JNMM

Journal of Nuclear

Materials Management

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Published by the Institute of Nuclear Materials Management ▪ Volume XXV, Number 2 ▪ February 1997

JNMM

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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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INMM
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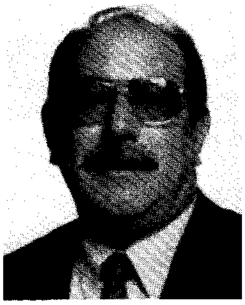
INMM — A Philosophical Perspective



I was honored to be invited to speak at the Annual Meeting of the INMM Japan Chapter in Tokyo during October. As you may know, the Japan Chapter was the first INMM chapter and remains one of the most active and well organized. While pondering what to say beyond my opening remarks and thank-yous, the often quoted keys to success of the late cofounder of *Golf Digest Magazine* Howard Gill came to mind: communication, caring, and curiosity. Although these specific items have not been previously identified as elements of the INMM philosophy, I believe they apply to the Institute. These tenets have been and will be important contributors to the success of INMM. I would like to share the rationale for my belief.

Communication has long been a major element of the INMM agenda and operating philosophy. The *Journal of Nuclear Materials Management* may be the most visible communication activity, but the topical meetings organized by the technical divisions and chapters are clearly communication tools. Interested parties from around the world exchange ideas on the latest nuclear materials management technology and policy developments. The international participation in these activities is growing and the activities themselves are more international in scope.

In addition to the Annual Meeting, INMM sponsors other important activities for the communication of technical information and policy issues. The recent seminar "Plutonium Inventories: Growing Challenges in MC&A and Nonproliferation," the "European Low Level Waste Management Seminar" held in France, and the INMM-ESARDA Workshop "Science and Modern Technology for Safeguards" held in Italy fostered communication of relevant technical information among the worldwide nuclear materials management community.

Caring is essentially the heart and soul of INMM. The Institute is comprised of members with demonstrated technical competencies who have a desire to see integrated, multidisciplinary knowledge applied to improving nuclear materials management. The Institute's members have made a professional commitment to ensure the proper protection, control, accountability, and management of nuclear materials throughout the world. The membership realizes that professional nuclear materials management is critical to advanced nuclear development, and they care about the open discussion of effective technical solutions to current issues.

The technical divisions were structured to promote individual involvement in focused technical areas — those areas which members personally care about. The technical divisions attract individuals who care enough to seize opportunities to enhance communication on relevant issues. For example, the Packaging and Transportation Division sponsored the "Third Uranium Hexafluoride Conference on Processing, Handling, Packaging, and Transporting." This was the first time one of these conferences was held under INMM sponsorship. This occurred because of the Division's desire to facilitate the exchange of information to enhance this aspect of nuclear materials management. It was not out of a desire to generate income, but because they cared enough to facilitate progress.

The formation of new chapters also typifies caring. Our world is a large place and chapters play an important role in meeting the needs of professionals on a local level. Recently the Executive Committee approved charters for two new chapters: the Korea Chapter and the U.S. Southwest Chapter.

What should the Institute do next to serve the membership? The Executive Committee wrestles with this question each year. During the last few years many changes were initiated to address the needs of the membership, and we are constantly striving to meet or exceed member expectations. The requirements for Senior Membership were restructured to extend the opportunity for advancement to more members. The Institute has implemented a home page (http://www.INMM.com), on-line storage of Annual Meeting Proceedings, and this year distributed the 37th Annual Meeting Proceedings on CD-ROM. These and other activities were initiated because the Institute, through its officers and standing committees, cares about the membership and the profession.

Curiosity is what motivates many INMM members. The quest for knowledge on the latest technical breakthroughs and changes in policy promotes professional development and enhances implementation of responsible nuclear materials management. The curiosity of members and other professionals engaged in nuclear materials management is evident by the attendance at the many workshops, seminars, and meetings held by the chapters and technical divisions each year.

The INMM is also concerned with meeting the needs of nonprofessionals who are in positions to drive policy issues and public attitudes regarding technical aspects of nuclear materials management. Too often political posturing and public opinions are based on emotion rather than sound technical information. If nonprofessionals lack the curiosity to become informed, it is the Institute's responsibility to enhance

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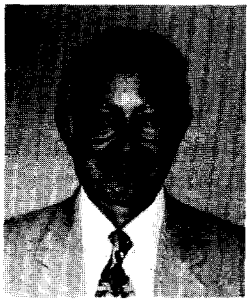
Here's to Change



I've been active — I hope *active* is the right word — in the Institute of Nuclear Materials Management for more than two decades. Of course, there are members who have been active far longer than I — Vince DeVito and Roy Cardwell come immediately to mind — but I've been around long enough to see many changes in the Institute.

At the Annual Meeting in Naples, Florida, I got to thinking about some of these changes. The Annual Meeting itself is a notable example. Long ago, there were a few tens of papers and no need for parallel sessions. In July, we had more than 200 papers organized into four to six parallel sessions. I know that many parallel sessions can be a real pain, but the need for so many is an indication of the importance of nuclear materials management and the importance of the Institute in today's world.

And the banquet — ahhh, the banquet — in the old days, the dinner was inevitably some sort of rubber chicken; but in Naples — and ever since Barb Scott has been negotiating for us with the hotels — the banquet meals have been outstanding. And we used to have an after-dinner speaker. The talks almost always were entertaining, but along with all of the thank-you-kindlys made for a very long evening.

Also, as I moved around the sessions at the Annual Meeting, I was struck by the rather large number of young folks, and especially of women who are involved in all aspects of nuclear materials management these days. When I joined INMM, most of the members seemed to be graybeards who had been doing safeguards for years (sorry guys, but that's how it seemed), and there were very few women — Yvonne Ferris and Nancy Trahey come to mind as notable counter examples. Both of these changes are important to the vigor of our profession.

One thing that has not changed (I think, or at least hope), is the way new members — even young squirts like I was — are welcomed into INMM and put to work.

So, here's to change! But let's also hang on to the best of the old days.

Now let's take a look at this issue of *JNMM*. For the last five years, the INMM's Government-Industry Liaison Committee has organized a half-day session following the conclusion of the technical sessions at the Annual Meeting, and 1996 was no exception. This issue contains summaries of the five invited presentations on nonproliferation.

This issue also contains two technical papers. Both papers discuss safeguards activities in operating facilities. The first, authored by Y. Orechwa and R.G. Bucher, is titled "Startup Calibration and Measurement Control of the Fuel Conditioning Facility In-Cell Electronic Mass Balances." It demonstrates quite convincingly that the uncertainties associated with measuring nuclear materials under actual operating conditions are greater than the uncertainties estimated under laboratory conditions. The authors propose a set of algorithms to address the problem and provide 18 months of experience for evaluation.

The second paper describes an online, real-time materials accounting system in the fully-automated Plutonium Fuel Production Facility in Japan. Several years of experience with this system have shown that an unattended mode safeguards system works well in an automated mixed-oxide fuel fabrication plant. The paper is titled "The Development and Experience of Safeguards at the Plutonium Fuel Production Facility." The authors are H. Nakano, M. Akiba, H. Kobayashi, and S. Takahashi.

Darryl Smith, Technical Editor
Los Alamos, New Mexico, U.S.A.

President's Message

Continued from previous page

their desire for sound professional advice and technical systems for responsible materials management through effective communication and outreach programs.

The INMM is a professional, technical society of members with excellent credentials in a wide range of disciplines. The various chapters, divisions, and committees of the Institute all employ, to different degrees, these keys to success. However, it is the members who play the most important role with respect to them by supporting responsible nuclear materials management not only in their country of origin but throughout the world. There are always opportunities to exhibit your personal application of communication, caring, and curiosity through involvement in the Institute. I would like to encourage each of you to get involved. To facilitate your participation, each article in this edition of the *JNMM* identifies a person who may be contacted for further information. Please do not hesitate to get in touch with those individuals or contact me directly if you would like to increase your involvement with the INMM.

Obie P. Amacker, Jr., INMM President
Pacific Northwest National Laboratory
Richland, Washington, U.S.A.

INMM N14 Standards Committee Meeting

The N14 Standards Committee held its annual meeting Nov. 7 in Washington, D.C. During the meeting, members of the ANSI N14 Standards Committee on Packaging and Transportation of Radioactive Materials reported their progress in various fields.

Charles Haughney, acting director of the U.S. Nuclear Regulatory Commission (Spent Fuel Project Office), delivered the opening address. Haughney discussed the de-emphasizing of standards such as those developed by N14. He mentioned the strong safety culture that exists in the hazardous materials transportation field and the quiet way that transportation business is conducted. He commended the committee for the difficult task of developing standards and promoting their usage.

Committee Head John Arendt informed attendees that according to *The Standards Forum*, a Department of Energy publication, ISO 14000 Integrated Solutions (IIS)™ will be available online for a short time. The document can be viewed at http://www.iso14000.org/.

Richard Serbu discussed "National Technology Transfer and Advancement Act of 1995: Implementation at the DOE." He also supplied committee members with contact information for the representatives to the Interagency Committee from the following organizations: (1) NRC: John Craig, Deputy Director of the Division of Engineering, NRR, T-10-D20, U.S. NRC, Washington, DC 20590; (2) DOE: Richard Black, EH-31, Room A430 GTN, U.S. DOE, Washington, DC 20854; and (3) DOT: Frank Turpin, Director of International Harmonization, National Highway Traffic Safety Administration, U.S. Department of Transportation, 400 Seventh St. S5220, Washington, DC 20590.

Larry Fischer of DOE presented the status of the N14.5 standard and discussed the future balloting schedule.

Richard Brancato, director of the DOE Office of Transportation, Emergency Management and Analytical Services, EM-76, discussed the organization and responsibilities of his office. He spoke about the changes ahead as DOE moves from providing tools for sites to perform DOE's business to the position of corporate logistics provider.

Richard Boyle told committee members that DOT rulemaking HM-169 was not completed yet, and a *Federal Register* notice will extend the regulations related to the radiation protection program. A new Emergency Responders Guide is due in 1997. He also stated the DOT is involved in training representatives from the old Soviet Block countries at Argonne and Hanford.

Beth Darrough of United States Enrichment Corporation discussed the recent compliance testing programs conducted in San Antonio for the 21 PF overpacks. Drop-and-puncture tests and fire tests were completed, and Darrough is pleased with the results and procedures.

Ralph Best discussed the status of the N14.3 standard, including a proposed name change. He suggested broadening the scope to include hazardous materials shippers who want to follow a higher standard to bolster public confidence. Best said the review would start in 1997, and he would welcome the participation of the American Trucking Association.

Ted Needels of EM-76 discussed the Packaging and Transportation Safety Special Interest Group and invited members of the N14 Committee to participate in the group's activities.

Larry Fischer spoke of a proposed new standard on gas generation, which he said is necessary to address issues of long-term storage of radioactive materials and the need to deal with internal contents at some point in the transportation and storage cycle. Phil Gregory is working with Fischer to develop the standard, and the committee will be asked to ballot the new scope and title.

Ron Pope of Oak Ridge National Laboratory and Mike Wangler of EM-76 did not attend the meeting but submitted a report about international occurrences. The 1996 edition was approved by the IAEA Board of Governors in September 1996 and will be published in early 1997. International leaders are meeting to discuss a uniform adoption date by modal organizations [ICAO (air), IMO (sea), AND/ADR (European road and rail)]. Experts say modal adoption will occur between 1999 and 2001. Changes in Safety Series N.6 for UF-6 should cause N14 to place high priority on getting N14.1 comprehensively revised. IAEA advisory material will be published in 1997 as a new edition of Safety Series No.7. Safety Series Nos. 6 and 80 will be combined and called ST-1, and Safety Series Nos. 7 and 37 combined to form ST-2.

