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An Update on INMM's Strategic Planning

By John C. Matter
INMM President

INMM's strategic plan is progressing. As you may recall, the Executive Committee and several others (who stayed an extra day following the Technical Program Committee and regular Executive Committee meetings) began this initiative in March. From the outset we have made every effort to avoid producing a plan that sits on a shelf, never to be implemented. Although only time will tell if we are successful, I share this information with you to encourage your feedback so we can make our strategic plan relevant and useful to our members, our profession, and the Institute.

In March, we spent very little time massaging our mission and vision statements and instead jumped right into identifying areas where we recognized needs and opportunities to be more proactive in the nuclear materials management profession in general and INMM in particular. We brainstormed and then selected a manageable subset of four subjects to develop and implement an action plan for each. These topics and associated goals are:

- Students and New Members—Attract students and others into the field of nuclear materials management and into INMM membership and activities
- Leadership Development—Develop current and future INMM leaders and involve more members in the many activities of the Institute
- Outreach/Communication—Reach out to people outside and inside our profession and help them understand and value nuclear materials management and INMM
- Funding—Explore the diversity of funding mechanisms available to INMM and plan for our current needs and future growth in support of our strategic plans

The March planning group identified four teams and team leaders for each of the strategic planning areas. The team leaders are:

- Jim Tape (jtape@lanl.gov)—Students and New Members
- Nancy Jo Nicholas (njnicholas@lanl.gov)—Leadership Development
- Jim Griggs (jrgriggs01@aol.com)—Outreach/Communication
- Paul Ebel (paulebel@aol.com)—Funding

The initial ideas and planning from these four teams were shared with attendees at the 43rd Annual Meeting of INMM on Wednesday, June 26. The Students and New Members Team plans to consider lessons from the past, identify recruiting targets, define INMM organization roles, define an outreach strategy, identify an action committee, and then begin aggressive outreach activities. The Leadership Development Team will consider which leadership positions to include, address the scope and options for development, determine leadership development goals, and then develop and implement an action plan. The Outreach/Communication Team will consider what should be targeted, what communication means and tools are available, how to optimize an effective and efficient mix of messages and interactions, and will propose an implementation plan. The Funding Team will consider short-term ideas for ensuring control of costs of current activities and increasing revenues for current activities, and long-term ideas for integrating project plans into new (strategic plan) activities and developing a menu of funding options for these new project plans.

As our next step the four teams will prepare and the four team leaders will present their recommended action and implementation plans at the next regular Executive Committee meeting, November 5–7, 2002. I look forward to helping lead the next steps in our strategic planning initiative so ably started by Immediate Past President J. D. Williams. If you have ideas to share or a strong desire to actively participate please contact me or one of the team leaders. Let us hear from you!

INMM President John C. Matter may be reached by e-mail at jcmatte@sandia.gov.

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For a complete list of INMM committee chairs, see the INMM Web site at http://www.inmm.org.

Fall Issue's Summary of Annual Meeting Always a Favorite

By Dennis Mangan
Technical Editor

As I have mentioned many times before, the fall issue of the *Journal* is my favorite each year. The summary of the Annual Meeting is always enjoyable, the Roundtable interview with the opening plenary speaker is always thought-provoking, and the summary of the Closing Plenary Session of the Annual Meeting is always a positive contribution. This issue is no exception.

Charles Pietri has written his usual excellent summary of the Annual Meeting. U.S. Representative Curt Weldon of Pennsylvania, who provided a provoking (and rather frank) opening plenary talk on the United States' relationship with Russia on arms control and nonproliferation issues, continued his frankness and demonstrated interest in the Roundtable discussion. Jim Lemley and Amy Whitworth, chair and vice chair, respectively, of the INMM Government Industry Liaison Committee, provide a good summary of the closing plenary session, which focused on combating terrorism. The speakers in that session, Mark Whitworth of the FBI, Michael Weber of the NRC, and Anita Nilsson of the IAEA, all provided keen insights.

The subject of addressing terrorism creates an interesting dilemma for the Institute. Immediately after September 11, 2001, the general consensus within the Executive Committee and members was that INMM has a definite role to play in combating terrorism. Arguably, each of our six technical divisions has a facet in their area of expertise that can contribute. The INMM is undoubtedly the premier professional society in understanding the issues surrounding this threat. The question is how the INMM should bring together its talents in this area. I was probably among the first to suggest a new technical division. However, when I considered that each technical division contributes to combating terrorism, I realized that forming a new technical division may not be the answer. But I put the question to you: Should we form a new technical division or should we form a new standing committee as a focal point for our abilities? Should we hang loose for the time being or is there another idea we should pursue? I'm sure the Executive Committee is interested in your thoughts. Give one of them a shout or send me an e-mail and I'll forward it on.

In addition to the articles on the Annual Meeting, this issue includes five topical papers and one book review. I hope you will find the article on *Proliferation Aspects of Plutonium Recycling* by Bruno Pellaud, former IAEA deputy director general for safeguards, provocative. I certainly did. Rudolf Avenhaus and Mort Canty in their paper, *Multi-Level Variable Sampling in the Variable Mode*, discuss the problem of determining the optimal falsification and inspection strategies for a two-level verification system in which false alarms are possible. From Pakistan (authors Iqbal Ahmed and K. G. Qasim) and the IAEA (authors Rolf Arlt and A. Heirmann) comes a paper titled *An* In Situ *Safeguards Verifier for Spent CANDU-Type Fuel Bundles Stored on Stacked Trays*, which describes a gamma-reading device that has been in use for several years and is solid proven technology. Don Close, Duncan MacArthur, and Nancy Jo Nicholas of Los Alamos National Laboratory take us back in history in their paper, *An Early Version of an Information Barrier*, where they opine that the words "transparency" and "information barrier," are spin-offs of older technologies. In the final topical paper, *Development of the Method for Characterization of Samples Containing Spontaneously Fissioning Nuclides Using Fission Products Gamma-Spectrometry*, authors A. V. Bushuev, A. L. Bosko, V. N. Zubarev, A. F. Kozhin, and I. M. Proshin, all of the Moscow State Engineering Physics Institute, suggest a new method for determining the mass of spontaneously fissioning material using gamma spectrometry only, without the need for neutron coincidence counting.

I hope that you have noted the *Journal*'s new look. We think it's a crisper format and look forward to your feedback on our new appearance.

In closing, while this issue is my favorite, I speculate that Managing Editor Patricia Sullivan does not share this view. For her, this is one of the most difficult issues to prepare because of the Roundtable and the coordination of all the other input. My congratulations to Patricia.

As always, your comments and suggestions are encouraged and welcomed.

JNMM *Technical Editor Dennis L. Mangan, of Sandia National Laboratories, may be reached by phone at 505/845-8710 or by e-mail at dlmanga@sandia.gov. His new fax number is 505/284-5974.*

New Chairs, More Students Highlight June EC Meeting

By Cathy Key
INMM Vice President

President J. D. Williams conducted the INMM Executive Committee (EC) meeting June 22 in Orlando, Florida, just before the start of the 43rd INMM Annual Meeting. The highlights follow. (Note: these are not the official INMM Executive Committee meeting minutes prepared by Executive Director Rachel Airth and approved by the EC.)

Standards Committees

Carrie Mathews of Pacific Northwest National Laboratory (PNNL) was selected to take over as chair of the INMM's ANSI N-15 committee prior to the June meeting. She replaces Joe Rivers who served as N-15 chair for several years. Mathews attended the EC meeting and highlighted some of her objectives as new chair, including reinvigorating the writing committees. Mathews held a committee meeting during the INMM Annual Meeting. The results of this meeting will be presented at the fall EC meeting.

INMM is responsible for two American National Standards Institute (ANSI) standards committees: Packaging and Transportation of Radioactive and Non-Nuclear Hazardous Materials (N-14), and Methods of Nuclear Material Control (N-15). In the Spring 2002 issue of *JNMM*, then Vice President John Matter mentioned that N-15 Chair Joe Rivers was stepping down and asked anyone interested in this position contact an EC member. Thanks to everyone who showed an interest. Thanks to Joe Rivers for his contribution over the years.

Waste Management Division

Chair Ed Johnson reported that arrangements have been made to hold the 20th Spent Fuel Management Seminar at the Loews L'Enfant Plaza Hotel in Washington, D.C., January 15–17, 2003. Johnson indicated that preliminary plans are in the works to hold an international spent fuel management seminar in Japan in May or June 2003. This would be in addition to the workshop planned for January.

Physical Protection Division

Chair Steve Ortiz reported that while the workshops he had planned for 2001 and 2002 had been canceled due to post-September 11 political sensitivities, two sessions on analytical tools were scheduled at the Annual Meeting. Sessions on physical protection continue to grow; last year the division had four sessions, this year it had six. If you have ideas and/or needs for other physical protection workshops, contact Ortiz at sortiz@sandia.gov.

Packaging and Transportation Division

Past Chair Billy Cole stepped down in March 2002. New Chair Ken Sorenson of Sandia National Laboratories reported that he plans to focus on the growing partnership between PATRAM and INMM. We welcome Sorenson into this new position and look forward to working with him.

Materials Control and Accountability Division

New Chair Ed Sadowski of the Savannah River Site (SRS) reported a full agenda for the division meeting held at the Annual Meeting that included several new initiatives. Over the course of the next year, the division plans to hold a couple workshops. Details will be announced when they are finalized. We would like to welcome Sadowski into his new position.

International Safeguards Division

Chair Jim Larrimore reported that the third International Safeguards Division meeting of this year was held May 27 in conjunction with the 24th Annual ESARDA meeting at the Congress Centre of the European Commission in Luxembourg.

Annual Meeting Committee

Technical Program Committee Chair Charles Pietri reported that INMM had another successful meeting underway, with two excellent plenary sessions planned. Pietri discussed the possibility of preparing only an online version of the preliminary program for next year's meeting.

