JNMM

Journal of Nuclear Materials Management

Published by the Institute of Nuclear Materials Management ■ Volume XXIV, Number IV ■ July 1996

JNMM (ISSN 0893-6188) is published four times a year by the Institute of Nuclear Materials Management Inc., a not-for-profit membership organization with the purpose of advancing and promoting efficient management and safeguards of nuclear materials.

SUBSCRIPTION RATES: Annual (U.S., Canada and Mexico) $100.00; annual (other countries) $135.00 (shipped via air mail printed matter); single copy regular issues (U.S. and other countries) $25.00; single copy of the proceedings of the annual meeting (U.S. and other countries) $65.00. Mail subscription requests to *JNMM*, 60 Revere Dr., Suite 500, Northbrook, IL 60062 U.S.A. Make checks payable to INMM.

ADVERTISING, distribution and delivery inquiries should be directed to *JNMM*, 60 Revere Dr., Suite 500, Northbrook, IL 60062 U.S.A., or contact Don Wink at (847) 480-9573, fax (847) 480-9282, or e-mail BScott@INMM.com. Allow eight weeks for a change of address to be implemented.

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An Exciting and Unsettling Time

It is difficult for me to believe this is my last message as chair. As my two-year tenure winds down, I have begun to reflect on the events affecting the nuclear materials management community and the Institute, as well my own personal experiences during this period.

As noted in a number of my messages, the last few years have been both exciting and unsettling for the world's nuclear materials management community. We have seen collaborations with our colleagues in Russia and the Newly Independent States grow from cautious exchanges of meetings to significant and beneficial technical interactions, all of which help protect and control nuclear materials worldwide.

We have seen nuclear smuggling become front-page news, along with plutonium in North Korea's spent fuel. In addition, the Nuclear Nonproliferation Treaty (NPT) signatory states indefinitely extended the treaty with the expectation of strengthening international safeguards by improving the International Atomic Energy Agency's (IAEA) ability to detect undeclared materials and facilities.

In the United States, nuclear materials in excess of what is needed for national security have been placed under Agency safeguards. Extensive discussion took place regarding fissile materials production cutoff, which has significant implications for the nuclear materials management community. In addition, nuclear waste management continues to be newsworthy and controversial, as is the related topic of nuclear materials transportation. Debates also continue about the future of nuclear power and the wisdom or necessity of using plutonium arising from weapon dismantlement or from civil power production as an energy source. Finally, in a number of areas of the world, there has been an increase in the openness of nuclear activities to further arms control and nonproliferation goals. For example, the U.S. Department of Energy (DOE) took a major step by releasing information about nuclear material inventories.

Within this framework of change and front-page news about nuclear materials, INMM continued its long-standing mission of promoting the responsible management of nuclear materials through its meetings, publications and professional interactions. We added a Russian Federation Chapter and we are now in the process of forming a chapter in South Korea. These additions underscore our role as an international technical and professional society. The Japan Chapter celebrated its 20th anniversary and the Vienna Chapter continued to provide a focus for nuclear materials management professionals stationed at the IAEA. U.S. regional chapters conducted local meetings, social events, workshops, and seminars to further the professional development of their members.

On the home front, INMM pursued the implementation of modern computer archiving and communications technologies, including an INMM Web page (http://www.INMM.com) and on-line storage of the Annual Meeting Proceedings. This year we expect to publish the proceedings on CD-ROM. As usual, we will continue to publish a membership directory, which many of us find useful as a telephone directory and a "who's who" of the profession. In addition, our membership committee has been extremely active as shown by the reworking of the senior member program.

Unknown to most members are the many improvements in the management of the Institute. Particularly noteworthy is the preparation of an INMM operations manual under the leadership and direct efforts of Debbie Dickman of Pacific Northwest National Laboratories. This "living" document will make life easier in the future for all new officers, members-at-large, division heads, and committee heads. We have also renewed our relationship with The Sherwood Group to provide administrative services and professional management for INMM.

Financially, INMM had a successful year; we anticipate and hope for the same for fiscal year 1996. After all, the only way to provide a uniquely focused professional forum in nuclear materials management is to remain financially healthy.

Though it may sound trite, it is people who make a difference. There is not room in this column to thank all the people by name who make INMM a success, but I do want to single out Secretary Vince de Vito, Treasurer Bob Curl, Vice Chair Obie Amacker, and Annual Meeting Chair Charles Pietri for special recognition. The members-at-large of the Executive Committee who served during the last two years are Gary Carnival, Phil Ting, Jill Cooley, David Crawford, Marcia Lucas, Scott Straight, and Dennis Mangan (as Past Chair). The leaders of the technical divisions also deserve mention: Cecil Sonnier, Rich Strittmatter, Ruth Kempf, J.D. Williams, Billy Cole, and Ed Johnson. Finally, I want to thank the committee chairs, chapter chairs, Barb Scott, and the entire staff at The Sherwood Group.

One of the real pleasures of serving as chair has been the opportunity to travel to meetings here and around the world to interact with INMM members

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The Eternal Problem Revisited

In an earlier column, I quoted extensively from one of Willy Higinbotham's editorials. I thought it might be interesting to the readers of *JNMM* to recall what was on the minds of the folks active in safeguards more than 20 years ago. (Surprisingly — or maybe not so surprising — the concerns have not changed much.)

I received no feedback on the column. Did you enjoy the historical visit? Did you hate it? Did you even read it? To tell the truth, I have never received feedback on any column. Or on any of the technical papers. Or on anything at all!

I would be mightily concerned if this lack of feedback were unique to me. However, in looking over past issues of the *Journal,* I find many editorials by Willy that address the same problem. At the risk of boring you, I quote from a couple of them from nearly 20 years ago.

"Every year it seems to be necessary to appeal to the membership to support the *Journal.* Several kinds of support would be appreciated by the editors, and should make the *Journal* more useful to the membership, and to others. For one thing, we need more technical contributions. The annual INMM and ESARDA symposia attract many contributions, since authors whose papers are accepted may be able to attend these interesting meetings. The *Journal* cannot offer that inducement. On the other hand, a paper in the *Journal* has more visibility, since there are no parallel sessions, and the competition is almost nil.

"A typical proceedings issue contains about 90 papers [now more than 200], compared to only about 16 technical papers in all of the four regular issues in a year. There are a few conscientious contributors. If it were not for them, the *Journal* would be only a newsletter. If some readers feel that the technical papers are unbalanced, it is their duty to provide material to restore the balance.

"Finally, we need feedback. No one ever writes the editor to suggest improvement, or even to complain. There is no way for us to tell whether the members are satisfied, or what they think about the *Journal.* Maybe no one reads it."

And from an editorial titled "Call for Greater Member Initiative:"

"In most professional organizations, there are letter-writers, some who disagree with policies, some who criticize articles, and some who offer constructive suggestions. For some reason, this *Journal* has not had this sort of feedback. Why is this so? Are our readers too busy? Are they lazy? Or are they afraid that they will be ignored?

"As you who read the *Journal* realize, a few interested members contribute frequently what they hope will be of interest. Officers and editors feel required to do so. It would be a relief to us, and undoubtedly more exciting for our readers, if other members were to submit competing essays. Don't be bashful."

So the problem continues: too few technical papers submitted to the *Journal,* no feedback, and virtually no input from the membership. Will you help solve it?

In this issue of the *JNMM,* we have five papers. Sounds great, doesn't it? But only one of the five was submitted to the *Journal.* This paper, introduced by Ken Sheely, is the second in an ongoing series of *JNMM* articles on international partnerships aimed at improving safeguards.

Titled "Smart Unattended Systems for Plutonium Safeguards," it describes a system of remote, unattended safeguards instrumentation that resulted from collaboration between the Power Reactor and Nuclear Fuel Development Corporation in Japan, the U.S. Department of Energy, and the Los Alamos National Laboratory. The system has been in use for nearly a decade. Incidentally, many thanks to Ken Sheely for stimulating these fine papers on international safeguards.

The remaining four papers were presented at the recent, very successful workshop "Plutonium Inventories: Growing Challenges in MC&A and Nonproliferation." Although not prepared for the *JNMM,* we felt the wider audience provided by the *Journal* would be interested in reading these most interesting papers. Collectively, they present several different ideas on how best to manage the rapidly growing plutonium inventories throughout the world.

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or via INMM's web site at
http://www.INMM.com

ITI News Awards

The Institute of Nuclear Materials Management, along with other organizations, received an award in May from the International Technology Institute (ITI) for its efforts to promote the responsible handling of nuclear materials. ITI is a nonprofit organization that "promotes the concept that technology is the most significant human-generated resource that in combination with natural resources can increase the standard of living and quality of life for all mankind in a safe and secure environment."

Victor Mikhailov, the minister of nuclear energy of Russia, received the highest award, the Willard F. Rockwell, Jr. Medal, for his contributions toward the generation, transfer and application of technology for the betterment of mankind. The medal is only awarded to individuals with extremely high stature in the international technology community and who are electable to the World Level of the Hall of Fame for Engineering, Science and Technology.

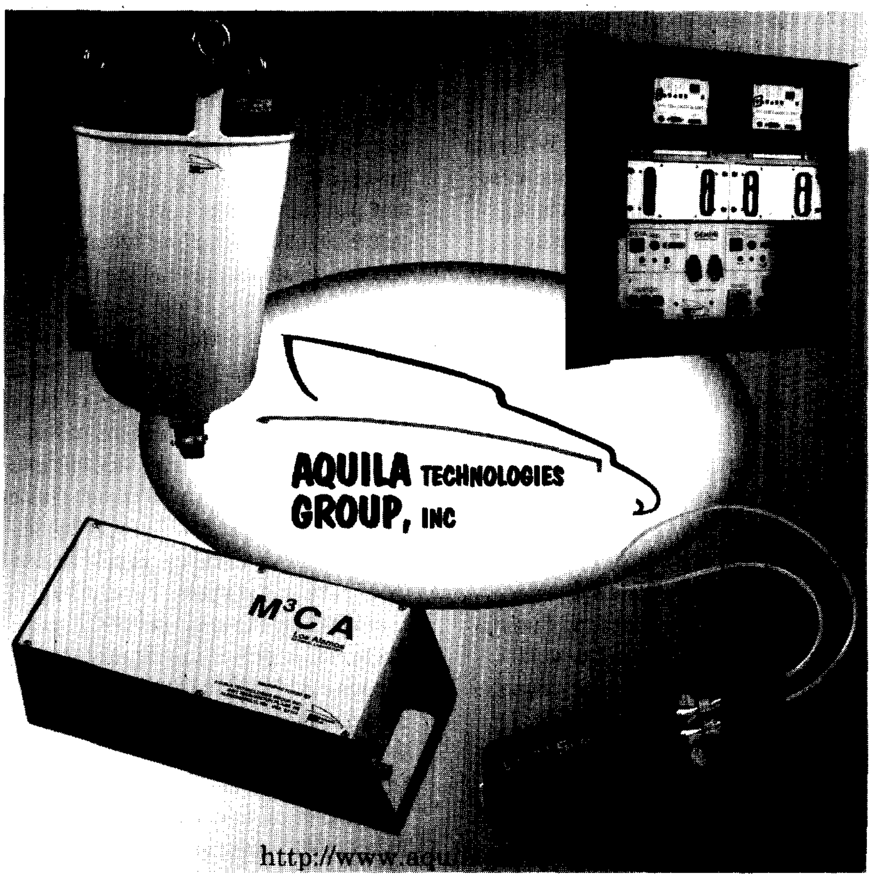
Mikhailov worked at the All-union Scientific and Research Institute of Experimental Physics and at the Scientific and Research Institute of Impulse Engineering. He is a scientific leader of the Russian Federal Nuclear Centre - Research Institute of Experimental Physics. He is also a professor and author of more than 250 scientific articles.

Vienna Chapter Safeguard Symposium

On March 14, the Vienna Chapter held its annual Safeguards Symposium at the Vienna International Centre. The keynote address was presented by Richard Hooper, director of the Division of Safeguards Concepts and Planning, who reported on the status of Programme 93+2. Of particular interest are plans for field tests of Part II measures. The discussion draft of Part II of Pragramme 93+2 invited member states to voluntarily begin implementation of Part II measures. Canada and Switzerland have already accepted this invitation.

Additional presentations were made by Jack King, "An Information System for Analysis of Environmental Measurements;" Mark Killinger, "An overview of IAEA Remote Monitoring Activities;" Ron Liikala, "The Safeguards R&D and IS Programme;" Marian Russel, "Using NMAX to Select a Random Sample of Items;" T. Dragnev, "Gamma and X-ray Measurements of Nuclear Material Element Mass Fraction;" and Bernard Wishard, "Technique for Automated Energy Calibration and Stabilization of Seeded NaI Detector Spectra." Liikala's paper was selected by a review panel to represent the Vienna Chapter at the Annual Meeting of the INMM in July. Bruno Pellaud, deputy director general for safeguards, will fund Liikala's travel to the Annual Meeting.

The Vienna Chapter Symposium provides a forum for Safeguards staff to discuss their work with colleagues from other sections of the IAFA. It also introduces the INMM to the international community of the IAFA.



Summary of the workshop "Plutonium Inventories: Growing Challenges in MC&A and Nonproliferation"

On May 1-2, 1996, the INMM MC&A Technical Division sponsored a workshop on "Plutonium Inventories: Growing Challenges in MC&A and Nonproliferation." The workshop was divided into three sessions followed by a panel discussion.

Session I focused on plutonium inventories, with talks on excess weapons inventories and disposition plans (Jim Toevs, Los Alamos), IAEA models of increasing inventories of commercial plutonium (Jim Finucane, IAEA), models of future electrical power usage and plutonium production (Ed Rodwell, EPRI), an update on the ANS Special Panel Report on Protection and Management of Plutonium (Hal Bengelsdorf), and DOE plutonium inventories (David Crawford, DOE).

The second session focused on near-term approaches and options for addressing the safeguards issues associated with plutonium inventories. This included a paper prepared by Denny Mangan and presented by J.D. Williams (Sandia) on an IAEA consultants meeting on excess plutonium safeguards/inspection, talks about minimizing inventories from reprocessing by Frank Shallo (COGEMA) and Y. Matsuo (Federation of Electric Power Companies of Japan), International Storage concepts (Rich Wagner, Los Alamos), and domestic approaches to physical protection (J.D. Williams).

The third session, on long-term options for addressing plutonium inventories, included talks by Mark Abhold (Los Alamos National Laboratory) and Ken Ystesund (Sandia National Laboratory) on advanced safeguards, Myron Kratzer on consolidated reprocessing and fuel cycle facilities, Ed Arthur (Los Alamos) on selected technologies for plutonium inventory reduction, and F. Venneri (Los Alamos) on accelerator-driven transmutation concepts.

The panel, moderated by Joe Pilat of Los Alamos, consisted of David Albright (Institute for Science and International Security), Larry Scheinman (ACDA), Myron Kratzer, Albert de Montalembert (COGEMA), and Y. Matsuo (Federation of Electric Power Companies of Japan), addressed the question "Is the accumulation of plutonium a growing proliferation risk or is separation of plutonium followed by its burning in nuclear systems a greater risk?"

Summary of presentations:
Because all of the presentations were closely related, the overall discussion is summarized here instead of a review of each talk. The observation was made that none of the disposition options being considered for U.S. excess plutonium will result in a significant net reduction in the plutonium inventories (although MOX burning will modify the plutonium isotopic composition). There were a number of discussions regarding the credibility of using high ^{240}Pu content plutonium versus weapons-grade materials to constitute or reconstitute nuclear weapons. Several participants asserted that none of the weapons states would consider using high-burn-up plutonium for military purposes, so burning excess materials in reactors is effective for ensuring irreversible arms reductions, even though it does not mitigate proliferation concerns. To track plutonium existing in the civilian fuel cycle, the IAEA is developing simple models of growth in the areas of spent fuel reprocessing capacity and MOX production It is projecting reprocessing capacity of 5,000-6,000 THM/a between the present and the year 2010, with MOX fabrication rates increasing from 93 tonnes to 700 tonnes. There are 126 tonnes of separated plutonium today (1995) with an expected peak of 180 tonnes in the year 2000. The United Kingdom is separating Magnox reactor fuel plutonium (because the spent fuel cannot be stored for long periods) but has no plans to use this plutonium. It is expected to accumulate 80 tonnes by the year 2010.