Ross Chappell presented an update from the Nuclear Regulatory Commission. The commission adopted the 1985 IAEA transportation safety regulations in the past year. Future fabrication of Type B packagings must operate under the new rules by 1998. A more complicated definition of low-specific-activity (LSA) has been established in the new rules, and nonfissile LSA now will be regulated by DOT. The current LSA rules were extended to 1998-1999. The LSA must be based on the DOT and use the IP-1, -2, and -3 packagings as defined in the new rules. NRC revised all Type B packagings' certificates of compliance to the new definition of the Transportation Index.

The next annual meeting will be held November 6. The DOE will host the meeting.

John Arendt, Committee Head
INMM N14 Standards
John Arendt Associates Inc.
Oak Ridge, Tennessee, U.S.A.

Division Reports

Physical Security

Two ideas for workshops emerged during the last division member meeting. One is to develop a workshop that focuses on the pros, cons, and possible methods of integrating physical security and materials control and accountability; the second is a workshop discussing the different aspects of explosive detection and protection.

The Physical Security and MC&A workshop would deal with the possibility of integrating the previously separate functions because of reduced financing, site size and staffing, and if so, whether they should be integrated partially or fully. Other aspects of the workshop should investigate how integration might occur while still maintaining adequate checks and balances.

The workshop may be a combined Physical Security and MC&A divisions activity. Greg Davis of Lawrence Livermore National Laboratories will co-chair the workshop with a representative from the MC&A division. Division members decided to tentatively schedule the workshop for the week of May 5 in San Diego. Davis estimates 50 to 75 people will attend.

The Explosive Detection and Protection workshop will address the increasing use of explosives in terrorist activities. National and international events have clearly demonstrated the need to discuss ways to protect citizens and facilities from terrorists' new weapon of choice.

Nigel Custance, a security facility executive for Special Services Group, is interested in organizing an explosive detection and protection workshop in Great Britain in the fall. Custance expects 60 to 80 participants from Europe and the United States. Planners are still deciding where to hold the workshop; a fee structure will be based on location.

Tentative topics are explosive detection methods and protection, including blast effects and blast mitigation. The main workshop will be limited to unclassified information, but organizers say a classified session also may be available.

Jim Chapek, Division Head
INMM Physical Protection
Sandia National Laboratories
Albuquerque, New Mexico, U.S.A.

Waste Management

INMM's Waste Management Division is working with ENRESA, the Spanish radioactive waste management agency, to organize a low-level waste technical seminar in Spain. The event, scheduled for autumn of 1997, should include a technical visit to the El Cabril low-level waste disposal site.

ENRESA is preparing a detailed proposal, including dates and possible hotel arrangements. As soon as division leaders review and approve the proposal, they will begin contacting speakers to lead workshop courses about technical issues related with storage and disposal of low-level radioactive wastes.

Meanwhile, Waste Management Division members completed the final edit on the INMM Spent Fuel Storage Monograph and sent the manuscript to INMM headquarters. INMM will oversee the layout of the manuscript as headquarters staff prepares the manuscript for publication.

E.R. Johnson, Division Head
INMM Waste Management
JAI Associates
Fairfax, Virginia, U.S.A.

Executive Committee Meeting Report

The INMM Executive Committee met November 6, 1996 in Phoenix, Arizona. The agenda included updates on committee and division activities since the July meeting.

Finances
INMM ended the year with a surplus of $56,477. Current assets are $363,737, the operating account is $123,390 and the Merrill Lynch Trust Account is at $111,652.

Technical Division Reports
The International Safeguards Division sponsored a joint INMM/ESARDA workshop on "Science and Modern Technology for Safeguards" held October 28, 1996 in Arona, Italy.

The Material Control and Accounting Division held a workshop February 19, 1997 in Washington, D.C. on "International Inspection of Excess Fissile Materials."

The Nonproliferation and Arms Control Division planned an add-on session for February 21, 1997 to The International Inspection of Excess Fissile Materials meeting.

The Physical Protection Division is considering two workshops. One workshop explores the pros, cons, and methods of integrating physical security and MC&A. The second workshop would deal with the different aspects of explosive detection and protection.

The Waste Management Division held the 14th annual Spent Fuel Seminar in Washington, D.C.

Committee Reports
The Membership Committee requested that all applications for Senior membership be approved by April 1. Don Six was approved for Emeritus membership. The total membership to date is: 432.

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Summary of the GILC Forum on Nonproliferation

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John C. Matter
Sandia National Laboratories
Albuquerque, New Mexico, U.S.A.

Robert G. Behrens
Los Alamos National Laboratory
Los Alamos, New Mexico, U.S.A.

James R. Lemley
Brookhaven National Laboratory
Upton, New York, U.S.A.

David Dougherty
Brookhaven National Laboratory
Upton, New York, U.S.A.

■

For the last five years, the Government-Industry Liaison Committee (GILC) has organized a half-day session on the day following the conclusion of the technical sessions at the Annual Meeting. In this session, invited speakers address topics of special interest to INMM members. In 1996, the GILC session took place on August 1, in Naples, Florida, and was chaired by James Lemley (Brookhaven National Laboratory). This year the topic was nonproliferation. The GILC session was organized as a forum with sequential presentations by each of the invited speakers uninterrupted by questions. Following a break, the audience addressed questions to the speakers in a panel format. This year's invited speakers were:

Kenneth E. Sanders, International Safeguards Division, Office of Arms Control and Nonproliferation, Office of Nonproliferation and National Security, U.S. Department of Energy, Washington, D.C.

Andrew J. Bieniawski, International Negotiations and Analysis Division, Office of Arms Control and Nonproliferation, Office of Nonproliferation and National Security, U.S. Department of Energy, Washington, D.C.

Vladislav G. Balamutov, Assistant Minister, Russian Federation Ministry of Atomic Energy (MINATOM), Moscow, Russia.

James A. Larrimore, Office of the Deputy Director General for Safeguards, International Atomic Energy Agency, Vienna, Austria.

Ronald C. Cherry, International Safeguards Division, Office of Arms Control and Nonproliferation, Office of Nonproliferation and National Security, U.S. Department of Energy, Washington, D.C., and

Myron B. Kratzer, Consultant and Former U.S. Deputy Assistant Secretary of State for Nuclear Energy, Annapolis, Maryland.

This is the second consecutive year that a summary of the GILC session has appeared in the *Journal.* James Lemley, Brookhaven National Laboratory, prepared the summaries of remarks by Larrimore, Cherry and Kratzer. David Dougherty, Brookhaven National Laboratory, summarized the joint presentation by Bieniawski and Balamutov. Robert Behrens, Los Alamos National Laboratory, summarized the remarks by Sanders.

Nuclear Smuggling

Remarks by Kenneth E. Sanders

Kenneth Sanders, Director of the U.S. Department of Energy's International Safeguards Division, presented a talk titled "Nuclear Smuggling." Sanders painted a broad picture of the issue of nuclear smuggling and presented his views on the framework of the nuclear smuggling threat.

Sanders likened the nuclear smuggling threat to links in a chain, the three major links being the source of the material, transit of the smuggled material, and the end user of the smuggled material. If any one link in the chain is broken, nuclear smuggling is thwarted.

Sanders noted that the nuclear materials of major concern from a theft perspective come from nuclear weapons; weapons-grade materials, such as plutonium and highly enriched uranium that are being stored as weapons components or in other storable forms; reactor grade plutonium; and other miscellaneous nuclear materials. Sanders sees that strong materials control and accountability at the storage sites is the key to addressing the threat of these materials. Radioisotopes are not included in Sanders' nuclear smuggling scenario, and he asked the question "to what extent can we afford to evaluate theft scenarios associated with these materials?"

The second link in the chain, transit or transportation, is an enormous link in the chain to break. International borders are extremely porous and there are already large burdens on customs officials to interdict other illegal materials, such as drugs. As an example of the problems associated with international borders, Sanders pointed out that the United States alone has 301 ports of entry through which 1.3 million people enter daily and through which massive quantities of goods are shipped daily. Issues associated with interdiction of shipments by nations, sharing of intelligence information among organizations, and training of border and customs officials about nuclear material smuggling all need to be addressed in the future.

The third and final link in the nuclear smuggling chain is the end user of the material. Rogue nations, terrorist organizations, and organized crime are the three perceived major potential users of smuggled nuclear materials. Successful interdiction of nuclear material destined for any one of these sources can only occur through bilateral or multilateral initiatives as well as initiatives through international organizations.

In summary, Sanders believes that nuclear smuggling can be effectively addressed as an international threat and the danger of stolen materials reduced through (1) prevention of theft at the source, (2) effective detection of nuclear material transit within countries and at their borders, and (3) development of effective responses to the theft and timely detection of stolen materials.

HEU Purchase Agreement

Remarks by Andrew J. Bieniawski and Vladislav G. Balamutov

Introduction

The government-to-government Highly-Enriched Uranium (HEU) Purchase Agreement between the United States and the Russian Federation, signed February 18, 1993, provides for the purchase by the United States of 500 metric tons of HEU from dismantled Russian nuclear weapons over a 20-year period for approximately $12 billion. Three additional documents were signed to implement the agreement:

1. Memorandum of Understanding Relating to Transparency and Additional Arrangements, signed September 1, 1993;
2. HEU Purchase Contract signed January 14, 1994, at the Presidential Summit in Moscow; and
3. Protocol on Transparency, signed March 18, 1994.

The Purchase Contract allows the U.S. Enrichment Corporation to purchase the HEU in the form of low-enriched uranium (LEU) suitable for fabrication into fuel for commercial power reactors. The first delivery of LEU under the Contract arrived on June 23, 1995, and shipments have continued monthly throughout 1995 and 1996. The rate of delivery is increasing: 186 metric tons of 4.4% LEU derived from 6.1 metric tons of HEU (enough highly-enriched uranium for about 240 nuclear weapons) was delivered in calendar year 1995; LEU derived from 12 metric tons of HEU will be delivered in 1996 (enough HEU for 480 nuclear weapons), and it is anticipated that LEU derived from 18 metric tons of HEU will be delivered in 1997. The Agreement mandates that at least 30 metric tons of HEU be blended each year beginning with the year 2000.

Facilities

Three Russian and six U.S. facilities process uranium under the Agreement and thus are subject to transparency monitoring under the Agreement. In Russia, the Siberian Chemical Enterprise (SChE) in Seversk receives HEU metal shavings from Russian dismantlement facilities, oxidizes the HEU metal, and packages and ships the HEU oxide to the down-blending facilities, which include the Ural Electrochemical Integrated Enterprise (UEIE) in Novouralsk and the Electrochemical Plant (ECP) near Krasnoyarsk. UEIE and ECP first convert the HEU oxide into HEU hexafluoride and then blend it with 1.5% low enriched blend stock to convert it into LEU product, typically in the range of 4–4.95% enrichment. The LEU hexafluoride product is loaded into industry standard 30B cylinders and transported to St. Petersburg for shipment to the Portsmouth Gaseous Diffusion Plant in Piketon, Ohio.