Student Paper Initiative

John Matter, INMM's new president, reported that much time and effort had gone into attracting new students to the field of nuclear materials management. The Southwest Chapter found such a student from the Texas A&M University. Aaron Watson and his professor, Paul Nelson, attended the Annual Meeting this year.

Several students presented papers at the Annual Meeting. A panel of judges was formed and given criteria for judging the papers. This panel sat in on each student presentation and cast votes for first and second place winners, Peter Jansson, Uppsala University, and Philip Hypes, National Technology University. We would like to thank all of the regional chapters for recruiting students to participate in the meeting. The student paper initiative will continue to be a significant focus for the Institute in the foreseeable future.

Communications Committee

Chair Jim Griggs reported that traffic to the

INMM Web site was high in May 2002, nearly three times as high as in September 2001. Griggs also asked for volunteers to join his committee. Contact an EC member if you would like to participate in the Communications Committee.

Membership Committee

Chair Scott Vance noted that seven senior membership applications were reviewed and approved by the Membership Committee. Those individuals were recognized at the Annual Business Meeting and Awards Banquet of the Annual Meeting.

A draft copy of a student membership brochure was presented. This brochure supports the efforts to continue to bring students into the organization and will be distributed to universities this fall.

New Business

INMM Web Site Link Policy

A list of possible guidelines to be used when considering links was submitted. A basic disclaimer will be placed on the INMM Web site concerning links we have to other Web sites. It was suggested that we have a separate section on our Web site that lists all of our sustaining members with links to their organizations.

Student Initiatives

The topic of forming INMM student chapters was addressed. After the student brochure has reached the universities this fall, the response will be evaluated and the possibility will be discussed further.

INMM Vice President Cathy Key works for Gregg Protection Services in East Pittsburgh, Pennsylvania, U.S.A. She can be reached by e-mail at cathykey@chartertn.net.

Author Submission Guidelines

The *Journal of Nuclear Materials Management* 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 and 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**. Files should be sent as Word or ASCII text files only. Graphic elements must be sent in TIFF format in separate electronic files. Submissions should be directed to:

Dennis Mangan
Technical Editor
Journal of Nuclear Materials Management
60 Revere Drive, Suite 500
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Papers are acknowledged upon receipt and are submitted promptly for review and evaluation. Generally, the author(s) is notified 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, telephone and fax numbers, and e-mail address
- Name and address of the organization where the work was performed
- Abstract
- Camera-ready tables, figures, and photographs in TIFF format only
- Numbered references in the following format:
  1. Jones, F.T. and L.K. Chang. 1980. Article Title. *Journal* 47(No. 2): 112–118.
  2. Jones, F.T. 1976. *Title of Book*, New York: McMillan Publishing.
- Author(s) biography

Peer Review: Each paper is reviewed by at least one associate editor and by two or more reviewers. 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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The 43rd INMM Annual Meeting—A Well-Oiled Machine

By Charles Pietri
INMM Technical Program Committee Chair

Despite the intermittent rain outside nearly all week, the 43rd INMM Annual Meeting held at the Renaissance Orlando Resort in Orlando, Florida, was one of the smoothest run and best-attended conferences we have had. There were no crises like meeting materials lost in transit (2000 New Orleans) or wholesale withdrawal of papers two days before the meeting (2001 Indian Wells).

Now we've had a long history of thriving Annual Meetings and the credit for these successes goes to the authors and speakers who contribute papers and posters to this premier nuclear materials management forum. In support of the speakers, again this year, were the thirty-four members of the Technical Program Committee, the Executive Committee, the exhibitors and sponsors, the Session Chairs, our INMM Headquarters staff, Glenda Ackerman (PNNL) and Chris Hodge (SRS) with the Registration Committee, and, of course, our president, J. D. Williams (Sandia), ably complemented by Vice President John Matter (Sandia). The overall effect was, with a few exceptions, another magnificent team effort.

U.S. Representative Curt Weldon (7th District, Pennsylvania) addressed the opening plenary session of the Annual Meeting. Weldon spoke on the importance of U.S.-Russian relations and his proposal, *U.S.-Russia Partnership: A New Time, A New Beginning*, for cooperating with Russia on a variety of issues.

There were 774 total attendees including seventy-six companions. We had 281 papers including fifteen posters in the poster session co-chaired by Sharon Jacobsen (BWXT Y-12 LLC) and Taner Uckan (ORNL), and forty-three sessions. (For comparison, last year we had 647 attendees, 145 companions, 285 papers including 17 posters, and 47 sessions.)

The Opening Plenary Session provided an opportunity for U.S. Representative Curt Weldon, (7th District, Pennsylvania) to discuss the road to securing our future by changing the nature of the United States' relationship with Russia and working more closely with them—an interesting concept in view of the prior fifty years of Cold War rhetoric and activities. His speech was based on his comprehensive proposal to cooperate with Russia on far-ranging issues from defense and security to health care and agriculture, titled *U.S.-Russia Partnership: A New Time, A New Beginning,* compiled in consultation with leading experts on Russia. This document can be found at http://www.house.gov/curtweldon/russia.html.

The INMM Roundtable hosted by *JNMM* Technical Editor Dennis Mangan (Sandia), provided even more insight into Curt Weldon's philosophy. (See the transcript of the Roundtable discussion with Weldon on page 11 of this issue.)

Our Closing Plenary Session, Combating Nuclear Terrorism, was co-chaired by Jim Lemley (BNL) and Amy Whitworth (NNSA) of the INMM Government-Industry Liaison Committee, and featured William Mark Whitworth of the FBI, who spoke on Explosive Terrorist Activities; Michael F. Weber of the U.S. Nuclear Regulatory Commission, who spoke on Ensuring Nuclear Security in a Dynamic Threat Environment; and Anita Nilsson, of the International Atomic Energy Agency, who spoke on Nuclear Security—Increased International and National Efforts. It was a good forum to address the global issues of security and terrorism with a very appreciative audience. See page 23 to read the summary of the closing plenary session.

As you may have expected, we had some interesting happenings at the Annual Meeting this year:

- Chris Hodge (SRS), our seasoned Meeting Registration Chair has relinquished that position to Glenda Ackerman (PNNL). Hodge has shifted to the Executive Committee as a Member-at-Large. Ackerman, who has worked on the Registration Committee for many years, moved effortlessly and successfully into the new chair responsibilities as we can all attest from this meeting.
- For the first time poster presenters were asked to provide a written paper of their work to be published in the *Proceedings of the 43rd Annual Meeting*. The response was almost perfect with 95 percent compliance. (The lone offender also failed to provide a paper for an oral presentation.) For too many years INMM has missed the opportunity of including papers based on poster presentations in the *Proceedings*. Thanks for this innovation go to Poster Session Co-Chairs Sharon Jacobsen (BWXT Y-12 LLC) and Taner Uckan (ORNL).
- Doug Smathers (Sandia) set up pilot sessions to evaluate the feasibility of using LCD projectors and PowerPoint-type presentations instead of overhead transparencies for greater effectiveness. The problem with LCD projec-

tion is that it can seriously interfere with the program schedule if there is any delay in setting up the system in the 20-minute period allotted for each talk. In other sessions, it was reported that several presenters had significant problems with their LCD projector setup. Doug reports success if all the papers are preloaded onto a CD ***before the session*** and tested and if the presenter is skilled in the system's operation. We will have a formal procedure for presenters next year if they wish to use LCD projection systems.

Once again we had as good a response to the meeting evaluation forms as in the past few years (5 percent). However, we find the questionnaire very informative in assessing the Annual Meeting and how we can further improve it. That assessment begins with the Call for Papers in October in one year and carries over to November of the following year when the *Proceedings* are published. We continue to assume that the non-responders were so satisfied with the meeting that they felt no need to comment formally. We did get numerous comments at the meeting. This year **Overall Annual Meeting** process was rated as good-excellent by more than 95 percent of respondents; the **Technical Information Exchange** and **Logistics** areas were rated as good-excellent by 91 percent of respondents, and as fair-poor by 9 percent. **Exhibits** were rated almost unanimously excellent. We had mostly favorable comments from our exhibitors—both verbally and in writing.

Some of the issues brought to our attention were the many changes to the preliminary and final programs, in the latter case, even while at the meeting. This is an ongoing and frustrating matter for the INMM. Perhaps a review of the program publication process would be helpful in giving you a more complete understanding of the issue. The hard copy preliminary program is published in April along with a Web site version. Within a month the printed preliminary program is outdated from changes in titles, speakers, and authors, and withdrawals that have been submitted. We update the Web site frequently during the weeks leading up to the meeting. With the preliminary program as a base, the final program is developed with the accumulated changes updated and sent to the printer three weeks before the meeting. (This three-week period is the bare minimum time necessary to print and proofread the final draft, make corrections, print the final document, and then have the final program packaged and shipped to the hotel in ample time. Now comes what may be a surprise to many of you. On May 15 of this year, three weeks after publishing the preliminary program, we received seventeen paper withdrawals plus other changes; we updated the Web site version. By June 20, **after the final program had been published**, we received an additional **twenty-eight withdrawals** plus other changes. INMM publishes meeting addenda to reflect these changes and those occurring at the meeting—yes, we had three addenda this year reflecting numerous changes that took place both prior to and during the meeting! So that's why, in spite of some excellent work by the Technical Program Committee and the INMM HQ staff, especially Rachel Airth, INMM executive director, the printed final program is only about 85 percent accurate. INMM understands that, in a perfect world, everyone's schedule and availability to present their paper as scheduled would never change, thus our program would be unchanged, too. However, we also realize

J. D. Williams, outgoing president of the Institute, at the opening plenary session of the INMM Annual Meeting.

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The Institute of Nuclear Materials Management thanks the following organizations for their support of the 43rd INMM Annual Meeting.

