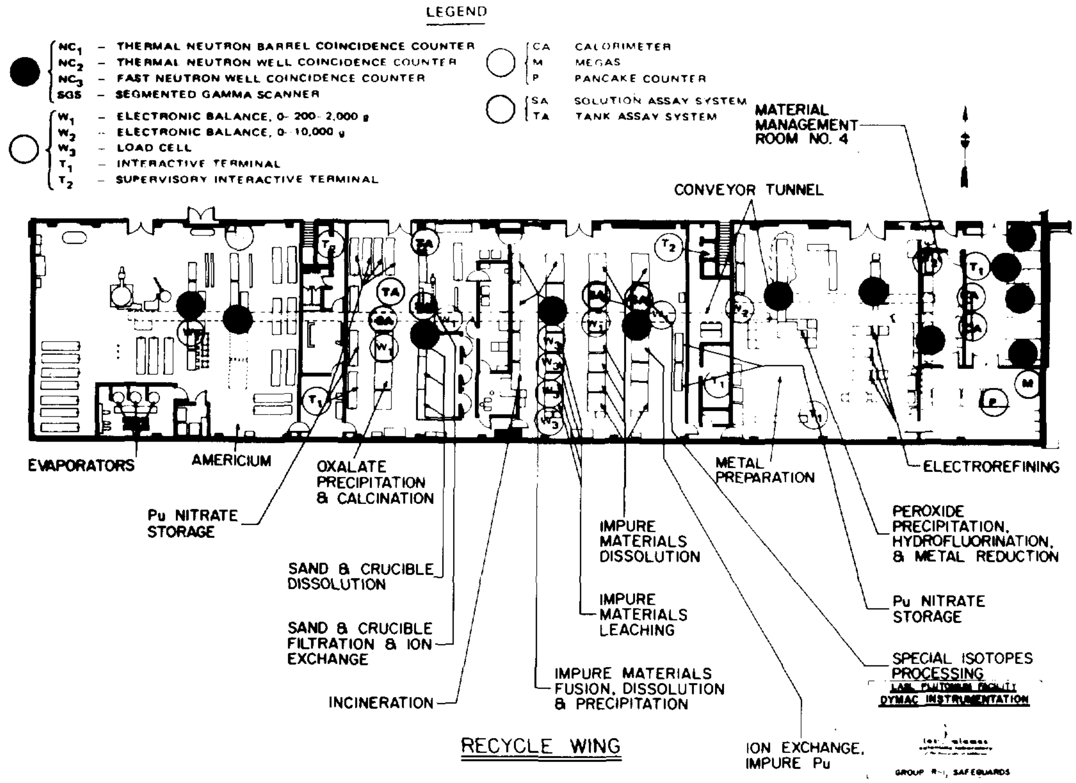


Fig. 1. DYMAC Instrumentation for the Plutonium Recycle Wing of the New Plutonium Facility (TA-55) at Los Alamos.

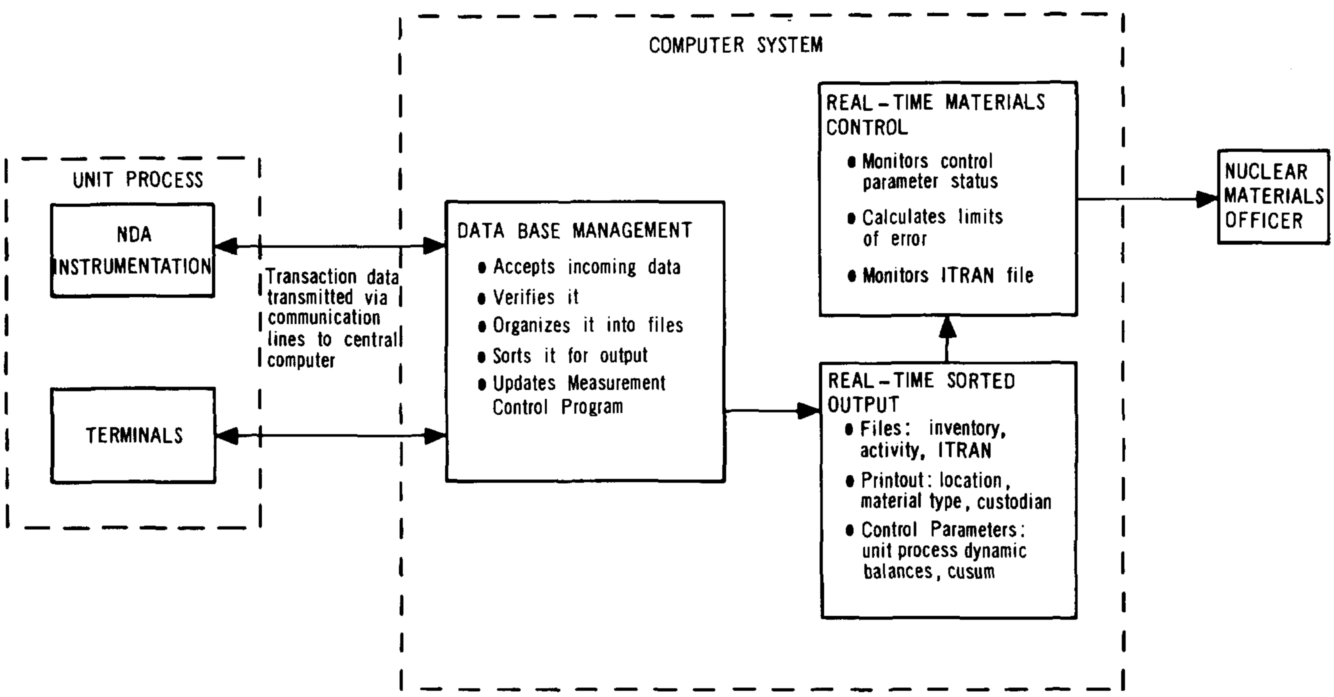


Fig. 2. DYMAC Information Handling System.

TABLE II
COMPARISON OF CONVENTIONAL AND DYNAMIC MATERIALS ACCOUNTING DIVERSION SENSITIVITIES FOR THE CONVERSION PROCESS

	Average Diversion per balance (kg Pu)	Total Diversion Sensitivity (kg Pu)	Detection Time
Dynamic Materials [(a)] Accounting	0.13	0.13	1 batch (1.35h)
	0.03	0.63	1 day
	0.01	1.24	1 week
	0.005	2.65	1 month
Conventional Materials Accounting	33	33	2 months

(a) For a single-unit-process accounting strategy as described in Ref. 21

parameters are calculated from information in the data base and are compared with pre-determined alarm levels. If alarm levels are exceeded, the system alerts the nuclear materials officer — or "safeguards coordination unit" who interacts with management and process-control coordination to continually assess the safeguards status of the plant and to advise plant management of appropriate response options and recommended actions. Needless to say, safeguards condition assessment and associated decision analysis procedures[31] must be carefully balanced to avoid unnecessary false alarms, while maintaining a high probability of effective response to an actual safeguards violation.

A key consideration in the design of an acceptable dynamic materials control system is the scrupulous avoidance of any significant intrusion into process operations and overall plant production. The workability and effectiveness of any system can be convincingly demonstrated only through extensive inplant operation and evaluation, as is currently in progress for a number of the systems in Table I.

VI. PROCESS SIMULATION AND SAFEGUARDS EFFECTIVENESS EVALUATION

Somewhat unique in the nuclear fuel cycle, the conversion process (i.e., converting plutonium nitrate solution to plutonium oxide powder) presents a particularly challenging safeguards problem[21]. The conventional conversion facility handles plutonium in large quantities as a concentrated, relatively pure material with generally low radiation levels, and is therefore extremely attractive as a target for diversion. Fortunately, these same attributes also make a conversion facility amenable to stringent safeguards, i.e. such features as well characterized, relatively pure materials and low radiation levels with resulting greater accessibility to the process, all facilitate on-line measurement and the full implementation of dynamic materials accounting and control.

Modeling and simulation techniques[51] have proved extremely valuable in the design, evaluation and comparison of the relative effectiveness of alternative processes, measurements systems and materials accounting strategies. These techniques permit the prediction of the dynamics of SNM flow under a wide range of operating parameters, and the rapid accumulation of data for relatively long operating periods. For each facility, this approach requires: (1) a detailed dynamic model of the process; (2) simulation of the model process on a digital computer; (3) a dynamic model of each measurement system; (4) simulation of accountability measurements on SNM flows and in-process inventories generated by the model process; and, (5) evaluation of the simulated measurement data from each accounting strategy.

As a specific example of the performance of dynamic materials accounting, in a modern high-throughput conversion facility, we cite recent simulation studies[21] on a reference conversion process based on plutonium (valence III) oxalate precipitation and calcination. In this conversion process, the key measurement points were located at the receipt tank, the output of the precipitator and at the product loadout area. At the receipt tank the solution volume and concentration are measured, the concentration being measured by an absorption edge densitometer (to be described later). The product canisters containing plutonium oxide powder are measured by a neutron well counter or calorimeter.

The estimated plutonium detection sensitivity levels (for a single-unit-process accounting strategy) are presented in Table II. Diversion sensitivity is given for periods of one material balance (one batch), one day (approximately 20 batches), one week (approximately 125 batches), and one month (approximately 530 batches). The results in Table II may be compared with current U.S. regulations[52] which require that conventional periodic material balancing in conversion plants be performed every two months with a material balance uncertainty (2σ) of less than 0.5% of the facility throughput. This limit of error corresponds to 33 kg of plutonium for the reference conversion process, which has a design throughput of 6600 kg of plutonium over a two month period. A recent estimate[53] of the 2σ limit of error that should be achievable by periodic, two month material balancing in conversion plants is 0.38%, which corresponds to approximately 25 kg of plutonium for the reference process.

These and other process simulation studies[13,20,22] have clearly demonstrated that dynamic materials accounting can offer dramatic improvement in terms of timeliness, spatial specificity and sensitivity, when compared to conventional materials accounting procedures. In the final analysis, of course, the effectiveness of any system must be fully demonstrated and proven out through extensive in-plant operation and evaluation by the process, quality control and materials management people who must use (i.e., "live with") the system on a day-to-day basis.

From the safeguards and nonproliferation standpoint, one of the more prominent alternate fuel cycles currently under consideration involves the coprocessing of both uranium and plutonium (in a ratio of roughly 6-10:1) in a fuel reprocessing facility. In general, alternative conversion processes that yield a product usable only as reactor fuel are clearly of potential interest from the safeguards standpoint. One conversion process Coprecal[54] has been developed specifically for production of mixed uranium-plutonium oxides for fast breeder reactor fuels, and should be ideally suited for coprocessing applications. The Coprecal process converts a coprocessed U/Pu nitrate solution to a mixed oxide powder through coprecipitation followed by cocalcination. The integrated safeguards system structure is similar to the three studies referred to above[13,20,22]. The modeling and simulation approach used previously has been applied to the design and evaluation of a materials measurement and accounting system for the Coprecal facility[55]. Dynamic material balances can be drawn approximately every two hours about the whole process as portions of the process. It is shown that dynamic materials accounting as compared to conventional materials accounting, can detect diversion in days or hours instead of months, can localize diversion to a single unit process accounting area instead of the whole process, and can markedly improve diversion detection sensitivity.

VII. MEASUREMENT TECHNOLOGY R&D — RECENT DEVELOPMENTS AND TRENDS

The implementation of dynamic materials accounting and control relies heavily on modern measurement technology, with particular emphasis on new NDA techniques and in-plant instrumentation. In this section, we review some of the recent developments and trends in SNM measurement technology and NDA instrumentation.

For NDA of plutonium in general, and particularly for solutions, passive gamma-ray assay has proved very useful, primarily for the determination of ^{239}Pu, ^{241}Pu and ^{241}Am isotopic concentrations. When isotopic composition is known, or determined independently, corrections can be applied to yield overall plutonium concentrations to better than 1%[56].

The increasingly popular technique of absorption edge densitometry[57] offers another very versatile method ofr NDA of solids as well as on-line measurement of actinide concentrations in process streams. The method is based on the difference in transmission of gamma rays with energies just above and just below the K and L_{III} absorption edges, which are uniquely characteristic of the elements uranium, plutonium and thorium. The absorption edge method, being based on the discrete electron binding energies in the electron shell structure of the atom, is thereby element specific, rather than isotope specific, as is the case with passive gamma rays emitted from the nucleus. The transmission source used for absorption edge densitometry may be either an x-ray generator[58] or natural radioactive isotope(s)[57]. The x-ray generator has the advantages that (1) multiple, simultaneous SNM determinations such as plutonium and uranium are possible and (2) the energy displacement from the absorption edge is limited only by the detector resolution. An x-ray generator-based absorption edge densitometry assay station has been developed at Los Alamos for rapid, simultaneous measurement of multiple concentrations of SNM and source materials[59]. The station forms the basis for development, test and evaluation of an on-line solution assay system for measuring uranium and plutonium concentrations of 1 to 50 g/liter. Such a system has been proposed for installation and in-line evaluation at the experimental coprocessing test location at the Savannah River Laboratory. The need for incisive measurement technology for different combinations of fissile and fertile fuel materials is underscored by the current interest (e.g., in INFCE) in coprocessing as one of several alternative fuel cycle possibilities for enhancing safeguards in the back end of the fuel cycle.

The assay of multiple SNM by the absorption edge densitometry method can be conveniently performed when the two fissionable components are present in roughly equal amounts (ratios between one and four). For concentration ratios greater than four, the densitometer will spend most of the limited pulse-processing time on the major component (e.g., uranium in a coprocessed stream), leaving the minor component (e.g., coprocessed plutonium) with poor statistics and thus poorly determined. The close proximity of the uranium and plutonium L_{III} edges (17.168 keV and 18.066 keV, respectively) also limits the energy range between the two L_{III} edges, in which the relevant transmissions can be measured.

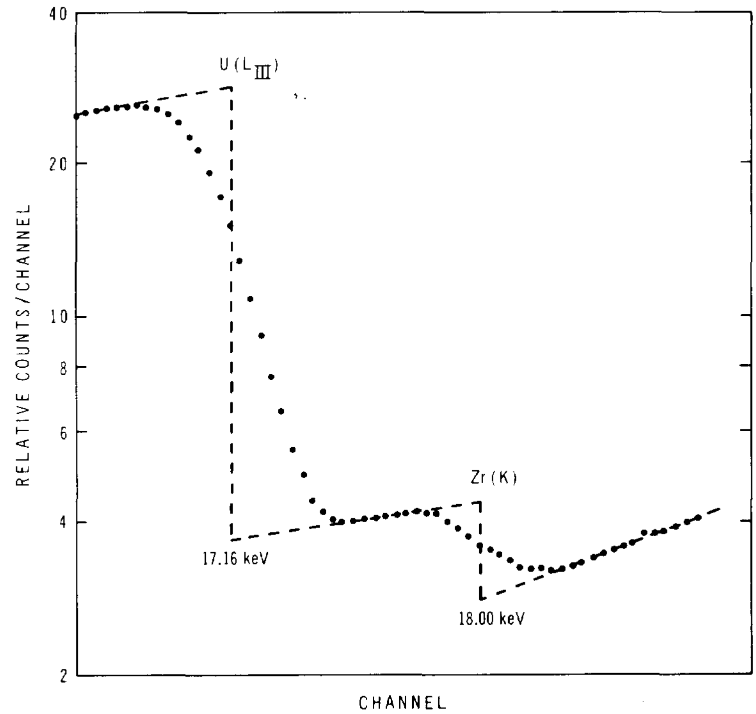
One approach[59] to improve the measurement statistics is to utilize as much data as possible. A typical x-ray spectrum transmitted through a uranium- and zirconium-bearing solution is shown in Fig. 3(a). For experimental convenience, zirconium can be used to simulate plutonium because the zirconium K edge at 17.998 keV is representative of the plutonium L_{III} edge at 18.066 keV. Selected regions of data have been linearly extrapolated, as shown, to the absorption edges to determine the transmission ratios as shown in Fig. 3(a).

By essentially differentiating the transmission curve (i.e., taking the difference in ℓn(T) at each discrete energy step, i), the plot shown in Fig. 3(b) is obtained. Over the narrow energy range of interest, the constant matrix material effects cancel out and the net area under each "peak" in Fig. 3(b) is proportional to the density of the respective SNM, i.e., summing over the N channels of the "peak" in Fig. 3(b):

$$\sum_{i=1}^{N} \ell n \frac{T_i}{T_{i-1}} \simeq \Delta\mu_s \, \varrho_s \, X$$

where $\Delta\mu_S$ is the discontinuity in SNM mass absorption coefficient across the absorption edge, ϱ_S is the density of SNM and X is the thickness of the solution sample.

This approach[59] of using the "peak" area as a measure of the SNM content has the distinct advantage that more data points are utilized in the data analysis, thereby resulting in a more precise determination. For a solution containing 6.2 g Zr/l and 37 g U/l, repeated runs of 10000-s counting time have shown that the uranium con-



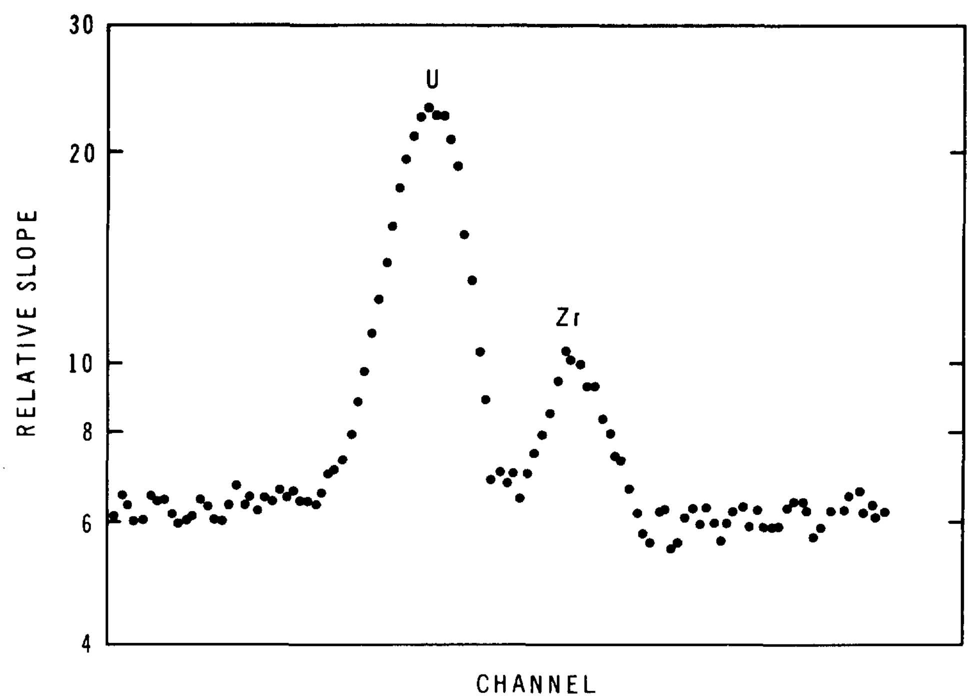


Fig. 3. Absorption Edge Densitometry of Multiple SNM Solutions.

a (upper plot). Continuous x-ray spectrum transmitted through a solution containing uranium and zirconium. Data are straight-line extrapolated to the absorption edges to determine the transmission ratios at the edges.

b (lower plot). The difference in the log of the measured transmission spectrum (in a above) for a fixed-energy increment as a function of energy.

tent can be measured to one-half per cent and the zirconium content to two per cent.