The 30B containers of uranium under the Agreement arrive at the Portsmouth Gaseous Diffusion Plant, where the uranium may be further processed before sale to the five U.S. nuclear fuel fabricators: ABB Combustion Engineering, Hematite, Missouri; Framatome Cogema Fuel (formerly B&W), Lynchburg, Virginia; General Electric, Wilmington, North Carolina; Siemens Power Corp., Richland, Washington; and Westinghouse Corp., Columbia, South Carolina.

Transparency

The nonproliferation goals of the Agreement require that transparency measures be implemented at U.S. and Russian facilities that process uranium subject to the Agreement. Transparency has been defined as those agreed-upon measures that build confidence that the arms control and nonproliferation objectives shared by the parties are met. These goals seek to ensure that HEU from dismantled nuclear weapons is down-blended into LEU that is no longer suitable for weapons and that this LEU is fabricated into commercial nuclear power plant fuel. As a result of the Joint Statement on Transparency Measures, signed at the Fifth Session of the Gore-Chernomyrdin Commission in Moscow in June 1995, the United States gained direct access to the heart of the Russian highly enriched uranium processing operation, the blending facility at the UEIE. These provisions in the Joint Statement augmented the existing transparency measures in the MOU and Protocol. Specific procedures to implement all of these measures are contained in 14 technical implementing annexes to the Protocol, which were negotiated and signed over the course of four Transparency Review Committee (TRC) sessions that met September 1994, August and November 1995, and April 1996. At the most recent TRC in April 1996, the United States and Russia signed all remaining HEU transparency implementing annexes. Additional details of this historic U.S.-Russian joint Agreement are available.[1-3]

Key features of transparency include:

- Special monitoring visits to Seversk, where highly enriched uranium from dismantled nuclear weapons is converted to highly enriched uranium oxide and shipped to the UEIE in Novouralsk and the Electrochemical Plant in Krasnoyarsk for blending.
- At Seversk, U.S. special monitors have the right to observe highly-enriched uranium metal being oxidized, to observe the analysis of highly-enriched uranium oxide to confirm that the enrichment is weapons grade, and to apply tags and seals to containers of highly-enriched uranium oxide being shipped to the UEIE.
- Special monitoring visits, as well as permanent presence at the UEIE, to ensure that weapons-grade HEU oxide is fluorinated and down-blended to low-enriched uranium for shipment to the Portsmouth Gaseous Diffusion Plant. Four U.S. permanent monitors are currently housed adjacent to the city of Novouralsk.
- At the UEIE plant, both special and permanent monitors have the right to check tags and seals on containers of HEU oxide arriving from Seversk, inventory containers of HEU oxide and HEU hexafluoride in storage, visit the blend point and request and observe the withdrawal and analysis of samples removed from the blend point, record pressure readings to determine the flow of uranium at the blend point, and observe the application of U.S. tags and seals on orifice plates in the pipes at the blending point.
- U.S. monitors have the right to all documentation regarding material control and accounting at both Seversk and UEIE related to the U.S.-Russian HEU Purchase Agreement.
- In addition, a joint development program is underway to provide additional monitoring capability using nondestructive assay instrumentation for containers and to provide continuous monitoring of uranium enrichment and flow of uranium hexafluoride gas in pipes at the blending point.

Transparency implementation

Transparency monitoring began in 1996 with U.S. special monitoring visits to UEIE in February and to SChE in July and September, and a Russian special monitoring visit to Portsmouth in March. A U.S. familiarization visit to the new HEU down-blending facility at the Krasnoyarsk ECP was conducted in July in preparation for negotiation of the transparency-implementing annex for the new ECP blending facility. U.S. permanent-presence monitoring at UEIE began August 12, 1996. The Russians have said that they intend to establish their permanent-presence monitors at Portsmouth in October following special monitoring visits to Portsmouth and several U.S. fuel fabricators.

Conclusions

Implementation of the HEU deal is accelerating. The total amount of HEU-equivalent LEU purchased by the United States is expected to total 36.1 metric tons by the end of 1997 and may reach or exceed 30 metric tons per year HEU-equivalent before the year 2000. Transparency procedures intended to provide confidence that the arms control and nonproliferation goals of the Agreement are being met are in place and are being implemented at both U.S. and Russian facilities.

References

1. Updates on the status of transparency under the HEU Purchase Agreement during the period when it was under negotiation have been presented at annual meetings of the INMM in 1993, 1994, 1995, and 1996 (the 1996 presentation is the subject of this summary). The presentations in 1993, 1994, and 1996 occurred in the Government-Industry Liaison Committee and so were not included in the Proceedings.
2. J. Bieniawski, D.R. Dougherty. "Overview of Transparency Issues Under the U.S.-Russian Highly Enriched Uranium Purchase Agreement," Proceedings of the 36th Annual Meeting of the Institute of Nuclear Materials Management, Palm Desert, California, July 9-12, 1995, Volume XXIV, pp. 1164-1169.
3. E.A. Martin, R.J. Hard. "The HEU Deal: Conflicting Interests & Resistance to the 'Irresistible Deal,'" pp. 28-38, NUKEM Market Reports, June 1996, and references therein.

The IAEA 25 Years After INFCIRC-153

Remarks by James A. Larrimore

James Larrimore presented highlights from the wide scope of IAEA safeguards over the past year. His remarks covered implementation of safeguards in 1995 including activities in Iraq, the Democratic Peoples Republic of Korea (DPRK), the Newly Independent States (NIS) of the former Soviet Union, and the United States for material released from military programs and voluntarily placed under IAEA safeguards.

The following statistics illustrate the scope of International Atomic Energy Agency (IAEA) safeguards in 1995: The IAEA has safeguards agreements with 125 states and carried out inspections in 66 states under comprehensive safeguards agreements, in five states under item-specific agreements, and in the five nuclear weapon states under voluntary agreements. Inspections of nuclear materials were carried out at 554 facilities and locations by 200 field inspectors in a total of 2,285 inspections. The regular safeguards budget was $88.6 million, and extra-budgetary funds of $14 million were provided by eight states. Sixteen states and EURATOM provided R&D and implementation support through technical support programs.

In 1995 the IAEA Secretariat found no indication of the diversion of nuclear material or of the misuse of any facility, equipment, or non-nuclear material that had been placed under safeguards. Therefore, it concluded that the nuclear materials and other items under IAEA safeguards remained in peaceful use or were otherwise accounted for.

In Iraq the IAEA has maintained a continuous inspector presence since August 1994 to monitor and verify Iraq's compliance with the relevant UN Security Council resolutions. In 1995, the IAEA obtained information about Iraq's 1991 crash program to produce a nuclear weapon shortly after its invasion of Kuwait. The IAEA began an extensive review of the information and conducted inspections to clarify matters relating to Iraq's former nuclear weapon program.

The IAEA is still unable to verify the initial declaration made by the DPRK, and the DPRK is still not in full compliance with its Nonproliferation Treaty (NPT) safeguards agreement. To come into full compliance with its agreement, the DPRK must enable the IAEA to verify the correctness and completeness of its initial declaration of nuclear material subject to the agreement, and it has not yet been willing to accede to this requirement.

At UN Security Council request, the IAEA has maintained continuous inspector presence since May 1994 in the Nyongbyon area of the DPRK to monitor the "freeze" on the DPRK's graphite-moderated reactors and related facilities. The DPRK has not accepted some inspection activities requested by the IAEA. These include the monitoring of the waste at the Radiochemical Laboratory (reprocessing plant) and measurements to determine the plutonium content of the spent fuel at the 5 MW(e) reactor. Negotiations held at the end of June in the DPRK addressed inter alia the safeguards on the current operations to "can" the spent fuel from the reactor.

The Newly Independent States (NIS) of the former Soviet Union have been joining the NPT, signing safeguards agreements with the IAEA, and submitting their initial reports listing the nuclear material in the state. In 1995 the IAEA began verification of the initial reports of Belarus, Kazakstan, and Ukraine. A number of states provided technical support for development of infrastructure needed to meet nonproliferation objectives. The IAEA has been assisting the NIS with the establishment of their State Systems of Accounting and Control, which are called for in NPT safeguards agreements.

In 1994 the United States voluntarily placed under IAEA safeguards nuclear material released from the U.S. military program. The IAEA began to apply safeguards to that material and also to additional material released from military programs by the United States in 1995.

In response to several of the events mentioned above, the IAEA is enhancing its ability to detect undeclared nuclear material, facilities, and activities. In March 1995 the IAEA Board of Governors reiterated its support for a strengthened safeguards system and endorsed the general direction of the IAEA's program for strengthening the effectiveness and improving the efficiency of safeguards (known as Programme 93+2).

In May 1995, the NPT Review and Extension Conference, which extended the NPT indefinitely, also decided on certain principles and objectives, several of which were of importance to the IAEA. The conference affirmed that the IAEA was the competent authority responsible to verify and assure compliance with its safeguards agreements with states party to the NPT and that nothing should be done to undermine the authority of the IAEA in this regard. The conference agreed that decisions adopted by the IAEA Board of Governors aimed at further strengthening the effectiveness of IAEA safeguards should be supported and implemented and that the IAEA's capability to detect undeclared nuclear activities should be increased. Fissile nuclear material transferred from military use to peaceful nuclear activities should be placed under IAEA safeguards as soon as practicable.

Also in May 1995, the IAEA Secretariat submitted for consideration by its Board of Governors the two parts of its Programme 93+2 to strengthen and improve the efficiency of IAEA safeguards: Part 1, measures to be implemented under existing legal authority; and Part 2, measures proposed for implementation under complementary authority. The IAEA's progress in implementing the Part 1 measures was reported at the INMM Annual Meeting in 1996 by Dirk Schriefer in the session of International Safeguards I.

At its June 1996 session, the Board had an extensive discussion of the proposed Part 2 measures. It emphasized that the new measures should strike a balance between the IAEA's need for information and access on the one hand and the State's need to protect its legitimate interests and to respect its constitutional obligations on the other. The Board agreed to establish a special committee, the Committee on Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System. It has been given the number Com.24.

The Committee is to negotiate a new legal document, a protocol that would be attached to existing Comprehensive Safeguards Agreements. Under that protocol, states will give the IAEA more information about their nuclear activities and will give the IAEA increased access to relevant installations in the state. These broader rights are intended to enhance markedly the IAEA's ability to detect possible clandestine undertakings.

The special Committee of the Board met for the first time July 2-4, 1996. Representatives from 65 states, the European Commission and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials attended the meeting. Wide support was expressed for the need to further strengthen the IAEA safeguards system. The Committee began preparing the protocol and agreed to meet again on October 1, 1996, and to report its results to the Board in December 1996.

International Safeguarding of Excess Fissile Material: Planning for the Future

Remarks by Ronald C. Cherry

The purpose of the U.S. excess fissile materials initiative is to demonstrate transparency and irreversibility of disarmament, to demonstrate openness in U.S. nuclear programs, to promote global controls on nuclear materials, and to support the strengthening of International Atomic Energy Agency (IAEA) safeguards. Inspections by the IAEA were begun successfully at three Department of Energy (DOE) facilities. Future inspections will be based on a long-range plan.

On September 27, 1993, President Clinton announced that as part of its nonproliferation policy, the United States would submit excess fissile material to IAEA inspection and develop necessary technical measures. On March 1, 1995, President Clinton announced the withdrawal of 200 metric tons of excess fissile material from U.S. military stockpiles. On September 20, 1995, the DOE was assigned to develop recommendations on safeguarding excess material.