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that our professional environment often requires a daily change of plans. INMM does ask all contributors to consider very carefully before submitting an abstract for presentation since thoughtless abstract submittals result in later withdrawals that disrupt the program.

Here are some additional comments we received:

- *Pocket schedule introduced last year was great but the spiral binding this year was faulty and the actual size needs to be reduced so that it fits in a pocket.* We apologize for the binding—the manufacturer goofed this time; better ones next year with a goal of reducing the size so that it fits a pocket better.
- *Better transparency projectors and the use of LCD projectors needed.* Lyn Maddox, INMM conference manager, corrected this problem (dirty faceplates) with the equipment vendor soon after we heard about it. We are addressing the LCD projector issue as noted previously in this report but, because of the very significant cost to INMM for the purchase or rental of this equipment for each session for four days or more, we may request that individuals, sponsors, and facilities provide the projectors.
- *Resorts are nice places but for those without cars it's like being imprisoned.* Agree but no one has been able to come up with a practical solution for this matter.
- *Quality of papers: although the greater majority of papers are very good some still don't meet high standards—INMM should be more ruthless about meeting standards.* Achieving high quality papers is always INMM's goal. The problem is that the Technical Program Committee makes judgments based on the abstracts submitted but the actual papers presented may not meet expectations. INMM continues to work on this issue and your personal comments directly to the offending author(s), by e-mail perhaps, could be of significant assistance.
- *Quality of presentations: some talks are really poorly presented with inferior graphics.* Several of the session chairs approached me this year describing how very disturbed they were by this fact. We try our best to provide guidance in the *Speakers Manual* provided to all speakers on how to present a paper but perhaps some of the speakers don't read it. We plan to expand the guidance, publish some additional references, and even provide a tutorial at the meeting if there's enough interest. We'll even include a section on the meeting evaluation form for attendees to indicate problem presentations—maybe we can help the speaker better prepare for their talk in the following year. Any more suggestions?
- *Solicit papers on non-technical issues that deal with management, stress, people relationships, and the aging workforce, and broaden the topical areas.* INMM will review such new topical areas and is looking for volunteers to identify the topics and organize such sessions. If you are interested, contact me. On the other hand, we heard comments that the Annual Meeting should have more technical and less policy and regulations papers.
- *The meeting was held too early this year.* The June date for this year's meeting was the best INMM could obtain to get optimum benefits such as an outstanding resort hotel/location, room rates, meeting space, and amenities; the other alternatives would have resulted in inferior benefits and a mid-August date. We'll be back on our regular July schedule for the next several years: July 13–17, 2003, Marriott Desert Ridge Resort, Phoenix, Arizona; July 18–22, 2004, Renaissance Orlando Resort, Orlando, Florida; and, July 10–14, 2005, Marriott Desert Ridge Resort, Phoenix, Arizona. Incidentally, INMM chooses locations that are "out of season" to get the best hotel rates. However, we

Three members of the INMM community were honored for their contributions during the Annual Awards Banquet at the INMM Annual Meeting in Orlando, Florida, Tuesday, June 25. John Carlson, above right, received the Distinguished Service Award. Outgoing INMM President J. D. Williams presented the award to Carlson at the banquet. Sergio Guardini (shown here with Williams), also received the Distinguished Service Award.

Vice President John C. Matter addresses the opening plenary session of the INMM Annual Meeting.

repeat what we said last year: regardless of the location, most attendees recognize that the Annual Meeting is a great opportunity to meet colleagues from around the world, participate in valuable private meetings and discussions, hear some really outstanding papers, and broaden one's perspective in nuclear materials management.

- *Issues with the abstract submittal database.* This is the second year with our conference planning program for the submittal of abstracts and final papers to INMM, which after some minor debugging appears to be working well. But we get a few responses telling us that they rate the process as only fair. Unfortunately, no specific issues, problems, or suggestions were provided. INMM Education Manager Nicki Patti (npatti@inmm.org), who manages the database, would be pleased to receive any suggestions to improve the abstract as well as the final paper submittal processes.

So what can we do better? Any suggestions on how INMM can improve meeting practices are welcomed at: cpietri@aol.com.

We also included several questions to help us plan future meetings, this year and, remembering that with only a 5 percent response we may not be looking at a statistically valid polling process, here are the responses:

- *Do you prefer the Web site version of the preliminary program in place of the mailed hard copy?* For 62 percent; Against 38 percent. INMM will continue to explore this area to determine the cost savings vs. the effectiveness of any action. Currently, we have no plans to make any significant change in the way the preliminary program is distributed.
- *If the preliminary program was only available online would that hinder or discourage your attendance?* Yes 3 percent; No 78 percent; Don't know/not sure/no response 19 percent. Again, we have no plans to make any significant changes at this time. INMM will continue to provide frequent updates of the preliminary program on the Web site.
- *INMM is considering having more than one poster session at the Annual Meeting. Do you feel that more of these types of sessions would enhance the meeting?* Yes 43 percent; No 43 percent; Maybe/don't know/no response 14 percent. At present INMM would consider having multiple sessions only if there was a significant increase in the number of posters submitted. (Note: surprisingly, we found out that some organizations do not support attendance at meetings for participation other than for oral presentations.)
- *If so, what types of presentations would you like to see?* Instrumentation, security systems, new technology. INMM will try to encourage these presentations. (Many of us remember when the laboratories actually brought instrumentation to demonstrate in the poster session, some even to complement their oral presentation.)
- *Do you like the current layout and location of the poster session?* Yes 73 percent; No 5 percent; Maybe/don't know/no response 22 percent. No action seems necessary here.

For the past two years INMM has requested that final written papers be submitted by authors two weeks *before* the Annual Meeting for publication in the *Proceedings of the INMM Annual Meeting*. Last year's response was a major improvement but this year's contributions are not quite as good although we have received about 95 percent of the papers that were presented. My **Delinquent Final Papers Blacklist** was posted for public view at the registration desk during the meeting to emphasize that INMM is serious about presenters meeting their obligation to provide a paper for publication. The negligent authors will now have to be judged for their participation in future INMM Annual Meetings. INMM thanks all of you who cooperated so well to make the meeting a success and provide a history of the event through the *Proceedings*.

Prominent INMM members were honored at the meeting for their tremendous service the Institute. Ruth Kempf, top left, who has completed her term as a member-at-large on the INMM Executive Committee, and Cathy Key, bottom left, who completed her term as a member-at-large (before assuming the role of vice president) were both lauded by J. D. Williams at the Annual Awards Banquet.

It's not all work at the Annual Meeting. A major attraction is to provide an opportunity to meet familiar colleagues and make new acquaintances. The President's Reception on Sunday, June 23, was one of those opportunities. This year there was plenty of food, drink, and lots of room to socialize. (Remember we promised you we would fix those problems we had last year.) President J. D. Williams, Vice President John Matter, and INMM Executive Committee members made the rounds of meeting attendees and their companions. New INMM members were not forgotten either; they (as well as Senior Members) had a special reception on Monday evening, June 24. Hopefully,

INMM Past President Debbie Dickman was honored by J. D. Williams at the Annual Awards Banquet. Dickman addressed the dinner attendees and expressed her thanks for the opportunity to contribute to the Institute.

we can fill the INMM ranks with these new members for the next generation nuclear community. The Awards Banquet took place on June 25 and was a treat to many of us. However, there are some folks who only rate the banquet as fair and we don't really know why. Perhaps the meal doesn't meet their expectations—it was very good but not as outstanding as the one we had last year in Indian Wells, California. Maybe some attendees are not interested in the awards ceremony—paying tribute to those individuals who had contributed much to INMM and to the nuclear community. We would really like to hear what you think of the banquet and what you would do to attract more attendees.

INMM continues to encourage meeting participants to organize special topical sessions of interest under the mentorship of a Technical Program Committee member. This process seemed to work well again this year and allows interested parties to actively participate in structuring the technical program for the Annual Meeting. **Special sessions like these need to be planned carefully and submitted in final form by February 1, 2003, for consideration and review by the Technical Program Committee.** If you would like to arrange a special topical session I need to hear from you very soon so that we can reserve space in the program for you. Please do it now!

This year's Annual Meeting was a particularly enjoyable one. Remember to start planning for the 2003 Annual Meeting right now either as a speaker, presenter, organizer, contributor, sponsor, exhibitor, or attendee. With your help we'll make it another success and a most pleasant event. We hope to see you all at the 44th INMM Annual Meeting at the Marriott Desert Ridge Resort, July 13–17, 2003, in Phoenix, Arizona. And I promise you won't have to bring an umbrella to Arizona—unless you want to get some shade.

Charles E. Pietri, chair of the INMM Annual Meeting Technical Program Committee, works in Western Springs, Illinois. He can be e-mailed at cpietri@aol.com.

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Amy Whitworth
National Nuclear Security Agency

James D. Williams
Sandia National Laboratories

INMM Roundtable

June 24, 2002
Orlando, Florida, U.S.A.