While absorption-edge densitometry techniques can provide accuracies of 1% or better for solution concentrations above ~5 grams per liter, measurement uncertainties increase to greater than a few per cent for sample concentrations below 2 g/l. To achieve higher precision in the NDA of lower-denisty solutions, new techniques of energy-dispersive x-ray fluorescence (XRF) are being investigated at Los Alamos[60]. Like absorption-edge densitometry, XRF) also measures the total elemental concentration. However, by judicious choice of the isotopic source (e.g., ^{109}Cd with a 435d, 88 keV γ ray) used to induce particular fluorescence x rays characteristic of actinide elements, the need for an x-ray generator can be eliminated, thus reducing the cost and simplifying the design of NDA equipment for solution measurements at lower concentrations.

This technique involves L x-rays typically in the 10-20 keV range and hence requires a method of correcting for sample attentuation effects on both the incoming (inducing source) radiation and the outgoing (induced fluorescence) x-rays. A recent innovation[60] in transmission corrected x-ray fluorescence measurements employs an appropriately selected transmission foil whose induced fluorescence x-rays bracket the characteristic line(s) from the actinide element to be analyzed. Measurements to date indicate that with appropriate combinations of source and transmission foil, assay accuracies and precisions of better than 1% should be routinely achievable on low-concentration solutions (e.g. from 10 g/l down to 0.5 g/l).

The two somewhat complementary NDA techniques just described — i.e., absorption edge densitometry in the concentration range 2 g/l to 50 g/l and transmission corrected x-ray fluorescence for lower concentrations — provide a versatile, relatively simple, and accurate means for assaying SNM-bearing solutions found in modern high-throughput process facilities. The importance of possible future applications of these NDA techniques to coprocessed U and Pu solutions, scarcely needs elaboration.

For highly radioactive solutions, the background suppression already inherent in the energy-selective absorption edge technique may be further enhanced by using a curved crystal spectrometer as an energy filter (with a few Kev width, centered around the absorption edge of interest) for a high resolution energy dispersive detector[61]. Further development test and evaluation will be required to determine the value of this approach to NDA of highly radioactive solutions under plant conditions.

One area that continues to present an in-plant measurement challenge is the determination of in- process holdup. Plant holdup measurements in specific locations are frequently made using passive gamma-ray methods[49,62], and more recently an integral neutron detection method has been used to measure total plutonium holdup in an entire process room[63,64].

Neutron coincidence counting[65] has found wide application in the assay of bulk plutonium product, scrap and waste. The net coincidence count rate is approximately proportional to the weighted mass of ^{240}Pu plus other even plutonium isotopes. If the isotopic composition of the sample is known, or independently determined, e.g. from GeLi spectrometry, then coincidence counting can be used to determine total plutonium content. For coincidence counting of large amounts of PuO^2 or scrap containing light elements having high a,n yields such as boron or fluorine, coincidence counters with short die-away times have been developed to maximize the ratio of real coincidence events to accidental events, and thereby reducing statistical uncertainties. Recent R&D on neutron coincidence counters has been directed toward upgrading assay capability for large plutonium samples. Improvements have been made in the detectors, moderators and coincidence circuitry to give shorter die-away times and coincidence gates, and decreased electronics deadtime. This has permitted accurate assay of high mass (e.g., 2 kg) plutonium samples with counting rates on the order of 10^5 counts/second. To accommodate a dynamic range of measurement from less than one gram to greater than 2 kg, a dual range coincidence counter employing removable cadmium sleeves has been developed[66]. A practical limitation on coincidence counting in the high mass range is the accuracy with which required sample self multiplication corrections can be applied[67].

Representative precisions and accuracies exhibited by neutron coincidence counters in the process environment are shown in Table III for the general categories of product, scrap and waste[56].

A ^{252}Cf "Shuffler" assay system[68] based on neutron interrogation and delayed neutron counting has been evaluated in the laboratory for bulk samples containing uranium and/or plutonium. This unit has been adapted to the assay of large (55 gal) barrels of hot radioactive waste[69] and to the assay of uranium feed materials as well as scrap and waste from the reactor fuel (U-Al) fabrication at the Savannah River Plant[70]. The Shuffler can also be used for the measurement of ^{233}U, ^{235}U, and plutonium over a wide mass range (1 mg - 2 kg) using thermal-neutron interrogation for the low mass range and fast-neutron interrogation for intermediate and high mass samples. A prototype shuffler system is being designed for test and evaluation at the Idaho Chemical Processing Plant where it will assay the ^{235}U content in radioactive centrifuge sluge from the fluorinel dissolution process[71]. It is important to note here that a comprehensive review of NDA methods for determining burnup and/or fissile content of irradiated nuclear fuels has recently been completed[72]. This in-depth review covers all applicable NDA techniques including gamma

TABLE III
TYPICAL NEUTRON COINCIDENCE COUNTER UNCERTAINTIES

Material Category	Precision (%)	Accuracy (%)
Feed and product	1	1
Scrap	2-8	2
Waste	10-15	5-10

spectroscopy, passive neutron counting, active neutron interrogation (including ^{252}Cf source interrogation[73]), neutron resonance absorption, reactivity and calorimetry.

A particularly interesting application of neutron coincidence counting in the area of international safeguards, is the portable High Level Neutron Coincidence Counter (HLNCC) which was developed for evaluation by the International Atomic Energy Agency[74]. The portable HLNCC, shown in Figure 4, was designed for field use by IAEA inspectors in the assay of a wide variety of plutonium samples. The term "high level" refers to the high neutron count rates (e.g., up to 10^5 counts/sec) produced by large (several kg) PuO_2 or plutonium metal samples. The recently upgraded detector[75] consists of 18 ^3He proportional counters embedded in 6 polyethylene slabs which form a hexagonal well (cf. Figure 4); the complete assembly is 30 cm wide by 75 cm high and weighs approximately 35 kg. The newly developed electronics package for the IAEA HLNCC, shown in Figure 5, includes high-voltage supply, amplifiers, discriminators, shift register coincidence circuitry, and control and display circuitry[75]. With the new HLNCC a 1 kg plutonium sample can be measured to a standard deviation of 1% or better in 1000 seconds.

In addition to measuring oxide and metal samples in various configurations and containers, the HLNCC has been applied to the measurement of plutonium content in mixed oxide LWR fuel assemblies[76] and to the assay and independent verification of fuel inventories in fast critical assemblies[75,77]. The latter application represents an important safeguards area both for international and domestic safeguards, and warrants some further discussion here.

Critical assembly research facilities are used to simulate advanced reactor designs — the largest such facilities being found in the United States, United Kingdom, Japan, Federal Republic of Germany, France, and the USSR. A typical critical facility maintains an inventory of a few hundred to a few thousand kilograms of relatively pure and highly enriched SNM distributed in many thousands of small fuel pieces. As international safeguards under INFCIRC/153 (the so-called NPT "Model Agreement") come to be applied in the large industrial nations of Europe, in Japan, the United States and the United Kingdom, some of the larger critical facilities will soon be coming under safeguards.

The major safeguards problem is the timely verification of in-reactor inventory during periods of reactor operation. This will require a judicious application of measurement techniques and careful design of statistical sampling plans to permit the incorporation of routine inspection and verification activities into normal facility operations. Technical implementation, as presently foreseen[23] will employ rapid NDA techniques to measure collectively the fuel pieces contained in reactor fuel drawers and in vault storage canisters, and to perform integral measurements of reactivity on the entire reactor inventory (in suitable reference configuration) — reactivity measurements being particularly sensitive to small discrepancies in the reactor inventory. The portable HLNCC has been evaluated, calibrated and deployed in IAEA inspections at a large fast critical facility[75,77]. Since neutron coincidence counting determines the ^{240}Pu content, supplementary gamma measurements of isotopic ratios are needed to provide an independent verification of fissile content. Figure 6 shows a ZPPR critical assembly fuel drawer being assayed using a combination of the HLNCC (in horizontal configuration) for coincidence counting and an IAEA intrinsic germanium detector with its collimator for measurement of plutonium isotopic gamma-line ratios. This combination of neutron plus gamma ray techniques for inventory verification in fast critical assemblies has the potential for extensive application in IAEA international safeguards inspection. Integration of such state-of-the- art rapid measurement and verification technology with modern containment and surveillance measures[78] and their practical application to critical facilities should provide a high level of assurance that diversity of significant quantities of SNM can be detected on a timely basis.

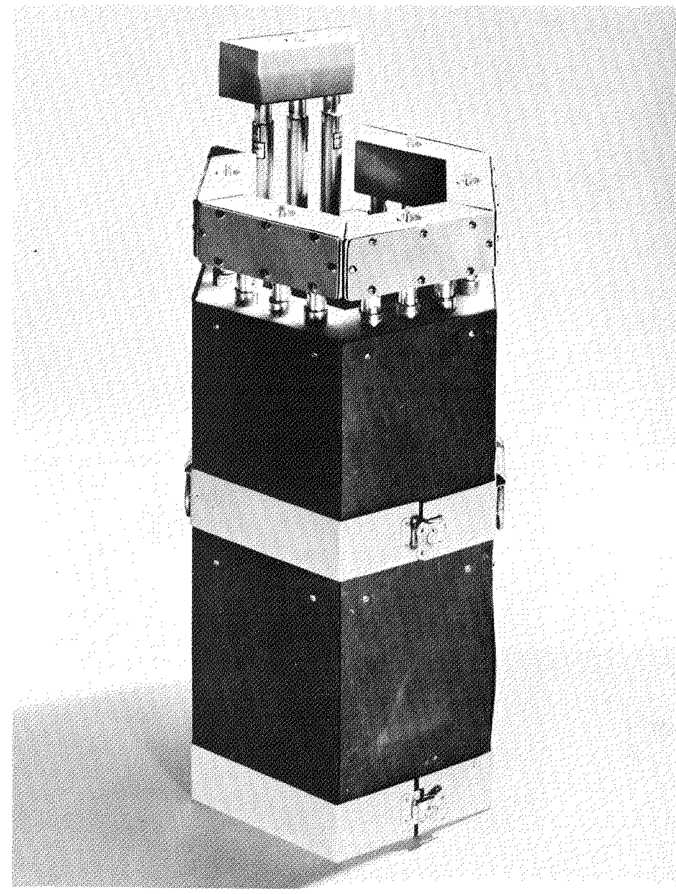


Fig. 4. IAEA Portable High Level Neutron Coincidence Counter (HLNCC) for Assay of High-Mass Plutonium Samples.

VIII. INTERNATIONAL SAFEGUARDS AND THE FUTURE

There is today an increasing awareness and appreciation of the global nature of the safeguards problem and the vital importance of effective international (IAEA) safeguards — as well as the various individual nations' safeguards systems that are the essential "building blocks" of an effective international safeguards system. Clearly the overall goal for safeguarding the worldwide nuclear industry is an ensemble of effective national

Fig. 5. Electronics Package for the IAEA HLNCC, Including High-Voltage Supply, Six Amplifiers, Discriminators, and Shift-Register Coincidence Circuit.

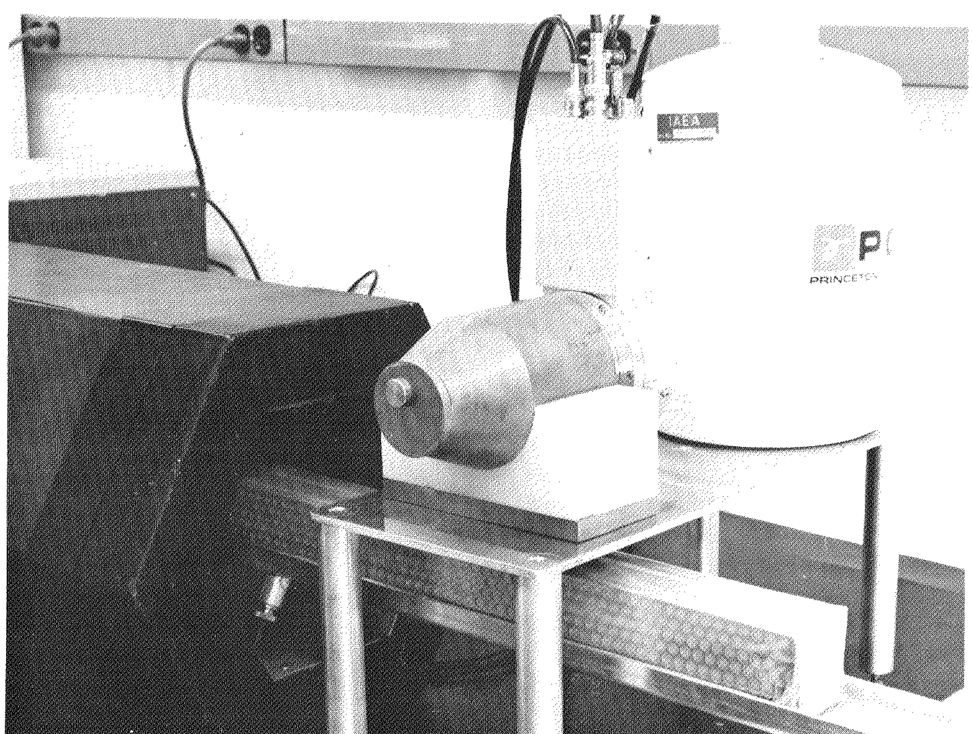


Fig. 6. Measurement Setup for a ZPPR Drawer, Showing the HLNCC for Neutron Coincidence Counting and the IAEA Instrinsic Germanium Detector with its Collimator for Measurement of Plutonium Gamma-Ray Line Ratios.

systems meeting certain broad consensus standards — the whole ensemble functioning under an overlay of truly effective international safeguards inspection and verification. As we are all acutely aware, we're a long way from this important goal and its achievement will clearly require much dedication and hard work on the part of the IAEA and individual nations — including both supplier and recipient nations.

In describing herein certain elements of the U.S. Safeguards R&D program, I've tried to convey something of the thrust of current U.S. safeguards technology in respect to both international and domestic safeguards. It is important to note that although most basic technology developments have potential application in both international and national safeguards, the necessary follow-through phases of engineering design, test and field evaluation may result in significantly different final hardware products, calibration procedures, and deployment methods.

An important part of the overall safeguards R&D effort in the United States is the development of technology and equipment in response to specific needs of the International Atomic Energy Agency. The IAEA performs certain essential functions in carrying out its mandate of independent verification of each facility subject to IAEA safeguards within a given State. These functions include review of facility design, operating records and reports, and verification of nuclear materials accounting procedures and records, including development of inspection sampling plans and independent verification by direct assay of nuclear materials. Instrumentation needs for the latter function are many, but for present pragmatic purposes, these needs can be lumped into two time categories: (1) the "here and now" needs — e.g., portable or transportable NDA, or other, measurement equipment for reliable assay and verification in the field, and (2) the "coming attractions" needs — e.g., methods, instruments and techniques for independent verification of safeguards effectiveness of various types of advanced in-plant materials accounting and control systems (i.e., as given in Table I).

In response to the category 1, "here and now" needs, portable NDA instruments and technologies specifically required by IAEA inspectors for field use are being developed, evaluated, and implemented* in cooperative programs between the IAEA and different member States. One such program, in the case of the United States for example, is the special technical assistance program which is coordinated by the International Safeguards Project Office (ISPO) at Brookhaven National Laboratory and participated in by several U.S. DOE laboratories including Los Alamos Scientific Laboratory, Sandia Laboratories, Argonne National Laboratory, Pacific Northwest Laboratory, and Brookhaven National Laboratory. The major task areas of the program are directed at six functions of IAEA safeguards activity: (1) measurement technology, (2) training, (3) system studies, (4) information processing, (5) surveillance and containment, and (6) support for field operations. U.S. technical experts and consultants are also provided on a cost-free basis under individual contracts with the IAEA.

The category 2, "coming attractions" needs are closely linked with coming dramatic changes in international safeguards implementation over the next few years:

(1) As more facilities come under IAEA safeguards, there will be a great increase in the sheer volume of information that must be gathered, assimilated and analyzed.

(2) Pursuant to "NPT safeguards" concluded under INFCIRC/153, new types of large, high-throughput facilities located in large industrial nations will come under IAEA safeguards for the first time. Such key fuel cycle facilities include isotope separation plants, spent fuel reporocessing plants, conversion and fuel fabrication plants producing mixed oxide fuel for power reactors, fabrication plants for highly enriched uranium fuel for research reactors, and large critical assembly facilities.

(3) With the rapid increase in the number and size facilities under international safeguards, the IAEA will be required to deal with complete nuclear fuel cycles within individual nations, or closely coupled international/regional groups of nations with relatively less information available on nuclear materials transfers from supplier to recipient.

(4) For a host of technical and economic reasons, including operational efficiency, quality and process control, radiological and criticality safety – not to mention the need to meet increasingly stringent safeguards and security requirements — large scale facilities of the future will employ timely, on-line materials measurement and accounting systems together with automated processing, remote handling equipment etc., to the maxium extent practicable. Thus it is essential that appropriate methods and techniques be developed for effective inspection and verification by IAEA (and national) inspectors.

