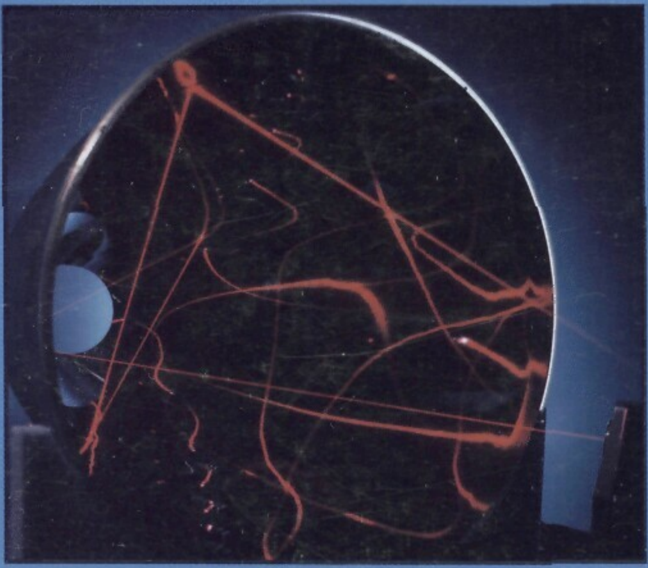
JNMM

JOURNAL OF
THE INSTITUTE OF
NUCLEAR MATERIALS MANAGEMENT



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TECHNICAL EDITOR'S NOTE

As others explain in this issue of the Journal, your officers have realized that our publications have become more and more delayed and that the contents have also declined in quality. Recognizing that the Journal is one of the most important activities of our organization, the officers and our management staff have determined that the regular and proceedings issues of the Journal should be of high quality and published promptly. This first new and improved issue has been produced by the cooperation of many members and headquarters personnel and at some cost to the treasury.

This edition represents the first step. Please, look it over and comment. You are the contributors and the users. You pay and you should tell us what you expect in return. I appeal to our overseas members as well as to those in the United States to respond.

It was twelve years ago that I was persuaded to be technical editor. The Journal then and now attempts to perform two functions. One is to publish technical articles of interest to those in safeguards and related fields. The other is to serve as a newsletter and exchange for the members of the society. The latter activity includes notices, reports of committees, reports of the officers, general news, and so forth. The technical editor has little, if anything, to do with these features. His job is to have contributed papers reviewed and to write editorials for the thin issues that are published between the fat proceedings issues.

Two years ago, the Executive Committee wisely decided that the technical editor should be supported by an editorial committee which would assist him in encouraging members to offer manuscripts for publication and in reviewing them for relevance, quality, and clarity. You will find the present members of the editorial board listed on this page.

One problem we have always had is that very few members submit papers for the regular issues. Considerably more submit abstracts to the annual meeting program committee hoping these will be accepted and that they will be paid by their employers to attend these annual meetings (or they offer abstracts to ESARDA or the IAEA or another organization for similar reasons).

There is no reason not to do that. I have and will continue to submit abstracts for consideration at meetings I feel it would be useful for me to attend. There is, however, an obligation for you and me to support the Journal. Technical articles in the Journal are reviewed by competent colleagues. Such articles generally are more accurate, more reliable, and more clearly presented than are those presented at colloquia. Many of the most important and useful articles can not be presented and assimilated in 15 minutes at a big meeting.

I have made this appeal before, with little effect. If we are to achieve our purpose of supporting a journal of high technical content and interest, you the readers, the inventors, the refiners, and the analysts, will have to send in your contributions. I can assure you that the editorial review process will be prompt and fair.

I feel compelled to end on a serious note. In our proceedings issue ten years ago, the future of nuclear energy seemed assured, though the peaceful nuclear explosion by India was raising questions about controlling proliferation. Many things have happened since then which have changed the public perception and the political situation. As a response to the Indian test and other developments, the U.S. made a big effort in 1977-80 to persuade the rest of the world to halt reprocessing and to postpone the use of plutonium fuels. Then came the reactor accident at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania. In the very recent past, the U.S. space shuttle exploded soon after takeoff and the Soviet nuclear power plant disaster occurred.

Most of us believe that nuclear energy is important for mankind and that such risks as reactor accidents, waste disposal, nuclear proliferation, and sub-national theft or sabotage can be controlled.

The recent examples of technical failure will, almost surely, have a negative impact on the perceptions of governments and society in general, which will probably affect attitudes and policies regarding domestic and international safeguards. We should redouble our efforts to understand these subjects ourselves and to explain to others our objectives and how we go about achieving them.

Dr. William A. Higinbotham
Brookhaven National Laboratory
Upton, New York

INMM CHAIRMAN'S MESSAGE

At the risk of being redundant and obvious, the Journal has a new face — and a new body, for that matter. I encourage each of you to read it thoroughly and let us know your opinion. I also encourage you to contribute an article on the work you have been doing. The Journal is an excellent mechanism for publishing your work and sharing your discoveries with peers.

Have you been reading about all the work the chapters of INMM are doing? To refresh your memory the chapters are:

Central U.S.A.
John Lemming, Chairman

Japan
Ryohei Kiyose, Chairman

Pacific Northwest U.S.A.
Dick Schneider, Chairman

Southwest U.S.A.
Michael Desmond, Chairman

Vienna
Joseph Nardi, Chairman

The chapters are very active, each hosting an annual meeting of one or two days. The papers are of general safeguards issues similar in scope to those of the annual meeting. If you live near any of the above mentioned areas, I urge you to become involved in your chapter's activities. Call the chairman nearest you and see what you can do to help the chapter. Please give the chairman a chance to recover from the shock of having someone volunteer. If you need his telephone number call me at 303-966-4867, or Beth Perry at INMM Headquarters at 312-480-9573. If a chapter is not near you, please consider starting one. It's not hard. Get in touch with Vince DeVito at 614-289-2331 or Beth Perry and they'll be glad to help you.

At the time of this writing, the annual meeting is shaping up nicely. It should prove to be one of our best meetings. With 136 papers and 19 sessions, there should be something for everyone connected with safeguarding nuclear material. I hope to see all of you there. The meeting should be lively and educational, and I, for one, am eagerly awaiting it. See you in New Orleans.

Yvonne M. Ferris
Rockwell International
Golden, Colorado

JNMM COMMENT

"It is is no good to try to stop knowledge from going forward. Ignorance is never better than knowledge."

— Enrico Fermi

The Institute of Nuclear Materials Management began publishing its journal in the spring of 1972. The intent was to provide a forum for the exchange of knowledge and ideas.

Fourteen years later, in response to the demand for more timely information and the need to reach a larger segment of the growing safeguards community, INMM is proud to reintroduce the *Journal of Nuclear Materials Management.*

The new journal will retain the integrity of previous issues, while improving timeliness and readability. Some of the changes are immediately evident: a new, crisper design; new features; and most importantly, scheduled publication.

Not so evident are the *8,000 new readers* that will provide the institute and its programs and technical writers with an enhanced audience, and hopefully, increased participation. To our new readers, welcome to the journal.

But our purpose has not changed. The journal will continue to emphasize the high-quality technical papers that have distinguished it. And it is still the communications channel for the Institute of Nuclear Materials Management.

Most of all, the *Journal of Nuclear Materials Management* still depends upon you for feedback, input and support.

We would like to thank the following INMM members whose work is included in this journal: J.J. Malanify, J.R. Phillips, T.E. Sampson, and J.L. Parker of Los Alamos National Laboratory, and Mark K. Snell, David J. Gangel, J. Ellis Heustess, J.M. de Montmollin, Dennis L. Mangin, and M. Teresa Olascoaga of Sandia National Laboratories, and Paul E. Ebel of BEI. We would also like to thank Darryl Smith for coordinating communications with Los Alamos, and Dennis Mangan for coordinating the Sandia effort.

Finally, this journal would not have been possible without the hard work and devotion of Willie Higinbotham.

* * *

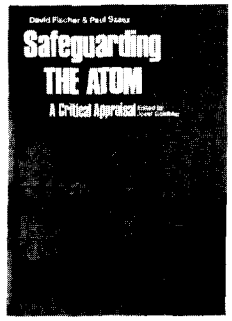
To adhere to our pledge of timely publication we have developed an editorial calendar for featured topics through 1988. We welcome and encourage your comments and contributions.

Summer 1986	Technical Reviews
Fall	Annual Meeting Proceedings
Winter	Physical Protection/ Personnel Security
Spring 1987	Waste Management
Summer	Materials Control and Accounting
Fall	Annual Meeting Proceedings
Winter	Future Technologies
Spring 1988	Transportation
Summer	Quality Assurance/ Quality Control
Fall	Annual Meeting Proceedings
Winter	Retrospective

Mary Jane Grube
Gregory L. Schultz
Nancy Trahey
Publications Committee Chairman

Watching Goliath

Safeguarding the Atom: A Critical Appraisal
By David Fischer and Paul Szasz.
Taylor & Francis, Inc., Philadelphia (1985), 243 pages, $33.



This slim volume (162 pages, not including appendices and index) is probably the most balanced and informed account of the international nuclear safeguards system available. Its principal author, David Fischer, was involved in the negotiation of the Statute of the International Atomic Energy Agency and was Assistant Director General of that organization, in charge of external relations, until his retirement in 1982. He knows the Agency intimately and is free to speak out frankly on the workings of the Agency's system, including its shortcomings.

Not that this is an expose — far from it. Rather, it is a reasoned analysis of a system that, on the one hand, is beset by all the failings of international institutions, and, on the other, is unique and indispensable. Whatever side one may be on in the controversies that have swirled about the Agency for years, in the end one must concede that we are better off with it than without it. As Fischer and Szasz put it, "IAEA safeguards have by now become an indispensable component of other parts of the nonproliferation regime . . . It would be nearly impossible today to revive the bilateral safeguards of the early 1950s, or to renegotiate the NPT so as to reassign the verification task to another entity or entities . . ." A few years ago, when the IAEA's General Conference rejected Israel's credentials, it was this stark reality that rendered U.S. threats to withdraw from the Agency incredible (far more effective was the suspension of payment of dues, which account for 25 percent of the Agency's budget).

The IAEA, of course, had its origin in President Eisenhower's much-maligned Atoms-for-Peace proposal, which envisioned an international agency as the repository and dispenser of fissile material donated to it by the nuclear weapon states for use in peaceful nuclear programs. However, this idea never got very far, and the Agency's safeguards role actually grew out of the need to verify the safeguards arrangements in the bilateral agreements between suppliers and recipients of nuclear materials and technology. As these become more numerous, the need for coherence and uniformity in the application of safeguards becomes apparent, and during the period 1965-68 the Agency's safeguards system was formalized in the document known as INFCIRC/66/Rev. 2, which elaborated the general principles laid down in the Statute.

The advent of the Treaty on the Non-Proliferation of Nuclear Weapons in 1970 enormously increased the Agency's safeguards responsibilities, since it brought all the nuclear programs of the industrialized non-weapon nations under safeguards. It also introduced new concepts and constraints into the operation of safeguards, necessitating a wholly new framework for their application, described in a second document, INFCIRC/153.

The book provides an excellent and succinct description of the safeguards system that grew out of these two basic documents. The differences in coverage are clearly explicated. The main one, of course, is that under "153" — that is, NPT — agreements all peaceful nuclear activities in a country are safeguarded, whereas under "66" — non-NPT — agreements only some may be. This more comprehensive application of safeguards under the NPT was purchased, however, at a price: its focus was narrowed to the accounting for nuclear material, and the access of Agency inspectors was limited to "strategic points," i.e., to certain agreed-upon locations within a facility, such that when the information from all such points is put together a material balance may be struck. Under "153" agreements the maximum allowable inspection frequency is also less than under "66" agreements. Under "66," access is essentially unlimited and the mode of operation of the facility — for example, whether an enrichment plant is producing highly-enriched uranium in violation of its declared purpose — is a proper object of safeguards scrutiny.

Ideally, one would have preferred a combination of the best features of "66" and "153," but diplomacy, as a branch of politics, is the art of the possible. Given the necessity to obtain consensus among nations of widely disparate views, whatever their shortcomings the NPT and its related safeguards document were probably the best that could have been achieved at the time. Concerning possible amendment of "153" in order to strengthen it, the authors warn that a more likely result could be a further watering down.

Excellent as the description of the safeguards system is, for me the most interesting and valuable parts of the book are those that deal with the basic purposes, limitations, and possible improvements of the safeguards system. At the very outset, in a chapter titled "Overview," IAEA safeguards are described as "first and foremost a means of promoting greater confidence between nations; the extent to which they actually deter states from breaking their word is secondary to their role of building confidence." In other words, nations do not voluntarily submit to safeguards in order to quell some otherwise uncontrollable urge to acquire nuclear weapons, the way a drunkard might commit himself to a sanatorium to overcome his compulsion to drink (I am indebted to Jim de Montmollin of Sandia for this analogy). This view is, of course, at great variance with the one frequently expressed in the U.S., especially in Congress, that the primary purpose of safeguards is to detect and deter diversion. The most extreme formulation along these lines is embodied in the concept of "timely warning," according to which safeguards must detect a diversion so promptly that diplomatic pressure can be brought to bear in time to prevent the assembly of the material into a weapon. To the authors this formulation is "a rather radical reinterpretation of the purpose of safeguards . . ." Moreover, they point out, "It . . . sets IAEA safeguards an objective . . . they cannot be guaranteed to achieve." Not that detection can be entirely dismissed as a legitimate concern of safeguards; on the contrary, they warn that "the NPT regime and IAEA safeguards would be severely damaged if ever IAEA-safeguarded fuel were found to have been diverted."

Many of the limitations and weaknesses of safeguards are well-known: the lack of authority for IAEA inspectors to roam a country at will to look for undeclared plants or material; the inability of the Agency to impose and enforce standards for material accounting, record-keeping, and reporting; under NPT safeguards the limitations on inspector access; the accuracy limits in accounting for materials in bulk-processing plants; the inadequacies of safeguards agreements; and so on. The importance of some of these, for example, the accuracy limits in bulk-handling plants, is exaggerated, while some, such as the restrictions on freedom to roam, are inherent in any system dependent for its operation on the acquiescence of sovereign states.

Other problems which have received less public attention are more serious, in the authors' view. Among the most persistent and frustrating are the restrictions on the choice of and the delays in accrediting inspectors. Some countries will not accept inspectors from countries that don't themselves accept safeguards (e.g., until recently, the Soviet Union); others object to inspectors from specified countries; still others insist on inspectors only from NPT countries. The motivation behind these restrictions is the suspicion — probably well-founded in at least a few cases — that inspectors from the proscribed states would be acting as agents of those states.

Another gap in NPT coverage that results from the narrow focus on nuclear materials is the lack of any requirement for a supplier to report to the IAEA transfers of nuclear plants, components, or technology to another country. A related problem is the inability of the IAEA to verify the absence of nuclear material in a plant claimed not to have started up yet or to have been shut down.

Complicating the Agency's job are the attitudes of many of the member states. Some — perhaps a majority — of the developing states seem to be indifferent to the problems of safeguards; others, such as India and Pakistan, are openly hostile to the whole idea; Euratom is jealous of its prerogatives and some, even, of the industrialized non-weapon states regard inspections as an annoying and disruptive intrusion. In fact, regardless of the high-flown rhetoric in support of non-proliferation expressed by many nations in public forums, it is probably safe to say that the IAEA inspector is not truly welcome anywhere outside Vienna. As Gilbert and Sullivan observed, a policeman's lot is not a 'appy one.

Nor is the Agency itself blameless. The authors criticize it for both its excessive secrecy and its timidity in pressing for improvements. To these faults might be added a bureaucratic resistance to change.

To their credit, the authors are not content only to criticize. Recognizing the poor prospects for improving or extending INFCIRC/153 and 66 or renegotiating the agreements under them, they concentrate on possible improvements in the existing systems, including such measures as creating a career inspectorate to attract and retain qualified people, conditioning the transfer of nuclear equipment under non-NPT agreements on the successful conclusion of an adequate facility attachment, exploring the possibility of instituting special or "challenge" inspections, insisting on full-scope safeguards as a condition for supply, and the novel idea of using satellite monitoring to ensure full safeguards coverage (originally proposed by the French).

I could go on about the virtues of this book, but then the review might exceed it in length. Suffice to say, it is simply the best work of its kind around. If you're interested in proliferation or international safeguards get it and read it. When you're done, if you know a Congressman — or better yet, since most Congressmen don't seem to read, a Congressional staffer — give it to him.

Eugene V. Weinstock

Waste Management

In the middle 1960's the INMM started to address nuclear material management areas other than nuclear material control and accountability. At that time there was a perception among some INMM members that the management of nuclear materials was not limited to accounting for it — but rather included all the special management and system considerations related to the use of nuclear materials. As a result, the annual INMM meeting included discussions of insurance, packaging and transportation, and licensing. However, this broadening of scope of INMM was essentially discontinued after 1967 when Congress discovered (finally) a major effort to be launched both nationally and internationally on safeguards and related matters. Since INMM resources were limited, they were subsequently completely devoted to safeguards activities.

In 1980-1981 when the Long Range Planning Committee of INMM was looking into the future of the organization and the services it was affording both its members and the industry, the prospect of expanding INMM's interest into transportation and waste management activities was considered. Only a short time earlier the American National Standards Institute (ANSI) had asked INMM to assume the sponsorship of the ANSI N14 Committee on Transportation Standards — primarily because ANSI recognized the effectiveness of INMM sponsorship of the N15 Committee on Nuclear Material Control Standards. In addition, it was observed that unlike other professional organizations, INMM members most frequently dropped their membership whenever their jobs changed to responsibilities outside the field of safeguards. It was recognized that this was to be expected when an organization could only offer a single field of service to members.