Speaker:
U.S. Representative Curt Weldon

Attendees

Robert Curl
INMM Treasurer

Vince De Vito
INMM Secretary

Debbie Dickman
INMM Past President

Stephen Dupree
JNMM *Assistant Technical Editor*

James Griggs
INMM Communications Chair

Rebecca Horton
JNMM *Associate Editor*

E.R. Johnson
Chair, INMM Waste Management Technical Division

Cathy Key
INMM Member-at-Large

Dennis Mangan
JNMM *Technical Editor*

John Matter
INMM Vice President

James Lemley
Chair, INMM Government-Industry Liaison Committee

Charles Pietri
Chair, INMM Annual Meeting Technical Program Committee

Bernd Richter
JNMM *Associate Editor*

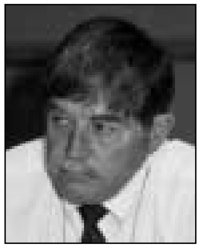
Gotthard Stein
JNMM *Associate Editor*

James Tape
Chair, INMM Memorial and Outreach Committee

Scott Vance
JNMM *Associate Editor*

J. D. Williams
INMM President

Patricia Sullivan
JNMM *Managing Editor*

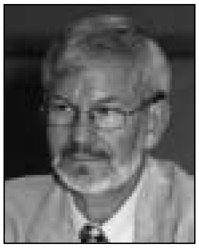


Dennis Mangan: We thank you for coming. I personally, and I'm sure the rest of the people here, enjoyed very much your plenary speech on *Strengthening our Relationship with Russia: Securing our Future.* I'm anxious to read the document on your Web site (www.house.gov/curtweldon) that you put forth there to capture all the issues that you discussed this morning. I think it's a yeoman's job. I'll ask the first question here. It's a good piece of work, obviously, but how are you going to ensure that what you put down here gets accomplished? Do you have a path forward in mind?

Curt Weldon: You know, it's very difficult to move a federal bureaucracy, let alone two federal bureaucracies, so my goal is to generate political support in the two parliaments that require that this be the direction we move in. I don't necessarily think that we have to adopt everything in this document. But the direction we go in our relationship is critically important. The role of the parliaments in the process is also critically important. One of the things that we did not take advantage of in the '90s was the inter-parliamentary dialogue. We have some German friends here. We've had a Bundestag/Congress relationship for decades. It's a very strong relationship and we meet regularly with the Bundestag. We have that with the European Parliament. We have it with the Japanese Diet. But we did not have, up until we started this, relationships with the parliaments of the former Soviet states. So besides this with Russia, I've started a similar program with the Ukraine. I've got Congresswomen Marcy Kaptur (D-Ohio) and Congressman Bob Schaefer (R-Colorado) to co-chair. We've started a similar program with Moldova with Congressmen Joe Pitts (U.S. Representative Joseph R. Pitts, R-Pennsylvania) and Dennis Kucinich (U.S. Representative Dennis J. Kucinich, D-Ohio) co-chairing that effort. I just was in Uzbekistan and the Uzbekis are interested in starting that up. And the ultimate purpose is to set up a similar document coming from the parliamentarians of these nations so we can continue to strengthen our relationship.

The reason why this is important, to be honest with you, is that parliamentarians in our country usually stay for long periods of time, and develop expertise. And unfortunately in the State Department, you have technical people who come and go, three-four years and you're out. So in some cases, there's more of a consistency when you have Congress and people who have been involved in the German relationship or the Japanese relationship, and you don't take advantage of it.

So it's also trying to show that while foreign policy is always going to be the purview of the president and secretary of state, there is a legitimate and necessary role for the Congress. And when you don't do that, then you inevitably have the '90s, where you had the Congress constantly going at odds with what the administration is trying to do. And that makes for a terrible situation. It makes for a lack of confidence, it causes us to take funding slaps because after all, the Congress controls the funding, not the White House. We set the authorization and appropriation laws. And so when you don't have that engagement, then you can cause significant problems. So ultimately, will this all be accomplished? Probably not, but the general direction and tone of what we're doing is to broaden our relationship in a way that we've never done before and to have a more coordinated focus on the future together.

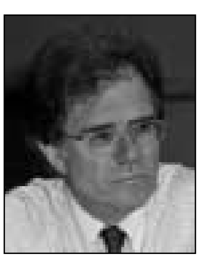


Bernd Richter: How does the Trilateral Initiative fit into your partnership document?

Weldon: The Trilateral Initiative between?

Richter: Between Russia and the U.S. on nuclear disarmament.

Weldon: The administrations of the two countries will determine in the end where they want to go. What I try to do is to have the members of the Congress more aware of what's going on, the process that's underway, and the kinds of initiatives that are being proposed, so that members of Congress who don't follow bilateral relationships or multilateral relationships come out with a better sense of appreciation. While I say that there are some members of Congress who specifically focus on relations between the U.S. and other countries, there are other members who have no interest in that relationship, who don't care, and so the goal is also to at least give them a basic awareness and understanding and as the administration comes in and makes proposals to us, whether there's bilateral, trilateral, or multilateral, we are in fact in a position to more quickly understand and appreciate that and hopefully work in a positive way to accomplish something. Generally this is an awareness building process by getting the congressmen directly involved.



Gotthard Stein: To follow up on this question, there is the new protocol of the safeguards system that is related to nonnuclear weapons states, especially to the so-called comprehensive states, but also to the nuclear-weapons states and what I learned is that this just went to the Congress for ratification. Can you say something about this? And the other point is, your speech was very much related to bilateral issues, but maybe you can say something about the possibilities of the Fissile Material Cut-off Treaty and the prospective of this.

Weldon: While the focus of my speech today was bilateral by purpose, I can tell you that much of our effort is multilateral and is concerned with the overall approach internationally for ways we can reduce the potential of a nuclear incident and also increase the confidence in transparency measures and in security of nuclear capability worldwide. We have inter-parliamentary dialogue sessions where we bring parliamentarians together from a multitude of nations. Some are through USCE, some are through U.N. taskforces, and we focus on specific issues. For example, I'm very heavily involved in the nuclear waste issue, and ocean security, especially as it relates to nuclear issues. We have thirty-five nations involved in that effort. I represent the U.S. Most of the people there are parliamentarians. We try to find ways of establishing common agendas, whether around protocols, treaties, or just understandings or legislative changes we can make internally.

We have another organization called Global List that is for a balanced environment and that involves the European Parliament, the Japanese Diet, the Russian Duma, and the U.S. Congress. Again, in a broader context, and not just on ocean and nuclear issues, but on issues involving global warming and land-based sources of pollution, we tend to come together and try to find common solutions.

In terms of specific treaty modification, one of the things you have to understand during the '90s, is the Congress lost total confidence in the arms control process. That's why you did not see the Congress seriously consider modification of major treaties during the '90s—because there was no confidence. Why would the Congress want to pass a law to require the administration to enforce an existing treaty? There was no confidence there. And the vote wasn't like some partisan vote of Republicans only; the vote was 398 in the House and 98 in the Senate. You don't get those kinds of votes unless there is a clear lack of confidence that our arms control process is in fact working. What happened over the '90s was that lack of confidence, the likes of which I've never seen in my sixteen years in Washington, where members were asking, "Why ratify a new treaty if we're not going to enforce the ones that are already in place? Why ratify a new agreement, whether it's bilateral or multilateral, if we're not taking seriously the treaties that are already on the books especially in the area of proliferation?"

During the '90s, Congress monitored outrageous proliferation on a continual basis in Iran, Iraq, Syria, Libya, North Korea, India, and Pakistan and the Congress was devastated by either the perceived or the real, depending on which case you look at, lack of holding accountable of those parties for those proliferation activities. In the end, I think that caused the Senate, in terms of ratifying any treaty, to say, "Just don't bring anymore treaties to us because we don't know how to enforce the ones that are already in place so we're not going to move forward with any consideration of any additional treaties."

Now that seems to be changing, and that's why I want to get the members more involved so that if members have legitimate concerns, they can do what I do. For instance when the administration tried to amend the ABM Treaty by sitting down with the Russians over in Geneva on the two issues of demarcation and multilateralization of the treaty, I went over to Geneva and sat across from the chief Russian negotiator and questioned him on why the Russians wanted to have a demarcation on missile defense systems and why they wanted to bring Belarus, Kazakhstan, and Ukraine to a treaty when they had no long-range strategic weapons. But I'm the exception in that area. Other members just don't care or didn't want to get involved. My goal is to try to get members to pay more attention and to engage them in processes both bilaterally and multilaterally with our colleagues that will allow them to understand in the end arms control is not a bad thing and that arms control treaties can work and do work. I can tell you during the '90s, there was a terrible lack of confidence that arose within our Congress about the whole issue of arms control agreements and whether or not there was any substance to the ones that were already on the books. That's changing now and that will allow us to more seriously consider the treaties that are out there including the one you just mentioned. I get a sense from my colleagues in the Senate that there's a new willingness to basically re-look at some treaties that were not considered in the past and to look at putting together some new treaties. I think the treaty that Bush and Putin came out with will be ratified by the Senate very quickly and that it could be a good precursor to other agreements, both bilateral and multilateral, that the Congress has not been willing to consider in the past.

Charles Pietri: Would you elaborate a little more on the oversight of transparency programs or proposals for the North Korean as well as the Iranian Bushehr reactors?

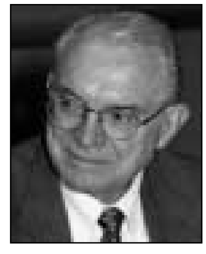
Weldon: That's really just a general idea that was thrown out to me by Velikhov right before (Minatom Administrator) Rumyantsev came to meet with me. As you all know, Rumyantsev used to work with Velikhov, and I've been to Kurchatov probably ten times. In fact I'm going to be keynote speaker at their fiftieth anniversary in January next year in Moscow. Velikhov is one of my best friends. He's an outstanding individual, a great human being, and I have the highest confidence in him as a professional. For people who don't know him personally, he's just such a genuine good guy. Before I answer your question, I was over there in February with him. He started the Junior Achievement program in Russia, which encourages young children in high school to understand how free markets work. You get involved in manufacturing or building some kind of a product and selling it to understand how free markets work. When I was there for this celebration of this program, and he's the father of it in Russia, I realized, through the American companies that were supporting it, that the second largest Junior Achievement program in the world, second only to the U.S. program, is now in Russia. And that was started by Velikhov. He's done so many great things beyond his work in the mentoring area, beyond his work with Kurchatov, that I just think we have to find additional ways to work with him. There were probably fifteen or twenty new projects that he proposed to me while I was there that I will take back to DOE and (U.S. Secretary of Energy) Spencer Abraham and (NNSA Administrator) General John Gordon and the other folks in the labs and try to bring them in and see if we can work together.