Given the growing trend toward automation and increased sophistication in nuclear materials measurement, processing and handling systems in today's competitive worldwide nuclear industry, the challenge of effectively safeguarding that industry is clear. But along with the challenge comes an important new opportunity, inasmuch as advanced materials accountancy systems can, in fact, provide far more incisive knowledge (in both time and space) of plant inventory than has ever been available in the past. This knowledge must, of course, be fully available to the inspector as well as the plant operator. To further strengthen independent verification capabilities, new techniques and procedures are being investigated to enable the inspector to carry out necessary independent calibration and measurement control functions on various assay instruments, material flows, process operations, etc. Also in the large automated fuel cycle facilities envisaged for the future, there would be minimal personnel access to hazardous in-process material (e.g., plutonium), and this strict containment feature will certainly provide an 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 of the future,

*It should be noted that "safeguards", as used by the IAEA, implies international safeguards; to avoid any possible confusion, we have used the qualifying adjectives, "international" or "domestic" (or "national") when a distinction between the two levels of safeguards is desired.

*A notable case in point is the IAEA High Level Neutron Coincidence Counter (HLNCC, described in Section VII. above) which has recently been evaluated and deployed by the IAEA inspectorate[75-77].

thus giving the inspector more opportunity to gain better understanding and familiarity with plant operations, materials accounting and control.

Whatever fuel cycles, or "mix" of fuel cycles, are to be pursued in various countries, groups of countries, or regions of the world, the nuclear safeguards community can, and I believe will, continue to meet the challenge of developing and implementing effective safeguards for the fuel cycle facilities of the future.

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NRC Amends Security Regulations

The Nuclear Regulatory Commission is amending its regulations to set forth requirements for training security personnel involved in the transportation of high-enriched uranium and plutonium or assigned to protect commercial nuclear facilities.

The amendments first were proposed in July 1977, and have been revised extensively as a result of public comments received by the NRC staff.

Licensees authorized to transport strategic quantities of special nuclear material—high-enriched uranium and plutonium—will be required to submit a training and qualifications plan which outlines the processes by which armed escorts will be selected, trained, equipped, tested and qualified to assure these individuals meet specified requirements.

The plan must also include a schedule to show how all armed escorts will be qualified—within two years after the new requirements become effective or two years after the security training and qualifications plan is approved by the NRC staff, whichever is later.

Under the amendments, power reactor and fuel-cycle facility licensees may not permit an individual to act as a guard, watchman, armed-response person, or other member of the security organization unless the individual is equipped and qualified to perform his assigned duty or duties. In addition, upon the request of an authorized representative of the Commission, the licensee will be required to demonstrate the ability of security personnel to carry out their assigned duties and responsibilities.

Facility licensees also will be required to submit a plan for staff approval containing the same elements as those required for transportation licensees as described above, which covers guards, watchmen, armed-response persons and other members of the security organization.

The security qualification and demonstration plan for transportation and fuel cycle facilities must be submitted within 120 days after the effective date of the amendments and for power reactors, 300 days after the amendments become effective. Plans must be implemented by fuel-cycle facility and transportation licensees within 180 days after the amendments become effective, or 60 days after their plan is approved by the NRC staff, whichever is later. Plans must be implemented by power reactor licensees within 500 days after the amendments become effective, or 60 days after the plan is approved, whichever is later.

The new amendments include the addition of an Appendix B to Part 73 titled "General Criteria for Security Personnel." Included in this Appendix are sections on criteria for employment suitability and qualification, training and qualifications, weapons training and qualifications, a recommended weapons qualification and requalification program, and a list of areas requiring security knowledge, skills, and abilities, and a list of guard, armed-response personnel, and armed escort equipment which would be appropriate to the individuals assigned security tasks.

The amendments to Part 73 of the regulations became effective 60 days after publication in the Federal Register on Wednesday, August 23, 1978.

DIQs: An Introduction To IAEA Facility Information Requirements

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Four major types of documents are prepared for the implementation of IAEA safeguards in a country under the Treaty for the Non-Proliferation of Nuclear Weapons (NPT): an Agreement for the Application of Safeguards, Subsidiary Arrangements under the Agreement, Design Information Questionnaires for all facilities which will be under IAEA safeguards, and Facility Attachments to the Subsidiary Arrangements. While the details of these documents vary from country to country and from facility to facility, each type always has certain general characteristics.

The basic document which defines IAEA safeguards in a country is the Agreement for the Application of Safeguards. The structure and content of agreements required under the NPT is given in IAEA document INFCIRC/153 (Corrected), dated June 1972.[1] The agreement between the US and the IAEA[2] is based on INFCIRC/153, but it differs where appropriate to take into account the fact that the U.S. is a nuclear weapons state.

Once an agreement has been negotiated between a country and the IAEA, Subsidiary Arrangements are prepared. Subsidiary Arrangements define the details of implementation of safeguards according to the general principles given in an Agreement. Formally, Facility Attachments are part of the Subsidiary Arrangements; the content of Facility Attachments is discussed below. The General Part of Subsidiary Arrangements normally contains the following ten sections, referred to as Codes 1 through 10:

Code	Subject
1	Regular Channels of Communication
2	National System for Control of and Accounting for Nuclear Material
3	Provision of information by the country
4	Provision of information by the IAEA
5	Publication of Information by the IAEA
6	Termination of, exemption from, and reapplication of safeguards
7	Advance notification of international transfers
8	Model inventory and export accounts for nuclear material (country-wide)
9	Inspection and Inspectors
10	Report forms and explanations for their use

Where the General Part of the Subsidiary Arrangements contains the details of the subjects listed above as they apply to an entire country, Facility Attachments contain details as they apply to specific facilities that will be under IAEA safeguards. In particular, Facility Attachments contain the definitions of Material Balance Areas (MBAs) and Key Measurement Points (KMPs) used for IAEA safeguards. In addition, Facility Attachments contain a definition of surveilance and containment measures to be applied, a list of typical batches and material types for each KMP, and the specific types of accounting records kept at the facility. Frequency and timing of physical inventories are covered. The exact format and timing of reports to the IAEA are also in Facility Attachments, as are the mode, timing, and extent of IAEA inspection activities at the facility. Finally, Facility Attachments detail procedures for IAEA personnel at the facility, and the content and timing of IAEA reports to the facility concerning the results of IAEA inspection and verification activities.

Preparation of Facility Attachments requires detailed information on facilities. Additional detailed information is required for the IAEA to be able to calculate independent material balances and estimates of limits of error, and for planning of the details of the IAEA's inspection and verification activities. The additional information required is provided to the IAEA in the form of a Design Information Questionnaire (DIQ) for each safeguarded facility, as specified in Agreements and further detailed in Subsidiary Arrangements. Preparation of Facility Attachments does not (and cannot) begin until DIQs have been completed.

Unlike Agreements, Subsidiary Arrangements, and Facility Attachments, which are prepared and negotiated by the country and the IAEA, Design Information Questionnaires are normally prepared by facilities and submitted by the country to the IAEA. Information contained in DIQs is verified by IAEA inspectors, and if necessary, additional information may be requested, but the DIQ *per se* is not subject to negotiation.

DIQs also differ from the other types of documents discussed above in that DIQs are submitted on preprinted forms provided by the IAEA (with attachments for any information which does not fit on the form). There are eight different types of DIQ forms, one for each of seven different major types of facilites, and one for nuclear material stored outside facilitties. The seven facility types covered are:

*Research and Power Reactors (IAEA form number N-72/Rev. 1, April 1977)
*Conversion and/or Fuel Fabrication Plants (N-73/Rev. 1, Apr. 77)
*Reprocessing Plants (N-74/Rev. 1, Apr. 77)
*Isotopic Enrichment Plants (N-75, Apr. 74)
*Research and Development Facilities (N-92, Nov. 76)
*Critical or Sub-Critical Facilities (N-93, Nov. 76)
*Separate Storage Installations (N-94, Nov. 76)

The eighth DIQ form (N-91, Nov. 76) is for "Information in Respect to Nuclear Material Outside Facilities".

The seven forms used for facility information share a common cover page and page 1 (which, together, have IAEA form Number N-71/Rev. 1, Nov. 76). The first page contains spaces for general information such as facility name, location, and address, a summary description of the facility's purpose and status, and the names and addresses of the facility owner and operator.

The remainder of each type of DIQ form contains questions relevant to each different type of facility. While the details differ from form to form, certain general characteristics are shared. Basically, the forms require detailed descriptions of 1) the layout of the facility, 2), the physical, chemical, and isotopic composition of all nuclear material in the facility, 3) nuclear material handling and physical flow in the facility, and 4) nuclear materials measurement and accounting at the facility. Additional descriptive information concerning matters such as health and safety rules and procedures is also required.

Some information required in DIQs may be considered commercially sensitive or proprietary. DIQs are considered "safeguards confidential" documents, by the IAEA, and as such have strictly controlled and limited distribution. Further, Article 5 of the US/IAEA agreement commits the IAEA to protect proprietary information and restrict its distribution to those IAEA staff who require the information for the performance of their duties. If the information is considered particularly sensitive, Article 8(c) of the agreement permits the U.S. to require that the information be kept in the U.S. and not transmitted to the IAEA in Vienna. In any case, Article 8(b) commits the IAEA to gather only the minimum amount of information necessary for safeguards.

1. **Basic Facility Description.**

In all seven of the DIQ forms for facilities, the first set of questions following the general background information discussed above require a basic facility description. In all cases, a general flow diagram is requested. This diagram should indicate the basic flow of nuclear material through the facility, with notes on locations where nuclear material may be held up in process and descriptions of the types(s) of equipment used.

For reactors and critical or sub-critical assemblies, the basic description requires data on the number of reactors and assemblies, their type, type of refuelling (on or off-load), enrichment range and/or Pu content of the core, rated thermal and (if appropriate) electric power output, and type of moderator, coolant, and blanket and/or reflector (as appropriate).

For processing facilites, this section of the DIQ requires a detailed process description, design capacity, anticipated annual throughput, and description of any equipment processing or using nuclear material not previously discussed.

A description of the major uses of nuclear material, typical inventory, anticipated throughput, and equipment which uses or processes nuclear material is required for R&D facilities. For separate storage facilities, only design capacity, anticipated annual throughput, and anticipated inventory are required.

Much of the information necessary for completion of this section of a DIQ is available for NRC-licensed facilities in Safety Analysis Reports (SARs). While the data in the SAR are not organized in the form required for the DIQ, only moderate editing and reorganization is usually required.

The basic facility description is intended for basic inspector orientation and inspection planning; data on the physical layout of the facility and the physical flow of materials are necessary for planning containment and surveillance measures.

2. **Nuclear Material Description.**

The next section of each of the seven forms is a description of the nuclear material in the facility. This section is one of the most important sections, because the information provided is used not only for general inspector orientation and inspection planning but also for preparation of Facility Attachments (particularly the sections detailing the composition of typical items and batches) and for input of basic background data to the computerized IAEA safeguards information system.

For reactors and critical or sub-critical assemblies, this section is primarily a detailed descritpion of the fuel. Data requested include fresh fuel enrichment and/or Pu content, nominal assembly weight, and physical and chemical form of the fuel. In addition, a complete and detailed physical description of the fuel is required, including drawings, dimensions, composition, and means of identification. The basic operational accounting unit (e.g. for LWRs, the assembly) must be specified, and if there are any provisions for exchange or replacement of fuel elements (e.g. rods), these must be discussed. If there is any other nuclear material in the facility (e.g. ^{235}U in fission chambers), it must be identified and described in this section.

The information required in this section of the DIQ for processing facilities includes not only a complete and detailed description of all nuclear material in the facility (including waste or scrap), but also a listing of typical process flow rates and typical in-process and storage inventory quantities. In particular, the information requested includes (for feed, any intermediate products such as powder or pellets which may be separately shipped or stored, and final product) chemical and physical form, enrichment range and/or Pu content, throughout, batch size, flow rate, campaign period, storage and in-process inventory quantities, and expected frequency of shipment and receipt. In addition, for waste materials, data are requested on source, type of waste, chemical and physical form, enrichment range and/or Pu content, estimated generation rates and storage quantities, and method and frequency of recovery and/or disposal. A detailed flow sheet for the entire process is also requested, as is a discussion of any recycle processes.

3. **Nuclear Material Handling and Flow.**

The third major section of the DIQ forms for facilities deals with nuclear material handling and its physical flow through the facility. The objective of this section is to provide the IAEA with the data necessary for planning of inspection and verification activities, and especially containment and surveillance measures. The data are also used for general inspector orientation.

For reactors and critical or sub-critical facilites, this section requests a schematic nuclear material flow sheet identifying measurement points accountability areas, and inventory locations. Other data requested include inventory ranges (in both quantity and number of items) for fresh fuel, the reactor core, spent fuel storage, and other locations, power reactor load factor, core loading (as number of elements or assemblies), refuelling quantity and interval, average burnup, and disposition of spent fuel (e.g. storage or reprocessing). Additional information requested on nuclear material handling includes fuel packaging, storage layout, a description of fuel transfer equipment, diagrams of nuclear material routes, and a detailed description of the reactor vessel and core. Spent fuel storage and handling are also to be discussed and described in detail.

The information requested for other facilities in this section is somewhat simpler, since material flows were dealt with in the preceeding section. Data requested include details of containers, packaging, storage areas, methods, means of transfer, and routes followed by nuclear material.

4. **Nuclear Material Accounting and Control.**

The last major section of the DIQ requests data on nuclear material control and accounting. This is often the longest section of the DIQ, and probably the most important, since the IAEA safeguards system depends primarily on nuclear material accountancy to detect and deter diversion.

For reactors and critical or sub-critical facilites, this section first requests a general description of the accounting system, including methods of recording and reporting accounting data, procedures for account adjustment after inventory or for correction of mistakes, descriptions of general and subsidiary ledgers, and assignments of responsibility and authority for accounting data. A complete set of specimen forms is also expected. Following the general description, specific discussion is requested of receipts, shipments, physical inventory, calculation of and estimated ranges of nuclear loss and production, and operational records and accounts. The form also requests discussion of any specific features of the system (such as routine storage of items under tamper-indicating seals) which contribute to containment and surveillance.

Following the general description requested, data to be provided on specifics of each measurement point in each accountability area (MBA) in the facility. The information requested for each measurement point is divided into the following categories:

1) description of the type, location, and identification of the measurement point,
2) anticipated types of inventory changes at this point, and whether or not the measurements may be used for physical inventory,
3) physical and chemical forms of nuclear material,
4) nuclear materials containers and packaging,
5) sampling procedures and equipment,
6) measurement methods and equipment,
7) level of accuracy,
8) technique and frequency of measurement equipment calibration,
9) measurement control program,
10) methods of converting source data to batch data,
11) anticipated batch flow per year,
12) anticipated number of items per batch (for both flow and inventory),
13) typical type, composition, and quantity of nuclear material in each batch
14) access to nuclear material, and
15) features relevant to containment and surveillance

For other types of facilites, the data requested are basically the same as those requested for reactors, with some additions are appropriate. In particular, in the general system description, discussion is requested for the methods used for determining quantities of unmeasured discards and the method(s) of their disposal. Data on quantities and measurements of retained waste and on its storage are requested. Methods of estimation of unmeasured losses are also to be described.

The data requested for each measurement point are also similar to those requested for reactors. The following categories of information are requested for each measurement point:

1) location, type, and identification of the measurement point,
2) expected types of inventory change at the point,
3) use of the measurement point for physical inventory,
4) physical and chemical form of nuclear material,
5) nuclear material containers and packaging,
6) sampling procedures and equipment (including number of samples and frequency of sampling),
7) measurement and analytical methods and equipment,
8) sources and level of random and systematic error,
9) calculative and error propagation techniques,
10) technique and frequency of calibration and standards used,
11) measurement control program,
12) program for statistical evaluation of calibration and measurement control,
13) method of converting source data to batch data,
14) means of batch identification,
15) anticipated batch flow rate per year,
16) anticipated number of inventory batches,
17) anticipated numbers of items per flow and inventory batch, and
18) type, composition, and quantity of nuclear material per batch.

In addition to these data, a description is requested of the methods used to propogate individual measurement errors and obtain an overall limit of error for S/R differences, book inventory, physical inventory, and MUF.

For facilities licensed by NRC and required to comply with 10CFR70, much of the information requested in this section of the DIQ is already available in the facility Fundamental Nuclear Material Control Plan and can be used in the DIQ with moderate editing and reorganization.

In the preceding discussion, I have briefly summarized the range of information required in DIQs. One of the tasks in the U.S. program for technical assistance to the IAEA is preparation of explanatory notes for DIQs, and the NRC is planning preparation of detailed instructions for licensees to use in preparing DIQs for their facilities. I hope that the brief introduction to DIQs given here will serve to familiarize U.S. facilities with what is required in DIQs and thereby aid the process of implementation of IAEA safeguards in the US.

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Membership Interest in INMM Is High

(Continued from Page 6)

Administration/Finances

In a show of support that would make **Jimmy Carter** envious, the vast majority (95%) feels that Institute leadership is dong at least a "good" job, and most (93%) believe the leadership is moving in a direction supported by a majority of the membership. The method of providing Institute leadership is approved by nine out of ten, and this same majority believes that there are adequate methods of input to the elected leadership.

About three-fourths (77%) continue to support the method of using volunteer help at all participation levels. However, a growing number (36%) are beginning to feel a need to consider some form of a paid staff, in view of the expanding size of the organization and to better fill specific needs. Interestingly enough, to finance such an operation the favored methods were solicitation of industry support and increase in Journal income while solicitation of government support should be avoided like the plague. An increase in either membership dues or annual meeting fees receives only half-hearted support.

Journal

The value of the Journal remains high as essentially every member (97%) finds it a useful tool in some way, and nearly everyone (98%) reads it regularly with most (78%) reading at least half its contents. Most (90%) find it at least somewhat useful in their work, and nearly all (98%) find it at least somewhat interesting. The most read and used portions are the technical articles (85%) followed by editorials (73%) and information about INMM activities (69%).

Despite the fact that the Journal represents a financial drain on the Institute, only a slight majority (58%) feels that the Journal should become self-supporting. Should self-sufficiency be implemented, the favored method (98%) is through an increase in advertising revenue (anomalously, advertisements were judged to be the least read and least useful Journal contents).

Annual Meeting

There is essentially unanimous feeling (one lone dissenter) that the annual meeting serves an important function, and a high proportion (85%) is at least occassionally attend. Attendance in most cases (89%) is dependent on employer support. One half (52%) bring family members at least occasionally. The favored reason (80%) for attending is to maintain personal contacts while the plenary and technical sessions also draw major interest from a majority (63%) of the attendees.

Most members (71%) feel annual meetings are sufficient. But a growing number (29%) are interested in more frequent meetings with added topical meetings being the favored route.

What Does It All Mean?