Therefore, the Long Range Planning Committee decided to recommend to the Executive Committee that INMM journey forth into the additional "nuclear materials management" fields of transportation and waste management. The objective here was not to trespass onto the basic technologies covered by the American Nuclear Society, AIChE, AIME or others, — but rather to concentrate on the applications and overall systems aspects of the technologies involved. This follows the notion that INMM members are managers of nuclear materials — and certainly the transportation and waste management aspects thereof involve materials management considerations and problems. It was believed that INMM could make a contribution to its membership by extending the range of interest of the INMM as well as to the industry in the areas of transportation and waste management from the overall systems standpoint.

As a result of the foregoing, the INMM Technical Working Group on Waste Management was formed in 1982 to extend the expertise of INMM members into the fields of radioactive waste management. It should be pointed out here that a TWG in INMM is basically the same as a division in other organizations. INMM has 4 TWGs — one on Physical Protection, one on Materials Control & Accounting, one on Transportation, and one on Waste Management. The TWG Chairperson serves at the pleasure of the INMM Chairman. The current Chairman of the TWG on Waste Management is E.R. Johnson, and Vice Chairman is J.A. McBride.

Since its formation the TWG on Waste Management has concentrated on the development of a series of seminars in the waste management field, and has conducted five such meetings as follows:

- *Spent Fuel Management and Waste Disposal Seminar*
  Hyatt Regency on Capitol Hill,
  Washington, D.C.
  October 20-22, 1982
- *Seminar on The Nuclear Waste Policy Act of 1982 — Its Requirements and Significance*
  Hyatt Regency Crystal City,
  Arlington, Virginia
  May 3-5, 1983
- *INMM Spent Fuel Storage Seminar I*
  Hyatt Regency on Capitol Hill
  Washington, D.C.
  January 11-13, 1984
- *INMM Spent Fuel Storage Seminar II*
  Hyatt Regency on Capitol Hill,
  Washington, D.C.
  January 14-16, 1985
- *INMM Spent Fuel Storage Seminar III*
  Loew's L'Enfant Plaza Hotel,
  Washington, D.C.
  January 22-24, 1986

The Spent Fuel Storage Seminar has become an annual event and has been well received by the industry. It is truly an open session where all aspects of spent fuel storage from technical to institutional considerations are covered and discussed in an open forum.

It was decided by the TWG to limit its activities to these seminars at the outset in order to establish the credibility and capability of INMM in the waste management field. This has been successful and now the TWG plans to extend its efforts in the future into the expanding of its membership participation and other waste management related areas.

Preliminary plans are now being developed for dividing the TWG into four main divisions, covering the following interest areas:

- Spent Fuel/HLW Disposal
- Low Level Waste Disposal
- Spent Fuel Storage
- Decommissioning (of nuclear facilities)

The TWG on Waste Management is

inviting both INMM members and non-members that have an interest in the foregoing areas of activity to participate in the activities of the TWG. Persons interested in participating in TWG assignments should contact Jerry Johnson (Mrs.) at (703) 471-7880 — or write or call Beth Perry at INMM Headquarters. (312) 480-9573.

E. R. Johnson, Chairman
E. R. Johnson Associates, Inc.
Reston, Virginia

Materials Control and Accounting

The Technical Working Group on Physical Protection has scheduled the following activities:

• The 27th Annual INMM Meeting, "Success in Integrated Safeguards," at the Fairmont Hotel in New Orleans, Louisiana, June 22-25, 1986.

Thanks to the help received from many of the members of the Physical Protection Working Group, we will have an outstanding meeting in New Orleans. There are 43 Physical Protection papers scheduled in six sessions (five presented paper sessions and one poster session.) We believe that everyone will find the meeting extremely beneficial. The working group will have its annual steering committee meeting in New Orleans, and your input in planning the activities of the working group is valued and encouraged. I hope to see you there.

• The use of computers in security is a workshop tentatively scheduled for spring 1987.

This will be a new workshop for the Physical Protection group. The workshop will include information display and control systems, vulnerability analysis and modeling and other applications of computers in security. Plans for this workshop will be finalized if enough interest is expressed. Please give me a call at (505) 298-9524 if you are interested in attending, moderating a session or know of any potential speakers or timely topics for discussion.

• Physical Protection Equipment, featuring intrusion detection systems, entry control systems and the delay element will be the focus of a workshop tentatively scheduled for fall 1987.

• The Security Force Training workshop has been tentatively scheduled for spring 1988.

"Security Force Training" was last held March 17-20, 1986 in Albuquerque, New Mexico. The meeting was very successful, primarily due to the efforts of Fred Crane, Dennis Wilson and the staff of the Department of Energy's Central Training Academy. A major addition to the workshop was a tour of the DOE's Central Training Academy. This was an extremely valuable tour for the attendees. In addition to a slate of other outstanding session moderators and speakers, we were fortunate enough to have Mr. Mike Seaton, director of DOE's Office of Safeguards and Security, speak during the closing session.

James D. Williams, Chairman
The WLS Group
Albuquerque, New Mexico

Physical Protection

The Technical Working Group on Materials Control and Accounting plans to conduct a workshop on the problems associated with nuclear materials hold-up in processing lines and equipment. The workshop is tentatively scheduled for late winter/early spring 1987. The exact date and location of the workshop will be announced in a future issue of the journal.

Darryl B. Smith and James W. Tape
Los Alamos National Laboratory
Los Alamos, New Mexico

Pacific Northwest

The activities of the Pacific Northwest Chapter of the INMM for 1985-1986 were highlighted by the Safeguards Symposium and four dinner meetings. The symposium was held on October 3, 1985 at the Battlle Auditorium in Washington. The full day of technical presentations, which was chaired by Dean Scott, was followed by a dinner meeting with music and a presentation on "Mt. St. Helens in Your Backyard." Two later dinner meetings in December and March were devoted to technical presentations. Robert Gruhn, chief counsel for Rockwell Hanford, was the featured speaker at the December meeting discussing some legal aspects of safeguards at Hanford. Robert Carlson, a former chapter president, was the featured speaker at the March meeting describing the "Hanford Security Applications Center." For the spring-summer meeting, an evening social event is planned to combine dinner with a sampling of the products of Washington State's wineries.

The chapter was represented at the Tri-City Technical Council by Executive Committee member Obie Amacker. The Executive Board is currently busy with planning activities for the 1986 Safeguards Symposium. This year's symposium is scheduled for October 14, 1986 in the Battelle Auditorium. Papers are being solicited from local members and other safeguarders who may be visiting Hanford during that time.

Chapter Officers for 1985-1986 are:

Chairman
Richard A. Schneider

Vice-Chairman
Dean D. Scott

Secretary/Treasurer
Marion R. Dowell

Executive Committee
Marjory N. Serier
Obie P. Amacker
Richard C. Hanlen
Herbert E. Smith

Southeast

The Southeastern chapter of the INMM has recently reorganized after having been inactive for a couple of years due to retirements and transfers of its officers. The new officers elected on April 4 are:

Chairman
William J. Desmond
DOE-Savannah River Operations,
Aiken, South Carolina

Vice-Chairman
John P. Clark
DuPont-Savannah River Plant,
Aiken, South Carolina

Secretary-Treasurer
James G. Fowke
DOE-Savannah River Operations,
Aiken, South Carolina

Members At Large
Paul E. Ebel
BE Inc.,
Barnwell, South Carolina

Barbi M. Wilt
Westinghouse Electric,
Columbia, South Carolina

Dennis L. Vernon
DOE-Savannah River Operations,
Aiken, South Carolina

As there are many safeguards and security measures being taken at the Savannah River site and surrounding commercial operations, we hope to have some interesting meetings in the future. The membership has been most positive in their response to the election ballot and in their desire to keep the chapter active.

N15 Committee

The ANSI Nuclear Standards Board recently developed and distributed a new form designed to provide concise information concerning standards and aid in the tracking of standards. The Nuclear Standard/Project Initiation Notice and Data Sheet forms were distributed to N15 Subcommittee Chairmen in April.

Activities of the N15 Standards Committee have been progressing in a positive manner, but at a rather slow pace. A concerted effort to develop realistic progress schedules is necessary to improve the productivity of the N15 Committee.

The next meeting of the N15 committee is scheduled for New Orleans, Louisiana in conjunction with the INMM Annual Meeting in June 1986.

Obie P. Amacker, Jr., Chairman
Battelle, Pacific Northwest Laboratory
Richland, Washington

N14 Committee

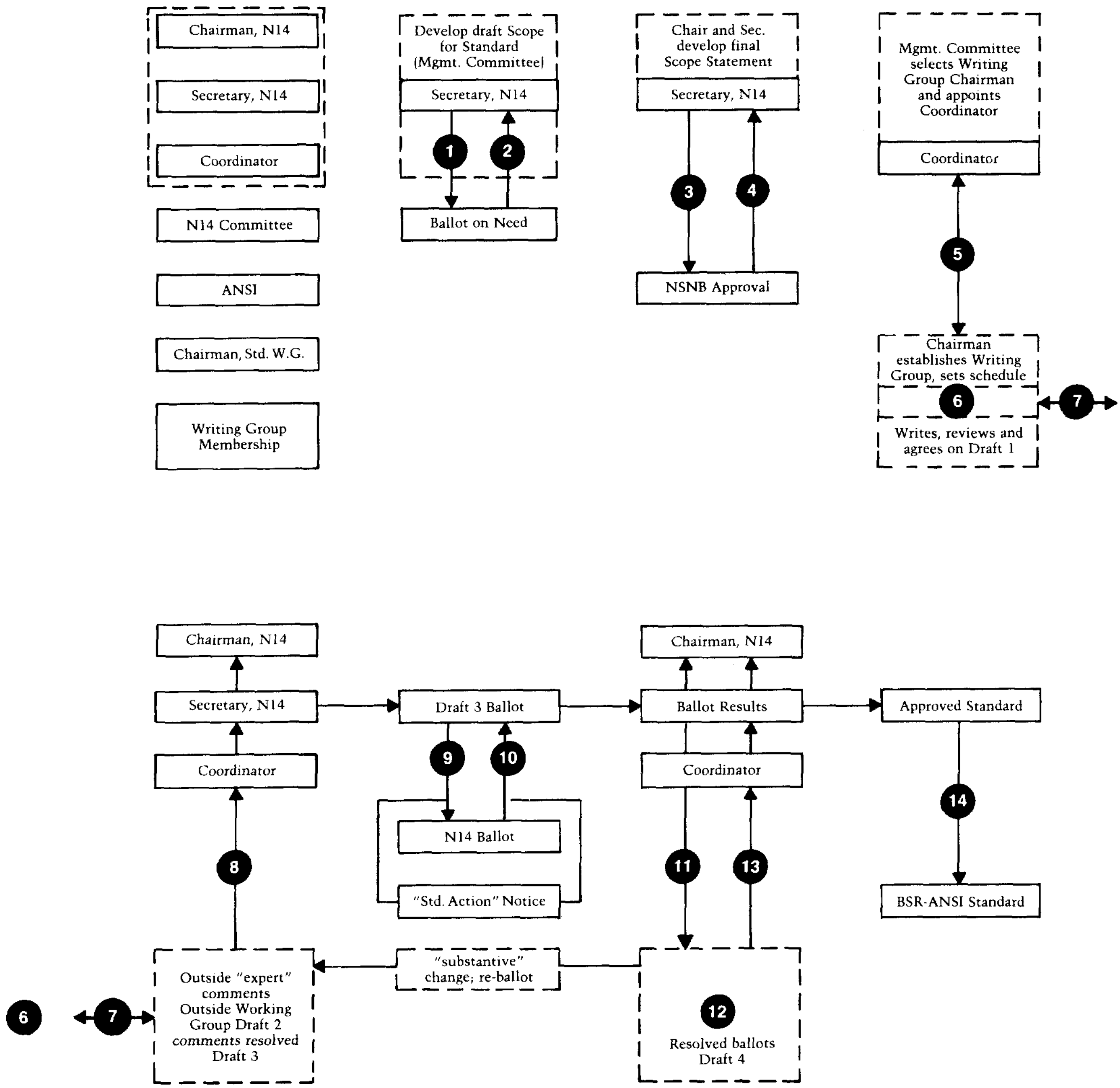
This ANSI Function Chart shows the steps involved in developing a standard, and the associated written communication and documentation.

John W. Arendt, Chairman
JBF Associates, Inc.
Knoxville, Tennessee

ANSI N14 Function Chart

1. Secretary mails Scope and ballot concerning need to full N14
2. Secretary tabulates results, c.c. to Chairman
3. Sec. mails statement to NSNB, c.c. to Chairman
4. Sec. receives the approval, c.c. to Chairman
5. Coordinator establishes communication lines
6. Writing Group correspondence,
7. c.c. to Coordinator
8. Draft 3 sent to Coordinator who forwards to Secretary, c.c. to Chairman
9. Secretary mails ballots to full N14
10. Secretary tabulates results
11. Ballot results to Working Group Chairman for resolution, c.c. Coordinator and Chairman
12. Resolution of neg. ballots, c.c. to Coordinator
13. Draft 4 to Coordinator, final to Sec., c.c. to Chairman
14. Secretary sends to BSR for issue as ANSI standard, c.c. to Chairman, Coordinator

Indicates written communication and documentation


Chairman, N14
Secretary, N14
Coordinator
N14 Committee
ANSI
Chairman, Std. W.G.
Writing Group Membership
Develop draft Scope for Standard (Mgmt. Committee)
Secretary, N14
1
2
Ballot on Need
Chair and Sec. develop final Scope Statement
Secretary, N14
3
4
NSNB Approval
Mgmt. Committee selects Writing Group Chairman and appoints Coordinator
Coordinator
5
Chairman establishes Writing Group, sets schedule
6
7
Writes, reviews and agrees on Draft 1
Chairman, N14
Secretary, N14
Coordinator
8
Outside "expert" comments Outside Working Group Draft 2 comments resolved Draft 3
6
7
Draft 3 Ballot
9
10
N14 Ballot
"Std. Action" Notice
"substantive" change; re-ballot
Chairman, N14
Ballot Results
Coordinator
11
13
12
Resolved ballots Draft 4
Approved Standard
14
BSR-ANSI Standard

Education

INMM's Education Committee has been reevaluating what the Institute's role in education should be. We're focusing on defining goals and benefits — who the program is for and who should be involved.

If you have ideas or are willing to help with this reevaluation, please contact either Jim Tape or John Lemming. Suggestions and comments are welcome.

James W. Tape
Los Alamos National Laboratory
Albuquerque, New Mexico

John F. Lemming
Monsanto Research Corporation
Miamisburg, Ohio

Certification

Participation in INMM's Certification Program constitutes a strong professional commitment to our industry.

The Safeguards Short Course is offered annually at various locations throughout the United States. In conjunction with the course, the Safeguards Certification Examination is administered to individuals who desire to become certified. Additionally, the examination is offered at the INMM Annual Meeting each summer. This scheduling affords potential participants two possible locations and dates to take the written exam each year.

The next Short Course is scheduled for the week of February 16-20, 1987, at the Garden Plaza Hotel in Oak Ridge, Tennessee. The Short Course is an excellent opportunity to review the various subjects which are covered in the examination process just prior to taking the exam.

To participate in the certification program, applicants must fulfill the certification education/experience requirements. Current examination fees are $250 (specialist) and $100 (intern). Short Course fees include the examination fee regardless of whether the participant elects to take the exam.

If you have questions or comments, please contact any member of the INMM Certification Board or INMM Headquarters.

In conjunction with the INMM Safeguards Certification Program, activity on INMM/ANSI NI5.28, "Criteria and Standards for the Qualification and Certification of Nuclear Materials Professionals" has begun. The target date for submittal of the final draft of the standard for ANSI review and acceptance is December 31, 1988.

Barbara M. Wilt, Chairman,
Westinghouse Electric Corporation
Columbia, South Carolina

Topic/Subject	1987	1988	1989	1990
Safeguards Short Course				
Date	February	February	February	February
Examination Registration Deadline	January 15	January 15	January 15	January 15
Location	Tennessee (Oak Ridge)	Colorado (Denver)	Florida (St. Petersburg)	Georgia (Atlanta)
Fee (*subject to change)	$500* (includes examination fees)	$550* (includes examination fees)	$550* (includes examination fees)	$550* (includes examination fees
Place	T.B.E.	T.B.E.	T.B.E.	T.B.E.
Annual INMM Meeting				
Date	Summer (June/July)	Summer (June/July)	Summer (June/July)	Summer (June/July)
Examination Registration Deadline	May 15	May 15	May 15	May 15
Location	Washington (Seattle)	U.S. Capitol (Washington DC)	California (San Diego)	New Mexico (Albuquerque)
Fee (*subject to change)	$100 (intern)* $250 (specialist)*	$100 (intern)* $250 (specialist)*	$100 (intern)* $250 (specialist)*	$100* (intern)* $250 (specialist)*
Place	T.B.E.	T.B.E.	T.B.E.	T.B.E.

T.B.E. = To Be Established

Joint ESARDA/INMM Document To Be Published

At the Copenhagen meeting, the Technical Working Group on Destruction Analysis (Paul De Bienne, Chairman), presented a draft document on target values for ESARDA review and subsequent adoption.