Currently approximately 12 tons of excess fissile materials are under IAEA inspection at three DOE sites. At the Oak Ridge Y-12 Plant, inspections have been underway since September 1994. At the Hanford Plutonium Finishing Plant, inspections have been underway since December 1994. At the Rocky Flats Environmental Technology Site, inspections have been underway since December 1995.

Inspections of excess fissile materials in the U.S. have employed standard IAEA safeguards practices. The legal framework is the U.S. "voluntary offer" incorporated in the U.S.-IAEA safeguards agreement. The IAEA's 1991-1995 Safeguards Criteria are the technical basis for safeguards implementation.

In planning for the future, the form, composition, and location of excess materials must be evaluated. Key issues include material stabilization, storage, and disposition plans; programmatic requirements and impacts; protection of sensitive information; environment, health, and safety; and resources.

The inventory of excess material consists of approximately 174 tons of HEU and 38 tons of weapons-grade plutonium. An additional 14 tons of reactor and fuel-grade plutonium are also considered excess. The total inventory was assigned to the following four categories based on availability for IAEA safeguards:

- Material currently under IAEA safeguards — 12 tons at Oak Ridge, Hanford, and Rocky Flats;
- Material available for safeguards in the near term (next 3-5 years), including excess HEU hexafluoride and oxide at Portsmouth;
- Unclassified material requiring further evaluation or other action; and
- Sensitive materials that cannot be safeguarded using current IAEA methods.

Long-range planning will update the availability of material for IAEA inspection taking into consideration the locations, programs, and schedules affecting excess materials. Planning includes the following milestones: approximately 13 tons of HEU will be down blended at Portsmouth by August 1998; approximately 15 tons of plutonium will be stabilized by May 2002; and 50 tons of HEU will be transferred to the U.S. Enrichment Corp. within approximately six years for downblending to LEU.

Continued progress requires that the following issues be addressed: coordination with current and planned programs and disposition schedules; means for verification of sensitive excess materials; protection of sensitive information; potential role of Program 93+2 measures; and provision of adequate resources (personnel and funding).

The next steps in planning include the following: A verification approach for downblending for excess HEU at the Portsmouth Gaseous Diffusion Plant must be developed and implemented. Consultations will be held regarding IAEA safeguards for stabilization, repackaging, and storage of excess plutonium. Consultations will be held on integration of IAEA safeguards with plans for disposition and storage of excess plutonium. The long-range plan will be developed in coordination with the IAEA.

In summary, IAEA safeguards were successfully implemented at three DOE facilities. Continued progress will be based on a long-range plan for inspection of excess material. Immediate steps are being taken to support the development of the long-range plan.

Safeguards and Undeclared Activities: Past, Present, and Future

Remarks by Myron B. Kratzer

Myron Kratzer is a consultant specializing in international nuclear policy issues. During his career he has held the senior nuclear posts in both the Department of State and the Atomic Energy Commission or its successors. Kratzer was the principal U.S. negotiator in the development of key elements of the International Atomic Energy Agency (IAEA) safeguards system, including INFCIRCs 66 and 153; the latter is the model for safeguards agreements between states and the IAEA for implementation of safeguards under the Nonproliferation Treaty (NPT).

Kratzer reviewed the issue of noncompliance with safeguards agreements in pre-Gulf-War thinking, in response to noncompliance by Iraq, and in post-Gulf-War efforts to further strengthen the international safeguards system. According to his interpretation and analysis, essentially all of the measures to strengthen safeguards that have been suggested following the Gulf War have a basis in INFCIRC-153 and can be instituted without modification of 153-type agreements.

Important conceptual advances in safeguards prior to the Gulf War were recounted. In early implementation of safeguards under the Nonproliferation Treaty (NPT), containment and surveillance (C/S) measures were overlooked in comparison with materials control and accounting (MC&A), the latter being recognized in INFCIRC-153 as the safeguards measure of fundamental importance. However, INFCIRC-153 did not downgrade the role of C/S; rather it should be viewed as upgrading the status of C/S measures by formally recognizing them as important supplementary safeguards measures.

In INFCIRC-153, as compared with INFCIRC-66, safeguards are viewed as focused on nuclear materials rather than on facilities. In fact, INFCIRC-153 upgrades the emphasis on facilities. It requires facility design information to be provided to the IAEA at an early stage of implementation and provides for inspections by the IAEA to verify design information before concluding the safeguards agreements for a facility (facility attachment) to verify changes in design information. INFCIRC-153 also mandates verification of the shutdown of a nuclear facility. Diversion is defined not simply as removal of material from facilities but as change from peaceful use to use in nuclear explosives or for purposes unknown.

The totality of commitment intended in the NPT is clear from the use of the word *all* — safeguards apply to *all* activities and *all* materials on *all* territories controlled by the state. The terms *declared* and *undeclared* activities are not used in the NPT. The NPT without question clearly applies to *all* activities.

Before the Gulf War, the rights of the IAEA were already clearly stated in the NPT and other documentation. Special inspections were permitted regarding the source of equipment and material; ad hoc inspections were "virtually unlimited" with respect to time, place, duration, and purpose. For example, verification of a specific inventory does not require a *special* inspection, and inspections carried out by the IAEA in the Democratic Peoples Republic of Korea (DPRK) were ad hoc inspections. Verification of the completeness of a declaration could be accomplished through an ad hoc inspection. Unannounced inspections were recognized and had been carried out before the Gulf War. Inspection for review of design information was an established right before the Gulf War.

In fact, the IAEA gets information from many sources. There is nothing in the NPT that supports a restriction to the use of only safeguards-generated information in the implementation of IAEA safeguards. The Board of Governors can ask for investigations of many types. Findings of the Board are based on relevant information, not just information developed by the Secretariat.

Iraq did not comply with its safeguards agreement with the IAEA under the NPT. Instead, the country committed undeclared activities and small-scale diversion through use of quantities of separated plutonium in undeclared activities. Iraq also averted design review at undeclared facilities. Clearly, transparency is not the same as verification.

Following the Gulf War, the IAEA's rights were reaffirmed. The IAEA has the right and obligation to apply safeguards to *all* material. It has the right to go anywhere in a country. Information from any source can be used to reach safeguards conclusions. The fact that one state wants to buy a product of another state should not be regarded as proprietary information and should be made available to the IAEA. Consensus developed that the IAEA should have comprehensive information. States are invited to report on exports of equipment and materials as well as imports. Recognition that the IAEA should not need to depend primarily on the end user for information on exports and imports is an important development. Design information should be reported whenever a state intends to build a facility. The IAEA can request information and begin a dialog at any time.

The IAEA must verify the completeness and correctness of declarations rather than simply accepting the state's word in this regard. Kratzer asserted that *complete* and *correct* are redundant: An incomplete report is incorrect, and this is really not a new interpretation.

Regarding further strengthening of IAEA safeguards, Kratzer thought that the forum and broadness of interpretation achieved in the extension of the NPT were significant. He commented on several elements of the IAEA's 93+2 program. Regarding wider reporting of information to the IAEA, all of the information needed by the IAEA is probably available in the public domain, but it saves resources for this information to be reported voluntarily without the IAEA asking for it or digging it up itself. Regarding *expanded access*, the term is incorrect because the IAEA already has access to everything in the country; however, lowering the threshold for access by the IAEA is good. Regarding environmental monitoring, although there are new techniques, the concept was foreseen in INFCIRC-153. Cameras look for photons, so why not look for emissions of particles and radiation with appropriate instrumentation?

Kratzer concluded that 93+2 is an evolution not a revolution. New measures will not supplant traditional means; completeness is the key. No pathways to proliferation should be overlooked. The IAEA's job is really confirmation rather than detection, since suspicion and real diversion will arise if confirmation is ineffective. Technical detection capability should be improved, but the responsibility to determine whether diversion could be known from other sources of information should not be overlooked. Transparency is a condition, whereas verification is a process. Transparency is not a substitute for verification.

In closing, Kratzer offered some final thoughts regarding practical implementation of safeguards. Inspectors should keep their eyes and ears open and include all relevant information in inspection reports. The country-officer system (as used by the U.S. Department of State) is a very effective technique for information treatment; although the compiling of information is important, it is more important to have a person who is responsible for understanding all the information about activities in a particular state or region. The IAEA should preserve or reassert its rights, e.g., for special inspections. However, inspection should not be viewed as the final result of the safeguards process. The IAEA must focus on establishment of a protocol that results in actionable findings. This is what will matter if activities indicative of proliferation are suspected or detected.

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Startup Calibration and Measurement Control of the Fuel Conditioning Facility In-Cell Electronic Mass Balances

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Abstract

A methodology is presented for the estimation of in-cell electronic mass balance uncertainties for variance propagation and measurement control at the Fuel Conditioning Facility. The experience of 18 months of operation is evaluated in light of the proposed algorithms. In particular, the need to take the operating environment into account through historical data in the estimation of the uncertainties is demonstrated.

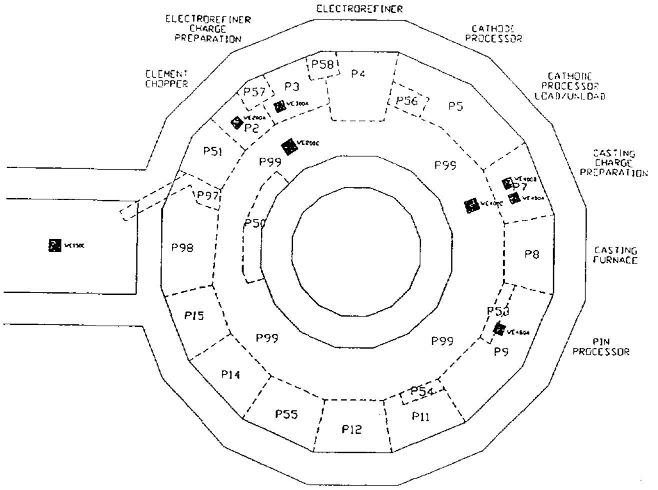
Introduction

The operation of the Fuel Conditioning Facility (FCF) is based on the electrometallurgical processing of spent metallic reactor fuel. It differs significantly, therefore, from traditional PUREX process facilities in both processing technology and safeguards implications. A major characteristic of FCF is that the fissile material is processed only in batches and is transferred within the facility only as solid, well-characterized items; there are no liquid streams containing fissile material within the facility, nor entering or leaving the facility. The electronic mass balances of the FCF are therefore central to much of the safe and economic operation of the facility, and especially to the accountancy of special nuclear materials. For example, an item, before it is moved within the facility, is always weighed on a balance to double check, by reference to its weight, its identity; and, thereby, assure a proper and safe operation. No distinction is made between measurements for material control and accountancy (MC&A) and operation; all measurements are recorded by the mass tracking system.

In view of the fact that the facility is new and of an innovative design, little experience exists with regard to the environment that the balances will initially confront during operation. That the environment is likely to be of importance to the precision balances in the cell is suggested by the high radiation field, expected temperature and pressure gradients, and the remote operation of equipment with manipulators. As such, the statistical issues associated with calibration and measurement control of the balances must be considered in light of the conflicting needs of operation and those of material control and accountancy. That is, control limits that are set too narrow because of the lack of measurement data in an operating environment will impede operation at a critical time in the deployment of the facility. At issue, therefore, is the estimation of appropriate uncertainties, both random and systematic, associated with a balance measurement, and their stability over time. It is these uncertainties that are propagated, together with those of other measurements, to give an overall uncertainty in the inventory difference of the special nuclear material over time for the facility or for some part of the facility A decision as to the loss or diversion of special nuclear material from or within the facility can only be made based on the estimate of the inventory difference and the associated uncertainty. This decision will have validity only if the uncertainty estimate is realistic and does not impede the operation of the facility.