The models used by the Electric Power Research Institute (EPRI) to project trends in future nuclear energy demand are complex. The nominal model reviewed at the workshop assumed nuclear power generation in the year 2050 that is five times the current capacity, resulting in one million tonnes of spent fuel. Electricity costs are not very sensitive to uranium costs. Under a number of assumptions, the model predicts that U_3O_8 costs of between $40-$85/lb would make plutonium fuels competitive with normal low enriched uranium fuels. However, it was reemphasized that the economic competitiveness of the fuel is only one of several considerations (such as the nonproliferation value of responsibly minimizing the global plutonium inventory) that must be made in developing long-term strategies for plutonium.

Discussions regarding the use of European MOX plants to fabricate fuel using excess weapons plutonium centered around the question of existing capacity. Statements have been made that there is no excess capacity in European MOX fabrication facilities. However, the COGEMA representatives expressed an interest in accommodating an "early start" on MOX fabrication of excess plutonium from U.S. or Russian sources. While they could not commit their entire capacity to this, they have several options available for increasing the existing capacity. This would provide the nonproliferation benefit of converting at least some excess plutonium to civil energy production while the broader disposition issue is developed.

DOE plutonium inventories, inventory differences, and normal operating losses were reviewed, and the fissile materials assurance working group was described. International storage approaches and consolidation of all "sensitive" fuel cycle facilities were discussed as an option for reducing the global plutonium inventory while controlling the proliferation threat of separated plutonium. The ideas are not new, but their relevance in the near future may increase as the world addresses the growing civilian and excess military plutonium inventories. International plutonium management is becoming a reality in that reprocessors are storing foreign spent fuel, separated plutonium, and high-level waste for customers until the customers can take delivery on the plutonium and waste. These stores are under regional and international safeguards in weapons states (United Kingdom and France), where diversion by the storing party is considered unlikely. Just-in-time delivery of MOX fuel to other countries for consumption in reactors could be an element of international plutonium management. This option of reducing or stabilizing the world plutonium inventory contrasts with the observation that all plutonium storage options, including deep bore holes and vitrification, result in fissile material that is retrievable to some degree.

Advanced safeguards for declared facilities and materials will depend on the use of technology for continuous, unattended monitoring with remote transmission of data. Remote monitoring is of concern to the IAEA because of the possible denial of inspector access to areas under remote monitoring. Likewise operators of nuclear facilities are concerned over increased levels of safeguards beyond what is presently agreed through the use of remote monitoring. At the same time, both sides acknowledge the need to reduce overall safeguards costs in this period of flat or declining budgets but increasing safeguards needs. Advanced safeguards techniques may provide a means to simultaneously address many of these concerns.

On the topic of plutonium accumulating in spent fuel, some hold that spent fuel is a proliferation risk and that buried spent fuel is retrievable. A number of advanced technologies for plutonium inventory reduction were reviewed, including high-burnup reactor and accelerator systems and development of nonfertile fuels that do not breed plutonium for use in current and future light water reactors (LWRs). A number of such technical options for inventory reductions could couple into current and advanced fuel cycle facilities. There is no reason to assume that the fairly primitive fuel cycles of today will be the choices for 50 years from now.

Summary of the Panel Discussion: Larry Scheinman began the panel session by noting efforts and current Clinton administration policies to deal with fissile materials in general and the commitments related to fissile materials made at the NPT Review and Extension conference last May. Accumulation of plutonium and separation and burning were both noted as risky. Solutions for excess military plutonium do not necessarily imply solutions for civil plutonium. A number of panelists mentioned the difficulty of assessing proliferation risks of plutonium. David Albright noted that many factors need to be considered, including the adequacy of safeguards and the proliferation credentials of the owner/custodian. The world must be realistic and recognize that some countries cannot be trusted. Plutonium inventories and even numbers of locations, by themselves, were not seen as good metrics of risk, although consolidation of sites and minimization of inventories is considered good practice.

There was a general consensus in the importance of improving safeguards. This is not to say that existing safeguards are inadequate, rather that all surety endeavors may worsen without continual improvement. Civilian nuclear power provides a potential cover for other nuclear enterprises, which reemphasizes the need for increasingly advanced safeguards techniques. The driving issue relative to the risks of any nuclear activities is the overall and regional state of security. States will do what is necessary to maintain national security.

Arthur de Montalembert described the strong ties between the nuclear industry and nonproliferation in Europe that results from all of their facilities being under EURATOM safeguards. He noted the need to understand the pathways to proliferation to assess the risks of plutonium use. He feels the risks in civilian plutonium use are small overall as compared to other routes to produce nuclear weapons. The French representatives expressed their position that there are significant nonproliferation benefits of converting weapons grade plutonium to reactor grade plutonium. Y. Matsuo stated that both MOX burning and vitrification (in the case of lower concentration materials) are good options for excess weapons materials. He said we should burn high-grade plutonium quickly. It is also important to place all these activities under IAEA safeguards, even though it will be costly. All countries should help with the financial burden. The Japanese fuel cycle will balance plutonium supply and demand, a strategy that relieves the near-term build up of separated plutonium and reduces the inventory of plutonium in spent fuel that requires disposal. Matsuo noted technical innovations by Los Alamos, for example beginning development efforts for nonfertile fuels for LWRs, as providing promise for helping to deal with plutonium in the future.

In his remarks Myron Kratzer asserted that the question before the panel was a very serious one. Spent fuel is a proliferation risk, but the context is important. He suggested simple examples comparing different risks to illustrate the point:

- 1 kg separated plutonium compared to 1 kg of plutonium in spent fuel;
- 100 kg separated plutonium compared to 10,000 kg in aged spent fuel; and
- 100 kg separated plutonium in a country with stable national security compared to 100 kg in a country that does not have stable national security.

Ultimately, there is a need to balance plutonium creation with burning.

As in the meeting of the Japan Chapter of the INMM in December, the question of the nonproliferation and arms control benefits of degrading plutonium isotopics was raised. No amount of unclassified opinion from the labs about the threat of all plutonium compositions in explosive devices will counter the widely accepted fact that all weapons states acknowledge using only low-240 Pu in their military weapons. Much of this debate hinges on the proliferation scenario. The possibility of a terrorist country arming itself with a nuclear capability based on high burn-up plutonium was generally accepted. Scenarios where a country builds a militarily significant nuclear weapons capability using high burn-up plutonium appears more contentious on historical grounds, even though it is technically viable.

James Tape, Ed Arthur, and Chad Olinger (Los Alamos National Laboratory)

ESARDA/INMM Workshop on Science and Modern Technology for Safeguards

In today's world, the nonproliferation of nuclear weapons is vitally important. Safeguards and nuclear material management lie at the heart of nuclear nonproliferation. In order to promote research and development in the field of safeguards and to encourage the advancement of nuclear materials management, the European Safeguards Research and Development Association (ESARDA) and INMM are jointly sponsoring a workshop on Science and Modern Technology for Safeguards. This workshop will be held October 28-31, 1996, in Arona, Italy, at the Hotel Concorde on the shore of Lago Maggorie, some 25 km from the European Community's Joint Research Center at Ispra. The co-chairmen of the workshop are G. Stein, KFA, Juelich, Germany, and C.S. Sonnier, DOE consultant, Albuquerque, N.M.

The workshop will be open to the memberships of ESARDA and INMM, as well as to other colleagues in the scientific and international safeguards community. The workshop is not intended to produce any immediate products for safeguards application, but rather to identify several areas toward which research may be directed for future safeguards applications.

Purpose of the Workshop

The purposes of this joint Workshop on Science and Modern Technology for Safeguards are:

1. To inform the safeguards community about selected sciences and advanced technologies that are currently available or will become available in the next few years and that could be used to support needed advances in international safeguards, and

2. To stimulate application of these sciences and advanced technologies to safeguards by providing an opportunity for technical interchange among experts in the various technologies and in safeguards.

Safeguards, as they exist today, rely on established procedures that are applied within a legal framework at the regional, national, and international levels. In particular, the EURATOM Safeguards Directorate of the European Commission is responsible for verifying the application of these procedures within the European Union, as provided by the relevant provisions of the Rome Treaty of 1957. The International Atomic Energy Agency (IAEA), on the other hand, has a worldwide responsibility for the application of international safeguards associated with the Nonproliferation Treaty (NPT) and with various international safeguards agreements.

A number of recent developments in various parts of the world have presented new challenges to the organizations responsible for international safeguards. These developments include the discovery and documentation of the Iraqi nuclear weapon development program; the statement by North Korea of its intent to withdraw from the NPT and subsequent nuclear inspection activities in that country; the breakup of the Soviet Union and subsequent creation of a number of newly independent states that possess significant amounts of nuclear materials; and the submission by nuclear weapon states of stocks of excess nuclear materials of military origin to international control.

It is essential to maintain an effective level of safeguards in our changing world. This will require a robust and flexible technology base that can cope with new situations. Furthermore, future safeguards activities must be conducted in a practical manner without adding unnecessarily to the existing requirements for staffing and funding. This will require that new technology, new data handling and analysis capabilities, and new procedural approaches be incorporated into safeguards activities. This joint workshop is one means by which this goal can be fostered.

Workshop Topics
The workshop will provide a forum for the presentation and discussion of selected fields of science and technology that have not as yet been considered or have not as yet been fully exploited by safeguards experts. The workshop will provide an opportunity for invited experts in these selected fields and invited experts in safeguards to explore possibilities for the application of these technologies to safeguards. We expect the workshop to help determine the extent to which the selected technologies can be used to improve safeguards in the future and to propose to the scientists and technologists currently working in these areas new research and development activities relevant to safeguards needs.

The workshop will be divided into four working groups. Each group will address a number of selected technology fields, with emphasis on the application of the technology to specific safeguards areas. The working groups and technology topics associated with each group are as follows:

Working Group I — Data Collection
- New sensor technology
- New measurement technology
- Open skies platform
- Environmental sampling
- In-process sampling
- Satellites

Working Group II — Data
- Collection/organization
- Computer hardware
- Networks
- Remote monitoring
- Multimedia
- Virtual reality
- Data storage/retrieval/transmission
- Relational databases
- Fuzzy logic/gray logic

Working Group III — Data
- Analysis/decision support
- Relational databases
- Fuzzy logic/gray logic
- Artificial intelligence
- Neural networks
- Expert systems
- Satellite imagery
- Bayesian analysis
- Theory of evidence
- Statistics/decision theory
- Game theory

Working Group IV — Political/Social
- Framework
- Statistics/decision theory
- Game theory
- Conflict theory
- Conflict analysis
- Compliance verification
- Regime theory

A number of technology experts will be invited to present papers describing their areas of expertise and current applications for their technologies. With the help of a moderator and several invited safeguards experts, the technology experts will be asked to engage the working group in a discussion of the prospective applications of their technology specialty to safeguards. During the workshop activities, other non-invited personnel interested in the subject under discussion can participate, but time will preclude their presenting papers.

Each working group will prepare a summary of its discussions. Following

INMM/ESARDA Workshop
The Institute for Nuclear Materials Management and ESARDA will hold a joint workshop, Modern Science and Technology for Safeguards, October 28–31, 1996, at the Hotel Concorde of Arona in Italy. The objective of the workshop is to discuss how the latest improvements in technology and sciences could contribute to establishing new and cooperative research programs for strengthening safeguards and improving its effectiveness and efficiency.

The meeting will assemble safeguards experts and specialists of various disciplines including:
- Environmental and in-process sampling,
- Satellites and satellite imagery,
- New sensors and new measurement technology,
- Networks and neural networks,
- Multimedia technology,
- Expert systems,
- Artificial intelligence,
- Decision theory,
- Game theory, and
- Conflict analysis.

Participants will discuss how the various disciplines can find application to data generation, collection, organization, analysis and use for decision support in the area of safeguards. Safeguards within the political and social sphere will be discussed. Although participation in the seminar is reserved to invitees, observers will be admitted at no charge. For more information please call F. Genoni at +39-332-789421.

Accommodations

The Hotel Concorde is a four-star hotel located only 200 meters from the center of Arona, facing the lake. The rooms are comfortable and equipped with modern amenities, including air conditioning and international TV channels. The hotel features an excellent restaurant, and there are variuos other restaurants within 300 meters of the complex.

Prices for a single room:

- Bed and breakfast (buffet): 140,000 Liras/day ($89)
- Half board with the possibility of choosing between a buffet lunch or dinner: 170,000 Liras/day ($108)
- Full board, which includes buffet breakfast, lunch and dinner: 210,000 Liras/day ($133)

Workshop participants will be free to choose between these three different arrangements. The U.S. equivalents are calculated on the basis of the present exchange rate of $1 to 1,580 Liras.

the working group sessions, the summaries will be presented to a panel of experts and to all workshop participants. We expect additional insights to be offered during this part of the program. The formal presentations, the Working Group summaries, and the results of the panel discussions will be published in the workshop proceedings.

The format of the four-day workshop will be as follows:

Day 1 — Opening plenary session in the morning; start of working group activities in the afternoon

Day 2 — Continuation of the activities of the working groups

Day 3 — Completion of the working group activities in the morning and preparation of the working group reports by the chairman in the afternoon

Day 4 — Plenary session including presentation of the results of working groups, panel discussions, and overall conclusions

We expect the workshop to entail lively and interesting discussions of technologies that offer significant opportunities for the improvement and expansion of safeguards technology. We hope to have a high level of participation from INMM. For additional information, please contact Cecil Sonnier at (505) 298-0490, e-mail css-bas@rt66.com, or Steve Dupree at (505) 844-9930, e-mail sadupre@sandia.gov. Please use the attached registration and accommodation form on page 13.

The city of Arona is 70 km northwest of Milan, on the shore of Lago Maggiore, a popular holiday resort about 25 km from JRC Ispra. The Hotel Concorde, a four-star hotel, is located 200 m from the historic center of the town, where shops and restaurants are located. Arona is easily accessible by air through Milan and inter-city trains. It is on the Simplon Pass rail line, and a hotel shuttle is available for transportation between the Arona railway station and the hotel. Guests arriving from the Milano Malpensa Airport will be met by a JRC courtesy car at the airport.

Steve Dupree
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Informal Report on the Seminar "NPR-96 on Nonproliferation and Safeguards of Nuclear Materials in Russia"

The Russian Federation Chapter of INMM cosponsored a seminar "NPR-96 on Nonproliferation and Safeguards of Nuclear Materials in Russia" along with the Russian Nuclear Society and the Russian Research Center-Kurchatov Institute (RRC-KI) on May 14-17. The conference was held in Moscow at the Kurchatov Institute and at a conference center near the meeting hotel. A high point of the meeting was Russians presenting papers to other Russians on MPC&A (Materials Protection, Control and Accounting) and export control collaborations being undertaken with U.S. and other international collaborators. This kind of information sharing was uncommon in the USSR, even in the basic sciences, and will be important in the future for achieving continuous improvements in Russian MPC&A, export control and broader nonproliferation initiatives.

In the opening talk, academician N. Ponomarev-Stepnoy reviewed the history of the nonproliferation regime and some of the current concerns, including threshold states, states with questionable credentials, Newly Independent States (NIS) with nuclear potential, and nuclear terrorism. He noted that proliferation is a major threat and should be a factor in all decisions.

Ponomarev-Stepnoy also covered the need to reduce the attractiveness of nuclear weapons and the importance of political approaches supported by technical measures. He briefly reviewed remote monitoring and touched on the requirement for verification technologies to support transparent dismantlement, cutoff and peaceful uses. In addition, he covered the following topics:

- The proposed fissile materials production cutoff treaty,
- Excess weapons materials (noting that the U.S. and Russian positions on Pu use/disposition are different),
- The continuing requirement for support to the International Atomic Energy Agency (IAEA),
- The need for improved methods to detect undeclared materials, and
- A suggestion for a systems analysis that would look at all treaties and how they work together.