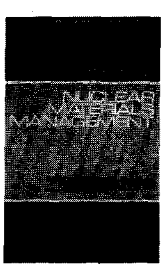
The document, titled "1987 Target Values for Random Uncertainty Components in Sampling and Chemical Assay of Fissile Elements for Nuclear Materials Accountancy and Safeguards Verification," was a joint undertaking of the ESARDA group and several INMM committees.

Following ESARDA examination and adoption, the document will be published in both the *ESARDA Bulletin* and the *Journal of the Institute of Nuclear Materials Management.*

Marc Cuypers
Joint Research Center
Ispra, Italy

INMM 1986 Annual Meeting Proceedings

The Institute of Nuclear Materials Management's 27th Annual Meeting program is the largest yet. The proceedings is a reference guide containing the complete text of the 139 technical papers presented at the meeting. The papers represent the work of leading safeguards professionals from around the world.



To reserve a copy of the INMM 27th Annual Meeting Proceedings send $50 (U.S.) to: **INMM Headquarters, 60 Revere Drive, Suite 500, Northbrook, IL 60062 U.S.A.**

The proceedings will be published in September 1986.

1986 Annual Meeting Sets Record

Last year we said that the INMM Annual Meeting Technical Program was "the largest ever" with 132 papers for presentation. The 1986 program now stands at 139 contributions! We have shown a steady growth in technical papers over the past few years (55 in 1983, 100 in 1984, last year, and now) and the quality is superb overall. Every year we say that the program is "outstanding" and it is — it gets better each year. And every year we address new issues, provide better solutions and face greater challenges. That's why our technical program is a success. And the secret is in the INMM's ability to attract participants who have something significant and important to share with the rest of us. The credit goes to the host of professionals from the nuclear community and the INMM Executive and Standing Committees who have worked as a dedicated team to provide an exceptional annual meeting.

In spite of the forthcoming IAEA Safeguards Symposium this fall and its impact on our meeting because of diminished travel, funding, technical material, and personnel resources, we had valuable contributions from ESARDA, IAEA, Vienna/Japan INMM Chapters, and other international entities.

The Technical Program Committee that helped put this program together consists of John Lemming, Dennis Mangan, R.D. Sherrill, Don Six and Jim Tape. A major contribution to the planning and execution of the technical program has been made by our INMM Executive Headquarters staff, especially Beth Perry and John Messervey.

This year we have 21 technical sessions (two quintcurrent sessions), 139 papers and a varied plenary session. (One of the purposes of our committee is not only to attract outstanding plenary speakers to our session to broaden our perspectives

INMM ANNUAL MEETING

but to raise the visibility of INMM by exposure of these speakers to our activities.) We cover every aspect of safeguards although we would like to emphasize the waste management activities in much more depth and detail. Again, we tried to enlist the participation of the nuclear utilities community in our program but although highly interested in our activities they found it difficult because of work commitments to take an active role at this time. This committee, with the support of the Executive Committee, will address these two issues for next year's meeting.

Some specific highlights of the meeting: a comprehensive yet focused transportation session developed by David Dawson, SAIC; an updated presentation of the "insider threat problem" by Rokaya Al-Ayat, Lawrence Livermore National Laboratory; two significant sessions on quality assurance (measurements and systems applications) headed by John Clark, EI duPont de Nemours & Co., Savannah River Plant and Wayne Delvin, Westinghouse Hanforel Company; sessions on physical protection developed by Dennis Mangan, Sandia National Laboratories and J. D. Williams, WLS Group, which emphasize improved operations based on past experiences and some highly innovative technology; and, at long last, a comprehensive overview of DOE inspection activities.

Although the number of technical papers increases each year there is a concern that the number of contributed papers (those which are completely unsolicited except by Call for Papers) decreases and is a small percentage — about 20% — of the total presentations. We continue to encourage more free participation in providing technical papers for the INMM Annual Meeting. The concept of selecting/inviting papers, while having much merit has an inherent weakness in that we tend to filter out the unfamiliar but vital areas. It also gives the INMM the undeserved aspect of being a "closed society" that precludes the "outsider" from even attempting to make a contribution. The committee's goals are to prevent this potential inbreeding and to broaden our contacts for greater strength and vitality. I would like to hear from anyone who has suggestions to improve such contributions.

It is the committee's unanimous sentiment that the breadth and technical quality of the program this year exceeds that of the past few years. However, we must continue to face the challenge of other specialized organizations in attracting prospective members and Annual Meeting participants, because they appear to better meet the needs of our membership and professional colleagues. Whether this perception is valid or imaginary it should stimulate the INMM and its Executive Committee to take direct action to promote INMM activities, make them more significant to its broad constituency, and provide a basis for continuing success in our Annual Meeting technical program.

Charles E. Pietri
Chairman

International Training Course on Physical Protection of Nuclear Facilities and Materials

Dennis L. Mangan
M. Teresa Olascoaga
Sandia National Laboratories
Albuquerque, New Mexico, U.S.A.
and
Paul E. Ebel
BE Incorporated
Barnwell, South Carolina, U.S.A.

ABSTRACT

The transfer of physical protection technology by the U.S. Department of Energy to the international community is an ongoing activity that takes many forms. One of the formalized means is through the International Training Course on Physical Protection of Nuclear Facilities and Materials, conducted by Sandia National Laboratories, Albuquerque, NM. This paper highlights the organizational structure of this course, summarizing the course content. A brief historical resume is also provided.

INTRODUCTION

The transfer of physical protection technology by the U.S. Department of Energy to the international community is an ongoing activity that takes many forms; it ranges from informal discussions to more extensive support resulting from bilateral agreements. However, there is one formalized means of technology transfer that began in 1978, the International Training Course (ITC) on Physical Protection of Nuclear Facilities and Materials. This program was initiated to develop an awareness of the need for physical protection of nuclear facilities against the threats of radiological sabotage and theft of nuclear material, and to transfer current technology to International Atomic Energy Agency (IAEA) member states or countries that would aid in the design, implementation, and evaluation of these protection systems.

The ITC is sponsored by the Department of Energy (DOE), in consultation with the Nuclear Regulatory Commission, under the general auspices of the IAEA. This course is presented by Sandia National Laboratories, the lead DOE laboratory in physical security. U.S. leadership in this program is based on its commitment to the Nuclear Non-Proliferation Act of 1978.

There have been six courses presented since 1978, occurring approximately every 18 months, in Albuquerque, New Mexico. The duration of the course is approximately 3½ weeks. Participation in these courses is summarized in the following table.

Table I
Summary of Participation

Course	*Date*	*Students/ Countries*
1	Nov. 1978	24/21
2	Nov.-Dec. 1979	21/20
3	Jan.-Feb. 1981	26/18
4	May 1982	24/16
5	Sept. 1983	26/18
6	Oct.-Nov. 1985	25/17

A total of 146 participants representing 39 different countries have participated thus far.

Although the ITC is intended primarily for representatives of developing countries that have nuclear programs in operation or in an advanced stage of preparation, students from developed countries have attended. Table II summarizes the countries represented.

Table II
IAEA Member State Participation

Argentina	4	Italy	2
Australia	3	Japan	14
Bangladesh	3	Korea	5
Brazil	5	Malaysia	5
Bulgaria	1	Mexico	10
Canada	8	Netherlands	1
Chile	6	Pakistan	8
Czechoslovakia	5	Philippines	14
Denmark	1	Poland	3
Egypt	7	Portugal	1
Federal Republic of Germany	2	Romania	4
		South Africa	8
Finland	3	Spain	6
France	7	Sweden	1
Hungary	1	Thailand	3
India	7	Tunisia	1
Indonesia	4	Turkey	3
Iran	1	Venezuela	2
Iraq	6	Yugoslavia	2
Israel	3	Zaire	3

COURSE DESIGN

Sandia National Laboratories has performed many surveys and upgrades of nuclear facilities in the U.S. and abroad, and over the years, has developed a methodology for accomplishing these surveys and upgrades. It is that methodology, coupled with supporting physical protection technology, which is transferred to IAEA member states through the ITC. That methodology follows six basic chronological steps:

1. Characterize the facility, its operations, and conditions;
2. Identify the threats;
3. Identify the targets and associated consequences;
4. Identify the available physical protection technologies and systems;
5. Evaluate the physical protection system's performance; and
6. Upgrade the facility physical protection system and re-evaluate.

Not only does the ITC teach these steps as the process for upgrading the physical protection of nuclear facilities, but in order to reinforce the chronological and systematic nature of the process, the ITC is itself structured around these basic six steps, as can be seen in Table III. In addition to the six basic sections of the ITC, three other supporting sections are included. The Introduction informs the students of the process they will be learning and the Summary looks back at the process in review. Supporting information includes lectures in the general area of IAEA safeguards, NRC security requirements, and physical protection in other countries. In all, the course contains 32 lectures.

Table III
Basic Course Sections

	Topics	*Specific Lectures*
	Introduction	1. Introduction to ITC
		2. Physical Protection Design Processes
I.	Facility Operations and Conditions	3. Radiation Hazards
		4. Nuclear Fuel Cycle
		5. Fuel Cycle Safeguards Concerns
		6. Reactor Systems
		7. Reactor Safeguards Concerns
II.	Threats	8. Threat Analysis
III.	Targets	9. Target Identification
		10. Logic Diagrams
		11. Vital Area Identification
IV.	Physical Protection Technologies and Systems	12. Physical Protection Systems
		13. Exterior Intrusion Sensors
		14. Interior Intrusion Sensors
		15. Alarm Communication & Display
		16. Assessment
		17. Entry Control
		18. Delay
		19. Response
		20. Response Communication
		— (SNL Equipment Demonstration)
—	*Supporting Information*	21. Physical Protection/IAEA Safeguards
		22. State System of Physical Protection
		23. US Philosophy & Regulation of Physical Protection
		24. Physical Protection in Other Countries
		25. Role of Material Control & Accounting in Nuclear Safeguards
V.	Evaluation Techniques	26. Analysis/Evaluation Techniques
		27. Adversary Sequence Diagrams
		28. EASI Model
VI.	Application	29. Physical Protection Upgrade
		30. Hypothetical Facility
		— (Field Trip — Fuel Cycle/Reactor
		— (Field Trip Review)
		31. Physical Protection System Design Process Review
		— (Design/Upgrade Problem Presentation
—	*Course Summary*	32. ITC Course Summary

Good, solid educational theory was used throughout the design of the ITC. Established principles of teaching were incorporated in the design of the course, to ensure that the technology transfer would be a success. It was recognized that factual material which is only presented and not used, is not retained. It was also recognized that factual material provides background information essential to the derivation of concepts and that concepts are retained indefinitely and are learned by the students from experiences in a training setting. Therefore, the ITC was designed to present the facts and background which will lead to exercises and then to retention of concepts by the students.

There are six elements of this approach:

1. knowledge — recalling and memorizing facts providing background for further subject development;
2. comprehension — being able to use the facts or information;
3. application — drawing simple conclusions from the use of the material;
4. analysis — examining different applications and seeing new relationships;
5. synthesis — reassembling the process in new, creative, and individually appropriate ways; and finally
6. evaluation — internalizing and understanding the entire process to be able to evaluate it, make judgments, and accept the material as sound and useful.

The ITC is structured around the tasks addressed by these six elements, and thus each appropriate lecture is followed by a corresponding subgroup exercise session. Together, the lectures and subgroup sessions accomplish all six steps. The lectures are designed to accomplish steps 1 and 2 (gaining knowledge and comprehension), and the subsequent subgroup sessions are structured to accomplish the remaining four steps (application, analysis, synthesis, and evaluation). All students attend the lectures as one group; the subgroups consist of typically five students supervised by a qualified, especially trained subgroup instructor.

Course materials consists of both lecture material and subgroup material. The lecture material which was designed to be a text for the students was written by the technical experts at Sandia. The subgroup material consists of a review of the subject lecture material, structured exercises for solving problems, and questions for discussion. Both sets of material are carefully edited for ease of understanding by persons whose native language is not English.

The ITC subgroups are structured to ensure that all are balanced and that the participants will be able to work well together. Prior to arrival, the students are ranked by the course staff according to the following attributes:

1. language — understanding of English and common foreign language fluency;
2. education — level of education in technical or physical protection fields;

3. work assignment and current job and work history.

The subgroup sessions provide the students with the opportunity to ask questions in a smaller, less threatening environment. The students complete the exercises provided in the material, thus having the opportunity to use the lecture material to solve simple problems. Once the problems are completed, more subjective and creative discussions are initiated if time permits. This allows those subgroups that are moving more rapidly than others to accomplish the "analysis" step in the learning process. As the course progresses, subgroup problems build upon data and conclusions from earlier problems, to enable the process of "synthesis" to occur in the exercises. A consistent exercise (Protection of a Research Reactor) is used throughout the subgroup progression to reduce the amount of background facility data necessary and to present common and related elements from which synthesis is possible.

The final subgroup problem is a long (3-day) design/upgrade problem in which the subgroups apply the methodology to protection of other nuclear facilities. Facility options in this exercise include the following:

1. pressurized water reactor;
2. reprocessing plant (theft);
3. reprocessing plant (sabotage);
4. fuel fabrication facility; and
5. Away-From Reactor (AFR) fuel storage facility.

This exercise requires the use of all the material presented in the course and brings the students to the point of being able to understand and evaluate the entire process. A presentation of the solution to the entire class, coupled with a discussion of the value of the process, is the final subgroup objective. With the completion of this large design/upgrade problem, the students will have completed all six steps of the learning process, resulting in more effective retention of the course material.

A number of other considerations are important in the conduct of the International Training Course which makes the process of learning occur much more readily. Throughout the course, broadening experiences are provided which add variety and provide important data for the final design exercise. Lecturers from foreign countries are invited to present lectures on physical security in their countries. Each country approaches the problem of physical security slightly differently, and thus dimensions of culture and politics are introduced to the students. During the course the entire class visits a power reactor and a fuel fabrication facility, to see first-hand the physical protection problems encountered and the facility layout. Upon return from the field trip, the large design/upgrade exercise starts which gives those students, analyzing reactors or the bulk fuel handling facilities a new appreciation for physical protection considerations.

Upon completion of the course it is important to use an evaluation process that will produce data to allow the course to be improved before being conducted again. Traditionally, evaluation questionnaires are completed by the students, the course staff provides a review, and an evaluation report is produced. The seventh ITC will be significantly improved as a result of the series of evaluations conducted following previous courses.

SUMMARY

The International Training Course on Physical Protection of Nuclear Facilities and Materials, the purpose of which is the transfer of physical security technology to IAEA member states, has been discussed. The ITC is structured according to a proven approach for physical protection system design/upgrade. The course is based on established educational principles that ensure the course's effectiveness in teaching this approach. The course consists of lectures, subgroup practice exercise sessions, and a field trip. A brief discussion of each of these topics was provided. Since 1978, six courses have been presented by Sandia National Laboratories in Albuquerque, New Mexico. The seventh course is tentatively scheduled in April-May 1987.

*This work was supported by the U.S. Department of Energy under Contract DE-AC04-76DP00787.

Dennis L. Mangan joined Sandia National Laboratories in 1960. He is now supervisor of the International Safeguards Division. Prior to assuming this position in 1985, he was involved in physical security research and development at Sandia for nine years. In 1979 and 1980, he was a scientific advisor to the Department of Energy, Office of Safeguards and Security. He has been a subgroup instructor at the International Training Course described in the article, as well as a lecturer. For the past two courses he was course director. He has a Ph.D. in Nuclear Engineering, as well as an MSEE, from the University of New Mexico. His BSEE degree is from the University of Notre Dame.

M. Teresa Olascoaga joined the staff at Sandia National Laboratories in 1975. After her initial work on engineering energy projects, she began work on nuclear security projects in three application areas: NRC, military (including NATO) and DOE. She has also been a sub-group instructor, lecturer and coordinator for the Fifth and Sixth International Training Courses, and a technical consultant and lecturer for an inter-regional training course sponsored by the IAEA and the Spanish government.

Paul Ebel is a vice president and director of B E Inc., an engineering consulting firm in Barnwell, South Carolina. Prior to joining BEI, he was the director of safeguards at the Barnwell Nuclear Fuel Plant. He holds B.S. and B.A. degrees in mechanical engineering from Rice University and an MBA from Tulane University. Mr. Ebel has been associated with the International Training Course on Physical Protection by lecturing, preparing course material, and training lecturers since 1977. In addition, he has served as a cost-free expert on training to the IAEA and as an IAEA inspector training lecturer on reprocessing plant safeguards.

Perception of Effectiveness of International Safeguards

■

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■

The effectiveness of any activity is judged in terms of perceived performance relative to what is considered to be adequate accomplishment of the purposes of the activity. Performance must be evaluated over some period of time — a stated interval, the recent past, or since the beginning. Since no diversions have been detected, and so far as is known none has been attempted, performance of international safeguards is itself intangible and subjective. Who can say what diversions have been deterred, or what value is to be placed on the international cooperation and understanding that has allowed world nuclear commerce to develop?

If performance is subjective, the other factors are no less so. There is agreement on the general purposes of safeguards by the safeguards community, foreign ministries, political leaders, and the general public. However, beyond some vague and general common understanding, there is no consensus on purposes that are specific enough to provide a standard of performance. Without such a consensus, performance, however defined, cannot measure effectiveness in a way that will satisfy all the important clients.