The position of the eight electronic balances in the FCF is show schematically in Figure 1. In this figure, the area within the facility has been divided into criticality zones. On the periphery of the facility, the processes that take place in that region are indicated. There are five Mettler Type A balances (operating range 0–32 kg) and three Mettler Type C balances (operating range 0–120 kg). Three of the balances are in the region of the electrorefiner charge preparation, three in the casting charge preparation area, one at the pin processor, and one outside the argon cell in the fuel assembly dismantling area. During the 18-month period of operation, two of the Type C balances (WE150C and WE400C) underwent recalibration. All of the Type A balances operated within statistical control over that period, in relation to the control limits established at the initial calibration. This latter exemplary performance appears to be the

Figure 1. Distribution of the electronic mass balances within the fuel conditioning facility



result of the a priori decision at the startup of the facility to take into account the likely effects of operation on the predicted control limits by increasing the variance associated with the measurements made with these balances. The current data indicate that this approach was justified. In this paper we present the algorithms and their application to calibration and the quantitative assessment of the measurement control limits for the balances. As a quantitative example, we prefer the experience with balance 400°C, whose performance was not as exemplary in that it required three recalibrations.

Calibration

The calibration of any measurement instrument is an integral part of its application to a particular task. Although the balances used in FCF have been calibrated by the manufacturer and performance parameters specified,[1] because of the reconfiguration of the electronic components of the balances for operation in the in-cell high radiation environment, a documented calibration program was deemed appropriate to meet the requirements for material control and accountancy.[2,3]

The calibration procedure for the in-cell balances is based on the sequential measurement of a set of standard masses spanning the expected operating range of the particular balance. There are 40 selections, taken in random order, from each set of standards associated with each balance type. For example, the set of calibration masses for the Type C balances consists of 1,000 g, 25,000 g, 50,000 g, 75,000 g, and 100,000 g. For in-cell operations, the calibration operations are time consuming, for they are performed remotely with manipulators. As such, a recalibration could incur considerable downtime for operations that depend on measurements with the balance requiring recalibration. With this in mind, the number of measurements of standards per calibration has been limited to 40.[4] Experience has shown, however, that the distribution of standards is often insufficiently smooth with only 40 measurements and can thereby introduce apparent biases. We mitigate this difficulty by selecting the standards based on a quasi-random sequence.[5] This algorithm picks random numbers, yet spreads them out to avoid the chance clustering that occurs with uniformly random points.[6]

The calibration measurements are fit to a linear model

$$W = \beta_0 + \beta_1 {*} S \tag{1}$$

where W is the balance reading, S the nominal mass of the standard, and β_0 and β_1 the parameters to be estimated in the calibration procedure. The fit is performed by linear regression with appropriate SAS[7] procedures.

The calibration of the in-cell balances has two functions in addition to the evaluation of linearity: the estimation of the error to be applied to each mass measurement for variance propagation and the determination of warning and alarm limits for measurement control. These two estimates are calculated differently for FCF operation to accommodate material control and accountancy objectives and operation constraints. Thus, in the case of error estimation for variance propagation via the code MAWST,[8] only one value is computed, which summarizes our knowledge of each error (random and systematic) over the operating range of the balance. On the other hand, for measurement control, we make use of the predictive interval, whose systematic component has a width that depends on the mass of the standard being used to test balance performance.

For mass measurements, with the in-cell balances in FCF, the random and systematic variances, for input to the MAWST variance propagation code, are computed as follows. Let S_k be the mass of the k-th standard and W_{ik} the i-th measurement of the k-th standard. The average observed reading for the k-th standard mass is estimated by the average $\overline{W}_k$, where

$$\overline{W}_k = \frac{1}{m_k} \sum_{i=1}^{m_k} W_{ik}, \tag{2}$$

and the k-th variance s_k^2, where

$$s_k^{\,2} = \frac{1}{m_k - 1} \sum_{i=1}^{m_k} (W_{ik} - \overline{W}_k)^2 \tag{3}$$

and m_k is the number of measurements of the k-th standard. The random component of the variance is then computed by

$$s^2 = \frac{1}{n - K} \sum_{k=1}^{K} \sum_{i=1}^{m_k} (W_{ik} - \overline{W}_k)^2, \tag{4}$$

where $n = \sum_{k=1}^{K} m_k$ is the total number of observations, and K the total number of mass standards.

Since the values for the masses entered into the mass tracking system are not bias corrected, we use the following algorithm to estimate the systematic component of the variance. The bias in the estimate of the mass of the k-th standard is computed as

$$\Theta_k = (\overline{W_k} - S_k). \tag{5}$$

The systematic component of the variance for a balance can be estimated by the square of the bias.[9] In the case of a balance operating over a wide range of masses, we use a weighted average of the squares of the biases with respect to the calibration standards. That is

$$\Theta^2 = \frac{1}{n^2} \sum_{k=1}^{K} m_k^2 \Theta_k^2. \tag{6}$$

However, if

$$\Theta^2 < \frac{1}{n^2} \sum_{k=1}^{K} m_k^2 \sigma_k^2 + \frac{S^2}{n}, \tag{7}$$

where σ_k is the uncertainty in the mass of the standard, the right-hand side of the above inequality is used as the systematic error variance.

An additional component that takes into account the nonlinearity of the balance may be required. The inclusion of this component is not routine, as in the case of the random and systematic components; it requires judgement on a case-by-case basis. If the nonlinearity is severe, replacement of the balance would be necessary. This, however, is likely to be an extreme situation, and not taken lightly. In the case of statistically significant, yet small nonlinearities, we can take them into account by adding in quadrature the following term to the systematic variance

$$\max_k \left| M_k - Q_{25,75}^{(k)} \right|, \tag{8}$$

where M_k is the mass predicted by the estimated regression for the k-th standard, and $Q_{25,75}^{(k)}$ is the 25th or 75th percent quantile of the measured values for the standard. For FCF operation, as a decision rule for the inclusion of the above nonlinear term, the rejection of the linear fit hypothesis is set at the 5% level. By taking the 25th or 75th quantile, we also filter against outliers.

Measurement Control

The analysis of the calibration measurements, discussed in the previous section, is the initial basis for the estimates of the balance performance, such as bias, variance, and linearity. These parameters must, in principle, remain constant in order that the estimates of the random and systematic errors of measurements be valid for application to variance propagation. The objective of the measurement control program is to assure that these balance performance parameters have not changed with time sufficiently to invalidate the error estimates and thereby lead to erroneous conclusions with regard to special nuclear material accountancy.

The control limits in the measurement control program for the FCF in-cell balances do not use the variances estimated in the calibration specifically for input to MAWST and described in the previous section. The application of these estimates would seem to be the logical way to proceed. However, in the DOE order[3] the requirement for checking the linearity of the balance, in addition to accuracy, and in particular, from the operational point of view, the need to minimize the number of weighing operations for measurement control dictated an approach based on the predictive interval associated with a specific balance. The difference between the two variance computations lies in the interpretation of the systematic error in each case. The systematic error estimate for input to MAWST is an estimate of the variation in the mean bias relative to the masses of the standards, given that the underlying relation is represented by $\beta_0 = 0$ and $\beta_1 = 1$. (Only one value of the systematic error is input into MAWST for each balance, and no bias correction is made to the masses in the mass tracking system.) On the other hand, the systematic component in the control limits is an estimate of the variation in the linear relation, as expressed by Equation 1, using the values of β_0 and β_1 estimated at calibration. The predictive interval is centered about the estimate of Equation 1 and therefore incorporates the estimate of the linear relationship. Thus, a test based on the predictive interval evaluates, not only the estimated variance, but also the linearity of the balance with minimum measurements.

At the startup of FCF, it was anticipated that the control limits, based only on data taken at the time of the initial calibration, would very likely lead to excessively tight control limits and be unrepresentative of the operating environment. Thus, to preclude unwarranted recalibrations during startup operations, a nonlinear term of the form

$$\max_k \left| Q_{25,75}(S_k - W_{ki}) \right| \tag{9}$$

was included in the computation of the control limits irrespective of the linear fit test. In Equation 9, $Q_{25,75}$ $(S_k - W_{ki})$ is the 25th or 75th quantile of the difference between the mass of the standard and the measured values of the standard. The expectation was, as will be demonstrated in the next section, that as operating data in the form of periodic calibration checks accumulates, a more truly representative value can be estimated.

The periodic measurements of randomly selected standards made during operation for measurement control of a particular balance should in principle represent the same population of measurements as those made at calibration. The two sets of measurements, calibration and measurement control, are compared for balance WE400C in Figures 2a and 2b, through their box plots of the difference between the mass of the standard and the balance reading for that standard for the first calibration period. The plots suggest that the basic behavior of the balances, as expressed through these box plots, appears (as we would hope) to be roughly the same for the measurement-

Figure 2a. Box plot of the deviations of the measured mass from the standard for the calibration measurements for balance WE400C

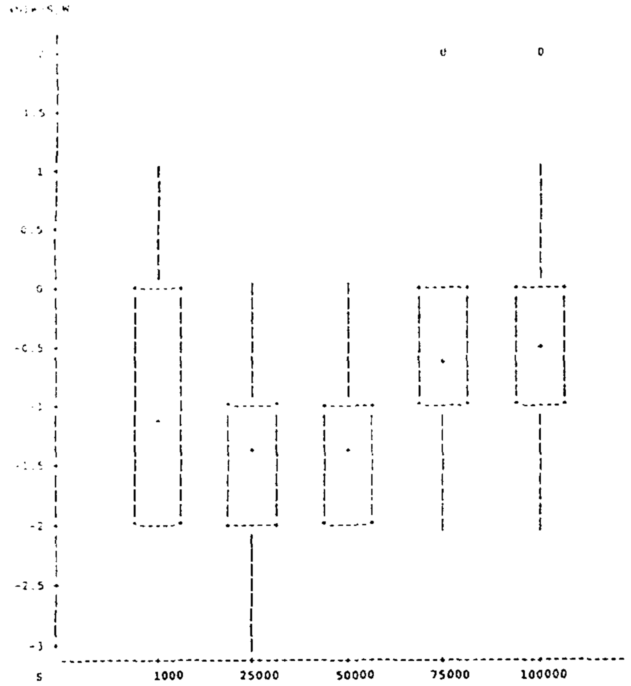
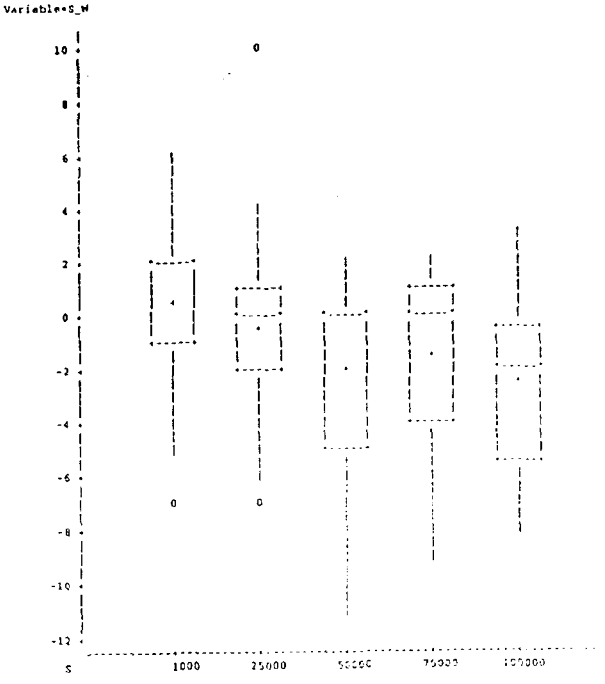


Figure 2b. Box plot of the deviations of the measured mass from the standard for the measurement-control measurements for balance WE400C



control measurements as for the calibration measurements. Similar characteristics are in evidence in the comparisons of the box plots of the other in-cell balances. One characteristic difference, which does stand out, is a generally greater variation in the control measurements for some of the balances when compared to those taken at calibration. (Note that the scale of the ordinate axis in Figure 2b is compressed by a factor of four relative to Figure 2a.) This is likely to be caused by operation and needs to be quantified.