During the opening session, Don Cobb (Los Alamos National Laboratory) discussed global nuclear materials controls, and described the interplay between facility-level controls; national, regional, and international controls; transparency and cooperative measures; and multilateral agreements and control measures — including export control and proliferation response. A.M. Dmitriev (Gosatomnadzor, Russia) touched on the development of the State's System of Accounting and Control (SSAC) of nuclear materials in the former Soviet Union and changes in Russia. Finally, Ken Luongo (U.S. Department of Energy) reviewed the initiatives undertaken from the Clinton administration and the Department of Energy relating to the control of nuclear materials — which included the lab-to-lab and government-to-government MPC&A programs with Russian and other NIS republics.

The afternoon program consisted of tours of sites at Kurchatov, where the opening session was held, to observe export-control computer systems, remote monitoring at the Gas Plant, the first European reactor and MPC&A upgrades at Building 116.

Talks on the second day shifted to a conference center located next to the hotel — the Central House of Tourists, a Russian hotel some distance from the center of Moscow. Various speakers talked about smuggling pathway analysis; export control efforts in Russia and how the U.S. laboratories support nuclear export controls; physical protection upgrades and MPC&A activities at Kurchatov; radiation measurements for MC&A; verification of spent fuel; the French program of support to the IAEA; and developments in nondestructive assay (NDA) equipment.

The third day highlights included a presentation by the Minatom Atominform Institute on automated nuclear MC&A systems, as well as other Russian talks on automated MC&A systems, remote monitoring, NDA equipment, and lab-to-lab MPC&A progress. A Russian paper on the physical criteria of nuclear nonproliferation analyzed the barriers to weapons use provided by chemical composition, including factors such as critical mass, heat output, neutron background radiation, and physical inaccessibility. The lab-to-lab programs were described as moving from a demonstration phase to large-scale implementation in Russian plants.

The day ended with a roundtable discussion on ex-military materials use and control. The exchange aired all of the usual issues and points of agreement and disagreement on this topic.

Friday morning's session consisted of non-Russian talks, starting with Britain's John Baker who talked about enhancing Russia's nuclear nonproliferation efforts. Dick Combs of the Monterey Institute and former staff member of U.S. Senator Sam Nunn, spoke on future Nunn-Lugar initiatives. Other talks on this day included reviews by U.S. participants on various aspects of the lab-to-lab and government-to-government MPC&A collaborations.

Overall, this was a successful seminar, and the Russian Federation Chapter members are to be congratulated for their efforts in helping to organize and cosponsor this meeting. Hopefully, this is the first of many meetings the INMM will facilitate in Russia — the goal being to expand professional development and communications broadly across the entire nuclear materials management community.

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Activities of the INMM Safeguards Division

The INMM and the European Safeguards Research and Development Association (ESARDA) will conduct a Joint Workshop on Science and Modern Technology for Safeguards, which will be held from Oct. 28–31, 1996 in Arona, Italy. Detailed material on the workshop is contained in this issue of the *Journal.* Given the expected results from this workshop, plans are underway for a similar event in the United States in 1998.

The next meeting of the INMM International Safeguards Division (ISD) will be held on July 28 at the Registry Hotel in Naples, Florida. Principal topics to be discussed include the status of the IAEA 93+2 Programme and perceptions regarding future safeguards.

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INMM Chair's Message

Continued from page 5

and our other colleagues. We truly live in a small world and our similarities and common interests are greater than our differences. And where we do differ in culture and background, we gain professionally and personally from our diversity.

It has been a privilege and an honor to represent the members of the INMM in this role and to have the opportunity to work with outstanding professionals from around the world in furthering the responsible management of nuclear materials.

Thank you!

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A *JNMM* Series: Safeguards Innovations Through Global Cooperation

■
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■

The global marketplace continues to demand the most cost-effective use of nuclear resources for the production of energy, medicine, and agriculture. This nuclear demand has lead to the global expansion and sophistication of nuclear production capability. The tremendous benefits of nuclear products are counterbalanced by the side effects of the increased risk of nuclear proliferation. The nonproliferation community's challenge is to improve the effectiveness of nuclear safeguards while minimizing its impact on nuclear productivity. The necessary safeguards innovations will become the cornerstones to the continued profitability[1] and acceptance of the international verification regimes.

The safeguards community has limited resources for the development of new safeguards innovations and should create partnerships to share costs. Such "global cooperation" will allow organizations to exchange ideas and expertise, and to develop safeguards solutions in a more economical and timely manner.

The U.S. Department of Energy (DOE) provides technical leadership to formulate and implement U.S. nonproliferation policy. DOE's safeguard activities range from conducting training to developing equipment for the world's most advanced plutonium and uranium handling facilities. Since the 1970s, DOE has sought the help of its international partners to develop solutions that will improve safeguards. Currently, DOE has agreements for cooperation in place with 11 other national and multinational organizations. These partnerships provide a unique opportunity to augment DOE expertise with the technical capabilities of international experts.

One important example of these safeguard-partnership efforts is the cooperation between DOE and the Power Reactor and Nuclear Fuel Development Corporation of Japan (PNC). The first PNC-DOE Safeguards Agreement was signed on March 31, 1988, for a five-year duration. The agreement was extended on March 31, 1993, and a new, second agreement was signed on September 15, 1993, for another five years. The primary objective is to collaborate on development of advanced safeguards equipment to be used by the International Atomic Energy Agency (IAEA) at PNC facilities. The agreement represents a mature relationship that, to date, has resulted in 23 separate projects, including six new ones in the last year.

The following paper is the second in a series of *JNMM* articles on partnerships aimed at improving safeguards. The paper "Smart Unattended Systems for Plutonium Safeguards," provides insight into PNC's and DOE's collaborations that resulted in the next generation of safeguards technology.

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[1] Profitability is the difference between the effectiveness of safeguards and the cost of applying them.

Smart Unattended Systems for Plutonium Safeguards

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Introduction

During the past decade, International Atomic Energy Agency (IAEA) inspectors, national inspectors, and facility operators have used neutron coincidence counters[1,2] and gamma-ray isotopics measurements extensively to measure the plutonium content of various forms of nuclear materials in the fuel cycle. Of special importance for these verification measurements are the input, output and in-process inventory of nuclear fuel fabrication facilities.

Large automated facilities for fabricating plutonium fuel present both difficulties and challenges for improved accounting of nuclear materials. The traditional methods of sample measurements, requiring the transfer of the sample from the production line to the assay measurement station, are not possible in automated facilities. The robotics used for automation require special containers for nuclear material that cannot be easily removed from the production line. Safety and radiation protection considerations also require that the assay instrumentation be installed in the fuel production lines because, in general, personnel cannot be in the fuel-handling area with nuclear material during operations. Such operational constraints are common in many of the modern facilities that have been designed for fabricating and processing plutonium fuel.

A bilateral safeguards agreement between the U.S. Department of Energy (DOE) and Power Reactor and Nuclear Fuel Development Corporation (PNC) in Japan was signed to develop and implement nondestructive assay (NDA) systems to provide continuous safeguards measurements for material accountancy in the robot-automated Plutonium Fuel Fabrication Facility (PFFF). The PFFF assay systems were required to operate in unattended mode with a size and fuel mass capability to match the robotics fuel manipulators. Unattended assay systems reduce the requirement for inspector's oversight of measurement operations, reduce the inspector's workload, and improve inspection efficiencies. In addition, unattended measurements become essential when facility constraints limit the access of inspectors to the operations area during material processing. Authentication techniques were incorporated into the NDA systems so that data obtained from unattended assays could be used by independent inspectors such as the IAEA.

The standardized containers and robot-controlled fuel movements in automated facilities enable more accurate nondestructive assay (NDA) measurements than are possible in conventional nonautomated facilities. The NDA instrumentation can be custom designed and optimized for the particular measurement goal in the automated facility.

PNC MOX Fuel — Fast Reactor Facilities

Construction was completed in 1987 on the Plutonium Fuel Production Facility (PFPF), which is located at Tokai-Mura, Japan. PFPF fabricates MOX fuel assemblies for the experimental fast reactor JOYO and the prototype fast reactor MONJU. Figure 1 is a map of Japan showing the Tokai site where the PFPF facility is located and photographs of the JOYO and MONJU reactors.

MOX Fuel Fabrication Safeguards

At the PFPF, NDA instruments were installed to give complete safeguards measurements of all the plutonium in the facility. PFPF uses state-of-the-art robot automated technologies to process efficiently and to produce up to five tons of MOX fuel per year. Table 1 lists the NDA measurement systems and their locations within the plant. Figure 2 is an illustration of the PFPF fuel-manufacturing-process floor plan and locations of the NDA instruments listed in Table 1. In addition to the input and output locations, the more difficult-to-access locations such as glove boxes, process equipment and waste containers are included in the measurement coverage.

The material categories that are measured (Figure 3) include the input mixed-oxide (MOX) powder and the output fuel assemblies. The process-line MOX powder, pellet trays, and scrap are measured inside the glove-box lines using detectors outside the glove boxes. The MOX holdup in glove boxes, furnaces, and process equipment is measured using large-slab

Table 1

NDA Systems in Use at the MOX Fuel Fabrication Facility Developed Under Agreement Between DOE and PNC.

Location	Detector System
1	*PCAS - Plutonium Canister Assay System (input)*
2	*FAAS - Fuel Assembly Assay System (output)*
3	*FPAS - Fuel-Pin Assay System counter*
4	*MAGB - Material Accountancy Glove-Box counter*
5	*GBAS - Glove-Box Assay System, holdup counter*
6	*WDAS - Waste-Drum Assay System*
7	*INVS - Inventory Verification Sample counter*
8	*PSMC - Plutonium Scrap Multiplicity Counter*

Figure 2. PFPF facility MOX fuel-manufacturing floor plan and locations of nondestructive assay instrumentation in the process lines.

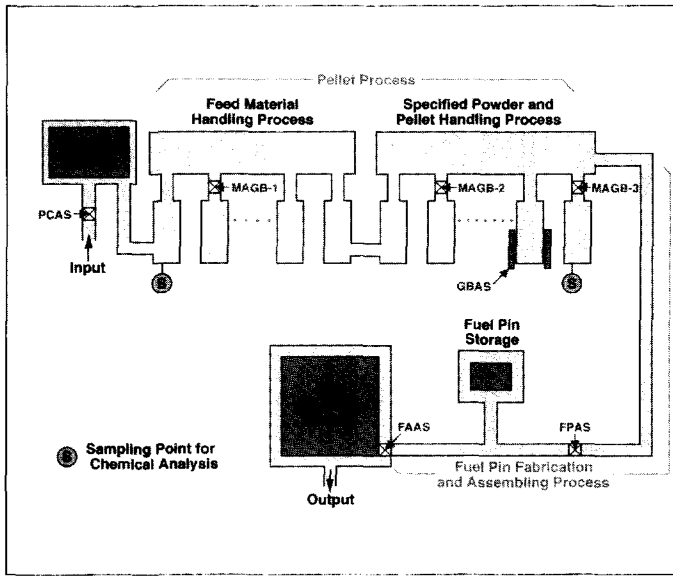
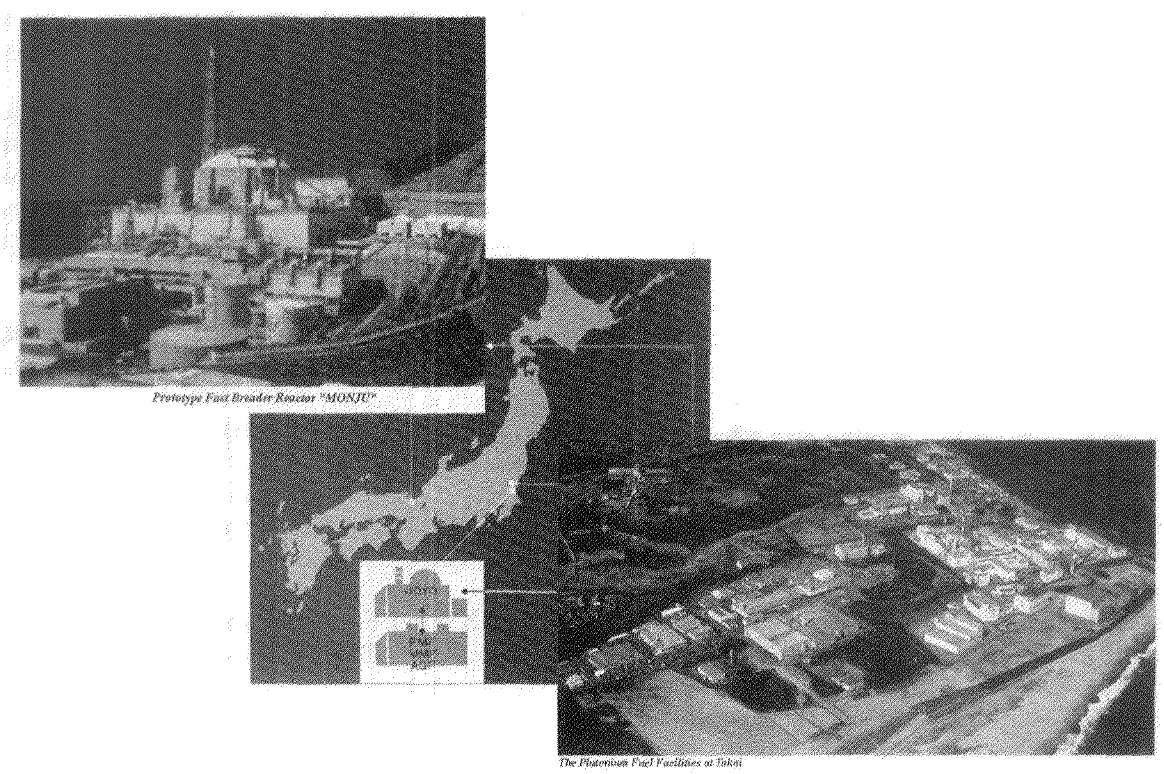


Figure 1. Map of Japan showing location of facilities.



detectors on the outside of the equipment. Small-grab samples destined for chemical analysis also are measured in the NDA systems before analysis.

The measurement systems listed in Table 1 are based on passive neutron coincidence and multiplicity counting of the ^{240}Pu-effective mass using ^{3}He counters and gamma-ray isotopics measurements that use high-resolution germanium detectors. Neutron multiplication corrections are made as needed. The plutonium isotopic ratios are obtained by mass spectroscopy of grab samples and/or gamma-ray spectroscopy. Isotopics in shielded samples are measured using the FRAM isotopics code[3].

After multiplication corrections, the coincidence neutron yield is directly proportional to the ^{240}Pu-effective mass. Thus, by measuring the coincidence neutron yield from all of the plutonium in the facility, the entire plutonium inventory can be verified. Of special significance for the PFPF facility is the capability to make routine quantitative measurements of the holdup and waste materials.

A description of the NDA systems used for material accountancy at PFPF follows.

Plutonium Canister Assay System (PCAS)

The PCAS[4] (Figure 4), measures plutonium powder contained in storage canisters. The counter was designed for installation in the fabrication plant as part of the automated canister-transfer system. Each canister contains from one to four cans of MOX or PuO_2. The neutron counter measures the spontaneous-fission rate from the plutonium. When this is combined with the isotopic ratios, the plutonium mass is determined. The system can accommodate plutonium loadings up to 10 kg, with 5 kg being a typical loading. Software permits the continuous unattended operation of the system.

To accommodate the shape and height of the sample container (canister), it was necessary to design the detector body to fit in an annulus defined by the canister cart and transfer barrel. The detector fits between the central concrete shield and the outside steel wall.

The canister is lowered into the detector by an automated overhead manipulator. After the sample is released, the combined sample, detector, and transfer cart move horizontally for several meters to the sample identification camera. The neutron measurement is performed during the travel of the transfer cart. Thus the power and signal lines connecting the detector to the electronics are designed to move with the robotics system.

A ^{252}Cf neutron source located inside an empty canister is used to check the calibration and performance of the system. The plant robotics system can automatically position this source in the detector for routine performance checks, control charting, and possible renormalization. This detector has an efficiency of 15.1 percent and a die-away time of 57 ms.

Because the canisters are filled with four or fewer separate cans, the PuO_2 distribution is guaranteed to be nonuniform along the canister axis. This makes it important to have a uniform counting efficiency. The calibration of the counter is based on the multiplication-corrected reals rate Rmc because the heterogeneous samples and variable uranium content affect the multiplication.