Perceptions are themselves a problem. They are inherently subjective, by definition. They are colored by preconceptions, biased views, deliberate attempts to distort, and lack of knowledge. To the extent that factual information must be judged for significance, judgments are inevitably colored by perceptions. That is particularly true with international safeguards where much factual information is confidential. The perceptions of those outside must be based largely on other perceptions reported to them by those who operate the system, supported by only such factual information as may be aggregated and generalized to protect confidential information that is more directly relevant.

Finally, what is to be accepted as adequate is a subjective value judgment. Those who have been active in safeguards issues — critics, supporters, observers, and decisionmakers — range from the idealistic to the pragmatic, from the naive to the sophisticated, from the neophyte to the experienced. Some maintain that anything short of near-absolute performance is useless or even counterproductive. Others note that progress in international arrangements is always slow and uncertain, and that even very modest results are worthwhile. They point out that politics are nothing more than the art of the possible, and in international affairs even less is possible.

DEVELOPMENT OF IAEA SAFEGUARDS

The problem of perceived effectiveness has dogged the IAEA for a very long time, almost from the beginning. The "IAEA Safeguards System" was defined in INFCIRC/66, with later additions.[1] The stated purpose was to establish a system of controls pursuant to Article III.A.5 of the IAEA Statute.[2] The document was intended to inform member states of how the Agency expected to administer safeguards, and to provide a basis for individual arrangements. INFCIRC/66 outlined circumstances under which safeguards were to be applied, called for accounting and operations reports, and set limits on the numbers of inspections. It provided for further investigation of any unusual incidents or apparent shortages of material. It did not specify what the product of routine safeguards inspections was to be, except by inference and in non-quantitative terms. Differing perceptions of effectiveness, arising from differing judgments over what safeguards measures were appropriate, generated increasing interest in a more objective and quantitative approach.

From the outset, material measurement and accounting has been the central safeguards activity. The implementation of the INFCIRC/66 system involved technical problems of measurement, sampling, and statistical analysis, and the development of safeguards centered on those techniques, which generate quantified information on material unaccounted for. System concepts increasingly focused on quantifiable information, with corresponding efforts to reduce dependence on subjective judgments in analyzing results.

When the NPT became effective in 1970, Agency safeguards responsibilities were greatly extended.[3] The special nature of the NPT required a new safeguards system, differing from the one defined in INFCIRC/66. At the same time, experience with the existing system generated interest in further improvements, including more explicit limitations on inspection activity and definition of the product. Safeguards development was predominantly the province of technical specialists, and the techniques of systems and statistical analysis were employed in the effort to eliminate subjective judgments in analyzing inspection results.

The IAEA convened a panel of specialists from some 50 countries soon after the NPT went into force, to advise the Board on the content of the safeguards agreements that were to be required in connection with the Treaty. The resulting document, INFCIRC/153, is responsive to the Treaty provisions[4] It also incorporates several other features that evolved from experience with the INFCIRC/66 system: tighter limits on routine inspection effort, explicit provision for containment and surveillance, and more explicit statements of purposes, objectives, and product.

Paragraphs 1 and 2 of INFCIRC/153 state that safeguards are for the exclusive purpose of verifying that nuclear materials are not diverted to nuclear weapons or other explosive devices. Par. 28 further qualifies diversion to include "for purposes unknown" as well as weapons and explosives; the actual disposition of diverted material is therefore outside the scope of safeguards. Par. 30 follows directly from that: the technical conclusion is to be statements of material unaccounted for; that is, material that can no longer be accounted for in peaceful use, whatever its disposition. Material unaccounted for is to be calculated from inventories and transfers in and out of specified "material balance areas," as the definition implies.

The above provisions suggest a system of information and accounting. Soon after INFCIRC/153 was completed, the IAEA Deputy Director General for Safeguards described safeguards as an information system[5] He defined the technical objective as "the detection of amounts of nuclear material that might be missing from peaceful uses, defined by the precise notion 'materials unaccounted for'." "Material unaccounted for" cannot be assumed to be diverted; there are other, more common causes such as poor control practices. MUF is also a measure of the quality of material control and accounting, which can be reported and analyzed continually, thereby providing a basis for confidence in periodic findings from safeguards operations.

If safeguards were perceived in those terms — a system that provides verified accounting — perceptions of performance would have a tangible, quantitative basis, not dependent on widely-differing, speculative scenarios of hypothetical diversions. Performance would be referenced directly to feasible, if limited, goals that themselves relate directly to the stated purpose of safeguards.

While that concept of safeguards was being developed, a quite different concept had re-emerged concurrently in the Safeguards Committee. (It had been proposed as early as 1959 by an advisory group in recommendations for the earliest IAEA system.) That concept is embodied in par. 28 of INFCIRC/153, in the familiar statement that "... the objective of safeguards is the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities ...." Under that concept, "timely detection," "significant quantity" and probability of detection were to be assigned quantitative values.

Ryukishi Imai, a Japanese representative on the Safeguards Committee who played a major part in its work, described the concept in the following way:

"its basic logic may be described as follows:

a. it provides for *timely detection* capabilities
b. of *diversion* from *peaceful nuclear fuel cycles*
c. of *significant quantities* of *nuclear material*
d. so that such capabilities will serve as a *deterrent* against
e. nuclear *proliferation*, because either
f. detection leads to international *sanction* or
g. lack of detection means *verification* of no diversion.

"... the logical chain from (a) to (g) is a shorthand description of the new system, which is much more satisfying (than INFCIRC/66 Rev. 2) as an objective technical system. *As long as the words in italics can be clearly defined, the system does not require any more subjective judgment.*"[6] (Emphasis added in the last sentence).

Imai did not advocate that the values assigned to the terms be universal and absolute quantities; in fact, earlier he had pointed out the necessity for relative and not absolute limits on acceptable MUF[7]

Imai's belief that subjective judgment could be avoided was combined with others' insistence on absolute limits based on one-bomb quantities. Technical working groups, convened by the IAEA in connection with the 1970 Safeguards Committee, had recommended threshold-quantity ranges from one kilogram to an upper limit approximating one critical mass as the basis for evaluating the Agency's verification activities[8] "Timely detection" as mentioned in INFCIRC/153 had been originally based on the concept of "critical time," the time from diversion to completion of weapon fabrication[9] Underlying the different opinions on the various concepts for implementing NPT safeguards was a value judgment: should it be limited to what was feasible, or should it aim higher, as a stimulus for future improvement? Beyond that was the even more fundamental value judgment: should quantities be based on external criteria, in particular one-bomb quantities, or some percent of the quantity under safeguards?

By 1975 there had been a very significant shift in the Agency's position. The difference between Rometsch's descriptions of NPT safeguards in 1971 and 1975 is striking[5, 9] The 1971 paper describes an information system; detection of diversion is not mentioned; and the concept is built around par. 30, the technical conclusion in the form of periodic determination of verified MUF[10] By 1975, the focus had shifted to par. 28 and the detection of diversion. However, in 1975 the Agency still agreed with Imai that quantification must be in relative rather than absolute terms, because of feasibility constraints.

"Timeliness" was to be based on practical intervals for inventory verification, which only indirectly reflects conversion times.

Meanwhile the position that quantification should be in absolute terms, based on rapid fabrication of a first bomb, was gaining strength. That position was most prevalent in the nuclear-weapon states, especially the U.S. Victor Gilinsky, later NRC Commissioner, has had a strong influence on U.S. policies involving safeguards. In 1970, before the Safeguards Committee had defined the NPT safeguards system, he took a firm position on "timely warning," saying that if safeguards are to make any sense, there must be "definite evidence of an actual or imminent diversion *in time to permit some preventive action to be taken*" (italics by Gilinsky).[11] At the same time, he took a more moderate position on significant quantity, saying that

> "The suggestion that a clandestine approach to a nuclear weapons capability represents a danger in a major industrialized nation . . . borders on the ridiculous . . . A weapons acquisition plan based initially on the diversion of a few kilograms of nuclear material at a time seems absurd.[11]"

In the U.S. there seems to have been little consideration of relative rather than absolute goal quantities. Except for Gilinsky's reservations in applying them to large states, the absolute values were taken to be a self-evident requirement. After 1975 that view prevailed at the Agency. In 1978 it accepted an advisory-group recommendation on absolute goal quantities which the U.S. had advocated. It stopped short the timeliness criterion that Gilinsky had advocated earlier, while rationalizing a higher limit on a similar basis.

Nevertheless, the feasibility constraints are real, as Imai and others have pointed out. The Agency's solution is to have two criteria: the "significant" (one-bomb) quantity or the feasibility limit, whichever is greater. The contradiction between professed goals and actual criteria is masked by a complicated set of terms and definitions.

U.S. PERCEPTIONS OF INTERNATIONAL SAFEGUARDS

Awareness of safeguards by the U.S. public and government authorities has been conditioned by international developments. The term became associated with nuclear weapons from the beginning, with the 1946 Baruch Plan.[12] From then until the 1970's safeguards with respect to peaceful uses of nuclear energy receded from view. With the term applied to various other things such as reactor safety, nuclear-test readiness, a ballistic-missile defense system, and arms-control verification, that is not surprising. Although people have since associated the 1953 Atoms for Peace proposal with the revival of international safeguards, the connection between Eisenhower's proposal and today's IAEA safeguards is quite indirect.[13]

The negotiation of the NPT in the late 1960's again brought safeguards to the attention of the foreign-affairs community, and the Indian explosion opened a wide debate that included many who had previously given little attention to safeguards. By that time IAEA safeguards had become firmly established in their present form. The only precedent that provided a standard for comparison was the Acheson-Lilienthal report of 1946, the basis for the Baruch Plan.[12] The report described safeguards and inspections that were to be very comprehensive and stringent. Many have since perceived safeguards in absolute terms as a means of preventing the spread of nuclear weapons, and not as a means of verifying whatever detailed information might be specified under a treaty obligation. Thus, safeguards were safeguards, and the standard for inspections had been defined in 1946:

> "Inspection means close and careful independent scrutiny of operations to detect possible evasions or violations of prescribed methods of operation. In addition to direct auditing measures as described above, inspection may include observation of points of ingress to and egress from an establishment or installation to ensure that materials and supplies are flowing in the prescribed manner, observation of the activities within the establishment or installation and measures in the form of aerial or ground survey and otherwise to guard against clandestine activities. To be fully effective, the power of inspection may require that the operations be carried on in a specified manner in order to facilitate the inspection. In this event, inspection verges on supervision . . . The treaty or convention establishing the international Authority should contain provisions . . . affording the duly accredited representative of the international control agency unimpeded rights of ingress, egress, and access for the performance of their inspections and other duties into, from, and within the territory of every participating nation, unhindered by national or local authorities."[14]

Since the purpose of both the 1946 plan and IAEA safeguards was perceived to be to prevent the spread of nuclear weapons, IAEA safeguards were judged by many to be only a poor and ineffective compromise of what had been considered necessary. They have been judged by many, not in terms of the purposes and constraints of the NPT, but rather the Utopian objectives of the Baruch Plan.

"Timely warning," as defined by Gilinsky,[11] is a predominantly-American concept. It was strongly advocated during the debate on the Nuclear Non-Proliferation Act of 1978, supported by testimony by Gilinsky and others.[15] They indicated that for safeguards to be effective, it must detect a diversion and preventive action must be taken before fabrication of the first weapon could be completed, a time stated to be only a few days or even hours. As passed, the Act requires that "timely warning" thus defined is to be given strong consideration in any determination of safeguards adequacy in connection with nuclear exports.

That perception of safeguards adequacy, needless to say, is not shared by the IAEA, nor by most outside the U.S. In effect, the timeliness of IAEA safeguards is geared to the limits of feasible inventory-taking, plus time for analyzing the results, the necessity for which had been indicated by Rometsch in 1975.[9] The difference between U.S. views and the practical constraints faced by the Agency continues to contribute to strong differences in perceptions of effectiveness.

IAEA REACTIONS

The allegations of IAEA safeguards deficiencies from U.S. critics since 1974 have led the Agency to intensify efforts to rationalize its verification criteria. However, it is caught in the dilemma of accommodating the strong U.S. influence and the practical operational limitations. Since 1980 the IAEA has greatly increased the flow of public-information material rationalizing its safeguards concepts. The results have not been entirely satisfactory, which might be expected considering the irreconcilable differences. However, some of the problems could be avoided. The Agency continues to accept the principle of "timely" detection (related to time to convert to bomb-material forms) and one-bomb quantities. Hidden in the elaborate structure of criteria and definitions, however, is the essential point that safeguards only verify periodically that materials are accounted for to the limit of measurement feasibility or one-bomb quantities, whichever is larger. That is presented in terms of "timely" detection of one-bomb quantity diversion. It has the effect of confirming the objective insisted upon by U.S. critics, while acknowledging that it is infeasible for the materials of greatest concern. If the Agency would present it in positive terms — verification of peaceful use to the practical limits of measurement and reinspection interval — they would no longer be on the defensive. The value of safeguards should not be dependent upon convincing critics that goals that are manifestly impossible to attain are somehow to be met. Above all, perceptions must reflect realities before proper judgments can be made.

Confidence in safeguards depends on perceptions of performance that are directly related to agreed purposes. Criteria for adequate performance must also reflect what is feasible, and therefore routinely attained. Somehow all of these factors must be brought into closer harmony, if the undeniable value of international safeguards is to be universally recognized.

NOTES

1. IAEA, The Agency's Safeguards System (1965, as Provisionally Extended in 1966 and 1968), INFCIRC/66/Rev. 2, 16 Sept. 1968. An earlier document, INFCIRC/26, 1961 and Add. 1, 1964, covered only certain types of facilities.
2. Statute of the International Atomic Energy Agency, 1956.
3. Treaty on the Non-Proliferation of Nuclear Weapons, July 1, 1968.
4. IAEA, The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, INFCIRC/153 (corrected), June 1972.
5. R. Rometsch, Development of the IAEA Safeguards System for NPT, *Proceedings of the Fourth General Conference on Peaceful Uses of Atomic Energy*, IAEA, 6-16 September 1971, V. 9, p. 385.
6. R. Imai, Safeguards Against Diversion of Nuclear Material: An Overview, *Annals of the American Academy of Political and Social Science*, V. 430, p. 60, Mar. 1977.
7. R. Imai, Nuclear Safeguards, *Adelphi Papers Number Eighty-Six*, International Institute for Strategic Studies, Mar. 1972, p. 34. In view of the present criteria based on absolute quantities, Imai's position is worth recalling:

   "One has to determine, then, the acceptable limits of MUF in each individual case: that is, the limits within which the unaccountable loss of nuclear material may be accepted as part of normal plant operation, as well as the level of confidence (probability) which can be attached to the determination of those limits . . . Much as it might be desirable to define MUF limits in terms of absolute amounts, because bombs are made from absolute kilograms of fissionable material rather than a percentage of something, it does not seem possible to calculate them in that form. There is a gap between what is desirable and what is possible, and this gap cannot be bridged by technical means."
8. The meaning of "threshold amount" has differed over time. Sometimes it has meant the minimum quantity of safeguards concern, with regard to some bounds such as an MBA. That is apparently the meaning given by Rometsch[9] as distinct from significant quantity. The Safeguards Glossary (IAEA/SG/INF/1, 1980) definitions of the two are indistinguishable.
9. R. Rometsch, et. al., Safeguards — 1975-1995, *Safeguarding Nuclear Materials*, IAEA, 20-24 Oct. 1975, V. 1 p. 3.
10. Nor is diversion defined or even mentioned in INFCIRC/153, except in par. 28.
11. V. Gilinsky and W. Hoehn, Non-Proliferation Treaty Safeguards and the Spread of Nuclear Weapons, R-501, Rand Corporation, May 1970.
12. The Baruch Plan: Statement by the United States Representative (Baruch) to the United National Atomic Energy Commission, June 14, 1946, USACDA 1945-1956, p. 13.
13. In his UN address, Eisenhower did not mention safeguards, and the central feature of his proposal was the withdrawal of fissile materials from U.S. and USSR weapon stockpiles. It was believed that the limited world supply of fissile material would curb the arms race, if some could be diverted from weapons to peaceful uses. He proposed an International Atomic Energy Agency that would receive the materials and allocate them to non-weapon states for peaceful uses, verified by the Agency.

    United States Atoms for Peace Proposal: Address by President Eisenhower to the General Assembly, Dec. 8, 1953, *Documents on Disarmament*, USACDA 1945-1956, p. 393.

    A related but separate development was the direct supply of materials and technical assistance by the U.S. under the new Atomic Energy Act of 1954, with the USAEC directly verifying peaceful use.
14. UNAEC Official Records, cited in *The Baruch Plan: U.S. Diplomacy Enters the Nuclear Age*, a report for the House Committee on Foreign Affairs prepared by the Congressional Research Service, Library of Congress, Aug. 1972.
15. Congressional Record, Feb. 2, 1978, p. 51055-51102; Feb. 7, 1978, p. 51310-51341.

The opinions expressed in this article are those of the author and do not necessarily reflect those of Sandia National Laboratories or the Department of Energy.

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Equations for Plutonium and Americium-241 Decay Corrections

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ABSTRACT

We present equations needed in various plutonium accountability measurements to correct for plutonium decay and ^{241}Am in-growth and decay. The equations are formulated in terms of the most widely available variables and are derived without approximation.