Figure 3 shows the standardized balance measurements in a Shewhart control chart as a function of day, rather than by observation. This allows for easier correlation with operating conditions. The calibration measurements, since they are generally performed over a period of one day, are bunched at the beginning of each calibration period. The FCF operates in a batch mode, and consequently control measurements are made only on days when the balance is used to support some particular operations. Thus, in general, these charts often exhibit long stretches where no measurements were made. In the control chart, the first 40 observations in each calibration period are the calibration measurements; the subsequent measurements are the control measurements. In the case of balance WE400C, the difference in the variations between the calibration measurements and the control measurements is clearly evident. This suggests that different environmental conditions are likely prevalent in the cell at those times and may have influenced the balance measurements. Such effects need to be taken into account in the control limits, for they reflect the operating environment, and not poor performance by the balances. No amount of recalibration, or even a replacement balance, will improve the results.

It is clear from Figure 3, that during operation balance WE400C is subject to effects not taken into account during calibration. It is difficult, at least at this point in time, to correlate the behavior of the balances to specific FCF operations or environmental conditions. What is clear, however, is that the variance estimates made, based only on the calibration measurements, may not adequately reflect the variance of measurements during FCF operation.

Application of Historical Data

The main difficulty with regard to uncertainty estimation for the in-cell balances is that the information in the calibration data, which is generally collected over several hours, does not sufficiently take into account the effects of day-to-day changes in the performance of a balance, because of changes in its environment from the operation of the facility. To overcome this shortcoming, we need to bring to bear relevant measurements that were made during operation. The ideal candidates for the in-cell balances are the measurement-control measurements made on the balances subsequent to the calibration, that is, during the calibration period. These, in principle, are the same as the calibration measurements, except that they are made over greater periods, and when equipment is likely to be operating in the vicinity of the balance. The objective, therefore, is to develop an algorithm for the uncertainty of the balance measurements that

Figure 3. Control chart of the measurements of the mass standards on balance WE400C within the fuel conditioning facility

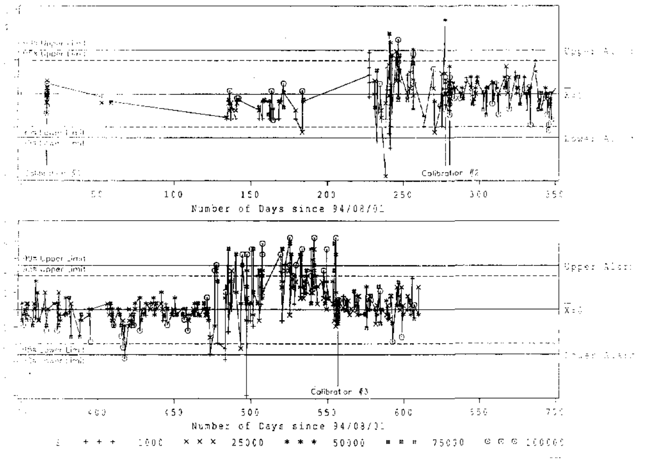
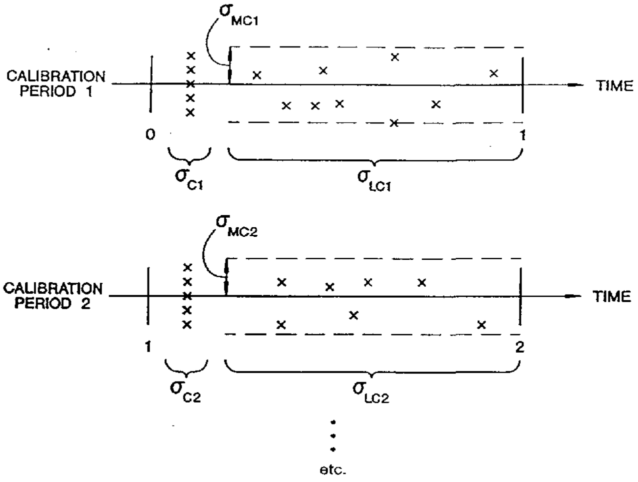


Figure 4. Schema of the evaluation of the variance components over sequential calibration periods



incorporates all data from previous calibration periods.

A heuristic description of the data collection over the calibration periods is shown in Figure 4, where σ_{Ci} represents the uncertainty estimated with only the calibration data for the *i*-th calibration; similarly σ_{LCi} represents the uncertainty estimate based only on the measurement-control measurements subsequent to the *i*-th calibration, and σ_{MCi} the estimate of the standard error used to compute the measurement control limit for the *i*-th calibration period. (We do not distinguish between the random error estimates for input to MAWST and those for measurement control. The basic algorithm is the same for each of these situations.)

The flow of calibration information is shown in Figure 4. For the first calibration period, the MAWST input and the measurement control limits are determined based only on the information in the calibration data, namely on σ_{C1}. Thus, schematically, we can represent this as

$$\sigma_{MC1} \leftarrow \sigma_{C1}.$$

The measurement-control measurements are compared during this calibration period to the control limits based on σ_{MC1}, and are saved. For the second calibration period, the available data are σ_{C2} the calibration uncertainty for the second calibration, σ_{C1} the calibration uncertainty from the previous calibration, and σ_{LC1} the estimate of the uncertainty in the measurement-control measurements from the previous calibration periods. Thus, schematically, the information available for estimating the uncertainty on which to base the control limits for operation during the second calibration period is

$$\sigma_{MC2} \leftarrow \sigma_{C2}, \sigma_{C1}, \sigma_{LC1}.$$

This generalizes to the *i*-th calibration period as

$$\sigma_{MCi} \leftarrow \sigma_{Ci}, \ldots, \sigma_{C1}, \sigma_{LC1}, \ldots, \sigma_{LC(i-1)},$$

or

$$\sigma_{MCi} \leftarrow \sigma_{Ci}, \sigma_{MC(i-1)}, \sigma_{LC(i-1)}.$$

The proposed algorithm for including historical data (i.e., data from the previous calibration periods) in the estimate of balance measurement uncertainties for the current calibration period is based on the sampling theory approach of pooling data from independent samples. That is, the estimate of the uncertainty for the current calibration period is given by

$$\sigma^2_{MCi} = W_C \sigma^2_{Ci} + W_{LC} \sigma^2_{LC(i-1)} + W_{MC} \sigma^2_{MC(i-1)}, \tag{10}$$

where W_C, W_{LC}, and W_{MC} are appropriate weights. In sampling theory these weights are the ratio of observations on which the particular variance component is based to the total number of observations, such that

$$W_C + W_{LC} + W_{MC} = 1. \tag{11}$$

The objective for pooling data, in our case, is somewhat different from that of the strict sampling theory approach. The notion is that the calibration data taken for a given calibration period does not adequately reflect the variation over the whole calibration period because of facility operation.

Thus, the weights should give higher value to the estimates that incorporate more of the expected variation from operation, rather than solely to the estimates based on more observations. In our case, the initial 40 calibration measurements are generally made over several hours, while the measurement-control measurements are made over an extended period of time during the operation of the facility. Clearly, if the goal is to account for operational effects, greater weight should be given to the uncertainty estimates based on the measurement-control measurements. To this end, we introduce an algorithm where the weights are a ratio of the number of days on which the measurements to compute the estimate for the particular variance component were made. Thus, the weights in Equation 11, for the i-th calibration period, have the following form

$$W_C = \frac{d_{C(i)}}{n_{tot}}, \tag{12}$$

$$W_C = \frac{d_{LC(i-1)}}{n_{tot}}, \tag{13}$$

and

$$W_{MC} = \sum_{k=1}^{i-1} d_{C(k)} + \sum_{k=1}^{i-2} d_{LC(k)}, \tag{14}$$

where

$$n_{tot} = \sum_{k=1}^{i} d_{C(k)} + \sum_{k=1}^{i-1} d_{LC(k)}, \text{ and } d_{C(k)}$$

is the number of days on which the *k*-th calibration measurements were made (generally one), and $d_{LC(k)}$ is the number of days in the *k*-th calibration period on which measurement-control measurements were made.

The algorithm given by Equation 10, with the above expressions for the weights, contains some desired properties. First of all, the weights sum to one. Secondly, as the number of calibration periods gets large, the weights associated with the current calibration and the measurement-control measurements from the previous calibration period, W_c and W_{LC}, respectively, go to zero. That is, the current information is discounted in relation to the cumulative historical information. This is likely to help in detecting progressive degradation in the performance of a balance. Thirdly, the weight of the cumulative historical information W_{MC} goes to one. The algorithm, therefore, has the fixed point property and converges to a value that reflects the inherent uncertainty in the measurement instrument, and the uncertainty caused by the variation in the operating environment.

This algorithm can then be applied in a straightforward manner to the computation of updated estimates of the random error for input to MAWST and the standard error used in defining the measurement control limits. Over the period of FCF operation under consideration, balance WE400C required three recalibrations. The application of this algorithm to the data is demonstrated in Table I for the random error component for input to MAWST,[1] and the standard error for computing the measurement control limits in the Shewhart control charts. As an example, let us consider the evolution of the estimate of the random component for variance propagation as shown in Table I. The initial 40 calibration measurements, all taken in one day, give an estimate of the random error as $\sigma_{C1} = 1.101$ g. Since we have no operating data at this point, this becomes the random error component for input to the variance propagation code MAWST. Measurements of standards for measurement control were subsequently made on 46 days before the balance required recalibration. The measurement-control measurements during this period lead to an estimate of the random error $\sigma_{LC1} = 3.129$ g. We note that this is significantly larger than our initial estimate based on the initial calibration data. We begin the second calibration period by again taking 40 measurements of standards; this time over two days. This calibration leads to an estimate of $\sigma_{C2} = 1.553$ g for the random error. Based on this estimate and the estimates σ_{C1} and σ_{LC1} from the previous calibration period, we use Equation 10 to compute the estimate of the random error $\sigma_{VP} = 3.052$ g for variance propagation with MAWST during the second calibration period. During the second calibration period, 164 days of measurement-control measurements were made before a third recalibration became necessary.