Fuel Assembly Assay System (FAAS)

The FAAS[4] (Figure 5) was designed for unattended measurements of plutonium fuel assemblies contained in storage capsules. The FAAS, or capsule counter, is coupled to the automated capsule transfer system. Each capsule contains one liquid-metal fast breeder reactor (LMFBR) fuel assembly. The neutron counter measures the spontaneous-fission rate from the plutoni-

Figure 3. Diagram of the PFPF facility MOX material locations and the corresponding NDA systems. The numbers correspond to the measurement systems listed in Table I.

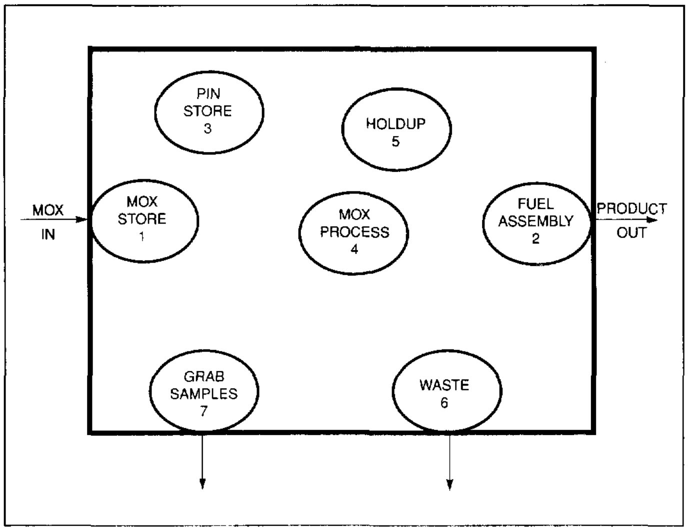


Figure 4. A photograph of the plutonium canister assay system.

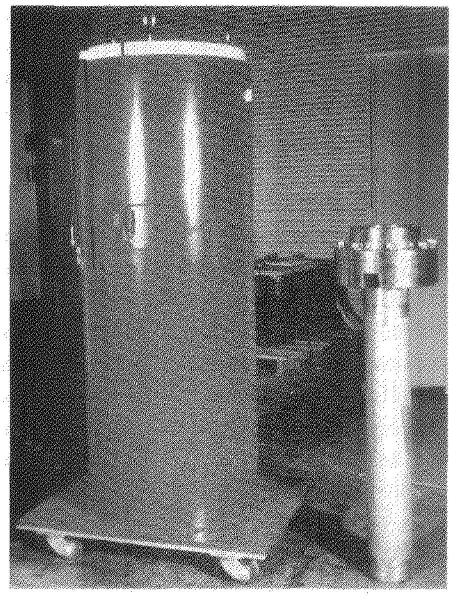
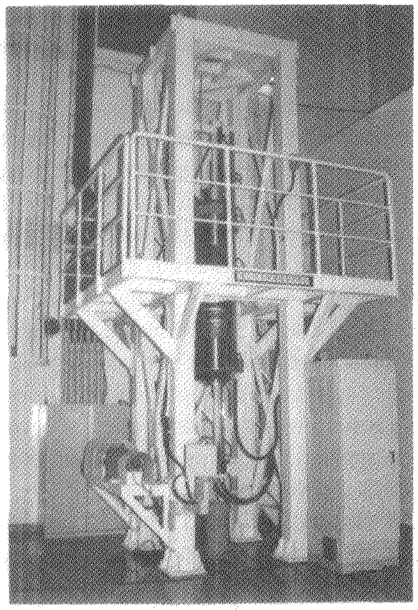


Figure 5. Photograph of the fuel assembly assay system.



um, and when this is combined with the plutonium isotopic ratios, the plutonium mass is determined. The system can accommodate plutonium loadings up to 10 kg.

The capsule counter is designed to accommodate the 5-m-long capsules containing fuel assemblies that are lowered into the detector by the capsule robotics system. When the bottom of the capsule reaches floor level, the plutonium zone is several meters above it; thus it was necessary to build a support stand for the detector to lift it to the fuel zone.

The neutron counting efficiency of the detector is 16.1 percent. Because of the well-defined fuel composition and good standards, the assay accuracy for fuel assemblies is better than 1 percent.

The detector operates in the continuous mode with data dumps every minute. The totals rate in the counter thus gives a time history of the movement of PuO_2 in the room or nearby areas. The detector is unshielded, has an exterior surface area of about 18,000 cm^2 and an intrinsic efficiency of about 16 percent. Thus the sensitivity is high for detecting neutron source material in the vicinity of the detector.

Fuel-Pin Assay System (FPAS)

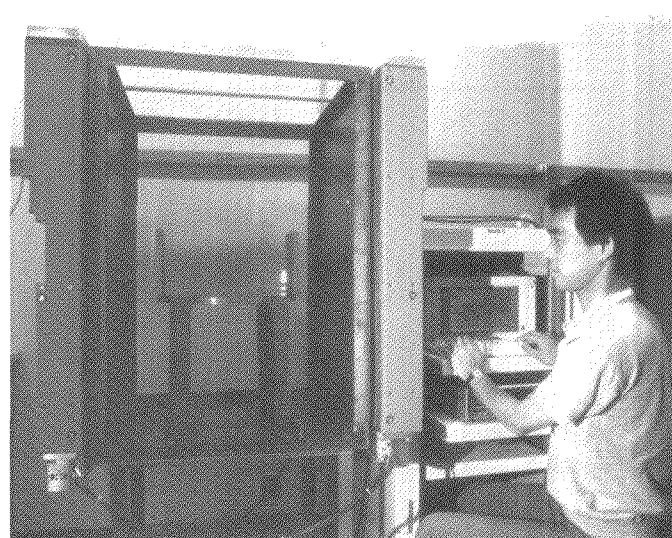
The FPAS[5] (Figure 6) measures the plutonium content of up to 24 pins of MOX fuel. Trays containing the pins to be assayed are retrieved by a robotic conveyor from the storage area and brought into the counter. The FPAS was designed to have a relatively flat response of more than a 1.2 m area to allow both JOYO and MONJU fuel pins to be assayed. Measurements may be collected either attended or unattended. If unattended, the FPAS computer sends a signal to a camera that automatically records the tray identification.

Material Accountancy Glove Box (MAGB) Counters

Three MAGB[6] counters (Figure 7) were developed to measure samples of powder and pellets from the various PFPF process areas. These samples are positioned on load cells inside the glove boxes by the robotic transfer system; the MAGB counters are mounted outside the glove box at the load cells. Samples may contain up to 18 kg MOX. MAGB-1 primarily measures feed powder, MAGB-2 mostly measures recycle powder and green pellets and MAGB-3 assays primarily sintered pellets. The accuracy of the MAGB plutonium assays is in the range of 1 percent to 3 percent, depending on the fuel category. All MAGB systems have similar detectors so that each counter serves as a backup for the other two. Software allows for either attended or unattended operation. When operated in unattended mode, the MAGB computer sends a trigger signal to a camera for sample identification.

Figure 6. Photograph of the fuel pin assay system.

Figure 7. Photograph of a material accountancy glove box counter.



Glove-Box Assay System (GBAS)

Accurate measurements of the plutonium holdup inside large glove boxes is determined nondestructively in attended mode using the GBAS[6] (Figure 8). GBAS consists of two large-slab neutron detectors positioned on opposite sides of a glove box. Measured data consist of neutron coincidence counts summed from the two slab detectors. A glove-box line is measured by positioning the GBAS detector pair in unison over the exterior surface of the glove box. The large glove boxes at PFPF (1 m wide by 3 m tall by 6 m long) require a 12-position scan for a full-size box. The integration of the scan is proportional to the mass of ^{240}Pu-effective inside the glove box. The scanning procedure averages differences in the scattering between boxes containing hoppers, blenders, calciners, grinders, and filters. A comparison of the calibration coefficients for all of the glove boxes showed an average variation in the separate glove-box calibrations of ±5 percent. For the case where plutonium powders become distributed throughout a glove box and adhere to the walls and floors, an improved approach that accounts for geometry effects of materials on walls is being developed under a current project.

The capability to measure glove-box holdup enables IAEA inspectors to treat the holdup as verified inventory. A sample identification number is assigned to each glove box. During routine monthly inspections at the facility, the IAEA includes these glove-box samples as part of the measured inventory. Thus a large source of inventory uncertainty is eliminated.

Waste-Drum Assay System (WDAS)

Process-line wastes are placed in 200-L drums and measured before leaving the plant. The WDAS,[7] shown in Figure 9, uses the classical NDA method of passive neutron coincidence counting of plutonium but has a new "add-a-source"[7] feature to improve the accuracy for matrix corrections. It also has new statistical techniques to improve low-level detectability limits.

The errors introduced from matrix materials in 200-L drums have been reduced by an order of magnitude using the add-a-source technique. In addition, the add-a-source method can detect the presence of unexpected neutron-shielding material inside the drum that might hide the presence of special nuclear material. For the in-plant installation at the PFPF MOX facility in Japan, the detectability limit is about 1 mg ^{240}Pu (or 3 mg plutonium) for a 15-min measurement. For a drum containing 100 kg of waste, this translates to about 10 nCi/g.

Plutonium Scrap Multiplicity Counter (PSMC)

The PSMC[8] (Figure 10) was developed to assay passively plutonium samples by using the multiplicity distribution of the neutron emission from spontaneous fission and induced fission reactions. The PSMC measures impure plutonium and MOX scrap materials. The PSMC is used in the PFPF facility to assay samples that have been bagged out of glove boxes.

Inventory Verification Sample (INVS) Counter

The INVS[9] (Figure 11) was developed to assay passively small plutonium samples using neutron coincidence counting techniques. The INVS counter has been widely used by the IAEA in its inspection activities at various nuclear facilities throughout the world. At the PFPF in Japan, the INVS (Mod-III)[10] counter is coupled to a sample well underneath a glove box in the analytical area. This instrument's high neutron counting efficiency (44 percent) provides a measurement precision of about 0.5 per-

Figure 8. Photograph of the glove box assay system.

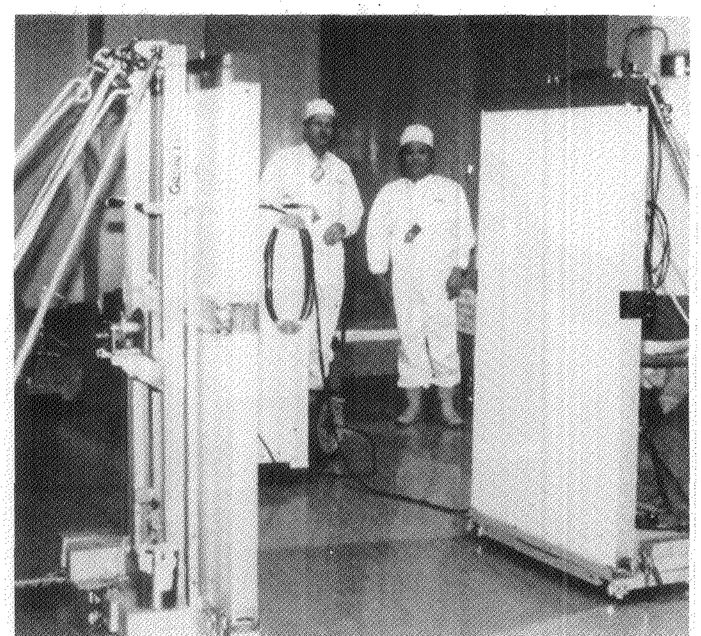


Figure 9. Photograph of the waste drum assay system.

cent in 15 min and the assay accuracy varies from 0.5 percent to 3 percent depending on the fuel category. The isotopic composition of the sample is determined by gamma-ray spectroscopy in this area, which enables the total plutonium content to be determined nondestructively.

Shielded Plutonium Isotopics System

Three FRAM[3] systems, Figure 12, are used to measure isotopics through shielded containers. The FRAM systems are used with the WDAS units and allow the plutonium isotopic concentration to be determined in 200-L drums by rotating and scanning along the height of the drum. FRAM determines the isotopic composition from high-resolution gamma-ray measurements at energies above 120 keV. Using the higher-energy region allows isotopics to be determined through shielded container walls.

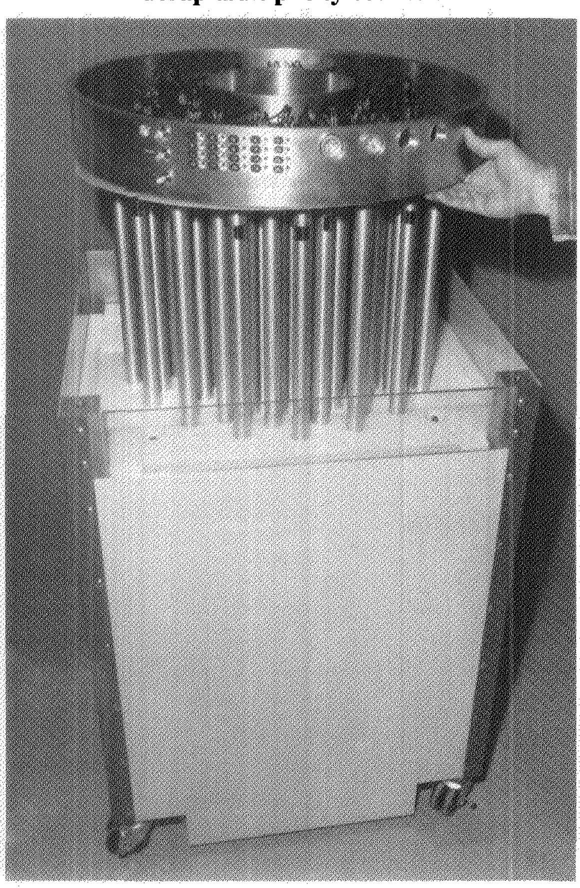
Software

The unattended continuous NDA instrument software comprises two main programs.[6]

Data Collect

The first program, called COLLECT, operates in an unattended mode and collects data continuously from the NDA instruments. Large amounts of data are produced during unattended operation. A campaign of one month produces approximately 43,000

Figure 10. Photograph of the plutonium dcrap multiplicity counter.



raw data runs for each NDA system. If each run were printed on a line, the results for one measurement system would require printing 780 pages.

Data Review

The second program, called REVIEW, is used off-line by inspectors to graphically display and review the large amounts of data obtained by the COLLECT program. The primary functions of the REVIEW program are to store the raw count data from the COLLECT program in a database, to rapidly inspect and provide graphical displays of the data, and to generate data files for input to IAEA codes. Separating the software into two programs allows inspectors to offload data from COLLECT once a month and then review the data off-line out of the radiation area. The REVIEW program displays COLLECT data graphically to aid inspectors in examining the COLLECT data quickly and accurately. REVIEW also organizes the COLLECT data and creates data files. IAEA inspectors input the data files into their high-level neutron coincidence program, which calculates grams of plutonium for samples that had been measured in unattended mode by the continuous operating COLLECT program.

Authentication

Tamper-indicating features were designed into the NDA system for authentication. This is necessary because the material-measurement system operates in an unattended mode without IAEA inspectors in the facility. These measures give an in-depth redundancy in authenticating the NDA system. The continuous monitoring of the room's background gives a record of any movement of MOX in the room. Because the recording of MOX movement is also part of the containment and surveillance (C/S)

Figure 11. Photograph of the inventory verification sample counter.