As with nearly every type of survey, the questions were imperfect, and perhaps the results could be interpreted in various ways. But despite any imperfections, the Exectutive Committee is sensitive to the results and is already busy making use of the received information. Chairman **Bob Keepin** has already implemented some new ideas in the areas of administration; committees are being reorganized and strengthened; new areas are being explored; participation is being expanded; and, most important, questions of individual members are being answered. Over all, the Executive Committee is working hard to be responsive to you, the members.

What can members do now? Well, the best thing to do is to get involved. We hope the survey provided stimulation in two directions, and will provide the bases for a continued vibrant organization—one in which we can all take pride. Thanks to all of you for your candor and interest. Your comments of today help frame the Institute of tomorrow.

Tracking Foreign Nuclear Material in the U.S.

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Purpose

The purpose of this paper is to describe a system for identifying and following nuclear material in the U.S. which is imported or which is subject to conditions attached by supplier countries (i.e., countries supplying the nuclear material or related fuel cycle services). The system permits the reporting of material by location and material type, by country of origin, and by country attaching conditions, from the time of its import into the U.S. up to the time of its export from the U.S.

Background

By reviewing the legal nuances of federal regulations and the conditiins contained in the agreements for cooperation (treaties) with foreign countries one begins to understand the need to place a new requirement on the the U.S. nuclear industry to track the origin of nuclear material received, used and exported by U.S. nuclear facilities.

Three pertinent actions establish the need for identifying the origin of nuclear material at this time. First, the Atomic Energy Commission published in October 1974 a regulation limiting through the year 1983 the amount of foreign origin feed material that could be furnished for enrichment for use in reactors in the U.S. or under U.S. jurisdiction, Second, as a result of a study by the General Accounting Office in 1976, tighter controls and on the export of U.S. origin nuclear materials must be established, and third, an agreement for cooperation with Canada (exchange of notes dated November 15, 1977), contains provisions that obligate the U.S. to know the location of Canadian nuclear material in the U.S., and to obtain approval before Canadian nuclear material can be exported or enriched to a level of 20% or greater U-235. Australia has requested similar information for Australian material.

Discussion

As used herein, the word "conditions" means any applicable supplier requirements such as requirements that material be used only for peaceful applications; that it be subject to IAEA safeguards; that the foreign country or countries concerned be informed of material location; or that the material may not be exported from the U. S. or enriched or reprocessed, without the prior consent of such country or countries. "Nuclear material" or "material" means source or special nuclear material. The conditions attached depend on the policies of the countries involved and the terms of agreements for cooperation and any other agreements reflecting such policies. Information as to the conditions stipulated by the individual countries attaching conditions must be communicated to the U.S. central nuclear materials computer system. (The Nuclear Materials Management and Sageguards System, NMMSS, jointly sponsored by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission.)

In order to track such material in the U.S., a record is established of the material at the time of import, using a code symbol representing the country of origin and any countries that have attached conditions to the material. The identifying code symbols serve as a "label" and are entered on the transfer form documenting the import of the material and on each transfer form reporting subsequent transfers of the material within the U.S. and its export from the U.S. The transfer data containing such coding is computerized which makes it possible to prepare a material balance for the account of each country or coding lable concerned. Using the coding label, the computer system is also able to print inventories of such material in the U.S. according to the facility where it is located, the country of source material origin, the country where enrichment has taken place, the country where production of Pu or U-233 (termed Reactor Products in this paper) has occurred, and the country or countries attaching conditions to the material.

The NMMSS will maintain an account for all foreign nuclear material in the U.S. Each facility by entering the Country Control Number (CCN) on the transaction document (DOE/NRC Form 741, or its equivalent), for each movement (shipment, loss, waste, etc.) of nuclear material will provide the NMMSS with the data needed to maintain a book inventory of foreign nuclear material at each location. A printout of the pertinent portion of the book inventory will be furnished each facility of its holdings of foreign material. This will not, of course, deter any facility from maintaining any records needed to meet its operating and contractual needs. The choice of material being shipped (i.e., by country of origin) will be the prerogative of the facility management, based on the contractual or other arrangements concerning the material, and will have to have the CCN identified.

Periodic reports as required by the agreements with foreign nations or to meet other informational needs will be based on the NMMSS records, which will be updated with each transaction and which will be verified through the periodic inspections and surveys made, as appropriate, by DOE and NRC personnel.

The "Country Control Number"

In the system being described, a "Country Control Number" (CCN) is used as the identifying code symbol. A CCN is assigned to material on its import into the U.S. and is used to follow material throughout the U.S. Each CCN is structured to be an eight (8) character number and can represent one of the following country associations or combination of them, as appropriate.

(1) the country of origin of source material,

(2) the country providing isotopic separation services,

(3) the country in which reactor products are produced, and

(4) any other country or international organization attaching conditions to the material in addition to any conditions that may be attached by the countries in (1), (2), and (3).

The same CCN is assigned to all imports of material having the particular combination of country associations it represents. When material is imported which has a country-association combination for which no CCN yet exists, a CCN will be established for this new combination. A reference file containing all CCN's structured both alpha-numerically and according to each country involved, is prepared and kept current within the system. This file also contains information as to the conditions attached (e.g., prior consent for reprocessing, enrichment or export) by the countries identified by each CCN.

In the scheme for structuring the CCN, the first two characters indicate the country of origin of the source material. The second two characters indicate the country providing the isotopic separation services. The third two characters indicate the country in which reactor products are produced. The last two characters identify any other country(ies) or international organization(s) attaching conditions, and are unique for each such combination of country associations attaching conditions. The unique combinations represented by these two characters are maintained in the system as part of the CCN reference file described above. In the illustrative CCN's discussed in this paper, these two characters are shown simply as XX, since the combinations actually used depend on the specific countries attaching conditions.

Copies of the relevant sections of the reference file are provided to all nuclear facilites in the U.S. possessing material imported or subject to conditions attached by supplier countries affected.

U.S, Transaction Document (DOE/NRC Form 741)

The material transfer document used to record all imports into, exports from, and transfers within the U.S. is DOE/NRC Form 741. This form must be initiated by every U.S. nuclear facility importing, transferring or exporting nuclear material. The form includes data fields for the entry of information on material type, quantity, etc. In addition, as part of the tracking system described in this paper, a data field is on the form for entry of the appropriate Country Control Number.

Operation of the System

The operation of the system is described below using typical transfers in the principal categories of imports, transfers within the U.S., exports, and transfers abroad between export and re-import, with no effort being made to cover all possible combinations of transfers.

Examples discussed in the following sections are portrayed graphically in the attached diagram.

A. **Imports**

The import of nuclear material into the U.S. requires an import license. The application for such a license must identify among óther things, the source of the material to be imported and if available, the U.S. Uranium Enrichment Contract Number. A transfer document DOE/NRC Form 741, which is used to document the receipt of the material in the U.S. and to support the shipping and receiving data entered in the U.S. central nuclear materials data base, must be prepared by the importing facility. This document must show as part of the data, the U.S. import license number* and a Country Control Number.

(1) Source material imported from Country AA, with no supplier conditions except those attached by that country.

The importing facility will prepare a U.S. transfer document DOE/NRC Form 741. For tracking purposes the facility will enter in the appropriate data field, the import license number and a unique Country Control Number (CCN) which will be used to follow that material in the U.S. In this case the CCN would be **AA 00 00 00,** which would visually identify the material as originating in Country AA, not enriched, not containing or consisting of a reactor product, and having no conditions attached except those attached by Country AA.

(2) Source material previously sent from Country AA to Country BB for conversion and now imported into the U.S. for enrichment, with conditions attached by Country BB.

The importing facility will prepare a DOE/NRC Form 741, entering in the appropriate data fields, the import license number and a unique CCN. In this case the CCN would be **AA 00 00 XX,** which would visually identify the material as originating in Country AA with no enriching or production having taken place. The last two characters would indicate that conditions have been attached by some other country or organization. The meaning of the last two characters would be maintained in the system as explained above.

(3) Material originating in Country CC, enriched in the U.S., irradiated in Country DD under IAEA safeguards, and now returned to the U.S.

The importing facility will prepare a DOE/NRC Form 741, entering in the appropriate data fields, the import license number and a unique CCN. In this case the CCN would be **CC US DD XX,** which would visually identify the material as originating in Country CC, enriched in the U.S. and containing plutonium produced in Country DD with conditions attached by some other country or organization.

B. **Transfers Within the U.S.**

(4) Transfers from the importing facility to a processing or utilization facility.

When the importing facility ships nuclear material to another facility in the U.S. the importing facility must prepare Form 741 to document the internal U.S. transfer. The form 741 must show in the appropriate data field a CCN assigned earlier to the material held by the importing facility. If material from more than one CCN is being transferred in the shipment a separate line must be used for the quantity associated with each CCN. in addition to the CCN the U.S. import license number, and if appropriate, the U.S. enrichment contract number, should also be included on the Form 741 in the appropriate data fields.

If the importing facility is an enriching facility and an enriched product is being transferred (as distinct from the retransfer of the original imported material), the CCN assigned to the product will retain the identity of the country of origin of the source material and the countries or organizations attaching conditions to the material. Further, the CCN will identify the country that produced the product. For example, Country AA material shipped directly to the U.S. enriching facility, with an enriched product produced which is being transferred to a fabrication facility, the CCN would be **AA US OO OO.**

This CCN would visually identify the material as originating in Country AA and enriched in the U.S., with the two last characters 00 indicating that no other country or organization had attached conditions.

The receiving facility in these examples and in those described in (5) below, must idenitify in its records system by material type the quantity of material received associated with each CCN. Reports prepared from the U.S. tracking system inventory files and furnished to each facility holding nuclear material will provide a means of verifying the accuracy of the facility records.

(5) Transfers from one internal U.S. facility (as distinct from an importing facility) to another U.S. facility.

Assuming that no enrichment or reactor product (i.e., enriched or depleted uranium or plutonium or U-233 has resulted from the work or use, the shipping facility will enter in the appropriate data field the CCN to be identified with the material. In this case, the CCN would be obtained from the shipping document (DOE/NRC form 741) originally transferring the material to the facility. For example, if the material was that received under (1) above, the CCN would be **AA OO OO OO.** If it were as that received under (2) above, the CCN would be **AA OO OO XX.** Assuming that an enrichment product has resulted from the work in the facility, then the CCN assigned to the material would retain the idenity of the country of origin of the source material and the countries or organizations attaching conditions to the material. For example, if the material was that received under (1) above, the CCN would be **AA US OO OO.** If it were as that received under (2) above, the CCN would be **AA US OO XX.**

C. **Exports**

(6) Country AA Material shipped to Country DD after enrichment by U.S.

The exporting facility must prepare a Form 741 transfer document entering in the appropriate data field the Country Control Number which identifies the material being exported. In this example the CCN would be **AA US OO OO.** In addition to the CCN the U.S. Export License Number and if appropriate, the Uranium Enrichment Contract Number will be entered in the proper data fields. If material from more than one Country Control Number is involved in the shipment a separate line must be used for the quantity associated with each Country Control Number.

(7) U.S. origin material enriched in the U.S. is shipped to Country BB for conversion of the UF_6 to UO_2.

The exporting facility would follow the procedure described in (6) above. In this instance, however, the CCN would be **US US OO OO.**

D. **Transfers Abroad Between Export and Re-Import**

(8) The U.S. origin/enriched material is converted to UO_2 in Country BB then shipped to Country DD.

Country BB must obtain U.S. agreement to ship the resultant UO_2 to Country DD. When such agreement is requested the associated Uranium Enrichment Contract Number or U.S. Export License Number must be provided to the U.S. on DOE Form MB-10. Upon receiving U.S. approval, which will include a U.S. retransfer number, Country BB must prepare a Transfer Document U.S. Form SER-1, showing in addition to pertinent nuclear material quantity data, the approved U.S. retransfer number. The quantity data together with this number will be stored in the U.S. central nuclear materials data base together with other appropriate information regarding the transfer, and will be linked to the CCN that applied to the material at the time of export to Country BB.

(9) County DD used the UO_2 received from Country BB to manufacture fuel elements and used the fuel elements in a power reactor in Country DD. Country DD now wishes to ship the spent fuel elements to Country EE for processing.

Country DD must obtain the necessary agreements (US., and other's attaching conditions) to ship the spent fuel elements to Country EE for processing. When requesting U.S. agreement Country DD must submit a COE Form MB-10 to the U.S., furnish the earlier Country BB to Country DD retransfer number, and if available, the associated U.S. Enrichment Contract Number or Export License Number. Upon receiving U.S. approval, which will include a new U.S. retransfer number, Country DD must prepare a transfer document, U.S. Form SER-1, showing the new retransfer number. This number is put in the U.S. central nuclear materials data base and is referenced to the earlier (Country BB to Country DD) retransfer number.

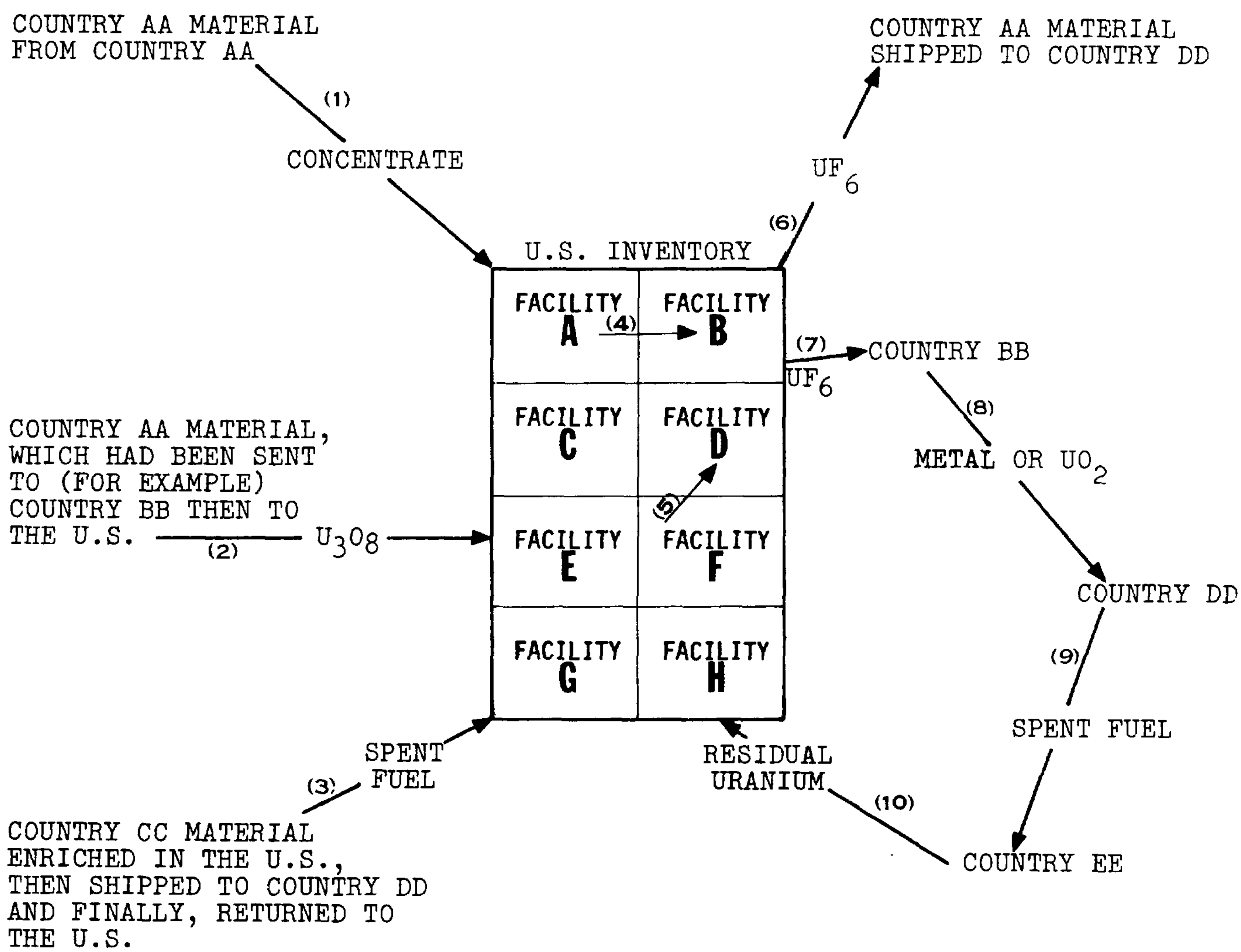
(10) The material from Country DD is processed in the Country EE and the resultant uranium component is being returned to the U.S for further enrichment.

The transfer of the resultant uranium component to the U.S for further enrichment requires a U.S. import license. The application for such a license must include the Country DD to Country EE retransfer number and the new U.S. Uranium Enrichment Contract Number if available. When an import license is issued and the material shipped to the U.S., the incoming transfer document DOE/NRC Form 741, prepared by the importing facility must show the new U.S. import license number, and a Country Control Number. In this example the importing facility would be advised of the appropriate CCN by contacting the U.S. Central Control Unit. The CCN for this transfer would be **US US OO XX.** indicating that the material was of U.S. origin, enriched in the U.S. with conditions attached by other countries or organizations. The specific countries or organizations attaching conditions would be in the data base.

Transfer of the separated plutonium from the Country EE would also be subject to U.S. and other appropriate approvals and the preparation of appropriate transfer documents.

The export license number, the transfer numbers, and the import license numbers form a chain for tracking U.S. material as it moves outside the U.S. The CCN identifies origin of and conditions attached to material entering, moving within and leaving the U.S. The two sets of numbers interface at the point material enters or leaves the U.S.

EXAMPLES



The Nuclear Materials Fungibility Concept

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Purpose

The purpose of this paper is to describe the fungibility concept as it is applied to nuclear material in the U.S., in particular to foreign nuclear material imported into the U.S. that must be tracked as it is processed, used and exported from the U.S.

Background

In the legal sense, "fungibility" is defined as "of such kind of material that one specimen or part may be used in place of another in the satisfaction of an obligation, as money, food, etc."

The concept of fungibility is one which is accepted on a day-to-day basis in certain activites. For example, it is used extensively in the storage and sale of food material such as grain. Wheat shipped by a farmer to one of the large grain elevators that exist throughout the midwest is mixed in the elevator with the wheat shipped by other farmers. At that point, the wheat from a specific farm loses its identity and becomes a part of a fungible mass, any part of which can be used to satisfy the claim of any farmer placing grain in the elevator.