INTRODUCTION

In accounting for plutonium one often must correct for the decay of the plutonium isotopes and the in-growth and decay of the ^{241}Am found in most plutonium. These corrections involve the solution of a rather simple differential equation, a process taught in all elementary courses on differential equations. The solution to this equation also is found in many textbooks describing radioactive decay.[1] However, in many cases the solutions found in the literature are not in the best form for use in plutonium accountability problems. For example, the equations often are given in terms of the number of atoms, whereas plutonium accounting is done on a mass basis. They also often are expressed in terms of absolute mass, whereas ^{241}Am is measured relative to plutonium. In addition, the textbook solutions usually simplify the initial conditions so that the initial ^{241}Am content and the initial isotopic composition of the plutonium are given on the same day, which is seldom true in practice. Finally, the textbook solutions seldom show how the total plutonium mass varies with time.

It is true that the approximations made to obtain these solutions can be adequate for many applications. However, with the widespread availability of computers there should be no reason for not solving the problem exactly and expressing the solution in terms of useful, observable variables.

In this report we present solutions for the variation of the plutonium isotopic fractions as a function of time, the ratio of ^{241}Am to plutonium as a function of time, and the variation of the total plutonium mass as a function of time. The solutions are presented in terms of mass and mass fractions.

It is assumed that three measurements characterize the plutonium sample: 1) its isotopic composition, 2) its americium content, and 3) its plutonium mass. All three measurements are assumed to occur at arbitrary and different times. Using these three initial measurements, the three parameters can then be calculated at any arbitrary time, past, present, or future. All time differences are expressed explicity in terms of the measurement time or date of the three initial measurements.

To apply these solutions, the following points should be noted. First, "americium," in the context of these derivations, refers only to ^{241}Am. Some plutonium samples, notably those of higher burnup may contain ^{243}Am. It will depend upon the specific analytical technique used as to whether "americium" content refers to total elemental americium or just to ^{241}Am. Also, in the equations ^{241}Am is expressed as a ratio to total plutonium. Analytical results for ^{241}Am are often expressed as ppm or a fraction of the *sample* mass rather than the *plutonium* mass. Finally, all plutonium isotopic measurements are expressed here in terms of mass fractions rather than atom fractions.

The user must be sure that the initial analytical results are properly interpreted before using them in the equations.

STATEMENT OF THE PROBLEM

Given the value of the mass ratio ^{241}Am/Pu at a known time and values of the plutonium isotopic mass fractions at a known (and generally different) time, compute the ^{241}Am/Pu mass ratio at an arbitrary time t.

NOTATION

Subscripts refer to isotopes

- i =plutonium isotopes, generally i=^{238}Pu, ..., ^{242}Pu,
- 1 =^{241}Pu, and
- A =^{241}Am.

Superscripts refer to times (absolute) or dates.

- I =values at time of plutonium *isotopic* determination.
- a =values at time of ^{241}Am/Pu ratio determination.

m = values at time of plutonium *mass* determination.

t^I = time of plutonium isotopic determination.

t^a = time of $^{241}Am/Pu$ mass ratio determination.

t^m = time of plutonium mass determination.

t = arbitrary time at which new values are to be calculated.

m = total plutonium mass in sample.

m_i = mass of i^{th} plutonium isotope in sample.

R_i = m_i/m, mass fraction of the i^{th} plutonium isotope relative to total plutonium.

T_i = half-life of the i^{th} isotope,

λ_i = $\ln 2/T_i$, decay constant of the i^{th} isotope.

N_i = number of atoms of isotope i, and

A_i = atomic mass of isotope i.

DERIVATION OF EQUATIONS

Details of the derivation of the decay equations necessary for plutonium accountability are given in Ref. 2. The derivations are outlined and summarized here.

Decay of Plutonium Mass Fractions

The differential equation for radioactive decay usually is given in terms of the number of atoms. However, the mass decays just like the number of atoms. Thus,

$$\frac{dm_i}{dt} = -\lambda_i m_i$$

which has a solution

$$m_i(t) = m_i^I \exp[-\lambda_i(t-t^I)]$$

if there are m_i^I grams of plutonium isotope i present at $t=t^I$. By dividing both sides of this equation by the total plutonium mass, equating the total plutonium mass to the sum of the isotopic masses, and expressing the result in terms of mass fractions, we obtain

$$R_i(t) = \frac{R_i^I \exp[-\lambda_i(t-t^I)]}{F(t)} \quad i = \text{all plutonium isotopes,}$$

where $F(t) \equiv \sum_i R_i^I \exp[-\lambda_i(t-t^I)]$

Equation (1)

This equation shows how the plutonium mass fractions change with time. The denominator is a normalization factor accounting for the condition that the mass fractions must sum to unity.

Americium-241/Plutonium Ratio

The amount of ^{241}Am in a plutonium sample arises from its formation in the decay of ^{241}Pu and its destruction from its own decay. The differential equation governing the number of atoms of ^{241}Am in a sample is

$$\frac{dN_A}{dt} = K_1\lambda_1 N_1 - \lambda_A N_A \quad ,$$

where $K_1 = 0.9999754$ is the fraction of decays that lead to ^{241}Am (2.46×10^{-3}% decay to ^{237}U).

Solving this equation and recalling that

$$N = \frac{m\,N_0}{A} \quad ,$$

where N_0 is Avogadro's number (6.022×10^{23} atoms/mole), we obtain for the mass of ^{241}Am:

$$m_A(t) = m_A^a \exp[-\lambda_A(t-t^a)] + K_1K_2\left(\frac{\lambda_1}{\lambda_1-\lambda_A}\right) m_1^a \{\exp[-\lambda_A(t-t^a)] - \exp[-\lambda_1(t-t^a)]\} \quad .$$

where $K_2 \equiv A_A/A_1 = 0.999999905$ and $K_1K_2 = 0.9999753$.

This equation is not very useful. It is expressed in terms of mass, not mass ratios, and we also cannot assume that m_1^a, the ^{241}Pu mass on the date of the americium determination, is known.

With considerable manipulation and using Eq. (1) to obtain R_i^a in terms of R_i^I, we can express this equation in terms of mass fractions.

$$R_A(t) = \frac{F(a)}{F(t)} R_A^a \exp[-\lambda_A(t-t^a)] + \frac{K_1K_2}{F(t)}\left(\frac{\lambda_1}{\lambda_1-\lambda_A}\right) R_1^I \exp[-\lambda_1(t^a-t^I)] \times\{\exp[-\lambda_A(t-t^a)] - \exp[-\lambda_1(t-t^a)]\} \quad .$$

where

$$F(a) \equiv \sum_i R_i^I \exp[-\lambda_i(t^a-t^I)] \quad .$$

Equation (2)

In this equation all variables are observables.

Decay of Plutonium Mass

Finally, if the mass of plutonium is known at time t^m, we desire an expression for the mass at arbitrary time t, where we assume that we know the isotopic composition at time t^I. This expression can be obtained from the earlier equations for the decay of the plutonium mass fractions and the isotopic masses.

$$m(t) = \frac{m^m \sum_i R_i^I \exp[-\lambda_i(t-t^I)]}{F(m)} \quad ,$$

where

$$F(m) = \sum_i R_i^I \exp[-\lambda_i(t^m-t^I)] \quad .$$

Equation (3)

SUMMARY

We have presented expressions for three time-dependent quantities used in plutonium accountability calculations.

1. The change in the isotopic composition as a function of time.
2. The ^{241}Am/Pu ratio as a function of time.
3. The plutonium mass as a function of time.

All three parameters are expressed in terms of the variables that are most commonly available to the user: the time of an initial plutonium isotopic composition measurement, the time of an ^{241}Am/Pu ratio measurement, and the time of a sample plutonium mass measurement. All of these times may be different. Because mass is used in accountability calculations, all ratios are expressed on a mass (not atom) basis.

It is important that the user assure that the inputs to these equations are in the proper units.

The results are summarized below.

Plutonium mass fractions at time t in terms of those measured at time t^I, Eq (1).

$$R_i(t) = \frac{R_i^I \exp[-\lambda_i(t-t^I)]}{F(t)}$$

The ^{241}Am mass fraction relative to plutonium, at time t from Eq. (2)

$$R_A(t) = \frac{F(a)}{F(t)} \quad R_A^a \exp[-\lambda_A(t-t^a)] + \frac{K_1K_2}{F(t)}\left(\frac{\lambda_1}{\lambda_1-\lambda_A}\right) R_1^I \exp[-\lambda_1(t^a-t^I)] \times\{\exp[-\lambda_A(t-t^a)] - \exp[-\lambda_1(t-t^a)]\}$$

The sample plutonium mass at time t in terms of its known value at time t^m, Eq. (3).

$$m(t) = \frac{m^m \sum_i R_i^I \exp[-\lambda_i(t-t^I)]}{F(m)}$$

Also summarizing the notation

- t =arbitrary time or date at which new values are to be calculated.
- t^I =time or date of initial plutonium isotopic composition determination,
- t^a =time or date of initial ^{241}Am/Pu mass ratio determination,
- t^m =time or date of initial plutonium sample mass determination,
- m =plutonium mass in sample,
- m_i =mass of i^{th} isotope in sample.
- R_i $=m_i/m$=mass fraction of i^{th} isotope relative to plutonium,
- R_i^I =mass fraction of plutonium isotope i at time t^I,
- R_A=mass fraction of ^{241}Am relative to plutonium,
- R_A^a=mass fraction of ^{241}Am relative to plutonium at time t^a,
- T_i =half-life of i^{th} isotope,
- λ_i $=\ln 2/T_i$=decay constant of i^{th} isotope,
- λ_A =decay constant of ^{241}Am,
- λ_1 =decay constant of ^{241}Pu,
- K_1 =0.9999754, ^{241}Pu branching ratio to ^{241}Am,
- K_2 =0.999999905, atomic mass ratio, ^{241}Am/^{241}Pu,

$$\left.\begin{aligned} F(t) &= \sum_i R_i^I \exp[-\lambda_i(t-t^I)] \ , \\ F(a) &= \sum_i R_i^I \exp[-\lambda_i(t^a-t^I)] \ , \\ F(m) &= \sum_i R_i^I \exp[-\lambda_i(t^m-t^I)] \ . \end{aligned}\right\} \quad i = \text{all plutonium isotopes}$$

ACKNOWLEDGMENT

We wish to thank Darryl Smith, Los Alamos National Laboratory, for his suggestions on the form of this paper.

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Safeguards Technology Applied to Arms Control and Verification

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ABSTRACT

Recent years have seen considerable technical progress in the safeguards community. Of particular note is the development of reliable nondestructive assay (NDA) and containment/surveillance (C/S) instrumentation, the integration of these instruments into materials control and accountability systems, and increased support to the International Atomic Energy Agency that has resulted in a considerable body of experience with the verification of safeguards systems in the international arena. It is appropriate to point out that this body of information, properly developed, constitutes a foundation for on-site verification of potential arms control agreements.

INTRODUCTION

The present goal of safeguards systems is to deter the unauthorized use of special nuclear material. Bluntly, this means to discourage or prevent nuclear proliferation, the development of nuclear explosives by countries not yet nuclear weapons powers, and to prevent the acquisition of nuclear material by subnational or terrorist organizations. On the other hand, nuclear warheads not only exist but are in fact deployed by the recognized nuclear weapons powers.

Both superpowers have proclaimed a willingness to pursue meaningful arms reduction agreements. The Soviet Union has indicated a desire to remove and destroy all existing nuclear warheads by the year 2000. The United States has invited Soviet on-site monitoring of nuclear tests for the purpose of verification. The Soviets also have espoused new willingness to consider on-site monitoring for the purpose of verification of selected potential arms control agreements.

At the present time the U.S. and the U.S.S.R. are considering a wide range of arms control concepts that involve nearly all aspects of nuclear weapons technology, and that includes possible monitoring by both national technical means (NTM) and cooperative verification technique. National technical means include remote surveillance (overhead photography) and collection (electronic, radar, and seismic monitors) techniques.[1] Cooperative verification is defined as voluntary or negotiated measures that enhance the verifiability of an arms control agreement. During the 1979 summit meeting, Presidents Carter and Brezhnev endorsed the use of cooperative measures in the verification of future strategic arms agreements.[2] The cooperative verification of any agreement may include on-site inspection, in-country monitoring, and international verification organizations. In evaluating proposed arms control approaches, the U.S. and the U.S.S.R. must determine what remote and/or on-site monitoring technologies are available for the verification process, because only arms control proposals based on well-understood monitoring technologies can achieve the level of credibility and consensus required for the negotiation of an effective arms control agreement. There are two factors that must be considered in evaluating the effectiveness of the monitoring technologies: 1) they must be able to identify a significant violation in a timely manner, and 2) they should be perceived as being effective to deter a covert violation.

In the field of nuclear material safeguards, the U.S. and other countries have developed a wide variety of nondestructive assay (NDA) and containment/surveillance (C/S) instruments and procedures that can be applied directly to various arms control approaches. These instruments and procedures already have established the required credibility in both the U.S. and U.S.S.R. technical communities, as well as in the international technical communities, (IAEA, EURATOM). We discuss here several arms control approaches that have been proposed by both the U.S. and the U.S.S.R., identify some of the verification problems associated with each approach, and show how the presently available instrumentation and procedures may be applied to a credible verification process.

ARMS CONTROL APPROACHES

Since the first bilateral arms control agreement (SALT-I), there has been an evolution of the basic underlying principles of arms control from focussing on delivery systems to limiting and reducing the total destructive power. In SALT-I the focus was on missile launchers and other delivery systems, as opposed to warheads and nuclear material. In part this reflected a perception that missile launchers were much easier to verify than warheads and nuclear material. Therefore, the Interim Agreement featured a freeze on the number of Intercontinental Ballistic Missiles (ICBMs) and a limit on Sea-launched Ballistic Missiles (SLBMs.)

The SALT-II process continued the emphasis on weapon delivery systems rather than on individual weapons. Aggregate limits were placed upon strategic nuclear delivery systems — ICBMs, SLBMs, and heavy bombers — with sublimits placed upon Multiple Independently Targeted Reentry Vehicle (MIRV) launchers. Additional limits were placed on the number of heavy missiles as well as restricting the throw weight and launch weight of "light" ICBMs. The development of new heavy missiles and mobile missiles was also restricted.

During the present negotiations the "SALT approach" of establishing equal aggregate levels of delivery systems has been rejected in favor of a call for significant reductions in the level of destructive power. For the first time the reduction and limitation of warheads is the focus of the arms control negotiations.

On-site monitoring, properly defined and executed, can contribute to world stability. Each country would enhance its effectiveness of agreement verification. This improved reliability would not jeopardize the retaliatory nuclear capability of either party but would provide increased assurance against first-strike capability. On-site monitoring agreements may not have received wide consideration in the past because no adequate technology appeared to exist to provide the basis for evaluation of effectiveness and acceptability.

The arms control proposals to limit nuclear weapons presently under consideration can be divided generally into five categories: 1) limiting the production of nuclear materials, 2) restricting the numbers and types of warheads and delivery systems, 3) establishing nuclear weapon free zones (buffer zones), 4) reducing the number of warheads, and 5) limiting the development of new or improved weapon and delivery systems. Each of the first four categories require the application of NDA and C/S technologies that have been developed within the nuclear industry. The last category traditionally has been verified using national technical means (NTM); however, on-site monitoring can enhance effectiveness.

1. Limiting Production of Nuclear Materials

Intuitively, the easiest way to limit the growth of nuclear weapons is to restrict the production of the nuclear materials used in their fabrication. These nuclear materials are highly-enriched uranium (HEU), plutonium, and tritium. HEU can be produced using a variety of enrichment techniques, including gaseous diffusion, centrifuge, laser, and other advanced isotopic separation technologies. In theory, uranium containing less than 20% U-235 can be used for weapons; however, uranium must be enriched to at least 20% U-235 for a practical weapon.[3] HEU is required not only for the weapons program but also is required for nuclear propulsion systems, research reactors, and plutonium/tritium production reactors.

Weapon-grade plutonium, containing less than 7% Pu-240, can be obtained from plutonium production reactors, research reactors, low-burnup power reactors, hybrid fission-fusion rectors, and civilian power reactors by employing advanced isotope separation methods. Both the U.S. and the U.S.S.R. are planning reprocessing and enrichment facilities capable of recovering weapon-grade plutonium from high-burnup reactor fuels.

In nuclear weapons, tritium provides a source of neutrons to increase the efficiency of the fission reactions. Tritium decays with a 12.33-year half-life and must, therefore, be replaced periodically to ensure a sufficient quantity will be available. Tritium can be produced in all types of nuclear reactors.