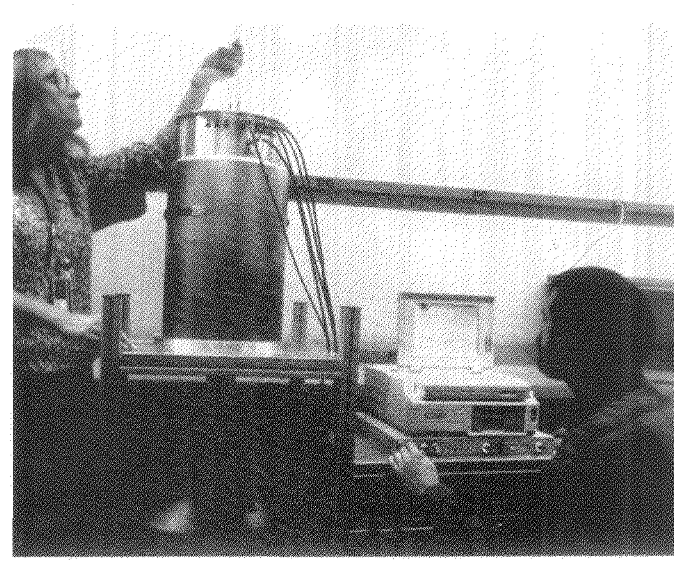
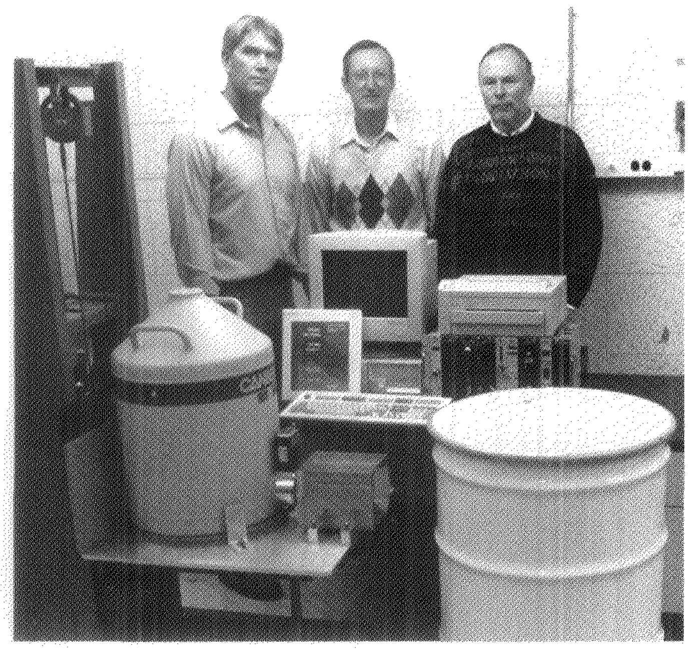


Figure 12. Photograph of the shielded plutonium isotopics system (FRAM).



system, the continuous neutron measurements provided by the NDA instruments provide an independent method that partially authenticates the C/S system.

Future Safeguards

Under Program 93+2, the IAEA and its member states are pursuing developments to maintain effective safeguards at reduced costs. Remote monitoring of facilities under safeguards is one approach that is being proposed. DOE has supported the International Remote Monitoring Project (IRMP) test and demonstration capabilities for C/S at static storage facilities.

Remote monitoring on bulk processing facilities where accountability is the primary safeguards presents new safeguards challenges. Requirements for unattended measurements on in-plant materials movements that provide assay information for material accountancy has the potential to enable near real-time accountancy (NRTA), which meets and improves timeliness goals for IAEA safeguards. Integrating the NDA and material accountancy safeguards systems, developed for unattended continuous monitoring in fuel fabrication facilities, is a feasible approach to improving the effectiveness and efficiency of safeguards inspections. Extending the integrated system to provide unattended monitoring and remote transmission of data has the possibility of allowing continuous inspection oversight by safeguards personnel away from the facility. A remote accountancy monitoring system for bulk facilities could allow safeguards inspectors improved options for application of resources and inspections at facilities based on needs determined by continuous unattended monitoring from the field office or IAEA headquarters.

Summary

Passive neutron coincidence counters were designed and implemented to measure the plutonium input, output, process lines, holdup, and wastes of an automated MOX fabrication facility. Most of the counters operate in a continuous and unattended mode with full authentication for independent inspection agencies.

The systems have been reliable, with no failure leading to loss of inspection data. The accuracy and precision of the systems that are installed in the automated facility are better than can be obtained with portable NDA equipment.

The continuous-mode operation, with automated data collection, storage, and convenient retrieval, makes it possible for inspectors to reduce time spent in the plutonium facility without any loss of measurement capability. In fact the sample constraints in size, mass, and containment dictated by the plant robotics system make it possible to obtain higher accuracy and precision with the NDA systems than is possible for older, more conventional facilities. The precision and stability of the neutron systems is 0.1 percent to 0.2 percent; the accuracy depends on the fuel category. Most of the NDA systems listed in Table 1 operate continuously in the unattended mode, giving near real-time information on the plutonium inventory in the facility.

Acknowledgements

This work is supported by the Power Reactor and Nuclear Fuel Development Corporation of Japan in cooperation with the U.S. Department of Energy, Office of Arms Control and Nonproliferation, International Safeguards Division.

A number of personnel at DOE, Los Alamos, Sandia, PNC, and the IAEA contributed to the work described in this paper. The NDA COLLECT and REVIEW software was produced by Shirley F. Klosterbuer, William C. Harker, Jo Ann Painter, and Edward A. Kern. The mechanical systems were designed by Gregory Walton, Kenneth E. Kroncke, Jacobo Baca, and Raymond Holbrooks. Many IAEA staff members contributed to the definition, testing, and calibration of the systems, with the primary input coming from Reza Abedin-Zadeh. The installation and calibration of the systems were performed by many PFPF staff members.

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Materials Control and Accountability Challenges Associated with Plutonium Inventories

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Washington, D.C.

Introduction

There are currently many initiatives underway within the Department of Energy (DOE) to safely and securely manage large plutonium inventories arising from weapons dismantlement, changing missions and facility operations. These large inventories — ranging from high-equity weapon usable materials to low-grade forms and scrap — will continue to be the topic of much debate and programmatic consideration now and in the near future with respect to long-term actions and priorities of the department. Plutonium inventory information is increasingly accessible to the public as a result of the secretary of energy's "openness" initiative. As a result, knowledge of these inventories and levels to which the department has accounted for and controlled these inventories, will be under increased scrutiny from a variety of interest groups. The quality of this accountability data and what this data means will greatly influence the public's perception of how the United States is protecting its plutonium inventories. In addition, the department's safeguards program provides an essential basis for the application of International Atomic Energy Agency (IAEA) safeguards that, in addition to possibly other international control regimes, will be in place over a large portion of these future inventories.* The capability and functionality of the department's nuclear safeguards program will be important contributors to the success of U.S. programs for the responsible stewardship of these vast plutonium inventories. This paper discusses some of the challenges, in terms of specific issues relating to one part of the department's safeguards program — materials control and accountability (MC&A) — to meet the growing domestic and international requirements and expectations associated with these plutonium inventories.

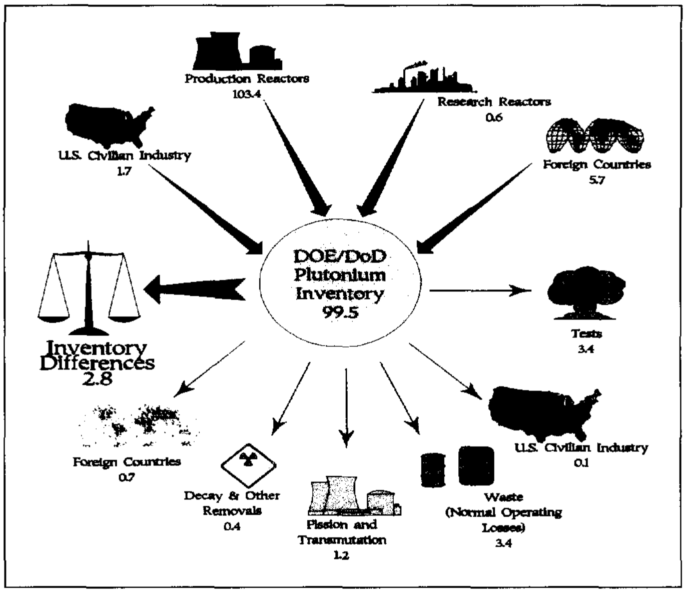
Openness

Over the past several years, the DOE has been actively involved in efforts to better inform the public on nuclear activities that have taken place within the department and to allow for a more informed debate over Departmental programs. This "openness" is also intended to assist in addressing many environmental, safety, and health issues associated with DOE's programs and activities. The secretary of energy has vigorously led this effort with particular emphasis on radiation testing, weapons testing, and comprehensive releases of plutonium inventory information. These releases are intended to support dose reconstruction efforts and to encourage reciprocal releases from other countries with respect to their nuclear activities.

Regarding the plutonium inventory releases, the DOE released in February 1996 a report on the first-ever accounting

* A safeguards agreement conforming to INFCIRC/153 (corrected) is required to provide that "... the state shall establish and maintain a system of accounting for and control of all nuclear material subject to safeguards under the agreement..." Safeguards agreements conforming to INFCIRC/66/Rev.2 do not explicitly call for states to establish and maintain a system of accounting for and control of nuclear material, but the fact that the document calls for agreements between the IAEA and States on a "system of records" and a "system of reports" implies the need for a system.

Figure 1. Plutonium acquisitions and removals (metric tons)



of plutonium production, acquisition and removals. This report, titled "Plutonium: The First Fifty Years," provides newly declassified information regarding these activities. This information, when combined with previously declassified data, has allowed the DOE to issue, for the first time, a truly comprehensive report on the total DOE plutonium inventory.

According to the plutonium history report, the United States, from 1944 through Sept. 30, 1994, produced and acquired nearly 111.5 metric tons (MT) of plutonium. During the same period, 12 MT of plutonium were removed, resulting in an actual inventory today of 99.5 MT (Figure 1). Of interest from an MC&A perspective is the cumulative inventory difference value, which is approximately 2.8 MT for this 50-year period.*

Environmentalists, arms control groups, and special interest groups view the inventory difference with particular concern. Such discrepancies can be viewed as resulting from diversion or theft of weapons-usable materials. Others may view it as material lost to the environment. MC&A programs will be challenged continuously by "openness" to demonstrate that material has not been "lost" and provide assurance that this unaccounted for material is not in the hands of malevolent groups.

As a postscript, the secretary has committed to releasing corollary information on highly-enriched uranium in the near future.

The department, although stating that the plutonium history report represents an accurate accounting of unclassified plutonium inventories at various sites, capitulated when discrepancies between normal operating losses and transfers of waste, amounting to more than 0.5 MT (Table 1), were reported by the Nuclear Materials Management and Safeguards System (NMMSS). NMMSS is the national nuclear materials database and serves as the "system of record" from a materials accountability standpoint. Normal operating losses are process removals from facilities that generally leave as waste. To further exacerbate this problem, discrepancies between NMMSS and the department's environmental management database, which possesses inventory information for plutonium at waste sites, were identified. The plutonium history report states that because of these unresolved discrepancies a working group will be convened to examine inconsistencies between existing DOE databases and work to resolve these inconsistencies, which may include developing a new nuclear material database. This working group is discussed later in this paper.

Table 1

Plutonium in Waste Inventory

Location	Kg Pu
Savannah River	*575*
Los Alamos	*610*
Nevada	*16*
Argonne-West	*2*
Hanford	*1,522*
Oak Ridge	*41*
Idaho (Waste Management)	*1,026*
Idaho (ICPP)	*80*
Rocky Flats	*47*
Total	3,919

Plutonium Normal Operating Losses

Location	Kg Pu
Rocky Flats	*1,024*
Hanford	*1,061*
Los Alamos	*610*
Savannah River	*508*
Other	*200*
Total	3,403

Difference: Approximately 0.5 MT

Plutonium Inventories: A Sampling of Measurement Issues

Some specific plutonium inventory issues that are currently challenging safeguards programs in the department are listed below.

- DOE possesses approximately 10 MT of plutonium and nearly 100 MT of enriched uranium scrap, representing nearly 10 percent of the total special nuclear material inventory within the DOE. Accurate values for these materials do not exist.
- At some facilities, holdup has either (a) not been measured or (b) not been accurately measured. Holdup is not reflected in the accountability records at facilities. Clean-up and decontamination/decommissioning activities will be severely hampered by the lack of accurate information on the quantities and forms of materials present at facilities.
- DOE does not have sufficiently accurate measurement data information about some types of materials, such as holdup and scrap, to meet IAEA standards.
- Stabilization and packaging will generate new nuclear material items that must be measured and placed in a facility's nuclear material accountability system. In addition, many existing items will need to have their accountability values updated when they are processed and repackaged for long-term storage.

Improved measurements (both in terms of technology and practices) and attention to MC&A requirements are necessary to address these issues.

Initiatives to Address These Challenges

Because of inconsistencies that were discussed above, as well as to improve the department's nuclear material inventory and tracking systems, the secretary established a working group on nuclear material inventory systems. The working group's task was to examine the various department data systems for man-

* Inventory differences, also called "materials unaccounted for" or MUF, are the differences between book inventory and physical inventory values and are largely attributable to measurements and overstatement of plutonium production values for criticality protection.

aging nuclear materials to understand what information is provided by each system to identify variabilities, overlaps, and inconsistencies in the data, and to determine what additional data are necessary to manage or utilize nuclear materials more comprehensively. Based on the review and the needs of the department, the working group will make recommendations on improving nuclear materials management systems. These will include steps to explain, resolve, or reconcile data inconsistencies of historical data to the extent possible and to reduce or eliminate these problems in the future. An option for consolidating all nuclear inventory data into a single tracking system will be evaluated as well. This working group is expected to have its recommendations prepared for the secretary by the end of fiscal year 1996.

In 1995 — in response to various internal study and audit reports within the department on problems related to the status of fissile material assurance and implementation of internal controls over plutonium and enriched uranium inventories — another working group was established to address these various deficiencies within the department. The issues identified in the documents, particularly in the audit report, identified safety and operational interruptions, such as facility stand down imposed by safety reviews, as contributors to MC&A deficiencies. These weaknesses raise issues relating to the department's ability to protect its special nuclear material sufficiently.

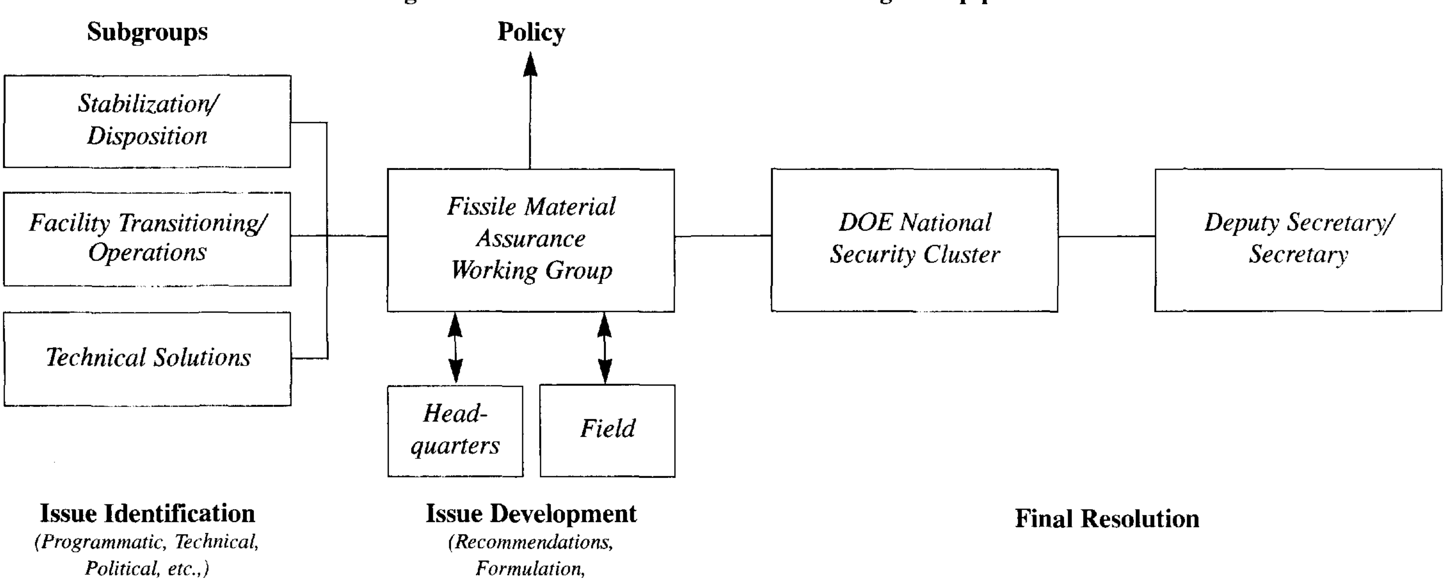
The working group, known as the Fissile Material Assurance Working Group (Figure 2), has as its major objective to serve as a forum to ensure that MC&A practices, such as physical inventories and measurements, are included as an essential part of the department's missions. The working group will also attempt to ensure that vital MC&A practices are considered in budgeting, planning, and management decisions regarding facility and personnel safety and operations.