In January 1977, the need to identify the location and quantity of foreign nuclear material by country of origin while it was in the U.S. became evident. It was recognized that specific identification of each foreign country's nuclear material at each location and at each step in the fuel cycle would present an almost impossible task. The problems associated with specific identification appeared to be solvable only by applying the concept of fungibility at certain stages of the nuclear fuel cycle to nuclear material received from foreign countries which would be unidentifiably mixed with nuclear material from the U.S. and possibly from other countries during processing steps in the nuclear fuel cycle.

Discussion

It is quite clear that there is no practical way of labeling each atom of nuclear material. Setting aside the fact that the weight of the contents may differ, from a practical standpoint one drum of concentrate is the same as any other drum of concentrate; likewise, one cylinder of natural UF_6 is the same as the next cylinder of natural UF_6, and in both cases, one drum of concentrate or any cylinder of UF_6 could be substitued for any other drum or cylinder.

There may, of course, be provisions in contracts or governmental agreements that make it necessary to segregate and identify specific materials. In general, however, a book record of the quantity of nuclear material from a particular source, or that is held for a particular purpose at a particular facility, can satisfy the requirement to identify the location and quantity of nuclear material from a particular foreign country. It is this feature of fungibility that has been exploited in applying the concept to the tracking of foreign nuclear material in the U.S.

Officials have at times needed answers to questions such as "How much nuclear material from country 'X' has been received in the U.S., where is it located, and how much has been exported?" Along a similar vein the question has been asked "How much U.S.-origin nuclear material has been exported from the U.S.?" Questions may also arise as to whether any foreign conditions, such as a requirement for a foreign country's consent to export material from the U.S., are applicable to material at a particular facility.

In order to answer these and similar questions, it is necessary to identify foreign nuclear material as it is imported into the U.S., to track it as it moves about within the U.S., and to be able to account for it when it is exported.

Role of Fungibility in the Tracking System

Except when there are specific contractual or other requirements that dictate otherwise, which must be handled through special arrangements, the fungibility concept makes it possible to meet reporting requirements on the basis of records maintained at each U.S. facility and centralized correlation of the data in such records. These records show the quantity of material by material type (plutonium, enriched uranium, etc.) received at the facility, broken down by countries or origin and by countries attaching conditions. Documents reporting transfers to and from each facility indicate whether the shipment is of U.S. or foreign origin (specifying the country or origin) and the allocation of quantities of material at each processing stage is based on information available as to countries of origin, contract provisions, and foreign conditions applicable to the materials involved. The existence of foreign conditions does not need to present a difficulty with respect to the fungibility concept, as long as there is a clear understanding between the parties concerned as to the stages at which and the extent to which the concept will be applied.

Since the country of origin will be shown on each transfer document (NRC/DOE Form 741), the Central Data Base (i.e., the Nuclear Materials Management and Safeguards System, or NMMSS) will be able to produce a book inventory, either country-wide or by individual facility, which will identify the quantity of foreign nuclear material in the U.S. The NMMSS will also be able to provide printouts showing imports and exports of foreign nuclear material and data on the quantity of U.S. origin nuclear material on inventory and which has been exported.

The allocation of material to the U.S. and foreign countries, utilizing the fungibility concept, is simple in some situations, complex in others. A simple case would be that of natural uranium concentrate, some of U.S. origin and some of Canadian origin, which is received at a facility for conversion to UF_6. The UF_6 product is assigned to the U.S. and Canada in proportion to the input.

For a more complicated situation, let us say that Canadian-origin uranium has been enriched in the U.S., subsequently exported to Japan, and used in a power reactor there, and the irradiated fuel (now containing produced plutonium) is returned to the U.S. In light of the processing and use of this material, it would now be subject to conditions of the three countries under governmental agreement and to IAEA safeguards. The conditions applicable to the quantity of nuclear material referred to the U.S. would be entered in the Central Data Base.

In the system developed in the U.S. to follow quantities of foreign nuclear material in the U.S., 8-character alpha numeric numbers ("Country Control Numbers") are assigned to materials in each facility and to materials when they are received in the U.S. Through the use of the Country Control Numbers and related information, all of which is computerized at the time of each import and subsequent transfer within the U.S., the system is able to identify material not merely by country or origin, enrichment, and production, but also according to countries attaching any conditions.

Uranium Enrichment

In this part of the nuclear industry fungibility is fully operative. Imagine the impossible task of keeping track of labeled atoms as they move through the cascade with the cycling and recycling of the enriching process!

The actual cascade operation, however, is not the only phase where the concept is applicable. The cascade tails are as mixed as the cascade inventory and the cascade product. Based on the relative percentages of material from various sources fed to the cascade, corresponding proportions of the inventory, tails, and product (with consideration given to losses, etc.) can be allocated to the countries concerned. These allocations might involve some overlapping because of conditions that might be attached to uranium feed material derived from fuel reprocessing. However, the tracking system would be able to identify all countries attaching conditions whether or not overlapping controls are involved.

A country providing feed for enrichment may wish to assure itself that "its" material is actually on hand. To avoid any difficulties in this connection, it is important to make sure, at the time enrichment contracts are negotiated, that all countries served by the enrichment facilities understand and accept the use of the fungibility concept at these facilities. In any case, there is a clear need to maintain sufficient stocks of feed and tails to cover all foreign materials, as well as U.S. materials, shown on the book inventory, so that foreign countries can be assured that a relatively small stock is not being shown at different times to a number of different countries as being the actual material belonging to each of them. The materials auditors should be able to provide assurance that the nuclear material assets held at the enrichment plants (and at any other facilities where the fungibility concept is applied) are sufficent to cover all the deposits of nuclear material made by all the customers.

Fabrication

In the fabrication processes, the concept of fungibility has been utilized for many years. Although there tend to be more specific controls through contract or agreement provisions at this stage than at some others, the concept is still valid and appropriate when it is necessary to keep a record of the quantities, but not the specific atoms, of foreign nuclear materials in the facility.

Establishing a book record of the make-up of the inventory, based on the transfer documents showing receipts and removals of material and the pertinent country associations, makes it possible to prepare a report at any time that shows the quantity of nuclear material in the facility by country of origin, or the quantities to which other countries attach conditions, without having to maintain physical country identification and take a physical inventory bo country of origin or by countries attaching conditions.

In some cases, applicable agreements or contracts may require the attribution of specifically numbered rods or assemblies to countries concerned. This attribution can be made on the basis of book records showing the quantities of material associated with the countries supplying the source material involved and the countries supplying enrichment and/or other processing services. From this point on, unless and until the rods are physcially destroyed in the course of reprocessing, their attribution can be maintained and their physical location identified. These specifically designated rods or assemblies may have to be atributed to more than one country; for example, if conditions are attached by both the country or origin of source material and a different country of enrichment.

Reactor Operations

As indicated above, fuel rods or assemblies whose specific country attribution is required will retain this attribution throughout their use in reactors and their retention in cooling ponds and storage. Material produced and burnup experienced in these rods, based on rather complicated calculations, would be allotted accordingly.

With respect to fuel not subject to a requirement for specific rod or assembly attribution, the fungibility concept may be applied in different ways in the operation of reactors. In a reactor loaded with a single type of fuel slug or element, the nuclear material would certainly be considered to be fungible. Any material produced or burnup experienced in this fuel during reactor operation could be allotted to the countries originating the material based on the percentage makeup of the loading, in cases where contracts or governmental agreements permit or require allocation on a pro rata basis. Although the matematical calculations may be complicated in determining the quantity of product produced, a fair allocation could be made. Allocation based on the average burnup of elements making up a loading may be the fairest approach, unless prior understandings dictate otherwise.

In a reactor loaded with fuel elements or bundles which are shifted from time to time to increase the reactor operation and fuel utilization efficiency, and which are not required to be specifically attributed to countries, the principle would still apply even though the calculations would become more complicated. There would be a need to develop procedures to assure that all countries having some interest in the fuel loading, through origin of the material and/or agreement conditions or contractual arrangements, could ascertain that their interests are being met. This need would exist in every instance of mixed loading and would not seem to be increased through the application of the fungibility concept. Here again, allocation based on calculated average burnup may be the most acceptable approach.

In some cases, contracts or agreements covering materials used in reactor fuel may contain conditions (e.g., on reprocessing or the use of produced material) applicable to an entire fuel load even if the load also contains material from other sources. In other cases, a country supplying a reactor to another country may require such conditions even if all fuel is obtained from other sources. With respect to such conditions, therefore, the same irradiated fuel would be subject to conditions attached by more than one country. However, maintaining accounts consistent with such overlapping conditions is entirely feasible, provided information on applicable conditions is made available when material is imported.

Reprocessing

In reprocessing, whether hot or cold materials are involved, the nature of the operation (i.e., the economics and other practical considerations) generally makes application of the fungibility concept essential. Where reprocessing is on an individual batch basis, without concern for efficient equipment utilization or cleanout problems, there may be no need to apply fungibility. With few exceptions, however, efficient equipment utilization and cleanout problems make the batch operation impractical and the application of fungibility a real need. Use of the concept and the related book records makes it possible to meet requirements to be able to report the quantity of foreign nuclear material received, on inventory, and shipped, and the amounts of separated uranium and plutonium assignable to the U.S. or specific foreign countries. As indicated in the discussion of reactor operations, the apportionment of separated material can be done both on a pro rata basis according to country of origin, and also according to the existence of conditions attached by any countries. When conditions applied by a country are applicable to all produced material, whether or not fuel from another country is used, there would be an "overlapping" situation such as is described in the discussion of Reactor Operations.

Scrap Processing

The problem necessitating fungibility in this area is the same one the nuclear industry has always encountered; that is, the need to mix different feed lots for processing efficency and economy. The input into the process may well not be considered fungible, but during the processing and in the allocation of the product to the various users the concept is applicable. One area of concern is that of properly allocating processing losses and inventory differences. (This of course is not unique to scrap processing.) However, any time when accounting for mixed material (e.g., material from two or more contracts) must be established, the book records provide the basis for allocations of losses, ID and product and, therefore, for answers to queries regarding quantites and locations of material.

Substitution

Substitution and fungibility are closely related. However, in the case of fungibility no specific material is set aside as a substitute for other material being processed. There may be instances where substitution is still applicable, especially in certain situations related to international safeguards. Generally, use of fungibility eleminates the need for substitution, as long as adequate stocks of the appropriate nuclear materials are on inventory.

Blending

When supplier conditions permit "blending" material from different suppliers (i.e., different countries of origin and/or enrichment, etc.) and of different assays is sometimes blended or mixed to form a product of a particular desired assay. This may occur, for example, in the manufacture of fuel assemblies. In such an instance, the records would provide the necessary information necessary for allocation of the material. The method used in allocating product to the different countries concerned must take into account whatever conditions apply to the materials blended. The inherent flexibility which the fungibility concept provides is a means of avoiding earlier problems encountered in blending or mixing assays.

Implementation Considerations

There is clear need for properly worded contracts and other agreements and formal acceptance of the fungibility concept at specifically identified and agreed on stages.

It is also essential to be able to provide some assurance that adequate stocks of material are on hand to cover the total of all of the assets of all of the customers with material at a location. There are well established ways of doing this that can be incorporated in governmental agreements or in specific contracts as appropriate.

Where two or more countries have attached conditions to the same material, increases in the accounting records are necessary. Properly labeled accounts and documented transfers provide the information necessary to identify inventories by location and country of origin. The method that has been developed of using an identifying number (Country Control Number) correlated in the computer with the country of origin and any countries attaching conditions to the material, to assist in tracking foreign nuclear material in the U.S., will only work with the acceptance of the fungibility concept at appropriate stages of the fuel cycle to the extent appropriate.

In sum, the use of the fungibility concept is essential to efficient operations at certain stages of the nuclear fuel cycle. Given the acceptance of the fungibility concept, an appropriate system for tracking nuclear materials can be devised and applied in a manner consistent with obligations to be able to report the quanties of domestic and foreign origin material exported and the quantities and locations of material in the U.S., according to countries of origin, enrichment, and production, and according to any countries attaching conditions such as requirements or prior consent for reprocessing or retransfer. It is, of course, essential for any such conditions to be clearly stipulated in contracts or governmental agreements, and it is equally important to have clear understanding and agreement by all concerned parties on the manner in which the fungibility concepts will be applied.

A Modification of the Leopard Computer Program In Order to Improve Isotopic Inventory Prediction Accuracy

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Periodically, it is necessary for personnel at a nuclear generating station to know such factors as the isotopic composition of reactor fuel in order to meet inventory and shipping requirements. In addition to this type of information, quick checks of reactor parameters are also often required.

A large variety of computer programs exist for these purposes. These programs vary in accuracy, complexity, and required computer size and computer time. Often time is not available for lengthy data preparation and lengthy computer use scheduling. In order to cope with this type of a situation, a fast running and relatively accurate method of calculating reactor parameters is needed. The computer program Leopard is such a program.[1]

The Leopard computer program uses basic geometry and temperature data to determine fast and thermal spectra, using a modified Muft-Sofocate model, and fuel depletion. The Muft computer program used in Leopard is a 3-group Fourier-transform slowing-down code that includes the energy range from 10 Mev to .625 eV. The Sofocate program calculates the thermal-group constants averaged over a Wigner-Wilkins spectrum with a cutoff energy of .625 eV. Both Muft and Sofocate utilize homogenous calculation techniques, hence heterogeneity must be accounted for by modification of the homogenous results.[2]

In Leopard, each resonance of each nuclide is shielded using an analytic expression valid at zero temperature in order to eliminate Doppler effects. The total resonance integral is then normalized to experimental correlations using the L-factor technique.

In order to account for heterogeneity, Leopard used a flux advantage factor which is the ratio of fuel flux to moderator flux. Once this parameter has been determined, the flux correction factors from the previously determined flux advantage factors are multiplied by the Muft group flux in order to obtain the actual flux in the fuel and nonfuel regions.[3] One important parameter needed for the above calculation is the resonance integral (I).

Leopard uses a metal oxide correlation formula to determine the U^{238} resonance integral. This correlation gives good results for low water to UO_2 ratios, but as this ratio is increased, the U^{238} resonance integral (I^{28}) appears to be underestimated.[4] The core for Bailly Nuclear-1, owned by Northern Indiana Public Service Company, will have about a 2.4 water to UO_2 ratio. In this range, an underestimation of I^{28} by Leopard by as much as 10% seems possible.

In order to check on the possible effects of this procedure on isotopic prediction, isotopic data was obtained from Commonwealth Edison Company for the Quad Cities-1 nuclear reactor. This type of data was felt to be applicable to the Bailly case since Quad Cities-1 is an 880 Mwe BWR and Bailly is a 660 Mwe BWR. A fuel assembly from Quad Cities was simulated with Leopard and excellent agreement was found between the reactor data and the calculated values for U^{235}. The U^{238} values, however, appeared to be over-predicted by about 12%. This would be true if the resonance integral for U^{238} were underestimated since there would be less loss of U^{238} due to neutron absorption. As mentioned previously, it appears that the metal-oxide correlation used by Leopard underestimates the U^{238} resonance integral by approximately 10% at the water to UO_2 ration used in Bailly type cores. In order to compensate for this effect, the computer program HRG3 was used in conjunction with Leopard.[5]

HRG3 is a computer program that computes the fast and epithermal neutron spectrum in a homogenized system by either the P_1 or B_1 approximation. Flux and volume weighted number densities were obtained from a base Leopard run. These were input to HRG3. Volume weighted number densities were input to a HRG3 case with $\bar{I}$ = mean chord length (fuel pin diameter) for the homogenous calculation. Flux weighted number densities with $\bar{I}$ - 0 were input for the heterogenous case. Output from these cases was then used as input to Leopard by means of the input L factor option as follows:

The L factor, which is the flux disadvantage factor described above, can be interpreted as the ratio of the heterogenous to the homogenous resonance integral.[6] This ratio can be determined by using the resonance escape probability, P.

It can be shown that[7]

$$P = e^{-\frac{N}{\xi \Sigma_s} I} \qquad (1)$$

P can also be determined from two group theory[8] as

$$P = \frac{\Sigma r}{\Sigma r + \Sigma a} \qquad (2)$$

equating (1) and (2) gives

$$e^{-\frac{N}{\xi \Sigma_s} I} = \frac{\Sigma r}{\Sigma r + \Sigma a}$$

On taking natural logarithms of both sides and rearranging terms, it is found:

$$L = \frac{I \text{ heterogenous}}{I \text{ homogenous}} = \frac{\ln\left(\frac{\Sigma r}{\Sigma r + \Sigma a}\right)_{het}}{\ln\left(\frac{\Sigma r}{\Sigma r + \Sigma a}\right)_{hom}}$$

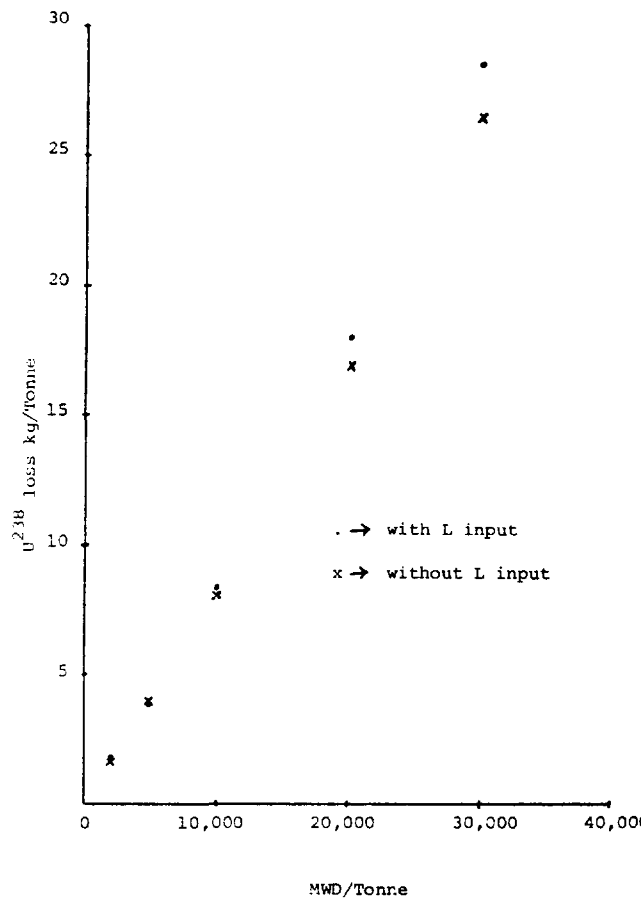
The value of Σr can be obtained from HRG3 as the P(0)- transfer term. Similarly, $\Sigma r + \Sigma a$ can be found as the total sigma removal term. By using these parameters, a value of L can be obtained. This value is then input to Leopard. When this is done, it was found that the U^{238} concentration predicted by Leopard varied by -.5% from the Quad Cities data at 20,000 MwD/T, which is a typical burnup discharge value.