In terms of the North Korean proposal, it was not specific. The Russians understand that there are major concerns with what are they doing with Iran, not just this year, but beyond this year. I knew Mikailov when he was the head of Minatom and to be honest with you, I couldn't trust him. And then he left that agency, he resurfaced again as the number two person with a specific purpose of involving a whole new class of small nuclear weapons. That bothered me. That still concerns me to this day. He truly is what he calls himself, the Hawk.

In terms of the North Korean initiative, and as you know there was some rumbling that he had cut a secret deal with North Korea beyond the shared plan for some other capability, which we never really, as far as I'm concerned, gotten full answers on. What Velikhov is saying is we know that America has very serious reservations about Russian involvement with Iran and he says there's some concern with what the U.S. is doing with Korea. He said, "Why don't we look at trying to find a way to provide transparency over both issues." I don't know what the construct of that will be. I threw it out there today, you know he's working on an op-ed, he's going to get it to me, I'm going to look at it, and we're going to go back and forth. But I'm throwing it out and that's why I came here, to get some response like I did today. Both the good sides and the bad sides, and find out if something like that can provide a productive purpose. The key thing here is again transparency. It's understanding what they're doing and having them feel comfortable about what we're doing. Not to equate the two projects, as the gentleman said in the question, but rather to have a more clear understanding of what our ultimate purpose is and to try to provide a way that we can assure ourselves that Russia is not deliberately helping Iran with a weapons program and so the Russians can feel assured that we're not doing anything that would provide that same kind of arsenal going to Korea.

Pietri: Whether intentionally or indirectly.

Weldon: Exactly. In fact, I'll be meeting with KEDO (Korean Energy Development Organization) when I go up to New York City to talk to the North Korean ambassador because one of the things we will look at when we get the delegation is the progress of what KEDO's doing in North Korea.



J. D. Williams: I guess that you've answered part of my question, which is, "What can we as the Institute do?" and I guess that those with experience in that area can give some input.

Weldon: Exactly. What I'd like to do, and that's why I put it out there, is I'd like to get responses and ideas, both pro and con. If we're going to do something like that how will it work and what will we do?

What will be the limitations? What will be the considerations? I mean, that's exactly what you can do for us.

James Tape: Continuing on this same subject, both North Korea and Iran are signatories of the NPT (Nonproliferation Treaty), both are subject to safeguards, and the IAEA (International Atomic Energy Agency) plays a role in both states. What are your thoughts on transparency as provided by international safeguards and the IAEA?

Weldon: Absolutely critical. The most critical element, I think is the old adage that you trust what you verify and the only way to verify is to have the international observers go in and look at what is actually occurring. It is the key process that will basically underscore the legitimacy of any agreement that we enter into.

Tape: So would part of the partnership between the U.S. and Russia include strong support for IAEA activities?

Weldon: As far as I'm concerned it would and it would be a way to develop that strong support in Congress for IAEA activities as well. So absolutely. And again, I think that's where you all can help us. The mood the Congress is in, it's never been in before in terms of moving forward with this. We need to take advantage of that quickly, because the stars are all lined up in a way we've not had in sixteen years and we may not have this opportunity again so whether it's a direct bilateral relationship with Russia, or it's a relationship with Korea, or opportunities in Iran, we have to take advantage of.

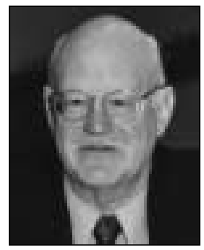
Now the president's comments, and I'm a strong supporter of President Bush, his "axis of evil" speech didn't help us in either country, but I've been in South Korea twice since he made that speech to assure them that we haven't changed, we don't want conflict on the peninsula. That's when I first started my effort to go to North Korea. I'm going to take a delegation to North Korea, if I have to go up to Panmunjom and run across the roadway. I get the hunch now, after the frustration of thirteen members of Congress repeatedly trying to get in for six straight days after having done the legwork, that the North Koreans won't accept us.

Calling names and making disparaging comments doesn't help in any situation. Dialogue is critically important. Whether you agree with the other country or not, you've got to have dialogue. That's why with China I've been there four times. This time I spoke at their national defense university for the second time. I think I'm doing an address to their midlevel career officers at that institution. I don't agree with the Chinese communist government. I don't think it's the best way that their people can be served, but right now that's not a decision that I can affect. But I absolutely believe that we have to have dialogue with them. We have to find ways to deal with them on environmental issues, on economic issues, on issues involving improving their quality of life. I think that same opportunity has to take place in North Korea. Eventually, I'm going to pursue the same thing with Iran and I'm also doing it in Belarus. As crazy as (President Aleksandr) Lukashenko is, we have a responsibility to reach out so that the people in those countries understand that America does not have a problem with the people. By not engaging North Korea, that sends the bad message to all the people who live there, that we really are a nasty people who don't want to engage. And the other thing, our country from time to time appears and is arrogant. We tend to want to run in and get things our own way and we have a double standard. As I mentioned about the Navy, on the issue of the Comsmolesk. It's an arrogant attitude that America has from time to time where you abide by this standard but don't expect us to abide by that standard. We can't do that.

Pietri: Because we're right.

Weldon: We're always right. So we have to show a little humility. And I know my German friends (noting Stein and Richter) are probably sitting there saying, "Yeah!" (Laughter)

Mangan: We're going to have a hard time living with them after you leave.



Stephen Dupree: Getting back a little to the arms control issue, if I have my facts correct, the U.S.'s withdrawal from the ABM Treaty took effect two weeks ago, and the next day the Russian Duma withdrew from START II. Do you see this as simply a reciprocal issue?

Weldon: The ABM Treaty is not the issue that everyone said it would be. Let's face it, the Russians wrote the book on missile defense. I was the point person for the missile defense bill that passed the Congress when Clinton was president by a veto-proof margin. And before the vote on the bill, I took (Secretary of Defense) Don Rumsfeld, (former CIA Director) Jim Woolsey and (Defense Science Board Chairman) Bill Schneider to Moscow to brief the Russians to show them that this was not aimed at Russia, but rather at other emerging threats from North Korea, Iran, Iraq, or developing systems that we had to be able to defend against. I know all their missile defense systems because I worked this issue aggressively—you have the SA10, SA12, the S300, S400, and they now have their own scientists working on the S500. They have the anti-2500; they have the world's only operational ABM system around Moscow. Now as I told my Russian friends, imagine if President Putin in a democracy said, "We're going to build a missile defense system and we're only going to defend Moscow." You couldn't do that in a democracy. You could do that in 1972. When the Soviet Union was dominated by communists you could say you're not going to protect Saint Petersburg or

Vladivostok because you had no choice, but now you cannot only protect one city. When you're in a free democracy, the people won't let you do that. Well, the Russians understand that and even the most hard-line Russians I dealt with put the fight up in terms of leverage, and the interesting thing is a week before the withdrawal date of the treaty, which was June 13, I had the CEO of Crudachev, one of the largest space launch institutes in Russia, in my office with an executive from the Lockheed Martin Co. and they were getting ready to go from my office to meet with General Kadish, who's our three-star in charge of our missile defense agency. They wanted to debrief me on what they were going to say to him. They had signed an MOU to work together on technology but couldn't talk about it until the treaty expired. The Russians went to Putin who said to them, do you agree with this? And he said, Yes, but don't talk about it until June 14. So the Russians are already looking at ways to work together.

Now my goal is to work together with Russia and the Europeans. We've been working with the Germans. The Germans and the Italians are working with us on a missile defense program called Mehats. The problem was, the misconception was we only want to provide protection for America. That was a gross mistake. Because it offended Europe; it offended Canada. So what we're now talking about is a layered approached that could protect any country that wants to come in and work with us. The European community, Russia, I wouldn't even exclude China because the threat is from rogue states who will take missile technology and use it against stable nations as a weapon of terror. Even though there are many who will make the case, "Well after 9/11, don't you understand that the real threats aren't from missiles, they're from truck bombs." The fact is that when Saddam Hussein chose to injure America in 1991, he didn't use a truck bomb. He sent that SCUD missile into our barracks and twenty-eight young Americans came home in body bags because we could not defend against a SCUD missile. Israel had a reign of terror with SCUD missiles going in. Iran has developed the Shadad 3; they're going to the Shadad 4 and the Shadad 5. The Shadad 3 threatens the whole region around them. The Shadad 4 will threaten all of Europe. The Shadad 5 will be a long-range system, 5,000-6,000 kilometers, that will eventually be aimed to have a threat against the U.S. So I think people understand that. In my most recent trips to Russia, not one time has the ABM Treaty been raised.

Dupree: And the START II treaty is essentially overtaken by the new agreement, so its demise is not an issue?

Weldon: I think that action was probably a reaction to the ABM Treaty, but there's no intent there to revert back. In fact it was interesting because Velikhov and I, three years ago, co-authored an op-ed piece titled "From Mutually Assured Destruction to Mutually Assured Protection." I don't think this is a problem. I think the Russians who really study the issue understand.