Specific issues being examined by the working group include ensuring that the following material assurance requirements are considered in department activities: measurements of unmeasured or poorly measured inventories are technically defensible; measurements are included as a part of material stabilization and repackaging of materials being offered for international inspection when such materials have questionable or outdated values; and physical inventories are routinely conducted and that facility material accountability records accurately and reliably reflect these inventories. This working group, whose charter has been signed by the deputy secretary, reports to upper department management to ensure that these issues are given appropriate attention. Figure 2 depicts the Fissile Material Assurance Working Group process.

Summary

The department must maintain a viable nuclear safeguards program to provide assurance that plutonium inventories are being protected, controlled, and accounted for. As plutonium inventory information becomes increasingly available to the public through official releases, the department must remain able to respond to inquiries regarding these data to maintain confidence that nuclear material is being properly managed. Materials accountability data are essential to supporting other program and stewardship responsibilities such as environment, safety, and health. Also, a strong domestic safeguards program assists in the identification of nuclear materials for international inspection and provides a sound infrastructure for the conduct of these inspections in the United States. As the demands being placed on the department related to its plutonium inventories increase, so will the need for the department to assure the public and the world that the United States is meeting its commitments for the security of its plutonium and other nuclear material inventories. A strong MC&A program provides this assurance and serves as a model for other countries in developing their own domestic safeguards system, and in accommodating international inspections over their plutonium inventories.

Figure 2. Fissile Material Assurance Working Group process



Japanese Utilities' Plutonium Utilization Program*

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I. Why Japan has chosen to recycle

Japan's 10 utility companies are working and will continue to work towards establishing a fully closed nuclear fuel cycle. The key goals of which are:

1. Reprocessing spent fuel,
2. Recycling recovered uranium and plutonium, and
3. Commercializing fast breeder technology by around the year 2030.

This course of action by the Japanese electric power industry is in full accordance with Japan's national policy outlined in the government's report "The Long-Term Program for Research, Development, and Nuclear Energy," which was published in June 1994.

Historically, there are three rationales for this policy:

1. Energy Security
Japan's energy structure is highly dependent on foreign sources of energy. Japan relies on energy imports for more than 80 percent of its total primary energy supply. Nuclear fuel recycling is a key option for ensuring long-term energy security.

2. Conservation of Natural Resources
Uranium and plutonium recycling contributes to the conservation of natural uranium. As the demand for primary energy in developing countries or regions increases, conservation is important for the global economy and for the environment.

3. Effective Management of Radioactive Waste
For a small country like Japan where the availability of land is limited, separating highly radioactive fission products from useful material is an effective way of managing radioactive waste.

II. Commercialization of FBR Technology

To maximize these benefits on a long-term basis, the commercialization of fast breeder reactor (FBR) technology remains the long-term goal in Japan's future energy program. To attain this goal, the Power Reactor and Nuclear Fuel Development Corporation (PNC) has developed both an experimental and a prototype FBR. The experimental reactor "JOYO" has been operational since 1977. In April 1994, the prototype reactor "MONJU" reached criticality.

By learning from the experiences of the experimental and prototype reactors, the Japanese utility industry will soon initiate the demonstration FBR program. The knowledge gained from this experience will be used for the commercial FBR, which will commence around the year 2030. The energy value of uranium and plutonium will be fully used by recycling the elements in fast breeder reactors.

Although Japan looks forward to the FBR's role in its future energy supply structure, it will require time and resources to reach a mature state of technology for commercial purposes.

III. MOX Fuels in LWRs

To accommodate the growth of electric power demand over the next 20 to 30 years, Japan must continue and also improve light water reactor (LWR) technology at the same time. In particular, Japan must continue the development of technical expertise relating to the use of mixed oxide (MOX) fuel in LWRs. The use of MOX fuel is an important intermediate step that must be maintained until the FBR technology comes on-line. In addition, in light of international concerns over proliferation of separated plutonium, it is better to burn separated plutonium as MOX fuel in LWRs in a carefully programmed manner.

First-hand experience of using MOX on an industry-wide scale is very important to improving the reliability, security, and economics in the management of plutonium recycling. In the Long-Term Program, as revised in June 1994, this aspect was newly emphasized. MOX utilization is important not only for extracting the full energy value of plutonium, but also for avoiding the unnecessary stockpiling of separated plutonium.

To make the Japanese program more transparent regarding safety, security, and the economy of plutonium, Japan welcomes the participation of the international community in technology and program development.

* Presented at the Workshop on Global Plutonium Inventories , Sponsored by the Institute of Nuclear Materials Management, May 1-2, 1996, Washington, D.C.

I would like to speak briefly about a recent development. As you are probably aware, the unfortunate sodium leak that occurred last December at the prototype breeder reactor MONJU caused public concern. It may also lead to occasional delays in the breeder program. Although the accident did not involve any release of radioactive material into the environment, any occurrence of this kind must be taken very seriously. The Japanese Atomic Safety Commission, government agencies, research institutes, equipment manufacturers, and PNC are working together to determine the root cause of the MONJU accident. The results of the investigation into the accident and the methodologies are now being made available to the public.

An important lesson learned from this accident is that strong steps need to be taken to achieve a broader knowledge of Japan's nuclear policy. On March 15, 1996, the Japanese Atomic Energy Commission announced the Roundtable Nuclear Policy Forum. The first forum was held successfully on April 24, 1996. This will foster greater openness of policy formulation. Japan will also encourage information openness to the international community.

IV. Security and Safety Features of the Current MOX Program

Under the Japanese electric utilities' reprocessing contracts with COGEMA and BNFL, approximately 30 tons of plutonium (fissile) will be recovered up until the year 2010. The majority of this plutonium will be fabricated into MOX fuel assemblies at fabrication plants in Europe and then transported to Japan to be loaded into LWRs.

Our selection of European MOX fabricators is the result of careful research. Some of the reasons are as follows:

1. Security (physical protection) reasons.

Transport of finished assemblies makes MOX fuel far less attractive for theft attempts. In a political agenda and among experts concerning proliferation risk, there is no difference between MOX assemblies and plutonium dioxide powder. This is also true for weapon-usable plutonium and weapon-grade plutonium.

A technical reality, however, is that a MOX assembly greatly discourages any attempted thefts. Plutonium dioxide is mixed with uranium dioxide, and the concentration of plutonium is diluted to 1/20. In the now planned Japanese MOX assembly transportation program, the assemblies will be carefully packaged in a heavy container to protect the integrity of the contents.

One of the purposes of the heavy container is to make any attempt to handle it impossible without using heavy-load lifting devices. It will also protect the product from outside impacts during transportation. The packaging will keep assemblies suitable for loading into the reactor core under normal transport conditions. All packaging is designed and made to withstand all accident conditions outlined in strict international and national regulations, as well as the ability to withstand physical attacks of sabotage.

The transport arrangement of the MOX assemblies will be accomplished in strict accordance with the security requirements of the International Atomic Energy Agency (IAEA) and of the Japan-U.S. Nuclear Cooperation Agreement. We will utilize the industry's experience to achieve safe and smooth transportation.

MOX assemblies have an advantage in being delivered directly to each reactor site in Japan. After arrival at the reactor site, they are stored securely until they are loaded into the reactor. During the entire operation of this transport, MOX assemblies are strictly subject to the IAEA safeguard system. Upon arrival in Japan, they are also placed under Japan's national safeguard system.

2. Introduction of proven technology

Several European countries have extensive experience using MOX technology, and this is a valuable opportunity for Japan to learn from their experience. On the other hand, Japan has learned many lessons and has established an impressive track record of successful performance in its 30-year history of uranium fuel use. In return, Japan can contribute knowledge in the area of quality assurance.

In any industrial application, as you know, reliable and safe technology and the continuity of a stable supply are critical elements. Close cooperation between European fabricators and Japanese utilities will enhance the Japanese infrastructure so that it will be suitable for future commercialization.

In Japan, the most important step for the implementation of the MOX program is to obtain consent from any local communities situated around the reactor site. Each of the 10 utility companies is responsible for utilization and disposition of recovered material from its spent fuel. Therefore, each company has, or will have, its own individual program that will not only be dependent upon its fuel management strategy, but also its efforts to build cooperative relationships with the local community. In general, safety is the major concern for local communities.

MOX utilization is not an unprecedented or new technology. In addition to the European experience mentioned above, some Japanese utilities already have experience with loading MOX assemblies. This was done in the late 1980s at a pressurized water reactor (PWR) and a boiling water reactor (BWR). Japan found no anomaly in the post irradiation examination that was conducted on spent MOX fuel assemblies removed from these reactors.

PNC also has extensive experience with the use of MOX at the advanced thermal reactor (ATR) FUGEN. Although the fuel design of ATR is different from that of the LWRs, no safety problems have occurred in any step of MOX usage. This includes fabrication, transportation, storage, and reactor burning.

For the Japanese electric utilities' MOX program for LWRs, no modification to the reactor will be necessary. A greater margin of safety will be achieved by limiting the quantity of each MOX loading to under one-third of the core. In the actual introductory stage, Japan will take additional prudent steps to confirm the safety of each reactor. The detailed procedures will be discussed among utilities, the licensing authority, and local communities. Therefore, Japanese utilities believe that the safety concern of local people will be alleviated.

V. Japanese Commitment to Peaceful Use of Nuclear Energy

Some proliferation experts argue that Japan's reprocessing and recycling program poses an international threat. It is said that some neighboring Asian countries worry about Japanese intentions on plutonium recycling.

Japan has made countless commitments in the international community to carry out only peaceful nuclear activity as part of the government's policy and the industry's programs. Public opinion is overwhelmingly against a nuclear weapons program from the grass-roots to the policy-making elite. In the area of national security, Japan now has the benefit of the U.S.-Japan Security Agreement. It is obvious that Japan would suffer tremendous international disadvantages if it pursued a nuclear weapons program. Japan will take a course to cooperate with the global community and will not pursue nuclear armament.

Japan submits every nuclear facility to the full-scope safeguard system of the IAEA. In addition, Japan has established a sophisticated national material accounting and control system applicable to every aspect of nuclear activity. This national system plays an important role in decreasing the financial and physical burden of the IAEA's inspections, without interfering with the IAEA's sphere of control.

Japan also cooperates with several international institutions and organizations to develop new technology for a more effective detection, control, and safeguard system. This is mainly done by government agencies and national research institutes, including PNC. The Japanese utility industry is also willing to cooperate in this area.

VI. Current plan and future course

Our current plan envisions that during the latter half of the 1990s, a few Japanese LWRs will begin using MOX fuel. The number of reactors will gradually increase to 10 or more by around the year 2010. In this program, the maximum loading of MOX will be one-third of a core.

In August 1995, Japan's Atomic Energy Commission accepted the industry's request to abandon the construction plan of an advanced thermal reactor demonstration plant, Ohma. Instead, an advanced boiling water reactor (ABWR) with full-core MOX will be constructed. This is expected to come on-line in the mid-2000s.

In an effort to increase Japan's domestic reprocessing capabilities, Japan Nuclear Fuel Limited (JNFL) is constructing the new reprocessing plant in Rokkasho-Mura, which is scheduled to begin operation in the year 2003. Operating capacity is designed to be 800 metric tons (MT)/year nominally. The recovered plutonium from this process will be fabricated into MOX assemblies in Japan. A domestic MOX fabrication plant will be designed with a annual capacity of approximately 100 MT. The overall picture of Japan's plutonium balance was published in the Long-Term Program in June 1994.

The key element to achieve a balanced supply and demand to avoid unnecessary build-up of separated plutonium depends on how smoothly Japan can keep its MOX program as planned. There are many difficulties we need to overcome politically, technically, and economically in order to move this program ahead. Japan will need help from international partners in carrying out this program.

VII. Conclusion

The Japanese civilian nuclear program is a long-term program that looks into the 21st century and beyond. It is quite true that sustaining the recycling option for energy security and the global environment demands a large investment. For it to be accepted by the public, safety must be the highest priority and will be pursued at a great cost if necessary. In its history, Japan has learned that as technology advances, costs will come down. The Japanese utility industry will continue investment in technology without compromising safety until the recycling option becomes more competitive with other options. This effort will be equally applied to the development of the commercial FBRs.

The Japanese utility industry is confident that Japan's stable policy and strong objective to develop competitive and peaceful technology will contribute to the global economy and the environment without increasing the threat of plutonium proliferation.

Fuel Cycle Centers Revisited: Consolidation of Fuel Cycle Activities in a Few Countries

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Background and Early Developments

The concept of limiting the spread of fuel cycle activities of a "sensitive" nature and surrounding those that are built by some type of international or multinational framework has been present since the earliest attempts to define a nuclear nonproliferation regime. The first serious effort, the Acheson-Lilienthal report of 1946, called for an international "Atomic Development Authority" that would own and operate all facilities regarded as "dangerous." The International Atomic Energy Agency (IAEA) itself, and especially its safeguards system, while lacking the concept of international operation of sensitive facilities, was nevertheless a deliberate step to place peaceful activities within an international framework. Moreover, the statute of the IAEA includes a provision yet to be implemented that authorizes the Agency to be the depository of plutonium stocks, the accumulation of which would arguably be the most sensitive of all aspects of the civilian nuclear fuel cycle. It should also be recalled that the IAEA was envisaged as a principal supplier of nuclear fuel, a function which, if fulfilled, would have given it a much more direct role in the operation of sensitive facilities.

The Treaty of Rome, which established Euratom, while not limiting the number or location of fuel cycle activities within its territory, called for creation of a strong multinational-safeguards system and community ownership of all fissionable material outside of defense activities. At present it tends to be overlooked that a reprocessing plant jointly owned by more than a dozen European countries was successfully built and operated in the late 1950s under the auspices of the then European Nuclear Energy Agency. But the enterprise did not survive to become the nucleus of a multinational European reprocessing endeavor, as the United States had hoped.

Uranium enrichment has been the subject of two significant and successful, but structurally very different, efforts at concentration and multinationalization — Eurodif and Urenco. Urenco is arguably the closest approach to the "classic" model of multinational fuel cycle activity (if such a model exists) with full ownership, operation, and control of its enrichment facilities vested in a multinational enterprise owned in equal shares by entities in three countries. It also has all international security aspects under the control of the respective three governments acting jointly. While this paper does not focus on the front-end of the fuel cycle, the largely successful effort to restrain the spread of commercial enrichment augurs well for the feasibility of accomplishing this for the back-end as well.

Even before the International Nuclear Cycle Fuel Evaluation (INFCE) of the late 1970s, which examined many aspects of international institutional arrangements, the IAEA initiated at the urging of the London Group of supplier countries an intensive assessment of the international fuel cycle center concept. It also tends to be forgotten that the Nuclear Nonproliferation Action (NNPA) of 1978, gives extensive and favorable consideration to the internationalization of fuel cycle activities. It also calls for the establishment of an International Fuel Cycle Authority (INFA) that would provide nuclear fuel and fuel cycle services and for a "prohibition against reprocessing," except "in a facility under effective international auspices and inspection."

The nonproliferation policy statement of the Reagan administration, which was released — presumably by coincidence — on July 16, 1981, the anniversary date of Trinity (the first nuclear explosion) gave intrinsic support to the concept of concentration of sensitive fuel cycle activities. The administration did this by pledging noninterference with such activities in countries with advanced nuclear programs and that are not presenting a proliferation risk. The American Nuclear Society, in its recent report on the protection and management of plutonium, endorsed a similar policy. It expressed the belief that it would be not only desirable but feasible to limit "reprocessing and recycle [to] countries in stable regions with large nuclear power programs, strong security systems, and excellent nonproliferation credentials."

Current Status

Despite these varied expressions of support for the broad concept of some form of concentration and internationalization of sensitive fuel cycle activities, as well as several successful concrete examples of this having actually taken place, the general impression remains that the international fuel cycle center concept, whatever its merits, is visionary. It also is quite possibly unattainable in light of strong national pressures toward independence and self-sufficiency in all things nuclear. Is the fuel cycle center an idea that has come and gone? Is it an idea whose time has not yet come? Or is it, as this paper suggests, an idea that has already arrived on the scene, attracting little attention or even acknowledgment of its presence?