To verify a production freeze on weapons materials, the methodology for monitoring HEU, plutonium, and tritium must be applied not only to the acknowledged weapon production facilities, but also to civilian facilities. The potential interrelationship between the entire nuclear fuel cycle is shown in Fig. 1, as are possible sources for nuclear materials. If an arms control agreement were based on the monitoring of the production of nuclear material, each of these six fuel-cycle components must be considered. The primary source of HEU comes directly from the uranium enrichment plants; however, there are two other possible sources: research reactors and naval propulsion systems. Incompletely burned HEU from these two sources could be used to supplement weapons production. Since 1964, the U.S. has not added any HEU to its nuclear weapons stockpile. All the HEU used in new weapons has come from the stockpile produced prior to 1964 or from retired weapons.[4]

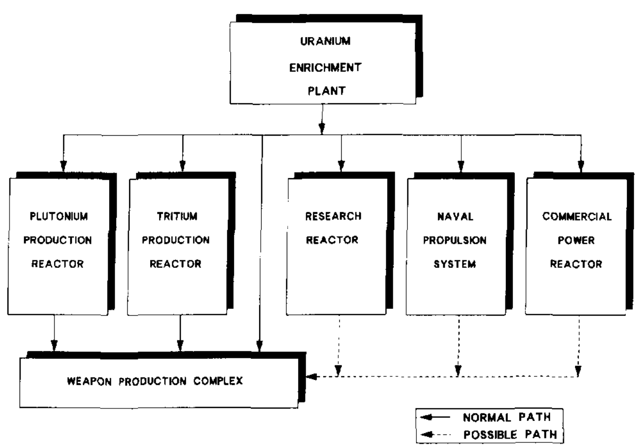

Fig. 1. Fuel cycles that must be considered in any arms control agreement that limits the production of nuclear materials used in weapons.

Plutonium and tritium can be produced either in specially designed reactors (as in the U.S.) or in civilian and research reactors. The U.S. has maintained a separation between the production of nuclear material for the weapons program and the civilian fuel cycle[5] The connection between the civilian and the military fuel cycles, up to the present time, has been hypothetical. None of the five weapon states has relied on the civilian fuel cycle to produce nuclear materials for the military[6] In reality, the connection between the civilian and the military fuel cycles can be as close or as remote as the national government wants it to be. With the development of isotope separation technology, the civilian fuel cycle may provide the most economical source of plutonium for the nuclear weapons[5]

The U.S.S.R. has developed large (1000 MW_e) channel type light-water-cooled, graphite-moderated reactors that can be refueled on-line to ensure flexibility and to increase the plant availability[7] More than 10 of these units have been constructed within the Soviet Union. (The Chernobyl reactors are this type of reactor). On-line refueling power reactors would be particularly difficult to monitor under any agreement limiting the production of nuclear material.

2. Restricting the Numbers and Types of Warheads and Delivery Systems

Another approach to arms control is to restrict the number and types of warheads and delivery systems, because these parameters are important in characterizing the capability of the total weapons system as first-strike or retaliatory. Essential monitoring capabilities for agreements limiting the number of warheads include the ability to verify whether a delivery system is equipped with a nuclear or nonnuclear warhead, to determine the number of warheads, and to estimate the upper bounds of yields.

This arms control approach is very similar to the problem of maintaining and verifying item accountability in nuclear safeguards. This possibly could be accomplished by applying nonintrusive tags to specific weapon or delivery systems as they leave the fabrication facility. This is equivalent to establishing an MBA (Missile Balance Area) around the fabrication facility and counting (or tagging) each weapon or delivery system as it leaves the facility to ensure that only the negotiated number has been deployed. The tagging process would allow for the return of a system for maintenance and/or replacement. The monitoring of egress and ingress of systems would require the establishment of a perimeter monitoring system, either remotely operated or continuously manned by personnel from both countries.

For this arms control concept to be effective, there also would have to be a challenge system in which the visiting inspection team could select certain deployed systems to ensure that each deployed "item" has the appropriate tag. All the tags for a specific system would have to be identical because a unique identification could provide sensitive information concerning a country's deployment strategy.

3. Establishing Nuclear-Weapon Free Zones

The establishment of nuclear-weapon free zones is another arms control approach that has been proposed by the Soviet Union. The monitoring techniques required to verify this arms control approach would be yes/no indicators that establish either the presence or absence of nuclear material within the predefined areas. This approach would require greater freedom of access than the other on-site verification proposals.

4. Reducing the Number of Nuclear Warheads

This is both the most desirable approach to arms control and the most difficult to verify. Both President Reagan and General Secretary Gorbachev have endorsed the concept of reducing or eliminating nuclear weapons. There are two critical questions that must be addressed before this approach will be accepted as a viable alternative to any of the other approaches: 1) how can an agreeable baseline be established for each side, and 2) how are the weapons to be destroyed or stored to ensure that one country does not attain an advantage over the other?

During the SALT negotiations it was fairly easy to determine the number of strategic delivery systems of each side. Missile launchers, ICBM silos and submarines, and heavy bombers could be counted accurately using satellite surveillance and other national technical means. To achieve a similar capability for individual warheads, we must be capable of closing an inventory around the entire country. This would require the tagging or unique identification of each warhead during the inventory period. Selected challenge inspections would have to be permitted to ensure all weapons deployed were included in the "baseline" inventory.

Once the weapons were removed from the strategic stockpile, they would have to be disassembled and stored in a jointly monitored storage facility to ensure that the materials were not re-introduced into the nation's stockpile. Simple storage of complete nuclear warheads can only be viewed as an interim measure. The personnel staffing this storage facility would have to verify the quantities of materials being placed in or removed from storage, as well as, to continuously monitor the inventory; both are familiar safeguards functions.

The timeliness criteria for a diversion would be in the range of several days to a few weeks depending upon the physical form of the stored materials. If the HEU and plutonium were stored as oxides, the time for conversion to usable weapon components might be two to three weeks.

5. Limiting the Development of New Weapon Systems

A limitation on the development of new or improved weapon systems has been proposed as an alternative approach to arms control. Agreements on this approach might attempt to restrict research and development, testing, and/or deployment for any new nuclear weapon system. In practice, it may be difficult or impossible to limit research and development, so limitations probably would be imposed on the testing and deployment phases. The verification of this type of agreement would rely heavily on NTM techniques that are outside the scope of this paper. However, the U.S. recently proposed on-site monitoring to verify the Threshold Test Ban Treaty.

VERIFICATION TECHNOLOGY

A variety of NDA and C/S instrumentation and procedures have been developed during the past twenty years for nuclear safeguards that are directly applicable to verifying the proposed arms control approaches under consideration at Geneva. To be acceptable, the technology must be perceived as being technically sound by both countries. Any instrumentation used in the verification process must measure only that characteristic which has been agreed upon, and cannot contain any "hidden capabilities" that might provide additional information about the weapon or delivery system.

1. Verifying the Production of Nuclear Material

A variety of NDA and C/S instrumentation has been developed to measure the presence and quantity of plutonium or HEU as part of the routine requirements for safeguards of nuclear materials. The unique gamma-ray signatures of both materials have been used to identify their presence in production and fabrication plants. The isotopic concentrations of plutonium can identify whether the plutonium is weapon-grade, fuel-grade, or reactor-grade. The enrichment of HEU can be measured under controlled geometry conditions.

The measurement of the passive neutron emission signatures of plutonium, using coincidence neutron counters, is a well accepted NDA method for verification. Active neutron interrogation techniques have demonstrated a high level of precision in measuring HEU materials. The basic NDA and C/S instrumentation has been applied to enrichment and reprocessing facilities within the U.S. and other countries. The technology is presently available to verify the production of HEU and plutonium in declared facilities.

2. Restricting the Number and Types of Weapon Systems

The application of NDA and C/S procedures to this arms control approach is more difficult because the negotiated measurement and C/S procedures must be capable of counting only nuclear weapons. The procedures must not be able to determine additional information about the components or construction of the weapon. By monitoring the passive gamma-ray and neutron signatures, the presence of a nuclear weapon can be verified. In multiple warhead delivery systems the problem becomes more difficult in assessing whether there are three, five, or more warheads in a delivery system. Nondestructive techniques that can answer this question, for example gamma-ray tomography, might also provide too much information concerning the components and the construction that are considered to be sensitive.

As was mentioned earlier, the problem with establishing an agreeable baseline may require the tagging of specific weapons as well as challenge inspections. Presently available yes/no gamma-ray and neutron monitors could be used to determine the presence/absence of a nuclear weapon.

3. Establishing Nuclear Weapon-Free Zones

The instrumentation and procedures required to verify compliance with this arms control approach are identical to those required in the previous approach. One extension could be the implementation of unattended monitoring stations at natural "choke points" (locations through which nuclear weapons would have to pass). As discussed in the previous two sections, the basic technology exists to implement effective monitoring procedures. However, the various technologies would have to be integrated into a verification system.

4. Reducing the Number of Nuclear Warheads

Any far-reaching nuclear arms reduction agreement is likely to include schedules for warhead destruction. The destruction of nuclear warheads will likely result in the reconversion of the fissile material to a safe form for storage. The monitoring technology required to verify the reduction in the number of nuclear warheads includes all the technologies required for the previous three arms control approaches, namely, accountability of nuclear materials and item accountability of warheads. The C/S instrumentation and techniques could be applied to storage facilities.

ON-SITE INSPECTIONS

Traditionally, the superpowers have relied on unilateral intelligence gathering techniques (NTM) to provide independent confirmation of each other's military status. However, recent military advances (for example, mobile missiles, interchangeable nuclear or conventional weapons, multiple warheads, cruise missiles, etc.) suggest that the future effectiveness of NTM may be questionable.

Much of the recent public rhetoric has dealt with nuclear test bans or monitoring. Such agreements, if successfully negotiated and implemented, might indeed stop increases in nuclear weapons development. Other agreements and proposed agreements have set numerical limits on specific weapon systems. Verification of some such agreements (for example, numbers of large fixed-site systems) are well established by satellite monitoring. Other agreements or more extensive agreements may have been hampered by the lack of credible on-site monitoring technology.

On-site inspections carried out under any arms control agreement could be performed by third-party inspectors (e.g., IAEA or Euratom inspectors) or adversarial inspectors (representatives from the U.S. or U.S.S.R.) The international safeguards inspections performed by the IAEA often have been proposed as a model for on-site arms control inspections. The Soviet Deputy Director for International Organizations. N. Timorbayev, said that the IAEA's "rich experience . . . in safeguards can usefully be employed over many phases of disarmament."[8] A. Petrosyant's, the chairman of the U.S.S.R. State Committee for the Utilization of Atomic Energy, also has stated that the IAEA should be the body responsible for verifying the elimination of nuclear weapons from national stockpiles[8] The extensive experience of the IAEA in negotiating specific inspection agreements and in planning and conducting inspections can serve as the basis for establishing similar arms control inspection agreements.

The primary purpose of IAEA inspections is to verify compliance with safeguards agreements "and to assist States in complying with such agreements and in resolving any questions arising out of implementation of safeguards."[9] There is a substantial difference between the goals of IAEA inspections (verification of declared values) and the goals of arms control inspections (assurance that there is not any significant amount of undeclared material unaccounted for). Another difference between the two types of inspections is the quantity of material that represents a significant breach of the agreement. The IAEA defines 8 kilograms of plutonium and 25 kilograms of HEU as significant quantities — desired levels of detection. In arms control verification, the quantity of material — the "breakout quantity" — that would represent a significant enhancement of a country's capability are much higher. It has been suggested that amounts of five tonnes of HEU and one tonne of plutonium might be reasonable goal quantities[4] Undetected amounts below these levels could still be used to fabricate hundreds of nuclear weapons, but would be insignificant compared, in absolute terms, to the numbers of weapons presently in the U.S. and U.S.S.R. stockpiles.

Aside from these two major differences, there are several aspects of IAEA safeguards inspections that could serve as the basis for verification of arms control agreements; 1) the form of the IAEA inspection agreements, 2) the IAEA approach to inspection planning, and 3) the instrumentation for monitoring facility activities and for measuring nuclear materials[10]

1. Inspection Agreements

The general agreement between the IAEA and a State describes in broad terms the obligations and privileges of the two parties with respect to implementation of safeguards. For each facility under safeguards, the IAEA and the State negotiate a Facility Attachment describing specific inspection activities permitted and the State's obligation for cooperation. A typical facility attachment includes: 1) facility design and process operating descriptions, 2) safeguards measures, including measurement of declared material and the application of C/S that the IAEA is permitted to apply at the facility, 3) records of facility operations to be maintained by the operator and made available for inspection to ensure completeness, correctness, and consistency, and 4) materials accounting reports to be submitted by the State to the IAEA.

2. Inspection Planning

The general IAEA objective of the timely detection of the diversion of a significant quantity of material from peaceful purposes is quantified in the inspection goals that specify 1) the significant quantity of nuclear material, 2) the detection time, estimated as the time for conversion into a weapon, and 3) the probability for detecting the loss of a significant quantity of material during the detection period. Inspection planning includes consideration of the following factors: 1) design characteristics of the facility; 2) terms of the agreements with the state and the facility attachment; 3) technical limitations of the measurement and surveillance equipment; 4) the resources (manpower and equipment) available; and 5) the technically credible scenarios for misuse of the facility.

3. Instrumentation

The NDA measurement and C/S instrumentation used by IAEA inspectors has been designed and fabricated for operation under adverse conditions. The instrumentation also has been designed to incorporate tamper-safing techniques to ensure the integrity of the equipment. Both passive and active interrogation techniques are used to determine the presence and to measure the quantities of uranium and/or plutonium.

Containment devices, for example, Type-E metallic seals, are applied to containers to ensure that the material has remained unchanged between inspections. Surveillance cameras are used to record all movements within an area to determine if there has been any undeclared movements of nuclear material.

Verification of arms control agreements to limit or eliminate the production of plutonium or HEU could be supported by adapting inspection procedures and technology currently employed by the IAEA.

This verification process could only be applied to declared production and/or fabrication facilities. Other monitoring techniques (i.e., NTM) would still be required to ensure that there are no undeclared production facilities.

CONCLUSIONS

For any arms control agreement to be effective, it must be verifiable using proven technologies. National technical means of verification were acceptable for the SALT I and II agreements because the emphasis was on counting strategic delivery systems. However, with the continued military advances by both the U.S. and U.S.S.R., this arms control approach may no longer be sufficient. Present arms control negotiations are focussing on the numbers of warheads and nuclear material. These approaches to arms control require the application of technologies developed for nuclear safeguards. These proven NDA and C/S instruments and procedures can be combined with NTM techniques to attain the required level of confidence in the verification process to assure both the U.S. and the U.S.S.R. are in compliance with the negotiated arms control agreements.

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Improving Security Communications at Fixed Site Facilities

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ABSTRACT

A list of several strategies for improving the resistance of the communications system at fixed-site facilities against eavesdropping, deception and jamming is presented.

INTRODUCTION

Physical protection communications at fixed sites generally are performed over a two-part communications system carrying alarm reporting and security communications traffic. The alarm reporting subsystem consists of equipment connecting remote intrusion detection and assessment devices to the protective force headquarters and to a secondary monitoring station, if present. The second subsystem comprises the procedures and hardware used to pass voice or other communications between members of the protective force during both normal and emergency operations; this subsystem will be referred to as the security communication subsystem and is the focus of this paper.

An adversary may try to exploit or degrade security radio communications through one or more of three threats: 1) eavesdropping, 2) deception, and 3) jamming. Eavesdropping is the unauthorized monitoring by an adversary of information carried over a radio network for the purpose of obtaining insights into security operations and to discover vulnerabilities. Deception is the transmission of messages by an adversary on the security communications net to confuse or fool members of the security force. Jamming consists of adversary acts to prevent radio communications, either through physical disruption of communications equipment or through intentional transmission of a radio signal on the security radio net.

During an adversary assault on a fixed-site facility, there are two levels of communication necessary for a security force to be successful. They are:

1. An Alert that informs all force members that the facility is under attack and provides the location of the assault.
2. Local communications to transfer details and tactical information between members of the security force once they have arrived at the location of the assault.

Radio jamming or deception, perhaps preceded by eavesdropping, might be used by an adversary in an attempt to interrupt either or both of these levels of communication.

POSSIBLE IMPROVEMENTS

The security communications system can be made more resistant to jamming, deception, and eavesdropping through improved communications equipment and better procedures. In the future, highly-resistant spread-spectrum radios may be available to combat some of these threats, particularly jamming. However, their use would require additional training, would require a larger maintenance operation, and would require special spectrum authorization. Therefore, it may be beneficial for sites to focus on procedural improvements and simple equipment changes in the near term. While the resulting security communications system will not be completely immune to jamming, deception, and eavesdropping, the system can be made very resistant.

There are several principles to follow in improving communications systems against eavesdropping, deception, and jamming threats:

1. Minimize dependence on the radio
2. Maximize the survivability of the radio network
3. Practice using procedures and hardware during a response exercise against a simulated jamming, deception, or eavesdropping attack.

Minimize Dependence on the Radio

Minimizing the dependency on the use of the radio reduces the adversaries' effectiveness not only in eavesdropping on the radio net but also in deception and jamming of that net. There are three general methods for reducing that dependence:

1. Shift detection, assessment, and/or entry control functions to an automated alarm communications system.
2. Send communications over alternate links to provide redundant communications mediums.

3. Preplan the response to minimize dependence on the radio.

Many sites have automated intrusion detection and assessment systems that carry communications in a protected fashion. If well-designed, these systems are immune to single-point disruptions in communications links and allow assessment to take place without committing personnel and without using the radio. Entry control systems, such as booths or keycard systems, allow such functions as key service and entry into vaults to occur without radio traffic for the benefit of the eavesdropper.

Redundancy can be achieved by using alternate links besides the primary radio channels. Possibilities include telephones, intercoms, additional security radio channels, public address systems, hand signals, sirens, lights, pagers, couriers, computer terminals, duress alarms, and CB radios. Alternate links may have their own vulnerabilities that must be assessed when weighing their use by the response forces. Public address systems can be very effective in small sites or at tactical locations. Hand signals can be used effectively where response forces can maintain eye contact. A standard telephone network enhanced by ring-down or hot-line phones can be used effectively if sufficient training and procedures have been provided. An intercom network interconnecting fixed posts is also an excellent alternative. Any standard telephone network or intercom system relied upon by the response should preferably be independent of the public telephone system. Providing additional security radio channels allows for more backup channels if jamming occurs and cuts down on net congestion during normal operations and non-security incidents. For this approach to be successful, effective procedures must be developed to instigate a change to different channels and to assure all are on the right channel.