We sent the wrong signals to Russia. Let me just quickly go through this because this is an issue I worked aggressively. We wonder why the Russians didn't trust us when the ABM Treaty expired. So let's look at what happened. First of all, in 1992, Yelstin challenged Bush Sr. to work together on missile defense. So Bush Sr. says, "Yes, let's do it." So the Russian Foreign Ministry and the U.S. State Department establish high-level talks called the Ross-Mamedov talks. The specific purpose of those talks was to have a common approach to missile defense between the U.S. and Russia. In 1993, we had a new administration. The new administration was opposed to missile defense and they cancelled the talks. Well that sent the Russians a signal. When I was with Kukoshin in 1995, who was Yelstin's security advisor, he said, "Wait a minute, Curt. You stopped the talks. You cut them off." And he was right. Then in '95 and '96 we had the only cooperative program with Russia, called RAMOS (Russian-American Observation Satellite). It's the development of a joint satellite program, identical satellites that each country will have that will detect rocket launches. I'm a strong supporter of it. In '95 and '96 with no advance warning, the administration announced that it was canceling funding for the program. Well, I got calls from my Russian friends, and they said, "Curt, what's going on? You talked about working with us, and you canceled the funding for the RAMOS program. So Carl Levin and I went to the wall on this and got the funding restored but that was the second signal we sent the Russians. We cancelled the only program we had. The third signal was when most people in this country were basically coming to the conclusion that if not abrogating the treaty, at least the treaty would have to be more flexible so that America and other countries could deal with the kinds of emerging threats that we saw occurring. The administration went over to Geneva to negotiate two tightening-up amendments to the treaty. One was demarcation—differentiating between theater and national missile defense, which was artificial on its face because a Thad program is national missile defense for Israel, because that's a small country, so how do you differentiate that, you know, it was artificial. The second was, and as I said I went over there, and I said, "General Cotunov, why do you want to bring in Belarus, Kazakhstan, and Ukraine to the treaty when they now build long-range missiles?" And the Russian negotiator looked at me and said, "Congressman, you're asking that question of the wrong person. We didn't propose that, the guy next to you did." Our negotiator from the U.S. proposed it. Why would you want to propose that? Because you want to make it more difficult to amend the treaty. Which didn't make any sense at all. The fact is that the administration convinced the Russians that those two amendments to the treaty were acceptable when they knew the Senate would not even consider it, including the Democrats in the Senate. So from 1997 to 2000, we negotiated two amendments to the ABM Treaty and the president never submitted them as required by the constitution for the advice and the consent of the Senate. But the Russians had been convinced by our White House that they in fact were going to be the law of the land. They never were submitted up until President Clinton went out of office. So three times we sent bad signals to Russia. As a result, the Russians say, "Missile defense? You don't want to cooperate on missile defense. Look at your track record."

Now I believe we should be cooperating and I've called for in the defense bill, further cooperation on a wide variety of missile defense programs with Russia and Europe. Use of assets and not just for the U.S. but to develop a capability that shows it's a common threat to all people, not just one that the U.S. alone should pursue.

Cathy Key: First, I would like to say that I enjoyed your talk immensely this morning. You gave an excellent speech. The topic is very close to my heart because I have worked with the U.S. government-funded Russian Material Protection, Control, and Accountability (MPC&A) program since the summer of 1995. I returned home from my forty-first trip to Russia on June 11. You certainly got my attention this morning when I heard you say you have been to Russia twenty-nine times working the U.S.-Russian relationship. A congressman willing to put this level of effort into this cause will be successful. I, as one U.S. citizen, thank you for the level of effort you put into this work. Listening to you talk this morning brings out the fact that you are obviously very passionate about this subject and the work.

I have two questions. Number one: you say, seize the moment, because everything is currently in line. This sounds great and it is a wonderful situation that we should take advantage of. What should we do to assure that we have the funding in the out years to be able to complete these missions that we're working with the Russians?

Weldon: That's an excellent question. And that is really the fundamental question and that's why there needs to be an attitude change inside the Beltway. For years, and many of the people here at the table and in your association have been saying, these are positive things that we're doing. They're bringing good results, but by and large the Congress wasn't buying in. Except for the cooperative threat reduction program. I had colleagues on my side… George Solomon, bless his soul, was a great member of Congress, chairman of the Rules Committee. He consistently wanted to cut funding for cooperative threat reduction. He said, "You can't trust them, you can't trust them." And so, the conservative wings of both the Republican and Democrat parties had this basic inherent mistrust about using this money in this way. That's changing now. That's changing because we've shown the Russians in a different light to the parliamentarians, that these are people who want the same kinds of things that we do. That doesn't mean that we look at Russia through rose-colored glasses. I mean, I call myself Russia's toughest critic and their best friend. When I go to Russia, I raise the issue of tactical nukes including that all the time. Because our intelligence maintains they're there. If you talk to the Poles, they think they're there. Well that's going to be an issue we focus with Russia on. I question the Russians about Yamatau Mountain, this huge underground complex that our intelligence doesn't know what it's being built for. I've questioned Perkosin; I've questioned Yelstin; I've questioned the defense minister and the minister of atomic energy.

There are those people in Russia, as there are those people in the U.S., who are not happy with the direction our countries are going together. Remember, just a month and a half ago, forty-one retired Russian generals and admirals and two former defense ministers took out a full-page ad in the *Nezavismaya Gazeta*, bad-mouthing Putin for becoming too close to the West and the U.S. So there are those people in Russia who don't like where we're going and I can tell you that there are those people in our country who are in the military, and some in this administration who I have to fight with, who don't like where we're going. What we have to do is have the center push forward with a consensus and I'm convinced the others will fall by the wayside. In the end, as we do more of this kind of engagement, the funding issue will not be a big issue.

You couldn't rely on the administration alone because they couldn't succeed at doing that in the past. That's got to come from within the Congress. So you've got to develop an understanding and you've got to develop credibility within the legislative body that can argue for the funding of these programs. We have that now. That won't solve all your problems, but the news is much better today.

Key: My second question is, one of the most important responsibilities and challenges we have when working with individual nuclear facilities in Russia is gaining the trust of the facility personnel. This is very important. But having that trust is not enough for us to be able to do our jobs effectively. Once we have the trust of the facility, then our next biggest challenge is obtaining appropriate access into the facilities to assure we know what is there and know enough about it to be able to define the level of protection that it needs. No matter how much the facility trusts us, they cannot give us the access we need to help them effectively. The Russian regulatory body over these nuclear facilities is Minatom. They determine the level of access we get into each nuclear facility. I am wondering what Congress or any other agency can/could do to help us with this access situation? Until we really do have full access, we can't do our jobs with full effectiveness concerning nonproliferation of nuclear materials.

Weldon: You've got a major challenge, and I agree with you. I personally visit Russia three or four times a year. Every time I go, I usually try to find two or three key issues, when they're not giving us the kind of access and the kind of transparency that we need, and I take it right to them, whether it's to Rumyantsev, or before him Adamov, or before him Mikhailov. I take it right to their face and say, "You want me to help you? Then you have to be open with me. I have to go back to my colleagues who don't want to do what I do, and convince them, so you've got to give me that ammunition." It's not going to happen overnight, but I see change occurring, I see openness occurring, and I see a willingness to do things that perhaps have never been done before.

I'll tell you this, sometimes I think the bureaucracy on the American side is more difficult to get transparency from than the bureaucracy on the Russian side. Now there's a real statement for you. But I agree with you. We haven't solved all the problems. There are still challenges, and what I would say to you is give me a call and I'll help.

The administrator of the interior for Russia is one of my very good friends, Boris Grizlov. He was the deputy speaker of the Duma. He's very close to Putin. He called me and asked me to host him at the Republican National Convention, which I did. He stayed with me and about 100 other members for the whole week, living with us, and we got to know him personally. I brought him back for the inauguration of President Bush. Well, he's now the top internal security person for all of Russia. So whenever I have security concerns, whether it's with Minatom or MOD (Ministry of Defense), I go to Grizlov and say, "Look Boris, you better get this resolved for us. There are problems here that need to be addressed." And I've told him that on the tactical nuke issue at Kaliningrad, and I've talked to him about Yamatau Mountain, that's why all through my amendment, I say alright it's time to challenge the Russians. "We'll give you access to our test site in Nevada. I want our side to have total and complete access to Yamatau. Let us see what's going on." Because you know there are some questions that we are unable to answer there. And I'm aware of that. But you don't solve those by backing away and calling them names. You challenge them and you push the envelope and you try to engage them and I see us making progress although there are still issues out there.

John Matter: You've mentioned the broad support you have within Congress for these initiatives. I wonder how you feel about support from the President and the administration: who do you believe are the key players there, and do you have their support, or what are some of the things that you need them to get behind?

Weldon: Well, it's mixed. I'm not going to name names here, because I'll get myself in trouble, but there are some in the administration who are still dinosaurs, who don't agree that the direction we're going is the right direction and they're using their positions and that's always going to be a problem. I can tell you, I have talked to the president about this personally on at least three occasions, twice on Air Force One when I was alone with him and once in the presidential limo when I was alone with him in my district, and he said, "Curt, I'm with you 1,000 percent. I want to move in this direction." That's the president who's not in tune with all the specifics and all the nuances. In terms of the agencies, it's mixed but the response I got when I started doing this Steve Hadley is (National Security Advisor) Condoleezza Rice's top deputy and he said, "We're with you. We think you're going in the right direction." (Deputy Secretary of Defense) Paul Wolfowitz, (Secretary of Defense) Donald Rumsfeld—I took Rumsfeld with me three years when I went to Russia—James Woolsey, former CIA director, Bill Schneider, chairman of the President's Defense Science Board, supports us. Deputy Secretary of State Richard Armitage, I met with him, he's positive. The new head of the Russian desk at State, John Evans, he supports us.

I guess, one, I'm a pit bull. I'm not a laid back personality. And the thing I can do that they can't do, is I can go to Congress. And my best friends in Congress are Democrats and Republicans. The president could never get Joe Biden and Carl Evans to sign any document, especially for missile defense. But I did. I've told the president, "If you want to succeed, this is the direction where we can succeed together." The president can take all the credit because he's the top guy and what I'll do is give him a bipartisan coalition to help make these things happen.

Matter: Following up on that, are DOE and NNSA going in the right direction?