The difficulty in answering this question arises, in part, from the fact that despite its long and obvious appeal, there has been very little systematic analysis of the concept itself. Such obvious questions as how many and where fuel cycle centers should be located; what characteristics should the host country or countries possess; and what are the institutional forms or features that endow the concept with enhanced proliferation protection have rarely been seriously and systematically addressed. The language of the NNPA, "effective international auspices," while admirably suited to the legislative purpose that it was designed to serve, is indicative of the lack of concrete definition that has always surrounded the concept.

It is not difficult to understand the appeal of the international fuel cycle center. If certain nuclear activities present serious proliferation risks, it makes sense to conduct these in as few places as possible (some would advocate none) and to protect them from national misuse by some form of multinational or international barrier. This is as far as most analyses have gone.

Any serious assessment of the concept must start with acknowledgment of a simple fact: In the world of nation states that now exists, any fuel cycle facility must be located on the territory of some sovereign nation. This nation will almost invariably possess the power, if not the legal right, to take full control of the facility and its inventory from any intervening international or multinational authority, whether proprietary, managerial, or verification in nature. This reality was specifically acknowledged in the Acheson-Lilienthal report, which advocated the creation of an international authority with the exclusive right to own and operate "dangerous" facilities. Not even the creation of international enclaves as sites for such facilities, as has been suggested at times, changes the fundamental nature of the problem. This step would simply move the barrier from the plant boundary to the enclave boundary.

The reality of superior national power, as the Acheson-Lilienthal conclusion reflects, does not however invalidate the general principle or negate the appeal of the concept that there is something to be gained in limiting the spread of sensitive fuel cycle facilities. Cynical beliefs to the contrary notwithstanding, nations generally honor their commitments and do not violate the frontiers of their neighbors, and they generally pay a price if and when they do so. Institutional barriers may be amorphous but they are not imaginary. Evaluating the concept of limiting and internationalizing sensitive fuel cycle activities, therefore, essentially involves assessing just what forms of institutional arrangements are most likely to be honored, what their cost or impact on peaceful uses are, and their prospects for acceptance.

The title of this paper focuses on limiting the geographic spread of fuel cycle facilities, and some may suggest that doing so does not necessarily call for any type of international or multinational arrangements applicable to those that exist. It is a premise of this paper, however, that a restriction on the number of countries possessing sensitive fuel cycle facilities necessarily involves some degree of multinationalization. This is not only because in every instance a nonproliferation pledge and international or multinational safeguards, or both, will be applied to the facility, but also because a restriction on the number of countries possessing these facilities implies that those in existence will serve a multinational market. This feature in itself is an important form of "international auspices." Thus, the two concepts — limitation and multinationalization — if not necessarily one and the same, are at least de facto corollaries.

An Assessment Methodology

An exception to the general conclusion that there has been virtually no systematic analysis of the fuel cycle center concept was a 1979 report, "Institutional Arrangements for the Reduction of Proliferation Risks," of which I was a co-author. This report was prepared for the Department of Energy as part of its NASAP activity, the U.S. domestic counterpart of INFCE. It seems likely that, like many other studies prepared for that monumental paper-production enterprise, it was read by few if any persons beyond its authors and the responsible contract administrators. The basic thrust of this paper was that institutional arrangements for fuel cycle centers could be best evaluated by disaggregating their components and assessing these components individually and separately from the viewpoint of both nonproliferation benefits and costs — including acceptability.

This methodology was applied to a number of potential forms of the concept. It was found, for example, that the possible institutional arrangements covered a wide range that included such elements as ownership, management, staffing, materials control, and market. This is in addition to the customary element of international and in some cases, multinational safeguards. Each of these elements could, in turn, exist in combination with all or any of the others. A conclusion of the study was that some of the elements, such as international or multinational ownership most commonly associated with the term "international fuel cycle center," offered relatively less proliferation benefit than other elements, such as multinational staffing or materials control. At the same time, it was found that elements such as multinational ownership or management, unless this clearly evolved from the voluntary choice of the parties involved, created the greatest obstacles to acceptability of the international center concept. How? By further complicating the already difficult task of building, owning, and operating these complex facilities.

A specific conclusion of the study was that the most promising arrangement, in terms of maximizing proliferation benefits and minimizing costs and adverse impacts on acceptability, was a feature termed "custody." In brief, this term meant that the control of and accountability for materials into and out of the facility and of facility inventory would be vested in a multinational group or entity.

More important than the specific conclusions and findings of this study — which clearly must be reassessed against the background of nearly two decades of experience in the evolution of the peaceful nuclear fuel cycle — is the assessment methodology. This involves disaggregation of the various elements that can make up "international auspices" and remains a valid and useful approach. In particular, it is useful — indeed, essential — to bear in mind the basic principle expressed earlier. International or multinational arrangements do not and cannot achieve their nonproliferation purpose by investing some international entity with superior police or military power. Rather, they achieve it through the creation of institutional barriers that are unlikely to be breached and that will result in costs and some form of remedial action if breached. There are numerous elements available with which these barriers can be erected, and no doubt there is no "one size fits all" combination. The obligations of the NPT and its safeguards arrangements are themselves institutional barriers that provide the first line of defense against misuse.

Number and Location of Sensitive Facilities

It is also apparent from this methodology that fuel cycle centers must be assessed in the context of the environment in which they might exist, including in particular the overall number of such facilities, their location, and the number and identity of their participating members.

The issue of number and location of sensitive facilities was explicitly recognized in the Acheson-Lilienthal report. The somewhat surprising conclusion of the study was that, recognizing that the institutional barrier of the Atomic Development Authority might be breached by a host nation, the best solution was to make sure that the facilities of this authority were dispersed among a sufficient number of countries. Thus no military advantage could be gained by a breach by one host country. This is probably the first recorded application of the later real-world emergence of "mutual deterrence" and is hardly a solution that would be recommended today. Over the years numerous suggestions have been made as to possible favorable locations for international fuel cycle centers, including the existing nuclear weapons states; small, neutral countries with impeccable nonproliferation credentials and long histories of territorial integrity; and, as noted earlier, even international enclaves.

There is no obvious solution to the question of how many and where, but the experience of recent years is both instructive and encouraging. The key fact, as the ANS report points out, is that the spread of sensitive facilities and of nuclear power itself has not been rapid. In fact, the number of countries engaged in or actively considering reprocessing for the civil nuclear fuel cycle today is lower than it was at the time of INFCE. Moreover, while modest size reprocessing facilities are in operation in Japan and India to serve exclusively national needs, the large reprocessing facilities in the United Kingdom, France and Russia — all nuclear weapons states — have evolved. In fact they were intended and justified as facilities serving a multinational market. In a very real sense of the word, they are international or multinational fuel cycle centers. Thus, the development of the international fuel cycle to date strongly supports the conclusion that the limitation of reprocessing to a relatively few countries has not been and need not be, an uphill battle.

The ANS report suggests that sensitive facilities be limited to countries in stable regions with large nuclear power programs, strong security systems and excellent nonproliferation credentials. These criteria were designed to deal with several specific issues. For example, they do not propose limiting sensitive facilities to the nuclear weapons states as defined by the NPT. Such a limitation, while no doubt favored by some, would clearly be non-negotiable and subject to attack as inconsistent with Article IV of the NPT itself. The suggested criteria of "in stable regions" and "large nuclear power programs" are intended to address the obvious problems of perceptions that arise when recycle facilities are located, or even considered for location, in countries engaged in intense regional rivalries. This includes countries where the activities bear no reasonable relation to the magnitude of national needs. The conclusion of an agreement between North and South Korea to abstain from reprocessing and enrichment is an example of the first criterion in application. This lends credence to the possibility of achieving it in other cases.

Many countries that are clearly capable of undertaking reprocessing, including several that have actually done so on a limited scale in the past, have refrained from reprocessing. It is clear that economic considerations, including the very large economies of scale, constitute an important factor in these national decisions or choices. This factor can be expected to continue to favor the concentration of such activities in the future.

The criterion of strong security systems is intended to address the problem that circumstances may arise in which some countries that meet the other criteria, even though beyond reproach in terms of assurances that they will not misuse the facilities, may not have in place a security system capable of providing a high degree of assurance against subnational theft or seizure of sensitive materials. Concerns regarding the current status of Russia's state system of accountancy and control are both an example and the obvious trigger for this criterion. The criterion of excellent nonproliferation credentials, although necessarily subjective, may not be as difficult to deal with as some may contend. The definition of "excellent nonproliferation credentials" falls in the same category as the well-known definition of pornography: You may not be able to define it, but you will know it when you see it. In fact, the term, if not the concept of "nonproliferation credentials," made its appearance in the Carter administration and also is found in slightly different words in the Reagan nonproliferation policy statement.

One seemingly obvious way to possess excellent nonproliferation credentials is to already be a nuclear weapon state. While it is a truism that a nuclear weapons state is not a "proliferant" state, countries that deliver spent fuel to nuclear weapons states for reprocessing have insisted on assurances that plutonium derived from their spent fuel remain in peaceful uses. This understandable position illustrates that serving a multinational market is in itself a form of "internationalization" of fuel cycle facilities providing a significant barrier to national misuse, at least in regard to fuel of external origin.

A key question is whether criteria such as those proposed in the ANS report should become binding obligations or simply serve as guidelines that might influence national decisions. While the possibility should not be dismissed that broad agreement might be reached on the adoption of such criteria as binding obligations, it is much more likely that in the future these criteria will remain as guidelines that will impact the national policies of countries that might seek to establish fuel cycle facilities and those that might serve as suppliers of the needed technology. In fact the guidelines developed and adopted many years ago by the London Suppliers Group strongly discourage the transfer of technology for reprocessing and enrichment. This restraint has been highly effective since its adoption. An important aspect of the suggested ANS criteria is that they are self-adjusting countries that do not fit the criteria, but at any point in time they may evolve through advances in their technological capacity to meet the criteria in the future. This is an essential feature of any guidelines likely to attract broad support.

Other Issues

Another important issue relating to the concentration and internationalization of fuel cycle facilities is what activities should be regarded as sufficiently sensitive to warrant such treatment. Reprocessing is the activity that commonly comes to mind when limiting the spread of sensitive fuel cycle facilities is considered. But the plutonium present in MOX fuel fabrication facilities is, if anything, more accessible than that in reprocessing plants and presents comparable problems of accountancy and control. This paper, therefore, treats fabrication and reprocessing as equivalent for the purposes of seeking the concentration and internationalization options.

Spent fuel storage or disposal also raises an important issue. As both the NAS and ANS studies explicitly recognize, spent fuel is a proliferation risk. It is best avoided by preventing the accumulation of spent fuel. However, where this takes place, both concentration and multinationalization of storage sites is desirable. It is also essential that safeguards be applied to spent fuel storage sites regardless of their supposed permanence and degree of irretrievability.

A key remaining question is where the product of fuel cycle centers — fabricated MOX fuel assemblies — should be used. Plutonium can obviously be removed from fresh fuel assemblies with little difficulty, and its subsequent purification involves far simpler operations than separation and purification from spent fuel. The plutonium inventory of even a single MOX fuel reload for a typical LWR would, moreover, be of the order of 300-400 kg, obviously a significant quantity. Diversion of a complete reload or substantial portions could well lead to reactor shut down due to insufficient fuel and would be readily detectable by safeguards as well. But the availability of alternative LEU fuel should not be ruled out. The disassembly of fabricated bundles and removal of small quantities of pellets followed by reassembly would be a costly and technically sophisticated operation that could well prejudice the safety and continuity of reactor operation. However, this procedure would be more difficult to detect through periodic inspections and cannot be entirely ruled out.

An approach worth considering that could make it acceptable to employ fabricated MOX assemblies in some locations in which reprocessing and fabrication was inappropriate is that of "just-in-time" delivery. Delivery of fresh fuel at the latest possible date before loading is economically advantageous. If such delivery takes place shortly before loading and the loading and reactor start-ups are subject to intensive, perhaps continuous, inspection, it would minimize the proliferation risks of MOX utilization in many locations.

Another approach that may emerge, however, is to limit plutonium utilization to the same countries in which reprocessing and fabrication take place. As a general rule, in an expanding nuclear power environment, plutonium will be more valuable in LMRs than in LWRs, and LMRs can be expected to emerge first in countries with large and advanced nuclear power programs. In this environment, as the ANS report suggests, spent fuel, rather than constituting a burdensome liability, will acquire economic value and will move to the locations where it has the greatest value. The ANS Panel concluded that this outcome — a spent fuel economy — was not only feasible but more likely than the emergence of a "plutonium economy."

Clearly, if such developments as the concentration and multinationalization of sensitive fuel cycle activities and a "spent fuel economy" are to occur, consensus on their desirability and at least the broad outlines of their structure must be reached. Discussions such as this conference (Plutonium Inventories: Growing Challenges in MC&A and Nonproliferation) offer a useful forum in which consideration of such concepts can take place. Another useful forum will be the IAEA's June 1997 conference on the future nuclear fuel cycle in which international cooperation and institutional arrangements are to be one of the specific areas of consideration.

The Institutional Dimension

The nature of the multinational or international entity associated with the operation of fuel cycle centers will depend on the functions for which the entity is responsible. For nationally owned and operated facilities serving a multinational market, there may be no formal organization beyond the customary IAEA safeguards and, where relevant, Euratom or other regional safeguards as well. Nevertheless, the multinational customers of such facilities, even when acting separately, are a key factor in the emergence of institutional barriers against host country misuse of the materials they deliver. It is worth considering how this institutional barrier can be maximized.

In other cases, one or more formal organizations may be called for to perform important functions. For example, in the case of Urenco both a private sector organization (Urenco Limited) and a governmental organization (the Joint Committee) perform indispensable functions that guarantee the multinational character of the enterprise and its exclusively peaceful purpose. It should be stressed that the term fuel cycle center used throughout this report does not necessarily imply a governmentally owned or operated enterprise. The trend then is clearly in favor of private sector entities operating under appropriate governmental authority and oversight.

As additional multinational or international enterprises evolve, it is worth keeping in mind that organizations that have specific responsibilities in relation to these enterprises must possess certain characteristics if they are to credibly meet their responsibilities. In particular to carry out a credible safeguards program or related materials control responsibilities, a multinational organization must at a minimum have political validity and technical competence. Political validity depends on the presence in the organization of a genuine, self-evident, and irrefutable self-interest on the part of at least the key members in the avoidance of proliferation on the part of other members. An international organization of essentially universal membership, such as the IAEA, meets this test. Multinational organizations, whether regional or otherwise, do not automatically pass muster. To illustrate this point, the former Soviet Union, at least for the record, questioned the nonproliferation bona fides of Euratom. The United States, however, accepted from the outset that an organization comprised of Europe's traditional adversaries was genuinely dedicated to nonproliferation. It is also probably an essential aspect of meeting the political test that an organization not be dominated by a single strong member. While other members of the organization could well be dedicated to the maintenance of nonproliferation, their practical opportunity to object could be limited.

An important collateral purpose of the international or multinational institutional framework is to increase the certainty and elevate the costs of any violation. To meet this purpose and to be more effective, the members of relatively small multinational, quite likely regional institutions, are tied together by many close political, economic, and social ties. As has been seen in the United Nations and other global institution's, the political consequences of violation of the institutions norms may be diluted by the sheer size and diversity of membership.

These observations lead to the conclusion that the international safeguards of the IAEA are essential to ensuring a universally credible verification of compliance or finding of noncompliance, but that these can also be an important role to play for smaller multinational institutions in the actual operation and oversight of fuel cycle centers.

The Future

It goes without saying that the polarization that has so often accompanied any discussion of plutonium recycle is not conducive to the development of a sound, proliferation-resistant structure for the future nuclear fuel cycle. The fact is that plutonium exists in many forms in many locations. Spent fuel is a proliferation risk in its own right and, in the long run, will become the dominant one as its quantity grows and its protective radiation barrier — already of little consequence to would-be national proliferators — diminishes. The carefully nurtured contentions that the reprocessing barrier is an effective one and that spent fuel can be permanently disposed of — or in other words are a "technical fix" to the proliferation risk of the nuclear fuel cycle — do not withstand even cursory scrutiny. It is time to change the terms of debate from whether plutonium should be recovered and used to how the proliferation risks of the future nuclear fuel cycle can be minimized.