Table I. The Variance Components of Balance WE400C over Three Calibration Periods

		Measurement Control (50 kg)	**Variance Propagation (Random)**
	***d* (days)**	**σ (g)**	**σ (g)**
σ_{C1}	1	1.104	1.101
σ_{XX1}	1	2.285	1.101
σ_{LC1}	46	3.139	3.129
σ_{C2}	2	2.698	1.553
σ_{XX2}	49	3.093	3.052
σ_{LC2}	164	3.909	3.886
σ_{C3}	1	2.528	1.244
σ_{XX3}	214	3.732	3.704

XX = MC for Measurement Control
VP for Variance Propagation

[1] Since each calibration is initiated by performing a manufacturer specified external calibration, and the subsequent assumption that $\beta_0 = 0$ and $\beta_1 = 1$, we believe it is inappropriate to update the systematic error component of the MAWST input with historical data; that is, the value computed from the set of calibration data will apply for that calibration period.

The third calibration period begins again with 40 measurements of standards over one day. These result in the estimate $\sigma_{C3} = 1.244$ g. This estimate is again combined with the previous data via Equation 10 to give the estimate $\sigma_{VP} = 3.704$ g to be applied to the measurements in the third calibration period.

Conclusions

The analysis of the balance measurements of mass standards on the in-cell electronic mass balances of the FCF has shown the need to take into account the effects of facility operations on the estimates of measurement uncertainty. In the case of a newly installed balance, where no historical data exists, the procedure of adding a term that takes into account some nonlinearity, whether it is statistically significant or not, appears to be effective. This procedure allows a sufficiently long operation so as to collect data for the estimate of the contribution of operational effects to the uncertainty estimate.

An algorithm for systematically taking into account historical data was developed and demonstrated for a balance over three calibration periods. The algorithm, both asymptotically and in the sample case, has the desirable properties for estimating the uncertainty in the measurements of balances in a new facility for which no previous experience exists.

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The Development and Experience of Safeguards at the Plutonium Fuel Production Facility

■

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Abstract

A safeguards system was developed for the fully automated plutonium fuel production facility, Power Reactor and Nuclear Fuel Development Corp. (PNC), Tokyo, Japan. An on-line real-time material accounting system that can provide timely declaration of nuclear material within the facility was adopted. Verification nondestructive assay systems (NDA) combined with an advanced containment and surveillance (ACS) system in a remote mode were developed mainly under the U.S. DOE/PNC cooperation agreement in consultation with the inspection authorities. Conventional material accountancy as well as near-real-time accountancy (NRTA) are evaluated. It is proven that the unattended-mode safeguards scheme works well in the automated MOX fabrication plant. Further improvements for operator's nuclear material accounting and so on were investigated.

Introduction

PNC constructed a MOX fuel fabrication facility, the plutonium fuel production facility (PFPF), to supply fuel for the prototype fast breeder reactor (FBR) "MONJU" and experimental FBR "JOYO" with 5 tons per year of MOX production capability. Reduction of radiation exposure possible from a large amount of plutonium is one of the most important objectives for a large-scale MOX fabrication facility. To resolve the problem, PNC introduced various automation technologies for the PFPF based on its past 20 years of experience and started the operation in 1988.[1]

The conventional safeguards approach to large, automated facilities for fabricating plutonium fuel has difficulties with traditional methods such as taking samples, seal application, installation of surveillance and measurement equipment, and so on. These activities consume much time and may disturb plant operation. Advanced safeguards approaches must be established in conjunction with an automated modern MOX fabrication facility.

In 1988, collaborative efforts to develop a safeguards system consisting of several NDA devices, authentication systems, etc. were started under the agreement between the U.S. Department of Energy and PNC. After extensive development, the unattended mode measurements system in combination with ACS system has been applied to the facility.[2-7]

Now, PNC has gained several year's experience in the implementation of safeguards in PFPF.[8,9] This paper describes the development of the safeguards system, experience in the implementation of safeguards, and further improvements to be achieved in the future.

Outline of the Facility

PFPF is a large-scale MOX production facility designed for supplying fuel assemblies for FBRs and advanced thermal reactors (ATRs). The construction of the PFPF for FBR line was begun in 1982 and completed in 1987. PFPF consists of a FBR building, an ATR building, and a common building that has three floors including a basement. In the FBR building, pellet fabrication process, fuel pin fabrication and assembling, analytical chemistry, and product stores are located. In the common building there are the feed store, the feed preparation process, track yard, central control computer, and the administration office.

Safeguards Concept

The PFPF consists of a single material balance area (MBA) that includes necessary key measurement points (KMPs) and strategic points (SPs) to account for bulk areas and item areas. In addition to conventional material accountancy, a near-real-time accountancy (NRTA) scheme to achieve the timeliness goal has been implemented in the facility. Therefore, interim monthly inventory verification has been carried out, as well as yearly physical inventory verification.

Operator's Material Accounting System

Nuclear material accountancy consists of the nuclear material accounting activities that are undertaken by the facility operator and independent verification activities carried out by inspection authorities. Various automated technologies have been introduced in PFPF in order to establish inventories and transfers of nuclear material in a timely manner.

Measurement points for material accounting

Feed materials are stored in the plutonium storage and transferred to the process whenever necessary. Transferred nuclear materials are first put into a transfer container and stored for a while in the intermediate storage for temporary storage and transfer. Nuclear materials are processed through the intermediate storage.

The intermediate storage is separated from the glove boxes by a thick wall, and personnel entries to the storage are prohibited. Intermediate storage units are located under the transfer path in the intermediate storage area to store transfer containers. Between the intermediate storage and the glove box, there are small weighing boxes (material accounting glove boxes), where the transfer container numbers are identified, and nuclear materials are weighed. The analysis for plutonium contents relating to the accounting is implemented by taking samples from feed materials, pellets, and dry recoveries.

Adoption of the computer system

In PFPF, where a large amount of nuclear materials is handled, equipment for production, transfer, and storage is automated. To control and manage the automated equipment, a capable computer system has been adopted.

The computer system consists of three levels: the central control computer, the process control computer, and the equipment control computers. The central control computer level provides material accounting and inspection data. The process control computer level implements production and inventory control. The equipment control computer level provides instructions to various equipment.

Weight and fuel pin and pin tray ID numbers are automatically entered into the accounting data, so timely declaration of nuclear material inventories and transfers are available through this computer system. The system is called the automated accounting system (AAS).

Figure 1. An example of nuclear material transfer control

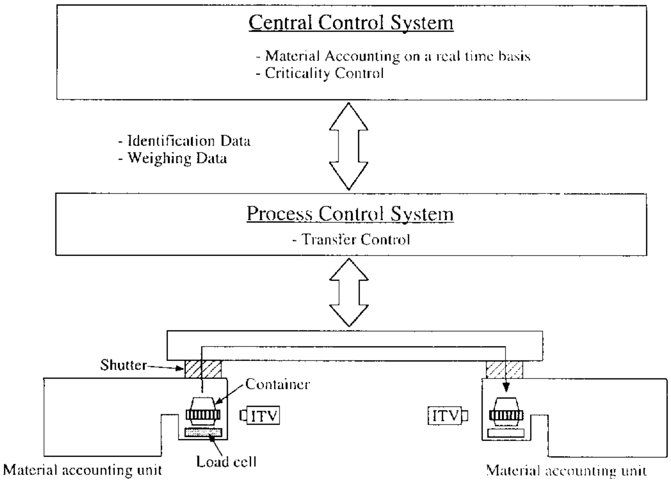


Figure 1 shows an example of transfer modes of nuclear materials. The central control system is shown at the top, the process control system at the middle, and equipment at the bottom. Data relating to material accounting, such as weight, transfer container number, and inventory location are collected automatically by the process control system and the central control system whenever a transfer occurs.

The holdup remaining in a glove box is established by the balance of measured quantity of material transferred into and out of a glove box. By summing the holdup for each glove box, the total holdup can be obtained for a given material balance period.

The system is characterized by (1) duplicate computer systems to reduce computer down time and enhance reliability, (2) a graphic panel to display inventory and transfer status, and (3) earthquake protection.

Inspection Activities

As the PFPF introduced various automated technologies, safeguards systems were designed to be compatible with the facility. Remote, unattended NDA systems and ACS systems have been developed to verify inventory change and physical inventory for bulk and item areas. Destructive analyses are also performed for verification activities.

NDA systems

The NDA instruments for verification have been designed to be automated, remotely controlled, and used unattended by inspectors. They are installed in-line to match the robotic nuclear material handling systems, providing authenticated data for safeguards use. The equipment was developed by Los Alamos National Laboratory (LANL) as part of the U.S. DOE/PNC cooperation agreement.

These systems are based on the high-level neutron coincidence counting technique. The designs were based on the IAEA User's Requirement to satisfy the IAEA basic requirements for authentication, capability, reliability, and maintenance.

The plutonium canister assay systems (PCAS) have been installed in the input storage transfer hall and are used to verify, unattended, all receipts of canisters into the storage, shipment of scrap canisters, and inventory verification of stored canisters.

The material accountancy glove-box assay systems (MAGBs) are based on two sealed-slab neutron detectors. Three unattended independent systems have been installed in the process area and are used to verify the plutonium content of the nuclear material transfer containers.

The fuel pin assay system (FPAS) for verification of the pins in a pallet and the plutonium fuel assembly assay system (FAAS) for verification of the flow of MOX fuel assemblies into product storage as well as out of the facility in an unattended mode have been developed and installed.

The glove box assay system (GBAS) to measure the hold-up inside glove boxes has been developed, since it was realized that the amount of hold-up is higher than expected.

Photographs of these remote-controlled NDA systems are shown in Figure 2.

A waste drum assay system (WDAS) for the measurement of waste drums and an inventory sample assay system (INVS) for measuring small grab samples destined for chemical analysis have also been developed.

All of the NDA systems described are routinely used for inspection activities.