The effects of losing radio communications during a tactical security response should be carefully analyzed by security operations personnel. To facilitate the development of a security communications network that is highly resistant to jamming, the security planner should first identify those radio links that are most critical to the success of the response force. He should then identify and evaluate for these links three or four mediums by which critical security messages can be transferred in a reliable and timely manner. Anti-jamming procedures can then be developed around the use of these backup communication mediums. Operating procedures that are totally dependent upon clear and timely radio communications should be carefully considered and minimized.

Some facilities have preplanned their response, and as a result, may have lowered their vulnerability to jamming, deception, and eavesdropping. As examples, field command posts can be located at or near alternate communications or alarm stations. Other facilities have set up predetermined response points or rallying points so that a minimum of information need be transmitted during a response. Offensive or entry teams (as opposed to containment) can also plan their assault to be independent of the radio or at least minimize its use.

Maximize the Survivability of the Radio Network

The radio network can be characterized by its survivability, that is, its ability to function in the face of jamming and deception. There are several methods of maximizing the survivability of the radio network against jamming. These methods include:

1. Providing attention to the proper maintenance of equipment,
2. The use of improved radio equipment and accessories,
3. Providing additional basic and tactical communications training, and
4. Developing and exercising anti-jamming procedures that exploit the spatial relationships of what we will call jamming geometry.

Similar approaches can improve the immunity of the radio system against deception and eavesdropping. For instance, radios using Digital Encryption Standard (DES) encryption provide a fairly high level of resistance against eavesdropping and deception. Additional training may allow for authentication procedures against deception and for communications procedures to minimize traffic to combat eavesdropping.

The following two sections on equipment maintenance and improved equipment address jamming survivability, while the third section on training applies to jamming, deception, and eavesdropping.

Equipment Maintenance — The security force should have enough functional radios to satisfy their communications needs or else they will be handicapped against an adversary employing jamming. If there are too few radios, or these radios are not adequately maintained, some security personnel may be "jammed" already because they cannot communicate at all. Others may have radios that are operating at lower effective transmitting power or receiving sensitivity, and as a result, are easier to jam.

In our opinion, sufficient inventories of radios, antennas, and batteries should be maintained at the site. While this may sound like common sense, this detail is too often overlooked. Ideally, each inspector should be issued his/her own hand-held radio complete with accessories and should be responsible for that equipment to minimize wear and tear. This responsibility is critical, because at sites where there are not enough radios, where inspectors pick up any random radio, battery, and/or antenna, there is no accountability and equipment is abused.

Some sites have such a "one-man, one-radio" policy and it seems to be working well. This policy also improves battery cycling; there is less chance that someone on the next shift will grab a hand-held radio 15 minutes after that radio is placed in the charger.

Vehicle and base-station radios should also be maintained in working order.

An adequate staff should be provided to calibrate radios, to condition batteries, and to maintain equipment. A badly-calibrated radio, or one with a weak battery, is of little use during a response. Maintenance should be performed quickly enough that equipment inventories are not drawn down excessively.

Improved Radio Equipment and Accessories — Improvements in radio equipment can increase the radio net's resistance to jamming.

Hand-held radios suffer from a multitude of "little" problems, such as ineffective antennas or low-capacity batteries which reduce the effective range of the radio. To address this problem, each inspector should be issued a hand-held radio, a rechargeable battery, one or more types of antennas, and perhaps an expendable battery (such as an alkaline).

Base station and vehicle radios may be provided with RF power boosters for use only during an emergency. Directional antennas and portable repeaters may prove to be useful.

Encrypted radios, such as DES radios, make the radio system more immune against eavesdropping and deception but do not provide any resistance against jamming. They may make the system more vulnerable to jamming if other precautions are not taken.

Basic and Tactical Communications Training — Both training and exercises are very important factors in insuring the resistance of the security communications system to eavesdropping, deception, and jamming. Technical training in the use of the radio is very important so that guards or inspectors can effectively use their equipment. Exercises and training in tactical communications are necessary to verify that procedures do in fact make the communications more resistant and to instill in inspectors the correct procedures.

Some useful topics for a communications training course include:

I. INTRODUCTION
- Why Communications are Important
- Threat

II. HOW TO USE EQUIPMENT
- Operation of Equipment
- Care of Equipment, Batteries

III. CORRECT COMMUNICATIONS PROCEDURES
- Normal Operations
- Tactical Operations

IV. HOW THE RADIO FUNCTIONS
- Antenna Patterns
- Simplex/Repeater Operations
- Line of Sight — Dead Spots

V. COUNTERMEASURES
- "Three Rs of Anti-Jamming"
  - Recognition
  - Reaction
  - Reporting
- Authentication

VI. FIELD DEMONSTRATION

Such a course consists of in-class training and a field demonstration. The material in the course could be presented as advanced training or could be included in communications training for new hires and/or new members of a SWAT-type team. Ideally, the course should be presented early in any SWAT training to provide personnel a chance to practice authentication and jamming countermeasures during training drills.

The course would begin with an explanation of why communications is important during the response. Even though many inspectors realize this, it is important in motivating them for the rest of the course. Before discussing any countermeasures at all, the course would cover three areas: 1) How to use the equipment, 2) Correct radio operational procedures (such as brevity and call signs), and 3) How the radio functions, i.e., basic radio theory. Without this sound basis, there is little sense in giving a guard or inspector advanced training. If an inspector does not know how to tell if his battery is going dead and what to do about it, teaching him how to use special features on the radio may prove worthless.

After this basis is established, the course would cover what we call the "Three Rs of Anti-Jamming:" 1) Recognition of Jamming, 2) Reaction to Jamming, and 3) Reporting Jamming. Training cannot expose your force to every conceivable form of jamming; however, they should be told that the adversary may try to hide his jamming and that there are methods to distinguish jamming from equipment problems. Reaction to jamming should cover all countermeasures. Finally, it is important that there be a covert way of reporting jamming back to headquarters or supervision.

Authentication procedures would also be covered.

At the end of the classroom instruction, inspectors would be given a field demonstration of how radio theory concepts, such as line-of-site propagation, antenna propagation patterns, and body orientation, can be used as jamming countermeasures with a hand-held radio.

Jamming Geometry — It is important that key people within a security system (particularly security operations personnel that set security policies and console operators at the security command posts) have a thorough understanding of the jamming geometry relationships illustrated in Figures 1 and 2.

It is likely that in the event of jamming at a fixed-site facility, security radio communications from low-powered (1 to 6 watt), hand-held transceivers to a more powerful (typically 100 watt) base station at the command post may be lost, but not vice versa. As illustrated in Figure 1, the console operation will most likely maintain one-way, out-going communication with most members of the security force even though he may not be able to receive their messages. The console operator should assume that his transmissions are being received and should accordingly continue to distribute as much information about the adversary as he has available to him. He should also request verification by telephone or intercom from fixed posts that his transmissions are being received. If the console operator verifies that his signal is being received, he could then use this one-way radio link as a PA system. That is:

1. Command a shift to an alternate security radio channel,
2. Alert the force of the assault and provide available information,
3. Initiate an appropriate response, and
4. Distribute subsequent information.

Another tactic that the console operator might employ is that of making contact with the intermediate powered (typically 30 watt) vehicle transceivers. It may be possible to establish a two-way radio link between these two because of the vehicle transceivers' power advantage over the low-powered, hand-held units. If this two-way link can be established, it may then be possible for the vehicle to relay messages to and from the hand-held units in close proximity, as shown in Figure 2.

The effectiveness of the jammer is thus dependent upon the type of security radios being used, the jammer's power output, and the geometry that exists between the jammer, the security command post, and all other units within the system. A thorough understanding of these jamming geometry properties can be very helpful in maintaining radio communications during a jamming assault. In general, the radio survivability is improved as higher powered units are used and/or as the units are moved closer together. If the effects of jamming geometry are understood, it may be possible for security inspectors to relay information that would otherwise be jammed. An inspector might also be able to significantly attenuate a jamming signal by moving to a position that puts an RF shield (a metal building, for example) between the portable unit and the jammer.

Power amplifiers are readily available which can be used in emergencies to boost the vehicle transceivers power to 200 watts and the 100 watt base station to approximately 2,000 watts. If amplifiers are used, precautions must be taken to assure that antennas used are capable of handling the additional power. The capability of amplifying these signals is desirable and is recommended. Increasing power is an obvious but often overlooked method of obtaining improved jam resistance.

The above jamming geometry discussions consider only a simplex mode of radio operation. A repeater network can provide improved radio coverage during normal security operations but should not be depended upon during tactical communications because of inherent vulnerabilities to electronic and/or physical destruction. If a repeater is used during normal security operations, security must possess the ability to remotely turn off and bypass the repeater during a jamming assault. If this is not done, the adversary can easily use the high-powered repeater to do his jamming for him, or he can physically destroy the repeater and, as a result, the security radio network. When a repeater is removed from a system during the early stages of a jamming assault, it is the above-mentioned simplex network and the resulting jamming geometries that will determine the jammer's effectiveness.

TRAINING EXERCISES

Field training exercises are necessary for improving security communications. From the conception of improvements, through testing and then implementation of these concepts, field exercises are vital. Jamming or deception exercises should be conducted with current protection schemes to determine if jamming or deception is a problem and under what conditions a vulnerability exists. Any vulnerability will suggest hardware or procedural changes; however, these changes should be tested under simulated conditions for effectiveness, just as any other response procedure.

Once countermeasures are selected, they should be instilled as second-nature in security inspectors. During the inherent confusion and stress associated with a facility assault, the use of unfamiliar countermeasures can only serve to aid the adversary. Even procedures as simple as switching to a backup radio channel are not effective until they have been rehearsed several times by all members of the security force.

CONCLUSIONS

Developing a high degree of network resistance to jamming, deception, and eavesdropping is difficult but not impossible. Spread-spectrum radios are becoming commercially available which could be used to provide a high level of resistance in certain applications. However, there are several other techniques that can be utilized at relatively low cost and operational impact to the facility. Procedures and hardware can be designed so as to minimize dependence on the radio. To the extent that the radio net must be used, it can be made as resistant as possible by use of better equipment, procedures, and training. Response exercises under simulated jamming and deception attacks are very important in designing countermeasures and maintaining proficiency in these measures.

Mark Snell joined Sandia National Laboratories in 1979 as a member of the technical staff working in safeguards and security. He has been involved in a program to generate counter-counter measures for security communications. Mr. Snell has a Ph.D. in operations research from Cornell University.

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J. Ellis Heustess joined Sandia National Laboratories in 1963. He has worked in telemetry, instrumentation, and systems design for approximately 16 years. Current assignments are in the Communications Systems Division and Facility Systems Engineering Division as project leader for security communications tasks and associated communications projects.

U.S. Experts Live in Vienna, Cost-Free

Surely many of you, over the past few years, have wondered what happened to a colleague only to find out — usually through a Christmas card — that he or she is a "cost-free expert" living in Vienna and working for the IAEA. Before going any further I had better explain "cost-free." At first sight it appears that these experts are making a donation to international safeguards. In a way they are, since they are providing a unique expertise to the IAEA. However, in practice experts are assigned to the IAEA staff and receive commensurate salaries and benefits. They are cost-free to the Agency because IAEA expenditures are reimbursed by the U.S. support program.

The backbone of the U.S. Support Program to IAEA Safeguards (POTAS) are the cost-free experts that are responsible for the transfer of safeguards technology to the IAEA. Over the past nine years the U.S. has provided about 140 man-years of technical support through experts. Experts usually spend two years in Vienna but many have been extended for an additional year or two. The experts provide assistance in measurement technology, training, system studies, data processing, and containment and surveillance. They work with the IAEA safeguards staff in every division. For obvious reasons, they never participate in any inspection activities.

Thirteen of more than 90 individuals who served as cost-free experts have joined the regular staff. For example, INMM members Dave Rundquist and Joe Nardi are both section heads in the Department of Safeguards. Last year John Jaech and Wendell Belew started their assignments as cost-free experts and will be in Vienna until 1988. This year Charlie Hatcher completes a two year assignment. During this period Charlie designed and installed a computer based equipment inventory system which will be of great value to the agency.

Five new experts will join the agency this year, bringing the current cost-free expert contingent to 25. A number of new openings will become available in 1987. So, if 1987 is the right year for you, please contact me

POTAS NEWS

for more information. The address is International Safeguards Project Office, Brookhaven National Laboratory, Upton, New York 11973.

Leon Green
Brookhaven National Laboratory
Upton, New York

U.S. Technical Support to IAEA Enters Tenth Year

The Program of Technical Assistance to IAEA Safeguards (POTAS), will soon enter its tenth year. This program, which is funded by the State Department, is under the direction of the Technical Support Coordinating Committee, an inter-agency group chaired by State and including the Department of Energy, the Arms Control and Disarmament Agency and the Nuclear Regulatory Commission. Since inception of the program, 290 tasks mutually agreed upon by the IAEA and the U.S. have been completed, and another 70 are currently active. Most of the research and development and expertise is provided by laboratories of the Department of Energy. Technical management of the program is the responsibility of the International Safeguards Project Office (ISPO). Assistance is provided in the form of, 1) equipment, 2) experts, 3) systems studies, 4) techniques and procedures and 5) training. Of the nine year total of about $43 million provided for POTAS, 30 percent was allocated for development of equipment and standards. About 25 percent was allocated to furnishing cost-free experts, 10 percent for system studies, 20 percent for developing techniques and procedures and 15 percent for training.

Achievements

Equipment

A major achievement has been the provision of safeguards equipment designed to be reliable, easy to use, and where required, tamper resistant. Of the more than 30 different types of devices developed and provided to IAEA for test and evaluation, more than 20 instruments are now used routinely or on a limited basis.

Experts

Over the past nine years, more than 90 experts have been assigned to work with the secretariat for periods of one to several years, with additional experts providing special consultation during short term assignments. The experts have placed an important role in technology transfer to the IAEA staff. They have participated in field evaluation of equipment, development of operating procedures, system studies, automatic data processing, training, and quality assurance.

System Studies

Studies carried out within POTAS have included the development of models for forecasting and allocating

IAEA inspection effort; for assessing the impact of technical safeguards criteria on requirements for manpower and other resources; and for developing quality assurance and effectiveness assessment programs. Relatedly, a POTAS-funded cost-free expert worked closely with the IAEA staff in developing a procedure to forecast the IAEA needs for safeguards equipment for the next few years. These forecasts are now made on a biannual basis.

Techniques and Procedures

Significant assistance was provided in developing techniques for calibration of instruments and analysis of data. For almost every piece of equipment developed under POTAS, operating manuals were prepared to provide the procedures and information needed for training and maintenance. Many generic procedures for making measurements have been tested in the field with joint participation of experts from the IAEA and the United States.

Training

Experts from the United States have played an important role in the establishment of the Safeguards Training Section, and in developing the current introductory course for new inspectors. Inspection teams received training in physical inventory verification conducted under realistic conditions at nuclear facilities. Two exercises having a MOX inventory were conducted at the Hanford Engineering Development Laboratory (HEDL). Another exercise was completed at the TMI-1 nuclear power plant. A fourth exercise, using an HEU inventory, was conducted at Los Alamos. Similar exercises are planned for other facility types.

Directions for improved support

A few years ago the United States recognized a need to change emphasis in the program. This change in direction was based on the recognition that the IAEA is greatly expanding its use of new safeguards instruments, devices and techniques, and, faced with budget restrictions, must use this new technology efficiently.

Implementation of new equipment places a substantial burden not only on inspectors, but on the technical support functions of the Department of Safeguards. Effective use of measurement and surveillance devices requires preparation of standard procedures describing their use. The expected large inventory of equipment will require greatly expanded and improved procedures for procurement, management, and maintenance of these new and complex devices. Methods for monitoring performance of this new equipment must be implemented to identify any deficiencies in the equipment design or in the procedures being applied.

Training courses must be expanded to give the inspector an opportunity to gain expertise in the use of these complex devices using standard procedures, under realistic conditions. Techniques for data evaluation and the use of in-field computers need to be expanded to assure accurate and rapid reporting of inspection results. Finally, methods for reviewing the implementation of safeguards, supported by a quality assurance program, must be put to use to provide Department of Safeguards management with a clear understanding of the effectiveness of the implementation of safeguards. It is in these areas that U.S. assistance will be directed and continued into the foreseeable future.

Leon Green
ISPO, Upton, New York

J. Christian Kessler
Department of State
Washington, D.C.

Posts Vacant in the IAEA

The Department of State, the U.S. Arms Control and Disarmament Agency and the Department of Energy have intitiated a program to improve recruitment of U.S. nationals for employment in the IAEA.

In an effort to support this program, INMM will publish IAEA vacancies in all upcoming issues of the journal.

Department of Administration

Division: Personnel. Position: Personnel Officer. Grade: P-3. Vacancy #86/22. Opening: 3/11/86. Closing: 7/11/86.

Division: Languages. Section: English Translation. Position: 86/20. Grade: P-3. Vacancy #86/20. Opening: 3/17/86. Closing: 7/17/86.