In order to further check the convergence of the method, the number densities from the above Leopard run were again input to HRG3 and L was re-evaluated. This L was then input to Leopard. By repeating this process,it was found that only minor changes were noticed after the second interation and none by further interations.

The following figure is a comparison of two Leopard cases, one with input L and one without input L. The data for this figure was obtained from computer runs for a typical assembly for the Bailly core containing 1.9% U^{235}. A similar simulation was done for the Quad Cities data and was then compared to actual process computer data.

As a consequence of the use of HRG3 in conjunction with Leopard, it has been possible to correct predicted U^{238} values from a 10% overprediction with Leopard alone to a .5%

U^{238} Loss for a Typical Assembly



under prediction at 20,000 Mwd/T. A typical Leopard run requires approximately 4 minutes of cpu time for 14 burn-up time steps on an IBM 370/158. A typical HRG3 run requires approximately 7 seconds cpu time. There are many other programs available that do much more sophisticated calculations than the Leopard-HRG3 system described above. Such a program is EPRI-cell which is being developed by the Electric Power Research Institute.

A typical run for EPRI-cell required 19 minutes cpu time for 3 burn-up time steps on an IBM 370/138. In cases where quick calculations of reactor parameters, employing relatively small amounts of computer core and auxiliary storage are needed, the above system can prove to be very useful.

Problems still exist with predictions for other isotopes. Work is presently being done on modifications for these other isotopes. A change has been made to the method of flux weighting used in the U^{238} decay chain and it appears that by this method the PU^{239} error will be decreased by an other of magnitude. Similar decreases in error for other isotopes also seems to be indicated.

Acknowledgment
I would like to thank Commonwealth Edison Company for supplying data from the Quad Cities reactor. This data was invaluable in making the program changes mentioned above.

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The Loss Detection Powers Of Four Loss Estimators

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ABSTRACT

The power-to-detect loss curves are developed for four loss estimators under different loss conditions. The loss estimators studied are MUF, cumulative MUF, $\hat{L}_{(n)}$ and $M_{(n)}$ where $\hat{L}_{(n)}$ and $M_{(n)}$, respectively, are designed to have maximum powers for the constant loss and the one-time loss situations.

INTRODUCTION

The objective of this article is to compare four loss estimators on the ability to detect losses under different measurement and loss conditions. The estimators are compared by their power curves. A power curve gives the probability of loss detection as a function of the magnitude of the loss. For this article the power is defined as the probability of loss detection in the nth accountability period. Another definition of power could be the probability of loss detection in at least one of the n periods. This latter definition of power was not used because the probability of loss detection under this definition is hard to calculate and to interpret as it involves both multiple-decision problems and correlated loss statistics.[1]

The four loss estimators studied are $MUF_{(n)}$, the usual mass balance loss statistic; $CMF_{(n)}$, the usual cumulative mass balance statistic which is usually written CUMUF; $\hat{L}_{(n)}$, the best, i.e., the minimum variance linear unbiased estimator of a constant loss; $M_{(n)}$, the loss estimator based on a best estimate of the beginning inventory for the nth period and which has maximum power against a block loss in the nth period.

The two types of loss conditions considered are constant loss and block loss. The constant loss as a diversion mode is sometimes called bleeding or trickle diversion; a block loss means that the loss occurs in one accountability period. When A units of material are lost the loss is distributed as A/n units of material per period for n periods in the constant loss case and as A units of material in the nth period in the block loss case.

The statistical model for y_i, the inventory measurement at the beginning of the ith period and the end of the (i-1)th period, is

$$y_i = \mu_i + \varepsilon_i$$

where μ_i is the true inventory amount and ε_i is a random error with variance σ_y^2. The statistical model for x_i, the net throughput measurement when no loss occurs, is

$$x_i = \mu_{i+1} - \mu_i + \delta_i$$

where δ_i is a random error with variance σ_x^2. Net throughput measurement = measured input minus measured output. In the case of a loss of L limits per period the model for x_i is

$$x_i = \mu_{i+1} - \mu_i + L + \delta_i \quad .$$

The usual MUF value is defined as

$$\text{MUF} = \begin{pmatrix}\text{beginning}\\ \text{inventory}\\ \text{measure-}\\ \text{ment}\end{pmatrix} + \begin{pmatrix}\text{net}\\ \text{throughput}\\ \text{measure-}\\ \text{ment}\end{pmatrix} - \begin{pmatrix}\text{ending}\\ \text{inventory}\\ \text{measure-}\\ \text{ment}\end{pmatrix}$$

$$= y_i + x_i - y_{i+1} \quad . \qquad (1)$$

Each of the three terms in (1) is an algebraic sum of amount values rather than a single measurement. The value c is defined as $c = \sigma_x^2/\sigma_y^2$. For the purposes of exposition c and the variances σ_x^2 and σ_y^2 are assumed to be the same for each accountability period.

STATISTICAL BACKGROUND

Let ξ denote a loss estimator. $E(\xi)$, the expected value of ξ, is a function of A, the amount of loss, and also of the nature of the loss. The standard deviation of ξ, denoted by $\sigma\xi$, is a measure of the inherent variability in ξ. For this article it is assumed that the loss estimators are normally distributed. This may be a reasonable assumption since the loss estimators are linear combinations of measured amounts.

The critical value for a loss estimator for rejecting the null hypothesis of no loss is taken as $2\sigma\xi$ where ξ is the loss statistic

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of interest. Thus if the null hypothesis is true the probability of rejection of the null hypothesis is 0.228.

The probability of not detecting a loss is

$$\Phi\left(\frac{2\sigma\xi - E(\xi)}{\sigma\xi}\right)$$

where $\Phi(z)$ denotes the area under a zero mean, unit variance normal curve from $-\infty$ to z. Thus

$$P = 1 - \Phi\left(2 - \frac{E(\xi)}{\sigma\xi}\right)$$

is the power of the test, i.e., the probability that ξ will be larger than $2\sigma\xi$ which is the probability of detecting a loss. Because of the symmetry of the normal distribution the simpler expression

$$P = \Phi\left(\frac{E(\xi)}{\sigma\xi} - 2\right)$$

can be used.

It can be shown that the mvue of μ_i, the beginning inventory for the ith accountability period, is

$$\hat{\mu} = p_{i-1}y_i+(1-p_{i-1})(\hat{\mu}_{i-1}+x_{i-1})$$
$$= p_{i-1}y_i+q_{i-1}(\hat{\mu}_{i-1}+x_{i-1})$$

where $q_{i-1} = p_{i-1}$, $p_0 = 1$, and p_{i-1} is obtained from the recursion relationship

$$p_{i-1} = (p_{i-2})/(p_{i-2}+c+1)$$

It can be shown that

$$\sigma^2_{\hat{\mu}_i} = p_{i-1}\ \sigma^2_y \quad .$$

The expected value of $\hat{\mu}_i$ is $E(\hat{\mu}_i) = \mu_i$ in the no-loss case where μ_i is the true value of the beginning inventory for the ith period. If there is a constant loss $\hat{\mu}_i$ is biased and has expected value $E(\hat{\mu}_i) = L\theta_i$. This assumes that constant loss L has been occurring for the last i periods.

$$\theta_1 = 1,\ \theta_i = 1 + q_{i-1}\ \theta_{i-1} \quad .$$

$MUF_{(n)}$ AND ITS PROPERTIES

If an amount A is lost in the nth period the expected value of $MUF_{(n)}$ is

$$E[MUF_{(n)}] = E(y_n + x_n - y_{n+1})$$
$$= E(y_n) + E(x_n) - E(y_{n+1})$$
$$= \mu_n + (\mu_{n+1} - \mu + A) - \mu_{n+1}$$
$$= A \quad .$$

If A/n units are lost in the nth accountability period, then $E[MUF_{(n)}] = A/n$. The standard deviation of $MUF_{(n)}$ is

$$\sigma_{MUF_{(n)}} = \sqrt{\sigma^2_{y_n} + \sigma^2_{x_n} + \sigma^2_{y_{n+1}}} = \sigma\sqrt{2 + c}$$

$CMF_{(n)}$ AND ITS PROPERTIES

$CMF_{(n)}$ is defined as

$$CMF_{(n)} = MUF_{(1)}+MUF_{(2)}+\ldots+MUF_{(n)}$$
$$= (y_1+x_1-y_2)+(y_2+x_2-y_3)+\ldots+(y_n+x_n-y_{n+1})$$
$$= y_1+x_1+x_2+\ldots+x_n-y_{n+1} \quad .$$

For a block loss of the amount A in the nth period one has

$$E[CMF_{(n)}] = E(y_1)+E(x_1)+E(x_2)+\ldots$$
$$+E(x_n)-E(y_{n+1})$$
$$= \mu_1+(\mu_2-\mu_1)+(\mu_3-\mu_2)+\ldots$$
$$+ (\mu_{n+1}-\mu_n+A) - \mu_{n+1} = A.$$

Actually this last result follows almost immediately from its definition as the sum of the $MUF_{(i)}$ values, i=1,2,...,n, since all these MUF values have expected value zero except $MUF_{(n)}$ which has expected value A. For a constant loss of the amount A/n, $E(x_i) = \mu_{i+1}-\mu_i + A/n$, so that $CMF_{(n)} = n(A/n) = A$. The standard deviation of $CMF_{(n)}$ is

$$\sigma_{CMF_{(n)}} = \sqrt{\sigma^2_{y_1} + \sigma^2_{x_1} + \sigma^2_{x_2} +\ldots+ \sigma^2_{x_n} + \sigma^2_{y_{n+1}}}$$
$$= \sigma_y\sqrt{2 + nc} \quad .$$

$\hat{L}_{(n)}$ AND ITS PROPERTIES

$\hat{L}_{(n)}$ is the mvue of L as determined from the data from the first n accountability periods. It can be shown(2,5) that $\hat{L}_{(n)}$ can be written as

$$\hat{L}_{(n)} = \sum^n b_i\ MUF_{(i)}$$

where

$$\sum^n b_i = 1 \text{ and } b_i = b_{n-i+1} \quad .$$

In the block loss case where the A units are lost in the nth period, the expected value of $\hat{L}_{(n)}$ is

$$E[\hat{L}_{(n)}] = \sum^n b_i\ E[MUF_{(i)}] = b_nE[MUF_{(n)}] = b_nA$$

since $E[MUF_{(i)}] = 0$, $i < n$. If A/n units are taken from each period then

$$E[\hat{L}_{(n)}] = \sum^{n} b_i \, E[MUF_{(i)}] = \sum^{n} b_i (A/n)$$

$$= (A/n) \sum^{n} b_i = A/n.$$

It can be shown[2] that

$$b_n = \frac{q_n \theta_n}{\sum^{n} q_i \theta_i^2}$$

and that

$$\sigma_{\hat{L}_{(n)}} = \frac{\sigma_y}{\sqrt{\sum^{n} q_i \theta_i^2}}$$

$M_{(n)}$ AND ITS PROPERTIES[2-4]

$M_{(n)}$ is defined as $M_{(n)} = \hat{\mu}_n + x_n - y_{n+1}$ where, as indicated before,

$$\hat{\mu}_i = p_{i-1} y_i + q_{i-1} (\hat{\mu}_{i-1} + x_{i-1}), \; i=1,2,\ldots,n,$$

and

$$\sigma^2_{\hat{\mu}_i} = p_{i-1} \sigma^2_y.$$

If no losses occur in periods 1,2,...,n-1 then $E(\hat{\mu}_{n-1}) = \mu_{n-1}$. If a loss of the amount A occurs in the nth period then $E[M_{(n)}] = A$. If losses of the amount A/n occur in all periods it can be shown that

$$E[M_{(n)}] = \theta_n A/n$$

where $\theta_1 = 1$, $\theta_i = 1 + q_{i-1}\theta_{i-1}$. The standard deviation of $M_{(n)}$ is

$$M_{(n)} = \sqrt{\sigma^2_{\hat{\mu}_n} + \sigma^2_{x_n} + \sigma^2_{y_{n+1}}}$$

$$= \sigma_y \sqrt{p_{n-1} + c + 1} = q_n^{-1/2} \sigma_y.$$

A SUMMARY OF THE PROPERTIES OF THE LOSS ESTIMATORS

The total amount A is taken. Under the block loss mechanism it is all taken in the nth period; under the constant loss mechanism it is taken at the rate of A/n units per period. The following table gives the standard deviation of the loss statistic, and the expected value and probability of detection under the two loss mechanisms.

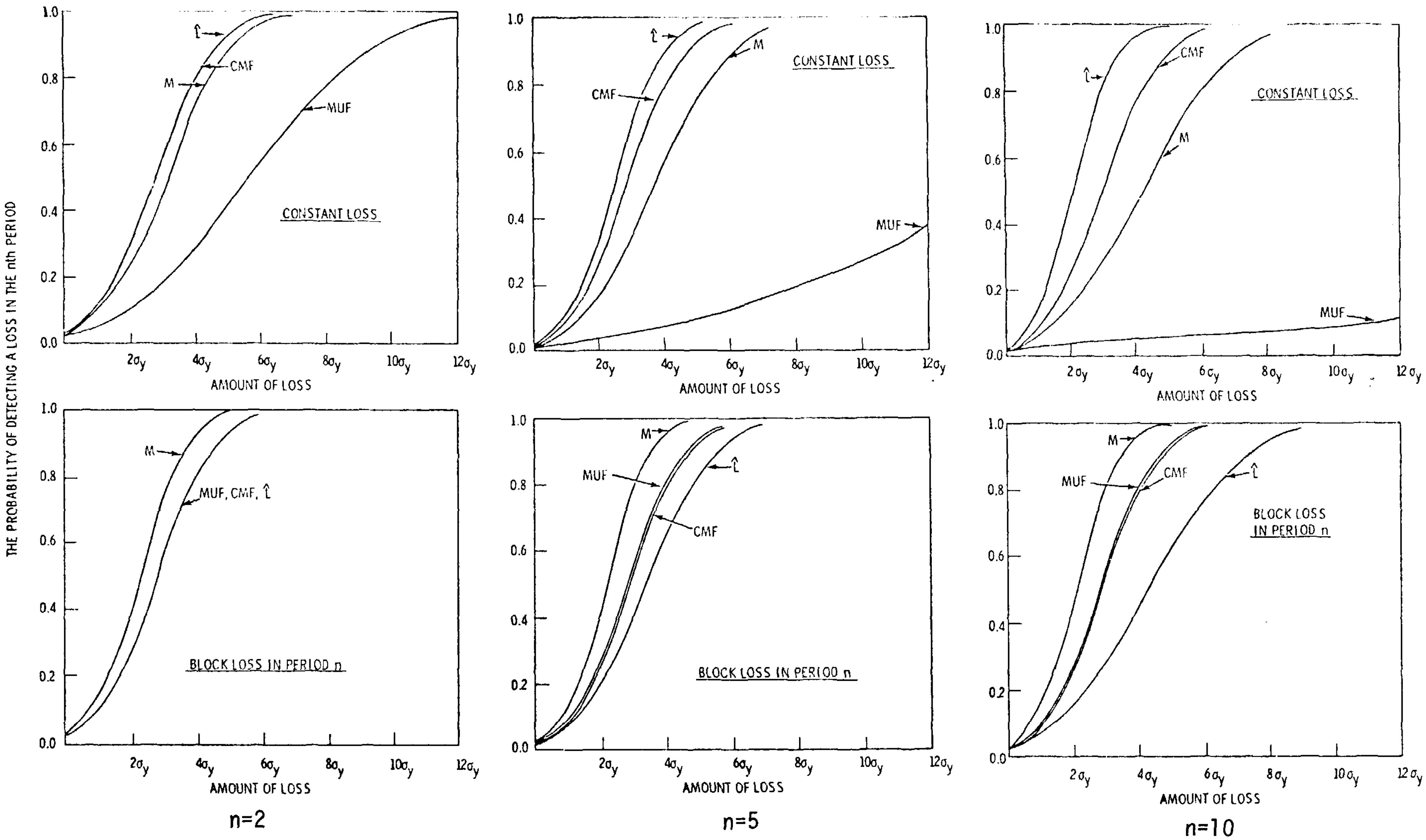
Statistic	Standard Deviation	Loss Mechanism	Expected Value	Probability of Detection
$\hat{L}_{(n)}$	$\frac{\sigma_y}{\sqrt{\Sigma^n q_i \theta_i^2}}$	constant	A/n	$\Phi\left(\frac{A/n}{\sigma_{\hat{L}}} - 2\right)$
		block	$b_n A$	$\Phi\left(\frac{b_n A}{\sigma_{\hat{L}}} - 2\right)$
$M_{(n)}$	$\frac{\sigma_y}{\sqrt{q_n}}$	constant	$\theta_n A/n$	$\Phi\left(\frac{\theta_n A/n}{\sigma_M} - 2\right)$
		block	A	$\Phi\left(\frac{A}{\sigma_M} - 2\right)$
$MUF_{(n)}$	$\sigma_y\sqrt{2+c}$	constant	A/n	$\Phi\left(\frac{A/n}{\sigma_{MUF}} - 2\right)$
		block	A	$\Phi\left(\frac{A}{\sigma_{MUF}} - 2\right)$
$CMF_{(n)}$	$\sigma_y\sqrt{2+nc}$	constant	A	$\Phi\left(\frac{A}{\sigma_{CMF}} - 2\right)$
		block	A	$\Phi\left(\frac{A}{\sigma_{CMF}} - 2\right)$