Report by a special panel of the American Nuclear Society on the

Protection and Management of Plutonium

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Comments by Harold Bengelsdorf
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Problem

We all know that unlike several European nations and the Japanese, the United States has adopted the so-called "once-through" nuclear-fuel cycle, which avoids reprocessing and recycling of plutonium. The United States also has tended to discourage reprocessing and plutonium use, both domestically and overseas, although it has stressed that it has no intention of interfering in the nuclear fuel cycles of Western Europe and Japan. Moreover, the U.S. government has ceased all research and development on liquid metal reactors, even though in the past it has felt the development of the breeder to be important to the future of nuclear power. It is no secret that the West Europeans and Japanese have found U.S. attitudes towards reprocessing and plutonium use to be troubling at worst or erratic at best; this has led to some serious tensions and an erosion of confidence between the United States and some of its closest allies. This situation has also made it difficult, if not impossible, to develop a common view between the nations most concerned as to how the potential benefits and risks associated with plutonium should best be managed internationally.

Within the United States, as we all know, the greatest attention over the past two years has been devoted not to civil plutonium but to the issues of how the plutonium from nuclear weapons in the United States and Russia should best be handled.

Following the recommendations made by the U.S. National Academy of Science (NAS) in 1994, the U.S. executive branch adopted the NAS's recommendation that plutonium should be converted as soon as possible to a form that is as resistant to proliferation as spent nuclear fuel is.

Two major technical options for achieving this so-called "spent fuel standard" are now undergoing a very elaborate assessment by the Department of Energy. One of these alternatives, of course, is known as the MOX or "reactor option." The other is known as the immobilization approach.

However, even though NAS stressed that these excess weapons materials posed a "clear and present danger" to U.S. national security, it is not expected that the United States will make a decision on how to proceed until this year. And once a decision is made it is estimated that it could take several years to implement either option.

In its major studies on this issue, the NAS only focused on excess weapons plutonium and did not attempt to address the far broader and more complicated question of how the greater quantities of plutonium being generated in the civil nuclear fuel cycle should best be dealt with. However, NAS emphasized that further steps are needed to reduce the proliferation risks posed by all the world's plutonium stocks, including the plutonium in spent fuel. It is also acknowledged that the conversion of weapons plutonium to the equivalent of spent fuel would only have, from a nonproliferation perspective, a transitory value because the radiation barrier protecting the material will diminish significantly in a few hundred years.

Scope of Study

Against this backdrop, the American Nuclear Society (ANS) established an independent and prestigious panel several months ago to take the matter up where NAS left off. The challenge was to look at the broader issue of what to do with civil plutonium, as well as excess weapons material.

Glenn T. Seaborg was honorary chairman; the operating co-chairmen were Richard Kennedy and Myron Kratzer. I was the rapporteur. Other members were Harold Agnew, Ken Davis, Alexander Haig, Marcus Rowden, Gerald Tape, Richard Wilson, Bertrand Goldschmidt, Sir John Hill, Amb. Imai, Peter Jelinek, Nikolai Ponomareo Stepnoi, and Rudolph Rometsch.

Approach

In terms of approach, the report focused on several short- and long-term issues. The short-term focus was on the disposition of excess weapons plutonium, while the longer-range issue concerned the disposition of the plutonium being produced in the civil nuclear fuel cycle.

While the report contains a number of significant recommendations that the panel members believe to be vital to the conduct of a coherent long-term U.S. plutonium management policy, it also was intended to serve as a new analytic tool for further use and discussion.

Some of the ideas that are subject to critical reevaluation include the presumption that it is desirable, from a nonproliferation perspective, to leave as much plutonium as possible in the form of spent fuel. Otherwise plutonium use in a few industrialized countries will lead to a dispersed and uncontrolled use of plutonium throughout the world (the so-called "plutonium economy"). The latter is an assertion that is often made about nuclear power in general by opponents of plutonium use.

Disposition of Excess Plutonium

For the short term, the ANS panel strongly endorsed the concept that all plutonium scheduled for release from the U.S. and Russian weapons stocks should be converted to a form that is intensely radioactive in order to protect the plutonium from theft of seizure (the "spent fuel standard").

However, since the conversion will at best take several years to complete, the panel has concluded that immediate emphasis should be placed on the assurance that all unconverted materials are protected as securely as when they were part of the active weapon stockpiles. The panel urged that higher priority should be given to assuring that this standard can be met. Indeed this is an area that is currently receiving much emphasis within the executive branch, but many of us feel that even more can be done in this area.

More importantly, the panel also recommended prompt implementation of the so-called "reactor option" for disposing of surplus U.S. and Russian weapons plutonium. This would be carried out in available reactors in the United States, Russia, or in third countries. The panel concluded that the reactor option is susceptible to more prompt implementation than the vitrification option and that it should be far more effective than the vitrification route in assuring against possible reuse by the country of origin of the surplus plutonium in nuclear weapons.

This reflects the fact that the reactor option changes and degrades the isotopic composition of the plutonium from a weapons perspective, whereas the vitrification option clearly does not. In this regard, the ANS panel took clear issue with the conclusions in the previous reports of the NAS, which judged the reactor and vitrification options to be equivalent from a security perspective. My personal view is that it is even something of a stretch to argue that the immobilization option meets the spent fuel standard.

The panel also noted that the vitrification option requires a development effort of some duration before it can be chosen with confidence, while in contrast, the plutonium as fuel in current commercial reactors is already taking place routinely in several countries. The group also observed that Russia has expressed a clear intention of adopting a reactor option for disposing of excess weapons plutonium. Accordingly, the panel expressed the view that any efforts to persuade Russia to accept the vitrification option can only serve to delay an agreement. My perception is that the executive branch has come to accept the reality, possibly somewhat grudgingly, that Russia insists on burning its plutonium.

Since the United States lacks an operating MOX facility, the panel felt the reactor option could be initiated most quickly through the use of available fabrication facilities, possibly in Europe. This would be followed by irradiation in either available Russian and U.S. reactors, or possibly in reactors in third countries. We felt it was crucial to start the process soon. My sense is that in looking at the MOX option, DOE is not really giving serious and sufficient weight to the use of European MOX fabrication facilities. While the draft EIS on the subject implies that European fabrication plants might conceivably be employed to help fabricate some initial loading, my sense is that some senior managers at DOE visualize possibly only fabricating some test elements in Europe. Last night I also read an article in the *Journal,* "Arms Control Today" by John Holden, which suggested that all of the European fabrication in capacity is booked and that the Europeans may not be that interested in fabricating excess U.S. weapons plutonium. If time permits, I would welcome receiving clarifying comments from some of the Europeans attending this working group meeting as to how interested they believe Europe might be in helping overcome the MOX fabrication barrier.

The ANS panel also stated that, although it would be undesirable to defer significantly the recycling of existing stocks of separated civil plutonium by substituting U.S. or Russia surplus weapons plutonium, it believed some delay might be justified to permit an earlier start of weapons plutonium disposition.

In order to help assure and demonstrate the irreversibility of the weapons reduction process, the panel recommended that all released weapons plutonium in the United States and Russia should be placed under international safeguards as early as possible in the disposition process.

The Longer-Term Issue

The longer-term issues covered by the panel were those posed by the growing stocks of both separated plutonium and spent fuel generated in the world's civil nuclear power programs.

These issues included what fuel cycle policies should be prudently pursued in light of proliferation risks and likely future energy needs, what steps should be taken in regard to the increase in the demand for nuclear power in the future, and how civil plutonium in its various forms should be protected and managed to minimize proliferation.

Overall, the panel concluded that plutonium is an energy resource that should be used and not a waste material to be disposed of. The report also questioned the common belief that plutonium disposed of as spent fuel can be assumed to be irretrievably protected from future proliferation threats. Over the long term the panelists expressed the view that it is preferable, from both an energy and nonproliferation perspective, to burn plutonium in reactors than to allow it to be present in increasing inventories of spent fuel. This was a key finding in the report.

More specifically, in looking for a potential need for nuclear power, the report noted that improved efficiency of energy generation probably would continue to constrain energy growth in the industrialized countries, but that energy demand, especially for electric power, is increasing steadily in developing countries.

Taking this into account, the panel observed that the industrialized countries cannot expect, and should not wish, developing countries to forego the benefits of abundant energy that they have enjoyed so long. Thus, the panel concluded that all sources of energy — fossil fuels, renewable, and nuclear, as well as improved efficiency — will have to be drawn on to meet the expected growth in demand in an environmentally acceptable manner. We took strong note of the environmental challenges associated with the burning of fossil fuels. The use of nuclear energy will take place primarily in industrialized countries, making fossil fuel resources more accessible and affordable for the developing world. To be on the safe side it was suggested that one should assume that nuclear energy would continue to meet roughly 20 percent of global demand for electricity.

The panel also stressed that currently proven, or reasonably assured, reserves of reasonably priced uranium are insufficient to support a long-term major contribution of nuclear energy to meet world energy demand. It acknowledged that additional reserves will undoubtedly be discovered but stressed that there is "no law of nature" that assures that the rate of discovery will match increased demand prices that will allow continued reliance on power reactor types using only about 1 percent of the available energy in uranium.

Against this background, the panel emphasized that breeder reactors that allow virtually complete use of the energy of uranium or thorium can serve to overcome this limitation.

The panel, however, could not be certain when or whether the use of breeder reactors would become necessary, and frankly, there was a range of views on when and if the breeder ever will be needed. However, from the perspective of prudent energy planning, all the members clearly believed that continued research and development on the breeder is essential in pursuing prudent energy policies. They felt that the current general level of R&D on the breeder was generally adequate, provided the United States reentered the field.

In this regard, the members all expressed the view that the U.S. decision to terminate the work on the advanced LMR or IFR concept (with its very promising proliferation resistant attributes) was most unfortunate and should be reversed. In my view this was another of these unfortunate theological decisions that the administration took early in its deliberations without careful and balanced consideration. However, I also should caution that theology still may be very much in the picture since I have heard rumors that some officials in the administration have been inclined to dismiss the ANS panel's suggestions simply because we recommended revival of the IFR.

As a further key point, the panel emphasized that it saw no need for international uniformity in selection of fuel cycle options. It believed that the recycle option is appropriate for countries in stable regions with excellent nonproliferation credentials and an economic basis for selecting this option.

The group also stated, "We do not favor the widespread adoption of plutonium recycle and we are convinced that it will remain limited for the foreseeable future to countries with the characteristics noted above. Countries vary widely in their abilities both to generate and to make use of nuclear power. As a result, the spread of nuclear power has, in fact, not been rapid, and the adoption of plutonium recycle has been limited to a few industrialized countries."

Thus, in commenting on national differences, the panel took sharp issue with the assertion often made by antiplutonium groups that reprocessing and plutonium use in a few countries is likely to "open the floodgates" to uncontrolled plutonium use all over the world.

With regard to actions to be taken at the international level, the panel concluded that the International Atomic Energy Agency (IAEA) is effectively safeguarding civil reprocessing plants and related plutonium recycle facilities. The group also expressed the view that the IAEA has the capability to effectively safeguard large plutonium handling facilities in the future. However, the group strongly recommended that IAEA should place increased emphasis in carrying out its safeguards on the defense in-depth concept, on containment and surveillance, and other safeguards measures that go beyond materials accountancy. It is also essential that the IAEA be assured of the financial, technical, and manpower resources, as well as the political support, necessary to carry out its increasingly vital tasks.

Finally, with regard to the physical protection of an area the panel stressed that the international community has a legitimate interest in the adequacy of national measures for protection of nuclear materials against subnational threats.

Thus, the panel proposed that the IAEA should be increasingly called on by states on a voluntary basis to review the adequacy of national physical security measures and to assist in strengthening them. Furthermore, the panel recommended the creation of a new international convention under which participating states would agree to submit to periodic reviews by the IAEA of the perceived adequacy of their physical security systems.

It is too early to assess the probable impact of the ANS report, bearing in mind that the question of plutonium use has become highly politicized and polarized in U.S. circles.

Internationally, we have received positive reactions from many members of the international nuclear community. However, in the United States there has been notable silence from the government.

I leave it to you to judge and assess the reasons, but I think they are mixed.

First, we have been taking issue with the attitudes of some people in the current administration and the arms control community who have had an almost religious aversion to any MOX use and plutonium burning. God forbid they should be prepared to reconsider any of their prejudices. An easy response has been to ignore our report, especially if there is not strong domestic political imperative at present to address our recommendations. I believe in the inept rather than the demonic school of government, but in this case one can suspect a conspiracy of silence.

Second, the timing has not been great since the executive branch nominally has been in the process of making a major decision on how to proceed on the question of how best to dispose of excess weapons plutonium. Since this is an election year, the big question regarding excess weapons plutonium is whether the administration really will make a meaningful decision in 1996 or elect instead to tread water and stay in a "study mode" for a prolonged period. Staying in a study mode would hardly appear to be compatible with past assertions that we are dealing with a severe problem (especially in Russia) that presents a "clear and present danger" to our national security.

Thus, if one agrees with our panel's recommendations, better ways need to be found to communicate the points made in our report to U.S. decision makers in the executive branch and Congress.

The realization of changes in U.S. policy attitudes also may depend to a considerable extent on the positions taken by the West Europeans and Japanese in their interactions with senior U.S. policy makers. In my view, we are just starting to scratch the surface in coming to grips with the plutonium issue, and I look forward with interest to see how the dialogue evolves in the forthcoming months.

BNFL Offers New Spent Fuel Monitor

BNFL Instruments, Calderbridge, U.K., introduced a new monitoring system for characterizing spent nuclear fuel. The Spent Fuel Monitor (SFM) provides high-integrity measurements which can be used for burn-up credit, allowing cost savings to be made in spent fuel storage, transport and disposal, according to the company. SFM allows plant operators to independently verify spent fuel characteristics and, with its modular design, can be optimized for either wet or dry conditions, dependent on the measurement technique chosen.

For more information, contact BNFL Instruments, Pelham House, Calderbridge, Cumbria CA20 1DB, United Kingdom; phone +44 (0) 19467 85000; fax +44 (0) 19467 85001.

Horizon, Canberra Join to Provide ER Characterization for DOE

Horizon Environmental Group Inc., Cincinnati, Ohio, and Canberra Industries Inc., Meriden, Conn. entered into an agreement to provide in-situ characterization services for the Department of Energy. The two companies will use gamma spectroscopy systems to support DOE environmental restoration projects. The technology provides immediate analysis results, which can reduce the time for decontamination and decommissioning activities.

For more information, contact Judy Miller of Canberra at 203/639-2362 or 800/243-3955; or Robert Hart of Horizon at 513/792-4477.

UST&D Releases Equipment Fabrication Capabilities Brochure

UST&D, Inc., a Pittsburgh, Pa.-based contract equipment manufacturer specializing in structural steel fabrications, published a brochure illustrating its design, fabrication and testing capabilities. The company's ASME certifications, engineering services and other capabilities are also detailed. UST&D was founded in 1950 as a manufacturer of tools and dies and has evolved into a source for equipment for the handling and storage of nuclear materials.

To receive a copy of the brochure, contact Bob Moscardini at 412/823-3773.

Selber Joins Newport News Nuclear as V.P. for Business Development

Newport News Nuclear, a division of Newport News Shipbuilding, announced that Arlene B. Selber joined the division as vice president for business development. Selber joins the Newport News, Va.-based company with a background in the environmental and waste management industries that are associated with Department of Energy projects. Her most recent position was vice president of corporate business development for Parsons Engineering Science Inc.

BNFL, Parajito Offer New Services for Radwaste Assay

BNFL Instruments and Parajito Scientific Corp. are offering a project management/equipment lease service for radwaste assay. Leasing options are extended to full-service contracts, under which waste montioring is undertaken by supplier personnel in a mobile facility.

For more information, contact BNFL Instruments, Pelham House, Calderbridge, Cumbria CA20 1DB, United Kingdom; phone +44 (0) 19467 85000; fax +44 (0) 19467 85001.

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