Advanced containment and surveillance (ACS) systems

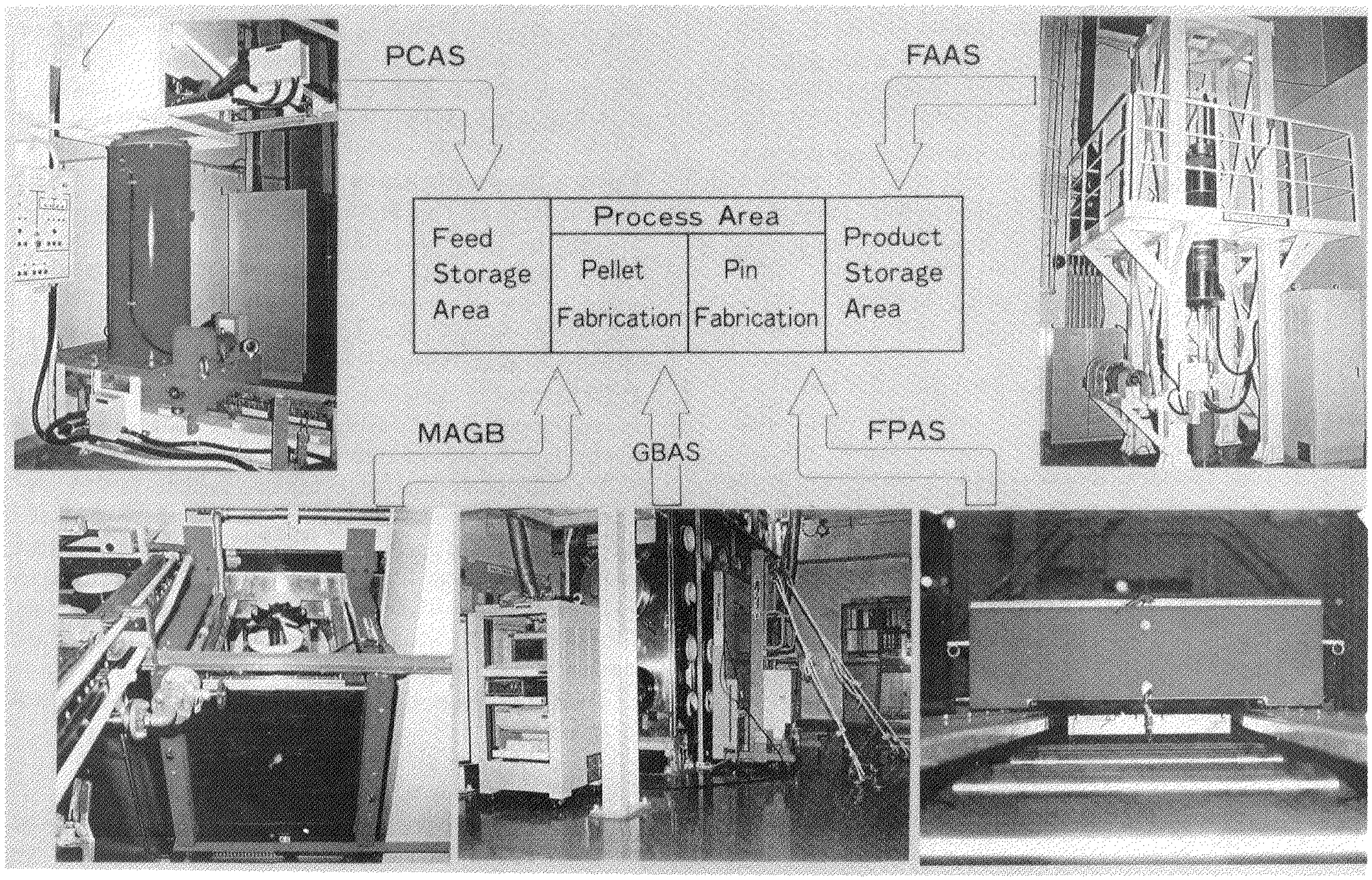
The ACS systems were designed and installed in item areas and the feed and product storage areas.

In the feed storage area, the ACS system, which uses a variety of sensors, monitors when canisters enter or leave the area, whether a canister is full or empty, and in which pit a given canister is stored. The system generates a map of the storage locations showing positions that contain canisters and whether or not the canister in a given location is full or empty. Video cameras provide periodic surveillance of the storage halls, show the identification on canisters, and provide surveillance of the transfer hall located between the two storage halls.

In the product storage area, video cameras monitor the area and record the operations by scanning and detecting the movement of green and red colors on the crane and fuel assembly capsule respectively.

The introduction of unattended mode NDA systems combined with ACS systems has led to considerable reduction in routine inspection efforts.

Figure 2. Remote-controlled NDA systems



Implementation of NRTA

As in conventional material accountancy, NRTA begins with the plant operator's declaration of nuclear material inventories at regular intervals as well as inventory changes. These declarations are verified by inspection authorities. The objective of NRTA is to improve the sensitivity and timeliness of detection for a variety of loss scenarios through sophisticated statistical analysis methods of observed material unaccounted for (MUF) sequences. The NRTA system determines the detection sensitivity of the implemented safeguards system by evaluating MUF sequences and the operator-inspector differences *(D)*. The evaluation of MUF is based on the operator's measurement system. The quality of operator's measurements is of primary importance because it determines the uncertainty associated with MUF. This quality depends on

- the operator's measurement instruments (methods),
- the estimation of errors associated with those instruments, and
- the propagation of errors to determine the error of MUF.

Random and systematic measurement errors are estimated for each stratum: feed powder, pellets, scraps, holdup, etc., based on analytical and plant operation experience.

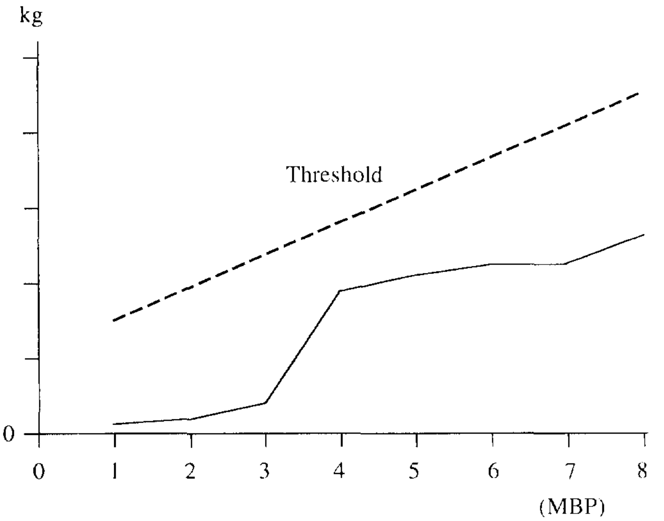
A non-detection probability (non-DP) of $\beta = 0.8$ can be used for calculating the sample size for verifying the inventory when an NRTA system is applied. This is because the detection probability accumulates over time when an effective NRTA system is used.

The NRTA scheme currently used in PFPF evaluates only MUF sequences. Results of MUF sequences obtained for recent material balance periods are shown in Figure 3, which indicates that all limit of error of MUF (LEMUF) values are within the test threshold.

If a LEMUF value exceeds the threshold, the operator must take immediate actions, such as:

- examining whether measurements are correct or not,
- examining the correctness of declared accounting information, and
- evaluating whether measurements errors are still valid.

Figure 3. GEMUF test for recent MBPs



If the operator cannot resolve the problem, the inventory verification for interim inspections will be carried out with a $\beta = 0.5$, and an on-site *D* evaluation will be carried out by inspection authorities.

Further Improvements at PFPF

Material accountancy is a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures to detect a diversion of nuclear material; therefore, more accurate measurements of each nuclear material stratum leads to more effective safeguards and improvement of material accountancy capability.

Measurement accuracy for holdup estimation, which contributes to sigma-MUF are under consideration.

It is pointed out that the NRTA scheme could be an operator's tool to manage nuclear material in near real time. Closing material balances at frequent intervals could give the operator timely indications of

- an abrupt or protracted loss or gain of nuclear material detected with the physical inventory or during transactions,
- an error for accounting records of inventory or during transactions, and
- unpredicted bias in measurements.

MUF sequences at very frequent intervals might provide an effective alarm for the events shown above. Therefore, the operator is studying the possibility of running the NRTA scheme at very frequent intervals as an operator's method of controlling nuclear material and for material accounting.

Future Issues for Safeguards

Some techniques being implemented at PFPF could contribute to improving future safeguards.

One of the measures being discussed in Program "93+2" to strengthen the effectiveness and improve the efficiency of the safeguards system is the use of NDA and C/S equipment in an unattended mode. Experience with the safeguards system at PFPF has proven the usefulness of the unattended mode technique. The technique, combined with remote transmission, could further improve the cost-effectiveness of inspection activities.

For sufficiently large bulk-handling facilities, it is recognized that it is necessary to increase the effectiveness of safeguards. In this connection, the technique of near-real-time accounting with very frequent time intervals will be used by both the operator and the international safeguards inspectors. The use of NRTA will upgrade the safeguards effectiveness and improve transparency.

To achieve this goal, further experience and evaluation will be required.

Conclusion

To facilitate international and domestic safeguards, advanced safeguards systems have been introduced in the PFPF in cooperation with the U.S. DOE under the support of the Agency. It has been proven, after several year's experience, that the system is effective and efficient in safeguarding PFPF.

The computer system, combined with process equipment, has been adopted to establish inventories and transfer of nuclear material whenever they occur. The accounting data are automatically accumulated and processed by the operator through the system. A conventional nuclear material balance has been closed at least once a year, and interim inventories are declared to inspectors for the implementation of the NRTA scheme.

Verification activities by inspectors have been carried out through unattended, remote NDA systems combined with ACS systems, thus considerably reducing inspection efforts.

Material accountancy has been evaluated by the operator and the inspection authorities. The evaluation of MUF sequences in the NRTA scheme has also been performed.

Development and application of the PFPF safeguards system proved that a large-scale MOX facility can be effectively safeguarded, indicating the direction of safeguards in such automated facilities.

Further studies are underway, involving topics such as improvements of material accountancy capability and running of the NRTA scheme at very frequent intervals as an operator's tool to control nuclear material.

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April 1997
(date and location to be announced)
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May 1997
(date and location to be announced)
1997 ESARDA Symposium, 19th Annual Symposium on Safeguards and Nuclear Materials Managment. *Contact:* F. Genoni, +39-332-789421; fax, +39-332-789509.

July 20–24. 1997
INMM's 38th Annual Meeting
The Pointe Hilton at Squaw Peak, Phoenix, Arizona. *Contact:* INMM Headquarters, 847/480-9573; fax: 847/480-9282.

Author Submission Guidelines

The *Journal of Nuclear Materials Management (JNMM)* is the official journal of the Institute of Nuclear Materials Management. It is a peer-reviewed, multidisciplinary journal that publishes articles on new developments, innovations and trends in safeguards and management of nuclear materials. Specific areas of interest include physical protection, material control and accounting, waste management, transportation, nuclear nonproliferation/international safeguards and arms control/verification. *JNMM* also publishes book reviews, letters to the editor and editorials.

Submission of Manuscripts: *JNMM* reviews papers for publication with the understanding that the work was not previously published and is not being reviewed for publication elsewhere. Papers may be of any length.

Papers should be submitted in *triplicate,* **including a copy on computer diskette.** All popular Macintosh and IBM word processing formats are acceptable.
If you have questions regarding your computer software's compatibility, contact Greg Schultz, (847) 480-9573.

Submissions should be directed to:

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Institute of Nuclear Materials Management
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Papers are acknowledged upon receipt and are submitted promptly for review and evaluation. Generally, the author(s) is notified by the technical editor within 60 days of submission of the original paper whether the paper is accepted, rejected or subject to revision.

Format: All papers must include:
- Author(s)' complete name and telephone number;
- Name and address of the organization where the work was performed;
- Abstract;
- Camera-ready tables, figures and photographs;
- Numbered references in the following format:
  1. F.T. Jones and L.-K. Chang. "Article Title," *Journal* 47(No. 2):112-118 (1980).
  2. F.T. Jones, *Title of Book*, New York: McMillan Publishing, 1976, pp.112-118;
- Author(s) biography.

Peer Review: Each paper is reviewed by two or more associate editors. Papers are evaluated according to their relevance and significance to nuclear materials safeguards, degree to which they advance knowledge, quality of presentation, soundness of methodology and appropriateness of conclusions.

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Reprints: Reprints may be ordered at the request and expense of the author. Order forms are available from the Institute's office, 847/480-9573.

Executive Committee Meeting Minutes

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Chapter Reports
The Secretary reported on the approval of two new chapters. They are the Southwest Chapter, which encompasses Arizona, Colorado, Nevada, New Mexico, and Texas, and the Korean Chapter. Plans for an INMM Chapter in the United Kingdom and Obninsk, Russia are underway.

A copy of the complete meeting minutes can be obtained from INMM headquarters, 60 Revere Dr., Suite 500, Northbrook, IL 60062; tel.: 847/480-9573; fax: 847/480-9282.

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