THE POWER CURVES

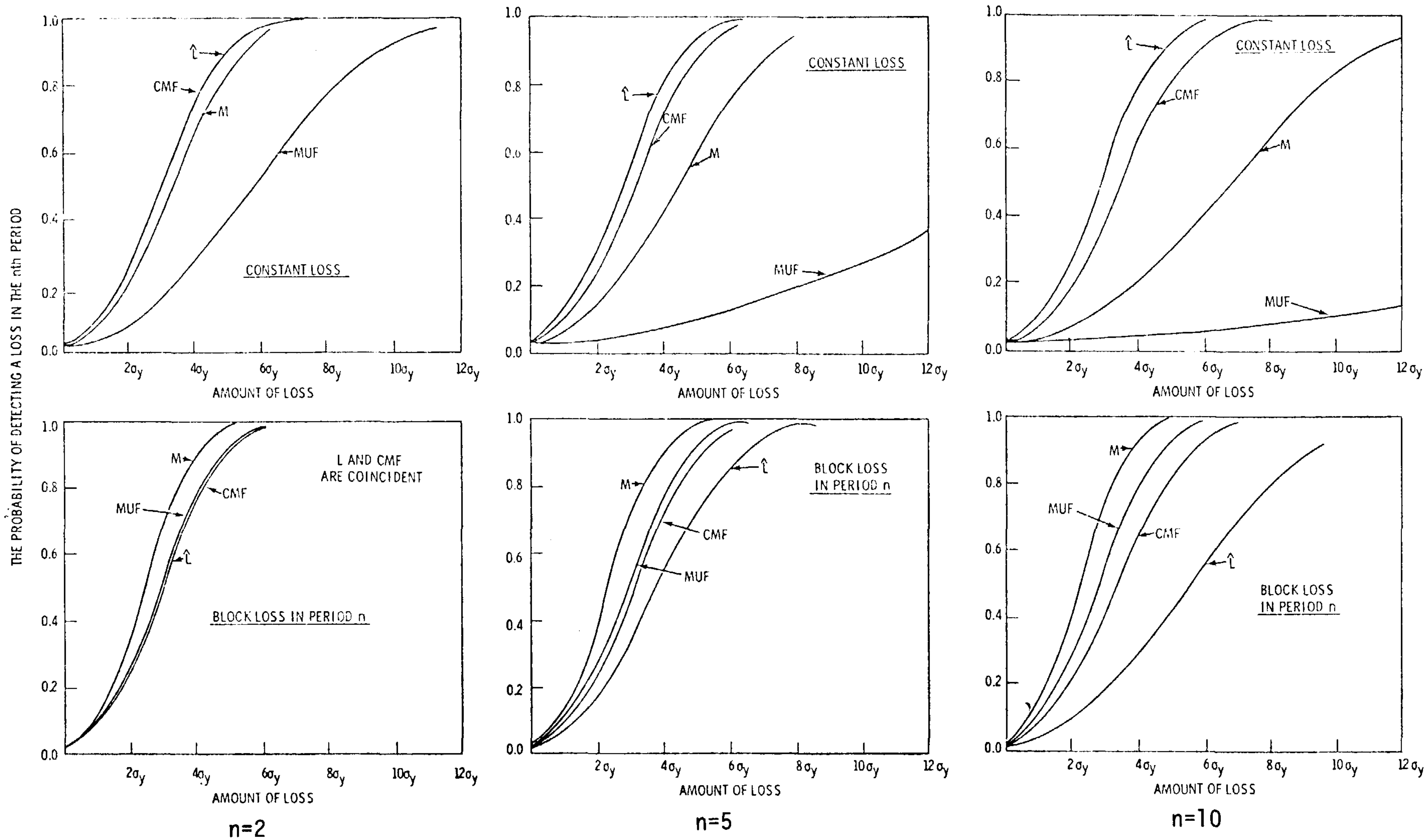
Power curves are given for the block and constant loss cases for n=2, 5, and 10 and for c=0.01, 0.1, and 1.0. The power curves give the value of

$$\Phi\left(\frac{E(\xi)}{\sigma_\xi} - 2\right),$$

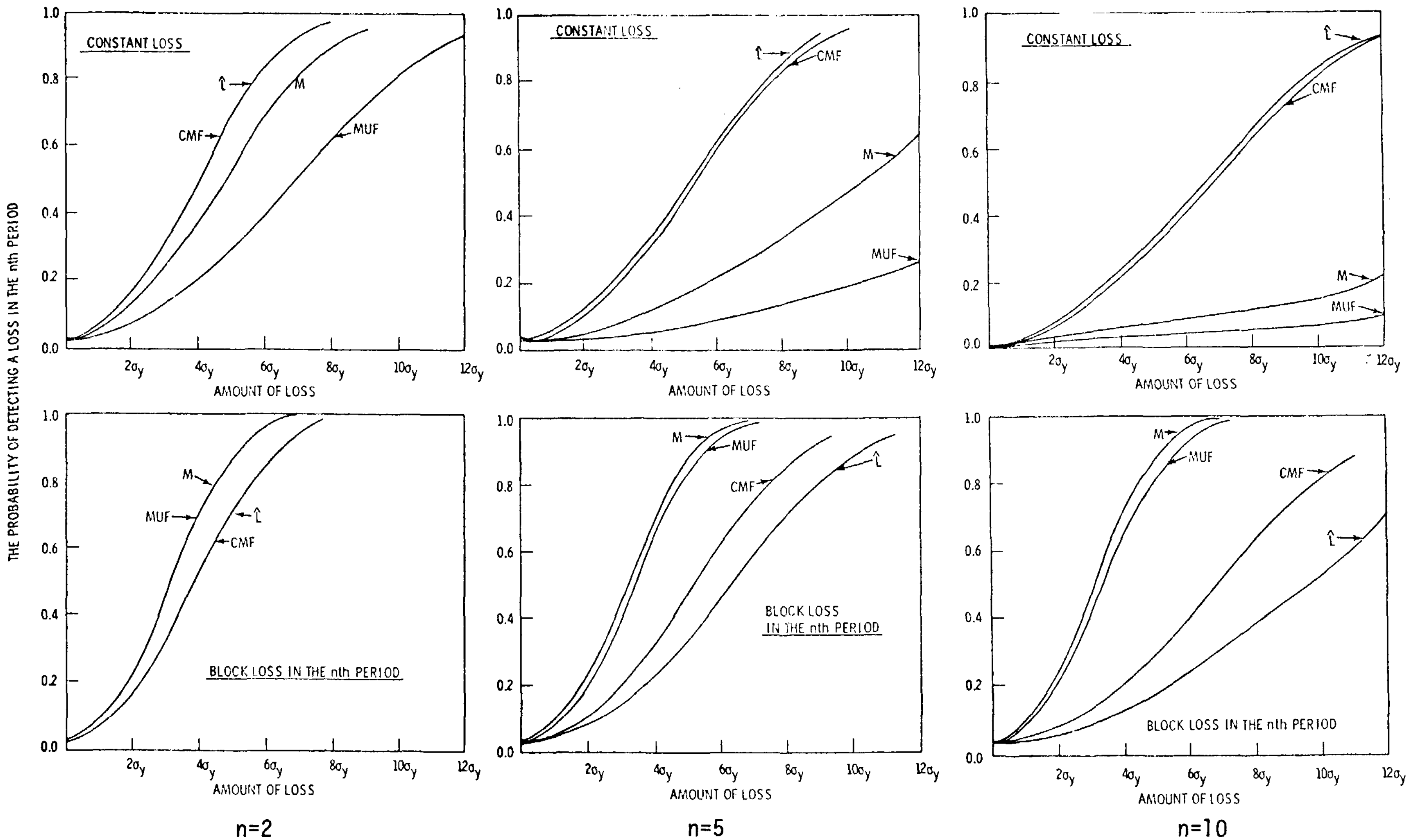
the probability of detection, as a function of the amount of loss. Since both $E(\xi)$ and σ_ξ can be expressed in multiples of σ_y, the power curves are normalized by expressing losses in units of σ_y.



Graph I--The Power Curves for c = 0.01



Graph II--The Power Curves for c = 0.1



Graph III--The Power Curves for c = 1.0

CONCLUSIONS FROM THE POWER CURVES

The conclusions from the power curves are as follows:

a. As n gets very large $MUF_{(n)}$, the usual MUF value, has very little power to detect the constant loss or bleeding situation.

b. Under the constant loss mechanism, $\hat{L}_{(n)}$ has the most power but for the block loss that is taken in the last accountability period it has the least power.

c. $CMF_{(n)}$ compares well with $\hat{L}_{(n)}$ in the constant loss case unless c is very small and n is large.

d. $M_{(n)}$ has the most power in the block loss situation and $M_{(n)}$ is always more powerful than $MUF_{(n)}$, the traditional mass balance statistic.

e. $CMF_{(n)}$ has the same power for the constant loss case and the block loss case, other conditions such as n, c and A being equal.

f. $CMF_{(n)}$ and $M_{(n)}$ are never the best nor the worst in the two loss cases so in this sense they are the least model-dependent statistics.

g. $M_{(n)}$ does fairly well in the constant loss case when c is small no matter what n is. It does the best when the block loss is taken in the last period. The place where the statistics based on the sequence of data really enhance the power is where c is small and in this sense $M_{(n)}$ is a rather robust estimate of loss.

h. A necessary condition for any of the above considerations to have any practical significance is that a strategic amount of material A say, falls somewhere in the range of the power curves as given. If A, the strategic amount (the alternative hypothesis), is too small then none of the techniques will do any good. If A is a sufficiently large block loss then almost any of the techniques will work. If A is sufficiently large and the sum of n smaller losses, then several of the techniques will give adequate sensitivities.

FURTHER DISCUSSION

The more complicated loss estimators such as $M_{(n)}$ and $\hat{L}_{(n)}$ should be considered as auxiliary analytical and diagnostic tools that increase the ability to detect certain anomalous conditions that are not readily detected by the usual mass balance statistics. These techniques can also be used to understand how the underlying mass balance accounting structure affects the estimation of loss and inventory values. The techniques when applied to real data should be used for guidance and the results should not be accepted without question. Assumptions about the models and about the values used in the error structures should be questioned. This is not to minimize the value of techniques such as these but to put them into proper perspective. The ultimate objective is a technique(s) that has the best combinations of the qualities of sensitivity of detection and robustness. Robustness means the ability to function along expected lines despite some departures from the underlying assumptions. The results indicate that it is necessary to use several of these techniques in order to provide a broad enough coverage against possible diversion mechanisms.

There are conditions that could affect the validity of the model; many of the items could have biases; the biases could be of both the short- and long-term nature; and there could be alternate periods of holdup and recovery.[6] Despite these limitations the power curves for $\hat{L}_{(n)}$ and $M_{(n)}$ look good enough for the conditions for which they were designed to be worth using as diagnostic tools.

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Estimation of Scale Accuracy and Precision: A Case History

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Introduction

The information on scale accuracy and precision that is derived from the weighing of known standards is often of limited use. For scales in which the operator must read the result, it is difficult to remove the bias introduced by his knowledge about the standard weight; he is likely to record the standard weight even if the scale is not exactly accurate. For scales with digital readout, the reading may be to the nearest 5, 10, or 20 g, say, for scales commonly used in a fuel fabrication plant. A 10 kg weight, say, will record 10.000 for a scale rounded to the nearest 5 grams even though the scale may be biased by as much as 2.5 grams in either direction.

One approach is to incrementally add weights smaller than the rounding interval, noting at what point the scale readout changes to the next level. This procedure is not satisfactory when the operator's judgment is involved in reading the weights, nor does it always provide satisfactory estimates of actual scale precision.

A rather different approach has been used at our fuel fabrication plant for the past several years. The germ of the idea began with a plant audit in 1972 when a member of the audit team became concerned that the operators, when given a 10 kg weight to weigh, reported to the audit team that the readings were always exactly 10 kg. The auditor picked up two large rocks of unknown weights and had different operators weigh them on different scales. As expected, the results were quite variable, and gave a truer measure of scale performance.

This led to the internal Quality Assurance audit practice of weighing "standard" rocks singly and in all combinations on the various plant scales, placing the rocks in an empty tared bucket. (Some plant personnel are amused and/or puzzled in the course of such an audit. "If you fellows really want to know what those rocks weigh, weigh them on that scale in the corner; it's the best one we've got". That remark, too, is a source of information.) The practice of using rocks as the standards has given way in more recent audits to using other items as standards, primarily because of handling difficulties. It was also realized that the use of one known standard provides a benchmark to obtain an estimate of true scale accuracy, as opposed to estimating relative biases.

This paper reports on a recent audit conducted involving 10 scales and 4 standard items. This case history will illustrate how this type of audit may be conducted, and how the data may be analyzed to provide estimates of scale accuracy and precision.

Standard Items Used in Audit

The "standards" used in this audit are identified as follows:

Standard S: A certified mass standard weighing 5000 g.

Standard B: An empty pellet boat weighing about 1600 g.

Standard P: A steel plate weighing about 3900 g.

Standard R: A rock used in prior audits and weighing about 3900 g.

Scales Involves in Audit

The 10 scales are of 4 types. The type 1 scale required operator readout, and was read to the nearest 10 g during the audit. (In practice the type 1 scale is read to the nearest 25 g.) Scales of types 2, 3, and 4 are all digital readouts rounded to the nearest 5, 10, and 20 g respectively. The scales are identified as scales A, B, C, ..., J, and are of the following types:

Scale A is a type 1 scale
Scales C, H, J are type 2 scales
Scales G, I are type 3 scales
Scales B, D, E, F are type 4 scales

Conduct of Audit and Raw Data

The audit was conducted by weighing each of the 4 standards singly and in all combinations of 2, 3, and 4 items. This gives a total of 15 weighings per scale. The data are given in Table I.

Table I

Audit Data (Weights in Kg)

Items	A	B	C	D	E
S	5.00	5.01*	5.000	5.00	5.02
B	1.60	1.60	1.595	1.60	1.60
P	3.88	3.88	3.880	3.88	3.88
R	3.94	3.94	3.935	3.94	3.94
S+B	6.59	6.60	6.590	6.60	6.60
S+P	8.88	8.88	8.880	8.88	8.90
S+R	8.93	8.94	8.935	8.94	8.94
B+P	5.48	5.48	5.470	5.48	5.48
B+R	5.53	5.54	5.525	5.54	5.54
P+R	7.83	7.82	7.815	7.82	7.82
S+B+P	10.48	10.48	10.470	10.48	10.48
S+B+R	10.53	10.54	10.525	10.54	10.54
S+P+R	12.82	12.82	12.810	12.82	12.82
B+P+R	9.41	9.41*	9.405	9.42	9.42
S+B+P+R	14.42	14.40	14.405	14.42	14.42

Items	F	G	H	I	J
S	5.00	5.00	5.000	5.00	5.000
B	1.58	1.59	1.590	1.59	1.590
P	3.86	3.88	3.875	3.88	3.875
R	3.92	3.935*	3.930	3.935*	3.935
S+B	6.58	6.59	6.590	6.59	6.590
S+P	8.88	8.88	8.875	8.88	8.875
S+R	8.92	8.93	8.930	8.94	8.930
B+P	5.46	5.47	5.465	5.47	5.465
B+R	5.52	5.53	5.520	5.53	5.525
P+R	7.80	7.81	7.810	7.81	7.810
S+B+P	10.46	10.47	10.470	10.47	10.465
S+B+R	10.52	10.525*	10.525	10.53	10.525
S+P+R	12.80	12.81	12.810	12.82	12.810
B+P+R	9.40	9.405*	9.400	9.41	9.400
S+B+P+R	14.40	14.405*	14.405	14.41	14.400

*The scale reading flip-flopped between the two rounded values and the mid-point was recorded.

Estimation of Scale Precision

The method of Grubbs for N≥3 instruments is used to estimate the precision for each scale [1]. The first step involves finding the differences in recorded weights for all 15 weighings and for all combinations of scales taken two at a time. There are C (10, 2) = 45 such combinations. The variance of the differences between scales A and B is denoted by V_{AB}; for scales A and C, the variance is denoted by V_{AC}, etc. The 45 variances are given in Table II. Rounding error is accounted for when computing these sample variances by application of the MERDA computer program [2].

Table II

Variances (g^2) for the Columns of Differences

Difference	Variance, Adjusted for Rounding	Difference	Variance, Adjusted for Rounding
A-B	61.1905	D-E	28.6996
A-C	31.7262	D-F	28.6996
A-D	26.8326	D-G	24.5834
A-E	61.1905	D-H	27.2024
A-F	61.1905	D-I	21.0086
A-G	37.9167	D-J	30.7738
A-H	32.4405	E-F	21.3407
A-I	49.5834	E-G	24.5834
A-J	43.1548	E-H	28.1548
B-C	28.8691	E-I	34.3453
B-D	32.6191	E-J	31.7262
B-E	45.9264	F-G	24.5834
B-F	45.9264	F-H	28.1548
B-G	26.0119	F-I	34.3453
B-H	28.1548	F-J	31.7262
B-I	37.2024	G-H	8.0961
B-J	17.4405	G-I	11.7196
C-D	29.3453	G-J	3.6279
C-E	33.1548	H-I	13.8677
C-F	33.1548	H-J	5.3984
C-G	4.8840	I-J	13.8677
C-H	3.4262		
C-I	14.5834		
C-J	3.4262		

Then, letting σ_A^2 be the random error variance for scale A, with σ_B^2, σ_C^2, ..., σ_J^2 similarly defined for the other scales, the estimates of these precisions are given in [1]. These estimates do not include the effect of rounding, because the rounding error was eliminated when calculating V_{AB}, V_{AC}, etc. These estimates are given in Table III.

Table III

Estimate of Random Error Standard Deviation (g) for Each Scale, Excluding Rounding Error

Scale i	$\hat{\sigma}_i$	Scale i	$\hat{\sigma}_i$
A	5.75	F	4.59
B	4.78	G	1.78
C	2.29	H	2.07
D	3.69	I	3.35
E	4.59	J	2.25

Average results are then found for each scale type, and the rounding error is re-introduced for each scale type in Table IV.

Table IV

Estimate of Random Error Standard Deviation (g) for Each Type Scale, Including Rounding Error

Scale Type	Standard Deviation (g) Exclude Rounding	Rounding	Include Rounding
1: (A)	5.75	$25/\sqrt{12} = 7.22$	9.23
2: (C,H,J)	2.20	$5/\sqrt{12} = 1.44$	2.63
3: (G,I)	2.68	$10/\sqrt{12} = 2.89$	3.94
4: (B,D,E,F)	4.43	$20/\sqrt{12} = 5.77$	7.27

Estimation of Scale Accuracy

Turning now to the estimation of scale accuracy, the first step involves assigning a weight to each standard. This is done by finding the appropriately weighted consensus weights as derived for each of the 10 scales. As a check, the consensus weight for standard S should hopefully not differ significantly from the known weight of 5000 g.