Weldon: I think General Gordon's great problem has been administrative in nature. You know it's a very difficult thing taking over a new agency like that. And that includes testifying before my committee because funding for NNSA comes through my subcommittee. It's DOE money. I think he's making progress. There are some things perhaps that I would like to do more in, in management, in oversight, I'd like to see us have a more cohesive approach so that we knew that all the agencies, all the labs are not in fact duplicating what other labs are doing. A better expenditure of federal dollars, but I want to give him some time to really have us fully assess after a year or two, before we make a judgment. I don't have any major criticism of NNSA right now. The general knows my feelings; we've had private meetings. But I think he understands what has to be done in the agency.

Mangan: You made a comment during your speech regarding terrorism that you think we're moving in the right direction. Would you give us your opinion on the proposal for the new Department of Homeland Security?

Weldon: What's interesting is that the other issues I work in the Congress, I was a firefighter and a fire chief before I went to Congress, I volunteered. So I formed the fire caucus, which is the largest caucus in the Congress, fifteen years ago. My first two co-chairs were John McCain and Al Gore. So I now have 360 members of the House and the Senate who look to me for leadership on fire and natural disasters issues. I've been at every disaster we've had in the last fifteen years, from the World Trade Center in '93 and 2001, to the wild lands fires in Colorado and California, earthquakes, Hurricane Andrew, Hurricane Hugo, and the Murrah Building bombing in Oklahoma City. So my concern with terrorism has been from the standpoint of how do we protect our communities and how do we respond; that's a key part of this new agency.

I also recall the emerging threats because when I was chair of R&D it was my job to place the $38 billion in defense money into where we thought the emerging threats were going to come from. The four emerging threats that we monitored were missile proliferation, weapons of mass destruction, narcotic drug trafficking, and cyberterrorism. So I've been very heavily involved in assessing the threats. I've also been very critical of our intelligence agencies. In my opinion, and I said this on September 11 at 12 noon on CNN live nationwide, that on that day our government failed the American people. And that wasn't just a quick sound bite from a politician. I said that because as far back as 1997, many of us in Congress, and I was at the forefront of this, were calling for the integration of our classified data systems. In fact, I put language in two successive defense bills in 1999 and 2000 calling for the creation of a national operations and analysis hub that would fuse together the thirty-five classified systems we have in the federal government—FBI, CIA, NRL, NNSA, all the agencies—and using high-speed computers and software tools, two of which were developed by Pacific Northwest National Laboratory, allow you to do massive data mining, and then you can do profiling from that and see conditions either involving individuals or regions that are emerging threats.

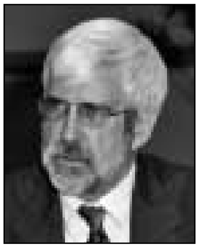
When you look back on 9/11, what we're now seeing is a bunch of tidbits of information coming from all the different agencies, which if they had all been combined, and we had had the analysis capability, we may have seen the picture. In 2000, an Al Qaeda leader said in an unclassified interview in a Rome newspaper that they were training *kamikaze* pilots. Well, the CIA doesn't look at open-source information. A data fusion center would look at all that. Intelligence capability prior to September 11 was a failure. They do good analysis within an agency, but it's all stove-piped. Now that's being corrected and that's why one of the four new branches of the new security agency will focus on intelligence.

There's a new chief information officer whose job is to do this. He was the former CIO of Corning Co. out in New York. So I feel good about that. From the consequence management standpoint, Joe Allbaugh of FEMA is a great guy; he's doing a great job there. We are putting up the mechanisms to provide better response for our 32,000 fire and rescue departments. Their biggest challenge has been we don't have a domestic integration communication system. It was true at the World Trade Center both in '93 and 2001; it was true of the Murrah Building bombing. Firefighters and emergency responders arrive on the scene and they can't talk to each other because none of our communications systems are integrated. Well, that's a challenge that this new section of the agency will focus on. Integrating the domestic communication system.

The third area is weapons of mass destruction. Basically because of proliferation, our enemies got technology they should not have gotten: chemical, biological. I saw the role intercept played in the '90s. What frustrated me the most was to see chemical and biological technology leaving Russia and going into the hands of the Iranians and the Iraqis and we pretended we didn't see it. Now what we're doing is trying to play catch up in terms of building sensor systems, integrating our capabilities. Generals in charge of nuclear security don't have enough detection units to detect a nuclear device or nuclear materials and they've asked for more funding and we're giving it to them. In the area of chemical and biological, we've got to be working with a guy like Ken Alibek, who was the number two guy at the Soviet agency where they developed all the biological weapons. He knows anthrax and small pox. He's now at George Mason University. He's been very critical of our country. He wrote the book *Biohazard*.

So what we're doing is trying to put together a coalition where he and the Russian scientists can work together; the people who built the biological weapons can work with us on how to deal with those same biological weapons and technology. And the same thing is true in the chemical weapons area. You know, Yavakov when he testified, said that Soviets estimated that the stockpile of chemical weapons was 40,000 metric tons. He maintained it's close to 100,000 metric tons. So again, Americans and Russians together—the Russians who worked on those chemical weapons stockpiles, the scientists who understand what they built, the types of technology, and how we can best protect ourselves against it. The other area is transportation security. So the new agency is designed to do that in these four areas and I'm convinced that we're moving in the right direction. Whether or not Tom Ridge will be secretary is still up in the air. I don't know whether he wants it. But you could not expect Ridge to do what needed to be done and not have any budget control. Many of you work for the federal government. You know federal agencies will tell you whatever you want to hear. So you have to have control of the actual budget and that's what he's going to be getting. The new agency is going to have a tough task, but if we put in a good strong leader in there who can understand the bigger picture and not play politics, I'm convinced this will be a good thing for us.

James Lemley: There's been a tendency



to reject or back away from treaties that have very explicit terms written into them. You also mentioned transparency as something that's very important and I guess I am wondering where you see the Congress will be with regard to making future agreements that have very explicit verification possibilities?

Weldon: You know, that was something that bugged me in the '90s. I said to myself, well maybe the reason the administration is not imposing the four requirements of the treaty is that perhaps the required actions are too severe, and we need some flexibility. So I went to the administration, working with Henry Sokolski who runs a nonproliferation think tank in Washington, and Henry had published a series of layered responses that could be included in any arms control agreement so that it gave the administration flexibility so we didn't have to have an all-or-nothing situation. The administration said, no we don't need that. So I guess what I would say is that in any future or existing arms control agreement, if the administration feels the required actions are too stringent, or too tough, the Congress will be willing to give them more flexibility. But if they don't want that additional flexibility, then they have to enforce what in fact is a condition of the treaty. Because if you don't enforce the treaty, what good is the treaty? And that's what I tried to give a couple of examples of today. That was the problem of the Congress in the '90s. The Congressional Research Service, not some Republican think tank, documented thirty-eight times that we had evidence of alleged violations of treaties from 1991 to 1997. Of those thirty-eight times, twice we imposed sanctions. Once when the Chinese transferred missiles to Pakistan; the second time when the Chinese bolstered Iran's chemical weapons program.

In the other thirty-six times, we either didn't follow up, we said we couldn't do anything because of sources and methods, or we didn't take the appropriate action. I am convinced that some of that was because we didn't want to embarrass Yelstin. In fact there was a secret cable that was sent from President Clinton to President Yelstin in the middle of the '96 campaign, which was revealed by Bill Gertz in one of his books, that basically said we're not going to do anything to embarrass you. Well an arms control regime that requires you to take actions when an enemy proliferates isn't going to embarrass anybody. If a company in America, even if it's a company that supported me in my campaign, does something wrong, I want them held accountable. I don't consider that an embarrassment. What we had to do, and what I don't think we did a good job of, in Russia was convincing them that if we hold an entity accountable, even if it's one of your agencies, that doesn't cast a reflection on you; it means we have to work together to prevent it in the future. And America has to understand that we've done some things to allow proliferation to take place. Other nations look at us and say, "Well, you talk a good game." I mean, I sat through the Chinese fiasco and I don't want to go into all this detail, but for seven months I saw with the FBI and the CIA, and as much as the administration gloomed and doomed about Chinese threat of technology, I'm convinced that wasn't theft. That was an open, wholesale auctioning off of American technology by lowering the threshold. By lowering the standard for what could be exported. The Chinese were willing buyers. I can't blame them for that. If we're willing to sell them high-speed computers, if we want to sell them separation stage technology for their missiles, if we're willing to sell them machine tool technology, that's our fault, not theirs. The problem was we did this and then we complained that China has all these new technologies, which we gave them. So the proliferation was of our own doing. Then we try to make it look like the Russians were all the problem of the proliferation. The point is, if we have a standard, it doesn't matter who are the proliferators, they have to be held accountable or the standard doesn't mean anything. So the perception of the Congress was that Russia allowed all this technology to flow and therefore the Congress blamed Russia alone and said therefore none of these programs are worth doing because you can't trust those Russians and the Congress wanted to cut funding for all these programs, which is why conservatives were almost successful and in some cases were successful in either controlling or curtailing programs that we need to work on.

Debbie Dickman: I wanted to ask a question about the current thinking about some of the Russian transition programs, the Nuclear Cities Initiative and the Initiative for Proliferation Prevention. There hasn't always been the greatest relationship between Congress and DOE as to how those programs were being managed. I was wondering if some of the recent interactions between Congress and DOE have increased the confidence of the Congress that these economic transition programs that we're working on in Russia have value and if we've been able to provide enough information back to Congress that they're increasing their confidence and therefore hopefully increasing the budgets so that we can focus on those areas that are not strictly nonproliferation but are a big piece of engaging that workforce in Russia in other activities.