Division: Budget and Finance. Section: Organization and Procedures. Position: Management Analyst. Grade: P-2. Vacancy #86/19. Opening: 3/17/86. Closing: 7/17/86.

Division: Budget and Finance. Section: Organization and Procedures. Position: Cost Analyst. Grade: P-2. Vacancy #86/18. Opening: 3/17/86. Closing: 7/17/86.

Division: Budget and Finance. Section: Organization and Procedures. Position: Cost Analyst. Grade: P-2. Vacancy #86/18. Opening: 3/17/86. Closing: 7/17/86.

Department of Nuclear Energy and Safety

Division: Nuclear Power. Section: Economic Studies. Position: Power Engineer/Economist. Grade: P-4. Vacancy #86/26. Opening: 4/8/86. Closing: 8/8/86.

Division: Scientific and Technical Information. Section: AGRIS Processing Unit (APU). Position: Multilingual Subject Specialist. Grade: P-3. Vacancy #86/14. Opening: 3/17/86. Closing: 7/17/86.

Department of Research and Isotopes

Division: Research and Laboratories. Position: Director. Grade: D-1. Vacancy #86/27. Opening: 4/8/86. Closing: 8/8/86.

Division: Life Sciences. Section: Medical Applications. Position: Nuclear Medicine Instrumentation Specialist. Grade: P-4. Vacancy #86/24. Opening: 3/17/86. Closing: 7/17/86.

Department of Technical Cooperation

Division: Publications. Section: Publishing. Position: Russian Editor. Grade: P-2. Vacancy #86/21. Opening: 3/17/86. Closing: 7/17/86.

Department of Safeguards

Division: Safeguards Information Treatment. Section: Data Processing Development. Position: Development Programmer. Grade: P-1. Vacancy #86/28. Opening: 4/8/86. Closing: 8/8/86.

Division: Safeguards Information Treatment. Section: Data Processing Development. Position: Development Programmer. Grade: P-1. Vacancy #86/23. Opening: 3/17/86. Closing: 7/17/86.

(Several Positions). Division(s): Operations. Position(s): Nuclear Safeguards Inspector. Grade: P-3. Vacancy #86-SGO-3. Opening: 1/8/86. Continuous recruitment until 12/31/86.

(Several Positions). Division(s): Operations. Positions(s): Nuclear Safeguards Inspector. Grade: P-4. Vacancy #86/SGO-4. Opening: 1/8/86. Continuous recruitment until 12/31/86.

How to Apply

Applications must include a vacancy notice number, and should be mailed to the United States Mission to the International Atomic Energy Agency, Kundmanngasse 21, 1030 Vienna, Austria (Attention: Ronald Bartell). After U.S. Government endorsement is given, the Mission will forward the application to the Division of Personnel at the IAEA.

U.S. Candidates must also send a photocopy of the original application to: (for positions in the Department of Safeguards) P.O. Box 650, Brookhaven National Laboratory, Upton, N.Y. 11973; (for all other positions) IO/T/SCT, Rm. 5336, Department of State, Washington, D.C. 20520.

Successful Tests of New Reactor Promise Safety

Just before the cataclysmic accident at the Chernobyl nuclear plant in the Soviet Union, the U.S. Department of Energy announced the successful completion of tests that demonstrated that the Experimental Breeder Reactor, EBR-II, will shut down safely without external power or operator action.

EBR is a small, experimental sodium-cooled fast test reactor operated for the department by Argonne National Laboratory at the Idaho National Engineering Laboratory near Idaho Falls, Idaho.

DOE called the tests a "milestone in the development . . . of plants that are passively safe, less costly, and simpler to construct and operate." Representatives from Japan, France, the Federal Republic of Germany and the United Kingdom observed the tests at the reactor site.

Two tests were conducted to demonstrate the reactor's performance when safety equipment was not allowed to function while the reactor was operating at full power. The tests effectively simulated a situation blackout, or loss of all externally supplied electrical power.

When power was shut off to all cooling systems in the first test, fuel and sodium coolant temperatures increased and the reactor automatically shut down, without external power or operator actions. Temperatures remained within safe limits.

In the second test, power to the secondary cooling system was turned off while the reactor continued operating. Again, the fuel and primary sodium coolant temperature remained within safe limits, and the reactor was shut down safely without operator action.

The test results confirmed the belief that properly designed sodium-cooled systems using metallic fuels — such as those tested at EBR-II — are attractive candidates for future development of nuclear power plants.

In both tests, the features that enabled the reactor to respond to abnormal events rely on "natural laws" such as thermal expansion, heat conduction, convection, radiation, and gravity. Thus, the safe shutdown of the reactor does not depend on the intervention of active, engineered components such as control rods, pumps, valves, or the use of the Balance of Plant for decay heat removal.

EBR-II operates at a thermal power rating of 62.5 megawatts or 19.5 megawatts electrical power and is on its 22nd year of successful operation.

DOE Proposes New Criteria for Enrichment Services

The U.S. Department of Energy has proposed to modify the criteria under which it provides uranium enrichment services to domestic and foreign commercial customers and reduce by nearly five percent its basic charge for enrichment services. The price reduction will become effective October 1, 1986.

"These steps represent good news for our customers," Secretary of Energy John S. Herrington said in announcing the proposed changes. "They demonstrate our continuing commitment to run the enrichment program in a more business-like manner and to provide our customers with the most competitive services possible."

DOE proposed the criteria changes as the next logical step in its competitive strategy to respond to marketplace changes. "The ground rules under which we have been offering enrichment services are antiquated," Herrington said. "They impede DOE's ability to conduct business efficiently. These proposed changes will revise the criteria to support our goal of maximizing the United States' long-term competitive position in the world enrichment market."

Herrington added that the changes will enable DOE to carry out more effectively its statutory mandate under the Atomic Energy Act of 1954.

The reduced price announced by the DOE will be from $125 to $119 per separative work unit.

NRC Evaluating Waste Storage Containers

Will containers designed for long-term storage of nuclear waste hold up for centuries once they are placed in underground depositories? How will they be affected by corrosion?

Materials researchers from the Commerce Department's National Bureau of Standards are helping the Nuclear Regulatory Commission answer those questions as part of a project to evaluate the design of containers to permanently store spent fuel rods from civilian power plants, along with other forms of high-level nuclear wastes.

Container packages are being developed by the Department of Energy under the Nuclear Waste Policy Act of 1982. The Act established a national policy on storage, transportation, and disposal of high-level nuclear wastes in a geological depository. The Act requires DOE to develop container designs to isolate the material within the waste package system for human safety over a 300-1,000 year span. The design proposals are to be submitted to the NRC by 1991 for review and licensing approval.

The evaluations may continue to the mid 1990s until the NRC has had time to review all of the DOE design proposals. Under the Nuclear Waste Policy Act, the regulatory commission has at least three years in which to complete the evaluations for any permanent storage system for high-level nuclear waste materials.

It is estimated that by the year 2000 the inventory of accumulated radioactive material from public utilities in temporary storage facilities will increase to approximately 50,000 tons.

Nuclear Plant Performance Improves

The nuclear industry's devotion to improving the performance of nuclear plants in the United States throughout the first half of the decade is continuing to pay dividends, according to data collected by the Institute of Nuclear Power Operations.

The data show U.S. commercial nuclear plants improved during 1985 in eight of INPO's nine categories. Among the findings:

• The number of significant events per unit dropped to 0.53 per unit in 1985 from 0.70 per unit the year before. It was the fourth consecutive annual decline since 1981, when the average was 1.64 per unit.

• The forced outrage rate declined to 11.7 percent in 1985 from 13.6 percent in 1984.

• Average collective radiation exposure per operating nuclear plant declined for both pressurized water reactors and boiling water reactors to the lowest level ever recorded by INPO, which began collecting data in 1980. For BWRs, the total dropped to 896 man-rem in 1985 from 1,003 man-rem in 1984. For PWRs, the total dropped to 394 man-rem from 555 man-rem in 1984.

• For the second year in a row, no personnel at commercial nuclear plants accumulated more than five-rem collective radiation exposure. By contrast, 311 personnel exceeded the five-rem limit in 1980.

• The "equivalent availability" of U.S. nuclear plants rose to 60.7 percent in 1975, from 59.5 percent in 1984. (Equivalent availability measures the ratio of the total power a unit could have produced, considering actual equipment and regulatory limits, to its rated capacity expressed as a percentage.)

• INPO also showed declines in the volume of low-level solid radioactive waste per plant, and in lost time accident rate for industry personnel.

• U.S. nuclear plants rated lower in only one INPO performance category during 1985, as average thermal performance (a measure of operating efficiency) declined slightly.

In Memoriam Ella C. Werner

Ella Werner was active in the INMM in the early years, providing an invaluable communication link among members. She created and then served as editor of the institute's first newsletter, the forerunner of the journal as we know it today.

Ella worked for the Atomic Energy Commission as a nuclear materials management specialist in the raw materials division.

She always retained an interest in the INMM and was the first person to be made a Member Emeritus of the institute.

Ella led an active and meaningful life and will be missed by all of us who knew her.

She died at the age of 86 on March 15, 1986, after a year's stay in the Health Center of Plymouth Harbor in Sarasota, Florida.

NBS Publishes Database Directory

The National Bureau of Standards publishes a directory to standard reference databases for those who need reliable evaluated data on the chemical and physical properties of substances. *Standard Reference Data Publications, 1964-1984* (SP 708), lists reprints and supplements from the *Journal of Physical and Chemical Reference Data*, other NSRDS data compilations and critical bibliographies, computer programs for handling technical data, and magnetic tapes in the National Standard Reference Database series. Author, materials, and properties indexes as well as ordering information and price lists are included. Copies are available for $5 prepaid from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Order by stock number 003-003-02705-7.

NBS Releases Engineering Standards Index

A new revision of the *Key-Word-in-Context Index of U.S. Voluntary Engineering Standards* has been issued by the National Bureau of Standards. The KWIC index contains more than 28,000 titles of standards, specifications test methods and recommended practices published by 422 U.S. standards-developing organizations. First published in 1971, the revised microfiche index provides the title, date, source, and number of standard for each entry. Titles can be found by all of the significant words they contain. For information on the KWIC index, contact the Standards Code and Information Office, A629 Administration Building, National Bureau of Standards, Gaithersburg, MD 20899. Microfiche copies of the index are available for $13.50 prepaid from the National Technical Information Service, Springfield, VA 22161. Order number #86-154408.

EQUIPMENT, MATERIALS & SERVICES

DOE-Developed Software Available

A computer software program developed at the U.S. Department of Energy's Oak Ridge Gaseous Diffusion Plant is now being made available to commercial and institutional analytical chemistry laboratories through a new licensing program. The Program was created to help keep track of the multitude of chemical analyses performed in the plant's laboratory.

AnaLIS is a time and labor-saving program which enables an analyst to record quickly the results of an analysis just performed or to retrieve data on several million analyses performed previously. The system also gives error messages if inaccurate results are reported for known standards used to calibrate test methods.

At ORGDP, the system is used to track samples, report and transmit sample results to other computers used by customers, maintain analyst and instrument certification records, and to provide administrative records for the analytical laboratories at ORGDP and the Paducah (Kentucky) Gaseous Diffusion Plant.

AnaLIS currently uses the VAX/VMS 4.3 operating system, FORTRAN 77, Datatrieve, Common Data Dictionary, Forms Management, and the in-house AnaLIS software. Additional supporting software includes Pascal 20/20, computer aided instruction for the editor and for Datatrieve.

The AnaLIS uses 8MB of memory on a VAX-11/750, 1900 MB of disk space with four controllers on two Unibuses, 80 ports, two lines for transmitting data to other computers on the DCA Network, and 16 lines for computer access from the DCA Network. The AnaLIS has Ethernet and DEC net capabilities.

For additional information on licensing contact: John W. T. Dabbs, Director Technology Transfer, Martin Marietta Energy Systems, Inc., P.O. Box X, Oak Ridge, TN 37830.

New Plutonium Standard Available from NBL

Now available from DOE New Brunswick Laboratory: NBL CRM #126 Plutonium Metal Assay and Isotopic Standard in 1 Gram Units. $1,600.65/$1,700.87.

ANSI Issues Report

ANSI standards coordinating groups report excellent progress and high levels of U.S. participation in international standards activities were maintained, according to The American National Standards Institute's just-released 1986 Progress Report.

ANSI also reports that the number of standards developers seeking accreditation is on the rise, and that it was a good year for cooperation between ANSI, the U.S. government and the voluntary standards system.

The Progress Report also provides details on institute membership, financing, organization and the boards and councils that carry out programs. Copies are available from ANSI, 1430 Broadway, New York, NY 10018.

CALENDAR

Event sponsors are listed in parentheses following event name.

June 14-20
ANS Annual Meeting (ANS), Reno, Nev. *Contact:* R. Jon Stouky, Power Cutting Energy Services, One Energy Drive, Lake Bluff, Ill. 60044, (312) 680-8100

June 16-20
IAEA International Symposium on Packaging & Transport of Radioactive Materials (PATRAM '86) (IAEA), Davos, Switzerland. *Contact:* Van Hoomissen/Voiland Paper

June 22-25
Institute of Nuclear Materials Management Annual Meeting (INMM), "Success in Integrated Safeguards," New Orleans, La. *Contact:* Beth Perry, INMM Office, (312) 480-9573

June 30-July 4
Fourth International Conference on Emerging Nuclear Energy Systems (ICENES 4). *Main Topics:* New Breeder Reactor Concepts; Role and Implications of Emerging Nuclear Energy Systems Madrid, Spain. (Spanish Nuclear Society, USSR Academy of Sciences, American Nuclear Society, Japanese Nuclear Society, Canadian Nuclear Society) *Contact:* Professor Guillermo Velarde, Director Dept. of Nuclear Energy, E.T.S. Ingenieros Industriales, Universidad Politecnica de Madrid, Paseo de la Castellana, No. 80, Madrid 6, Spain, Tel: 411 41 48, NSTO PRISM paper

July 20-23
Joint ASME/ANS Nuclear Power Conference (ASME/ANS), Philadelphia, Pa. *Contact: David Ciarlone, Philadelphia Electric, 2301 Market St., Philadelphia, Pa., (215) 841-4766. Waste management papers proposal.*

July 20-23
IEEE Annual Conference on Nuclear and Space Radiation Effects, Providence, R.I.

August 17-22
8th International Heat Transfer Conference (ASME), San Francisco, Calif. *Contact:* R. J. Goldstein, University of Minnesota, Minneapolis, Minn. 55455 (212) 705-7788

Fall
2nd International Conference on Radioactive Waste Management (CNS), Canada. *Contact:* Eva Rosinger, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, Canada R0E 1L0

September 1-5
International Conference on Nuclear and Radiochemistry (CNS, CCS), Beijing, China. *Contact:*Conference Division, 137 Madison Avenue, New York, N.Y. 10016 (800) 221-7179

September 7-10
Nuclear Records Management Symposium, Denver, Colo. *Contact:* Nuclear News Office (312) 352-6611

September 7-12
Second International Conference on Radioactive Waste Management (CNS), Winnipeg, Canada.

September 14-17
International Topical Meeting on Waste Management and Decontamination and Decommissioning (ANS), Niagara Falls, N.Y. *Contact:* Anne E. Englert, Spectrum '86 Technical Program, Box 191, West Valley, N.Y. 14171 (716) 942-4258

September 17-19
Topical Meeting on Advances in Reactor Physics and Safety (ANS), Saratoga Springs, N.Y. *Contact:* Donald R. Harris, Dept. of Nuclear Engineering, Rensselaer Polytechnic Institute, Troy, N.Y. 12180-3590 (518) 270-6407

September 22-23
First Regional Conference (ANS), Pittsburgh, Pa. *Contact:* ANS Conference Office (312) 352-6611

September 29-October 3
International Topical Meeting on the Operability of Nuclear Power Systems in Normal and Adverse Environments (ANS), Albuquerque, N.M. *Contact:* Lloyd L. Bonzon, Division 6446, Sandia National Lab, P.O. Box 5800, Albuquerque, N.M. 87185 (505) 844-4313. Summary deadline May 1, 1986. (Paper by B. M. Gordon)

October 5-11
13th World Energy Conference, Cannes, France. *Contact:* E. Ruttley, World Energy Conference, 34 St. James St., London SW1A 1HD

October 19-23
Joint Power Generation Conference (IEEE, ASME, AIChE), Portland, Ore. *Contact:* M. I. Olken, Gibbs & Hill, 393 Seventh Ave., New York, N.Y. 10001 (212) 760-4032

November 16-21
Joint Meeting of ANS/AIF (ANS/AIF), Washington, D.C. *Contact:*Raymond W. Durante (202) 737-0660

January 27-29, 1987
Annual Reliability and Maintainability Symposium (ASME, ASQC), Philadelphia, Pa. *Contact:* V. R. Monshaw, RCA Astro Electronics, P.O. Box 800, MS55, Princeton, N.J. 08540

February 8-12, 1987
12th BWR Operating Plant Technical Conference (NP&CSD), Monterey, Calif. *Additional Information:* Full sponsor

March 9-13, 1987
Corrosion 87 (NACE), San Francisco, Calif. *Contact:* Barry Gordon, Chairman — Corrosion in Nuclear Systems

June 6-12, 1987
ANS Annual Meeting (ANS), Dallas, Texas. *Contact:* Meetings Department, ANS, 555 North Kensington Ave., La Grange Park, Ill. 60525

ADVERTISER INDEX