First, the weight of each standard is estimated for each scale individually. Letting μ_1, μ_2, μ_3, and μ_4 represent the true weights of the four standards S, B, P, and R respectively, denote the estimate of μ_j (j = 1,2,3,4) based on the scale i data (i = 1,2,...,10) by $\hat{\mu}_{ij}$. Further, for scale i, let the weight of S be y_{i1}, of B be y_{i2}, ..., of (S+B+P+R) be $y_{i,15}$ so that there are 15 estimating equations of the form

$$\mu_{i1} = y_{i1}$$
$$\mu_{i2} = y_{i2}$$
$$\vdots \qquad \vdots$$
$$\mu_{i2} + \mu_{i3} = y_{i8}$$
$$\vdots \qquad \vdots \qquad \vdots$$
$$\mu_{i1} + \mu_{i2} + \mu_{i3} + \mu_{i4} = y_{i,15}$$

The least squares solutions for the μ_{ij}'s are easily found. In matrix notation, the solutions are (dropping the i subscript for simplicity):

$$\begin{pmatrix} \hat{\mu}_1 \\ \hat{\mu}_2 \\ \hat{\mu}_3 \\ \hat{\mu}_4 \end{pmatrix} = 1/20 \begin{pmatrix} 4 & -1 & -1 & -1 \\ -1 & 4 & -1 & -1 \\ -1 & -1 & 4 & -1 \\ -1 & -1 & -1 & 4 \end{pmatrix} \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix}$$

where

$$\begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} = \begin{pmatrix} 1&0&0&0&1&1&1&0&0&0&1&1&1&0&1 \\ 0&1&0&0&1&0&0&1&1&0&1&1&0&1&1 \\ 0&0&1&0&0&1&0&1&0&1&1&0&1&1&1 \\ 0&0&0&1&0&0&1&0&1&1&0&1&1&1&1 \end{pmatrix} \cdot \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_{15} \end{pmatrix}$$

The estimates, $\hat{\mu}_{ij}$, are given in Table V.

Table V

Estimates of Weights of Items (g)

Scale	$\hat{\mu}_{i1}$(S)	$\hat{\mu}_{i2}$(B)	$\hat{\mu}_{i3}$(P)	$\hat{\mu}_{i4}$(R)
A	4997.5	1595.0	3885.0	3937.5
B	5002.5	1597.5	3877.5	3937.5
C	4999.3	1591.8	3879.3	3934.3
D	5000.0	1600.0	3880.0	3940.0
E	5007.0	1597.0	3882.0	3937.0
F	4999.0	1589.0	3874.0	3929.0
G	4998.8	1592.5	3878.8	3933.8
H	5000.8	1590.8	3877.0	3932.0
I	5001.3	1591.3	3878.8	3937.5
J	4999.3	1590.5	3875.5	3934.3

The data in Table V are now used to obtain a consensus value for each standard. A weighted average of the 10 estimates of μ_j is found for each standard, where weighting is inversely proportional to the variance of each $\hat{\mu}_{ij}$. From the above expressions for $\hat{\mu}_{ij}$, it follows that

$$\text{var } \hat{\mu}_{ij} = 0.16\ \sigma^2_{\theta i} + 0.20\ \sigma^2_{\varepsilon i} \qquad (1)$$

where $\sigma^2_{\theta i}$ is the systematic error variance for scale i, and $\sigma^2_{\varepsilon i}$ is the random error variance. Now $\hat{\sigma}_{\varepsilon i}$ is given as the last column of Table IV for each scale type, except that the value for Scale A should be 6.44 g rather than 9.23 g since rounding was to the nearest 10 g for the audit and not to the nearest 25 g as in practice. In order to calculate var $\hat{\mu}_{ij}$, it is necessary to also know $\sigma^2_{\theta i}$. But $\sigma^2_{\theta i}$ will be estimated for a given set of consensus values, and hence, an iterative procedure is called for as follows:

(1) Assign the value $\sigma^2_{\theta i} = 0$ for all i initially

(2) Obtain the weights as the inverse of var $\hat{\mu}_{ij}$ using (1), and calculate the four consensus values.

(3) Using the consensus values, obtain new estimates of $\sigma^2_{\theta i}$ by methods to follow.

(4) Insert these in step (1) and repeat the procedure until input values of $\sigma^2_{\theta i}$ on a given iteration agree with output values.

The calculations are indicated for the first iteration. Using (1), the weights are calculated for the four scale types.

Scale Type	var $\hat{\mu}_{ij}$ (g^2)	w_i = weight (g^{-2})
1	8.2947	0.121
2	1.3834	0.723
3	3.1047	0.322
4	10.5706	0.095

Then, with reference to Table V, the first consensus value is

$$\hat{\mu}_1 = (0.121)(4997.5) + (0.095)(5002.5) + \ldots + (0.723)(4999.3)/\Sigma w_i = 5000.0 \text{ g}$$

Similarly, $\hat{\mu}_2 = 1591.9$ g $\quad \hat{\mu}_3 = 3878.0$ g

$\hat{\mu}_4 = 3934.4$ g

With these values assigned the standards, the sums of standard values are then found for each of the 15 weighings. The observed values are then subtracted from these sums of standard values for each scale and the average difference computed. For scale i, the expected value of the square of this average difference is

$$\sigma^2_{\theta i} + \sigma^2_{\varepsilon i}/15 + 64\sigma^2_o/75 \qquad (2)$$

where σ^2_o is the variance of a given consensus value, and where it is assumed that the value for standard S is its known value of 5000 g, known without error. It can be shown that

$$\hat{\sigma}^2_o = \frac{\Sigma w_i{}^2 \sigma^2_{\theta i}}{(\Sigma w_i)} + \frac{1}{\Sigma w_i} \qquad (3)$$

where $\sigma^2_{\theta i}$ is replaced by its estimate from the previous iteration, and where w_i is the weighting factor for that iteration. Thus, by equating the square of the observed average difference to its expected value given above, it is possible to obtain new estimates of $\sigma^2_{\theta i}$ to use in the next iteration. This process proceeds until the input and output values for the $\sigma^2_{\theta i}$ on a given iteration are the same.

The calculations are illustrated for the first iteration. Input values were $\sigma^2_{\theta i} = 0$ as previously indicated and the corresponding consensus values were found. Then, for scale A (type 1 scale), the average difference between observed and standard values was 5.7067 g. Also, $\hat{\sigma}_{\varepsilon i} =$ 6.44 g for this scale, and from (3), $\hat{\sigma}_o = 0.55$ g. Therefore, from (2), solve for $\sigma^2_{\theta 1}$:

$$(5.7067)^2 = \sigma^2_{\theta 1} + (6.44)^2/15 + 64\,(0.55)^2/75$$

From this equation, $\hat{\sigma}_{\theta 1} = 5.44$ g. This value is used as input for scale A in the next iteration.

Seven iterations were required in this example before the final parameter estimates were found. The results are given in Table VI.

Table VI

Estimates of Parameters for Each Iteration

	$\hat{\sigma}_{\theta 1}$=Systematic Error Standard Dev.(g)				
Iteration	A	C,H,J	G,I	B,D,E,F	$\hat{\sigma}_o$(g)
1	5.44	1.98	0.91	8.76	0.55
2	5.43	1.75	0.49	8.74	1.05
3	5.50	1.74	0.69	8.78	0.98
4	5.61	1.64	0.81	8.83	1.00
5	5.56	1.70	0.78	8.81	0.96
6	5.55	1.70	0.76	8.81	0.97
7	5.55	1.70	0.77	8.81	0.97

Final consensus values for the four standards are:

Standard	Consensus Value (g)
S	5000.0
B	1591.7
P	3878.0
R	3934.3

Note the perfect agreement for the standard S between the consensus and known values. As a group, the scales are free from bias. The standard deviation of each of the remaining three consensus values is 0.97 g from Table VI.

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

INMM STATISTICS COURSE

May 7-11, 1979

The INMM, in cooperation with Battelle Columbus Laboratories at Columbus, Ohio, is planning a presentation of the course, "Selected Topics in Statistical Methods for SNM Control," in May. Course dates are May 7-11, 1979, at Columbus, Ohio. The course was last given in the United States in May, 1978. For further information on future courses, contact Mr. Harley L. Toy, Battelle, 505 King Avenue, Columbus, Ohio 43201. Phone: 614-424-7791. Fee: $350. Enrollment limited to 20.

Columbus, Ohio

D. M. Bishop Elected

SAN JOSE, Calif. — A San Jose man has been elected to a two-year term on the executive committee of the Institute of Nuclear Materials Management (INMM).

Dennis M. Bishop, senior program manager, with the fuel projects department of the General Electric Company in San Jose was elected from a national field of six candidates to the INMM executive position.

The INMM is a technical organization made up of over 600 professional engineers and scientists around the free world working in government, industry and academic institutions who deal with nuclear energy technology. Its prime emphasis includes such timely technical issues as nuclear materials safeguards, worldwide nuclear nonproliferation and international nuclear trade.

Bishop, his wife and three children reside in Soquel, Calif. He holds a B.S. degree in metallurgical engineering from California State Polytechnic University (1967) and an MBA in business from the University of Santa Clara (1973).

In addition to his other responsibilities, Bishop will direct American National Standards Institutes activities for the INMM. He has been an active contributor to various aspects of nuclear technology for more than 10 years.

Mr. Bishop

IN SECOND YEAR WITH INMM — Lyn McReynolds is beginning her second year as an accounting major at Kansas State University, Manhattan. She continues to serve as the student assistant to Tom Gerdis, editor of Nuclear Materials Management which is the leading journal in the world in the field of nuclear safeguards.

Dr. O'Hara Elected

COLUMBUS, OHIO — A Columbus man has been elected to a two-year term on the executive committee of the Institute of Nuclear Materials Management (INMM).

Dr. **Francis A. O'Hara**, a senior research scientist at Battelle Memorial Institute, Columbus Laboratories, where he is associated with the Nuclear and Flow Systems Section in the area of nuclear waste management and nuclear material safeguards, was elected from a national field of six candidates for an INMM executive position.

Dr. O'Hara, who holds an A.B. degree in physics from Thomas More College (1963), an M.S. degree in physics from the University of Kentucky (1965), and a Ph.D. degree in nuclear engineering from the University of Cincinnati (1971), also is on the faculty of The Ohio State University as an adjunct professor in the Nuclear Engineering Department.

He has been an active contributor to various aspects of nuclear technology for more than 15 years. Last year, he represented the United States as an official delegate to the International Conference on the Nuclear Fuel Cycle in Salzburg and has recently been nominated as a U.S. Participant in the International Symposium on Nuclear Materials Safeguards in Vienna.

In addition to his other responsibilities, Dr. O'Hara will direct INMM activities in the areas of Education, Certification and Awards.

DOE Publication

Technical Books and Monographs, a bibliography of books and monographs sponsored by the U.S. Department of Energy (DOE) and by the organizations brought together to form DOE, is published to help meet the information needs of scientists and engineers working in energy-related fields. This catalog provides access to a large body of knowledge generated by many programs — programs as diverse as the field of nuclear medicine, the exploration of physical mechanisms at work in the environment, and the varied technologies required to realize the potential of the country's energy sources.

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Technical Books and Monographs is available as TID-4582-R13 without charge from DOE Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

INMM Award to John L. Jaech

RICHLAND, Wash. — A Richland man has been honored by the Institute of Nuclear Materials Management (INMM).

John L. Jaech, staff consultant in statistics for the Exxon Nuclear Company, Richland, is the recipient of a plaque "in recognition and appreciation of his outstanding contributions to the advancement of nuclear materials safeguards and to this society."

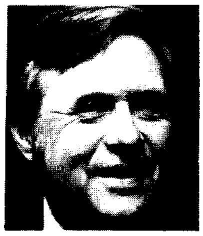
The award was presented in appreciation of Jaech's involvement in several INMM activities, including the educational area in which he has given several INMM-sponsored courses on statistical methodology in nuclear materials safeguards, the journal area in which he has contributed numerous articles, and the national standards area in which he has just completed a four-year term as Chairman of the INMM standards writing activities. Jaech was relieved of that assignment coincidental with his being named program chairman for the next annual meeting of the INMM to be held in Albuquerque in July 16-19, 1979.

INMM is an organization of some 600 professionals around the world working in governmental, industrial, and academic institutions where nuclear materials are used.

A resident of Richland since 1953, except for a three year stint in California, Jaech attended Pacific Lutheran College (now University) near Tacoma, Wash., and received a B.S. degree in mathematics and an M.S. degree in mathematical statistics from the University of Washington, Seattle. Prior to joining Exxon Nuclear Company in 1970, Jaech was manager of the Statistics Section and later of the Applied Mathematics Department of Battelle Northwest for four years, following 13 years as statistician for the General Electric Company at Hanford and at Vallecitos Nuclear Center at Pleasanton, Calif.

Jaech has been heavily involved in problems of nuclear materials safeguards for several years. The author of the book, "Statistical Methods in Nuclear Material Control," he has been a consultant to the International Atomic Energy Agency in Vienna, Austria, on statistical problems of inspection since 1972. He has authored several articles on the subject of statistics and safeguards. He has also contributed several articles to statistical journals on a variety of topics in applied statistics.


Bowie


Cardwell


Donovan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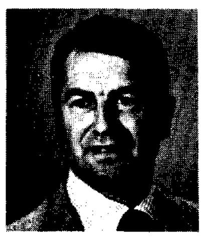
Soucy


Toy

Chairman and Locations of past INMM ANNUAL MEETINGS

(organization)	1958	Pittsburgh	**Ralph Lumb**
	1959	Washington	**Ralph Lumb**
1st Annual	1960	Columbus	**Ralph Lumb**
2nd	1961	Denver	**Ralph Lumb**
3rd	1962	St. Louis	**Tom Bowie**
4th	1963	Buffalo	**Ed North**
5th	1964	Pittsburgh	**Hugh Donavan**
6th	1965	Cincinnati	**Ed Johnson**
7th	1966	Columbus	**Ed Johnson**
8th	1967	Washington	**Lynn Hurst**
9th	1968	Chicago	**Lynn Hurst**
10th	1969	Las Vegas	**Bernie Gessiness**
11th	1970	Gatlinburg	**Bernie Gessiness**
12th	1971	West Palm Beach	**Jim Lovett**
13th	1972	Boston	**Jim Lovett**
14th	1973	San Diego	**Harley Toy**
15th	1974	Atlanta	**Harley Toy**
16th	1975	New Orleans	**Armand Soucy**
17th	1976	Seattle	**Armand Soucy**
18th	1977	Washington	**Roy Cardwell**
19th	1978	Cincinnati	**Roy Cardwell**


Bieber


Gailar


Haycock


Jaech


Keepin


Kramer


Stewart


Wielang

ABOUT THE AUTHORS

Dr. Alan M. Bieber, Jr. is with the Technical Support Organization for Nuclear Safeguards at Brookhaven National Laboratory. He has been with TSO since, completing his doctoral research at BNL in 1975. Bieber's primary efforts are now involved with implementation of the US/IAEA Safeguards Agreement. His previous work has included development of a computer model for assessing fixed-site physical security and participation in physical security assessments at ERDA facilities.

Owen Gailar (Ph. D., Purdue University, 1956) worked for Westinghouse Bettis from 1949 to 1957, then moved on to work at Combustion Engineering (1957-1961). He is currently an Associate Professor of Nuclear Engineering at Purdue University where he has taught since 1961.

Thomas J. Haycock, Jr. (B.A., Chemistry, University of Utah, 1941) is Assistant Director for Information Support, U.S.DOE, Division of Safeguards and Security. A member of INMM, Haycock was the U.S. representative during the development and final acceptance of the International Atomic Energy Agency Safeguards Program. Haycock has been with the AEC, ERDA, and DOE since 1946 in various aspects of safeguards work. He has been in charge of the development and operation of the Nuclear Materials Management and Safeguards System (NMMSS) since 1965.

John L. Jaech (M.S., Mathematical Statistics, University of Washington, Seattle) is Staff Consultant, Statistics, Exxon Nuclear Co., Inc., Richland, Wash. Mr. Jaech, a frequent contributor to this Journal, received a plaque this past June at the INMM annual meeting in Cincinnati "in recognition and appreciation of his outstanding contributions to the advancement of nuclear materials safeguards and to this society." He is the technical program chairman for the 1979 INMM annual meeting July 16-19 in Albuquerque, N. Mex.

G. Robert Keepin, the Institute's current Chairman, is well known in the nuclear community for his many contributions to nuclear and fission physics, as well as reactor kinetics and control. He is a Fellow of the American Physical Society and a Fellow of the American Nuclear Society. From 1963-1965, he was with the Headquarters Staff of the International Atomic Energy Agency in Vienna where he headed the Physics Section of IAEA. In 1973, Dr. Keepin was the recipient of the American Nuclear Society Annual Award—for Nuclear Materials Safeguards Technology. As Nuclear Safeguards Program Director at Los Alamos Scientific Laboratory, his professional interests and activities in U.S. and international affairs are directed toward the development and implementation of new technology and systems for stringent safeguarding and control of nuclear materials on both the national and international levels.

Robert Kramer (M.S., Purdue University, 1973) is a graduate student in Nuclear Engineering at Purdue University and is employed at Northern Indiana Public Service Company, Chesterton, as a Nuclear Fuel Engineer. He is also an associate faculty member at Indiana University, Northwest, in the Physics Department. He joined INMM three years ago, and has been a member of the standards subcommittee on audit techniques for the past two and a half years.

Kirkland B. Stewart (M.S., University of Puget Sound) is currently with the International Atomic Energy Agency, Vienna, Austria. Prior to his recent appointment, he was a Senior Research Scientist in the Safeguards Systems Studies Section of Battelle Northwest, Richalnd, Wash. He has published several technical articles on the statistics of nuclear safeguards in *Nuclear Materials Management* and given papers at INMM annual meetings.

Joseph A. Wielang (B.S., Chemical Engineering, University of Washington) is associated with the Idaho Chemical Processing Plant, operated by Allied Chemical Corporation. As Principal Nuclear Material Accountability Agent had administrative and physical audit accountability responsibility for safeguards of nuclear materials. Current activities include research and development of the Fluorinel headend process for the dissolution of zirconium alloy clad nuclear fuel. The facility will consist of dissolvers, complexing and surge tanks, and a liquid feed system. Auxiliary equipment to support the headend process to be installed in the facility are a fuel storage and handling area with off-gas facilities at the Idaho Chemical Processing Plant will be used to extract the uranium from the dissolver product stream and process the radioactive waste. **Editor's Note** — Mr. Wielang's article, "Qualifying Nuclear Mterials Specialists," appeared in the Summer 1978 issue, p. 30-31. This author's sketch was left out of the issue by the editors.