Weldon: It's better but… I'm glad you brought this up and I hope that you will spread this out in your report that you give to your members. Your members need to understand that as successful as your programs are, you need to engage the Congress with you. I need to get members of Congress out to the Nuclear Cities sites and let them see the kind of works they can place. I need them to visit. It's not a case that they won't travel; I've taken 200 members of Congress to Russia. It's not enough to visit Moscow and all the major sites. You need to get out as Dick Luger did when we visited last time—he went to some chemical weapons sites. We need to get members of Congress out to the nuclear cities. And I can tell you that the Duma deputies in those regions would love to have members of Congress come to their regions. So where your people can be very helpful to us is where you have projects underway, request that we bring members to those sites. Send them to me and I'll get you pockets of members who will be glad to spend a day or half a day in seeing firsthand and talking to local officials about what's happening. If you really want to solve the budget problem, that's the way you do it. You give members of Congress a firsthand look so they come back and say, "I was there, don't tell me. I saw it. I talked to those people. I know them." So that's where you really can help us.

Dickman: So then there's that issue with the access again. Many of us even aren't able to get into some of those places.

Weldon: But when you tell the Russian leaders you're going to bring some members of Congress…

Dickman: That ought to do it.

Weldon: That will greatly help. And the American members of Congress will let our Duma counterparts know that we're going in. Every region of Russia is represented by a Duma deputy. So all of the sudden it's important to them to bring us in. I'll guarantee that they'll put the pressure on.

Dickman: On the issue of metrics and things that are quantifiable data that we feed back to you, are we getting any closer in being able to provide that data? There's been a lot of confusion in the past.

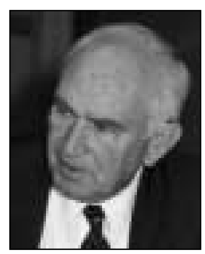
Weldon: What kind of data?

Dickman: We've been asked a number of times to provide metrics—you know, things we can count to demonstrate our successes. Some of them are tough to count because you count the number of jobs or certain kinds of things that are really difficult to do. I'm wonder if the current thinking is still along those lines or is it looking at other kinds of things that help show what activities are going on.

Weldon: I think there's a general concern that we're not achieving the level that people tell us we're achieving. We can't actually see the warhead being taken apart. We can't actually see the hard evidence of what's occurring. That still is a concern. That's not going to be easy to overcome because the Russians are always going to be reluctant to give us that kind of access. But I think the more you can quantify the work that you're doing, and give us that quantification, the more you can get us involved, the better. Every time you do a project in a Russian region on a nuclear city, if I were able to assign a taskforce of members of Congress to work with you on that particular project, and you took them there and you built relationships with them, I think it would help you in Congress for money but it would help you on the Russian side too. The Duma in Russia is not as powerful as the Congress in the U.S. Their constitution does not give them the same authority we have.

One of the ways we can improve this is getting members of Congress to more sites so it's not just you as a paid person going in doing the job. But you're bringing our elected officials and their elected officials together with you. We're doing press accounts, we're doing public comments about what's going on, so it develops more openness. I've done that with certain people there. I can go to Kurchatov and Velikhov will take me any place I want to go. Through the Tokomak reactor to the most recent new products we're doing called thorium fuel, which is an alternative, and I got $10 million in a defense bill to approach an alternative type of nuclear material that doesn't present the environmental problems, doesn't present the weapons-grade problems, and they took me in and we looked at the reactor and what's going on. I've never had him stop me from doing anything I wanted to do, ever. Some things he had to go through clearances and up the ladder. The current minister of atomic energy (Rumyantsev) used to work for Velikhov and now has the direct ear of Putin. You take a guy like that because you know the type of person he is. You know he always wants to do the right thing.

By the way, on the nuclear waste issue, I have another study underway that's going to look at the feasibility of using an underwater storage site as a possible storage site for nuclear material. A mile down. The guy who's working on this is Dr. Mike Champ from Texas A&M, and he's working together with Kurchatov. And as I understand, I'm not a nuclear physicist obviously, I'm a teacher, but all of our nuclear material is under water wherever it is above ground. The idea is if you want a true terrorist-free location, you put it down a mile under the ocean and it's perhaps one of the safest ways to store it.



E. R. Johnson: I'm sure the state of Nevada could come up with an argument for you right now.

Weldon: I'm sure they could. I'm a big supporter of Yucca Mountain. The problem is, I think any time DOE comes up with an alternative to Yucca Mountain we go crazy, but that doesn't mean we should not continue to research other possibilities.

Johnson: I agree wholeheartedly.

Weldon: So being in a position to, I'm encouraging this project and Dr. Champ and Kurchatov are going to do a study. In fact, the interesting thing is I told them you can't do this because I'm also a green Republican on the environment, I said, I want you to bring in the environmental community to work with us so we're working closely with Jean Pierre Costeau, who's Jacques Costeau's son, he's going to be an advisor. And Alexi Yabakov, who hates Minatom—he loves atomic energy but he hates Minatom—he's going to be an advisor. So when you bring Yabakov and Costeau in with this taskforce to study this, it's kind of an interesting beginning.

Johnson: A good chemistry.

Weldon: Good chemistry. So they're starting off now to look at this issue.

Stein: In Russian waters?

Weldon: In international waters.

Weldon: Velikhov proposed to me that we do a site in Russia, that he would help his government to have it become a joint U.S.-Russian facility with a laboratory above ground that would take nuclear waste from the U.S., Russia, and other countries. That was not well received by the Russians, as you can imagine. It has some security concerns from our side obviously, so that's not moving very far. But we should not predispose any ideas. We should research them. That's what research is all about. It doesn't mean we're going to do it. But at least we should look at it. I mean, you're all scientists. We ought to give you the ability to think and look at alternatives and then dismiss them if they're not practical and pragmatic.

Rebecca Horton: I have two questions. My first is related to not enforcing the treaties and I've heard a lot of comments that are more policy related about decisions that we haven't followed up on, things that we saw and we didn't take any action on. Do you also see on the technology side a need for different approaches to balance technology/policy integration? Or do you really see it as focused on policies that we haven't committed resources to enforcing?

Weldon: I guess to me it's more policy, but I don't have the technical background to know whether or not there are technical opportunities that we're not taking advantage of. I can tell you one of my other priorities that I think might help us here. The Congress doesn't operate as a 21st century entity. By that I mean a lot of our challenges are technology oriented because of the emerging threats to our security, whether it's weapons of mass destruction, missiles, or cyberterrorism. It's difficult to get members to go and talk to an academic leader, researcher, or a professor. It's hard to get a member to travel to Battelle Lab or to Livermore or Sandia or Los Alamos. Unless they're representing there, they don't want to go there. So one of the other things that I have been pushing, and is an immediate priority for me for this year, is I want to build in the Capitol a virtual-reality hearing room, which would take the secure lines that run out of the Pentagon, put them in the Capitol, and build a hearing room that would be non-traditional where you have a cutting-edge IT capability to two-way interface in a secure environment. So instead of trying to get members to travel to a lab, I can have a real-time dialogue right from that site with a lab director or a researcher who can show the members what they're doing in real time. If we want to have a group of members observe a missile test, it's very difficult to fly over to Hawaii, but if you do in real time you can uplink and downlink it in a secure setting and you can actually be an observer. So the big challenge for us is not having elected officials sitting up on a platform with the witnesses down low and we're like talking heads. We need to make these technology challenges real.

I spoke at an IT event last week and I challenged the IT companies to build a facility inside the Capitol complex that would have cutting-edge capability so we can better understand technology. If that would be the case then maybe I could answer your question about whether we're not doing enough in the technology area. I can't answer that because I don't know what the parameters are. But if we have a chance to have more of a give and take in a nontraditional way than what we have now, which is a talking-head hearing, then I think maybe we could have a better understanding. So where you could also be helpful would be for your Institute to come out and support the idea of Congress getting into the 21st century and giving us the capability to more coherently understand the technology associated with some of these threats because they're all technology related. And the bulk of the members are not rocket scientists. We have one or two Ph.D.s in the Congress. The bulk of them are ordinary business people, teachers, and lawyers. So you have to make technology real because many of these challenges are very technical.

Horton: This is related to sharing information on lessons learned. Take for example in the bilateral context with U.S. and Russia. It seems like history repeats itself, that we make decisions in one area and we see that it's impacted us and there's some unintended consequences in another area. So could you comment on how do we work on sharing information with regard to nonproliferation, providing more transparency, without having the unintended consequences for our two countries in counterterrorism for example. Are there some ideas you might have on sharing that information?

Weldon: Great question. I can tell you that Russia's been very cooperative. The world has been very cooperative, but Russia in particular, as our former enemy. I mean Putin has opened up much of his classified capability to share it with us and given us the use of a former Soviet military base in Afghanistan. In terms of trying to provide transparency, I don't know. You must have some suggestions yourself? I mean, you must have some thoughts in this area or you wouldn't have asked the question.

Horton: I'm thinking back on my experience with the Russian program and it seems that we needed some information channels to be able to exchange information that would be able to protect information. We often couldn't get access because there was concern on both sides that we didn't know if the people had a need to know; we didn't know how we could jointly protect the information. We have our own way of protecting information. The Russians have their way of protecting information. We have no means of protecting jointly and building confidence that we could protect it.

Weldon: We should talk about this. That's a very interesting thing.

Mangan: We have some new initiatives where the weapons labs in the U.S. and the weapons labs in Russia are thinking about joint efforts in counter-terrorism and that issue is a big issue. How can we do a good job and protect each other?

Weldon: We have established a taskforce on terrorism between the two bodies. Kulakov is the chairman on the Russian side. He has nine deputies. And also we are also working with the Bundestag for a trilateral legislative taskforce on corruption. And Kulakov on the Russian side is the lead. We've put together a team and eventually were going to have a meeting of the legislators from the three countries, hopefully this summer, to discuss joint efforts on terrorism. And that will be one of the issues that I'll raise.

Scott Vance: What is your prediction regarding the designation of Yucca Mountain as the site for the repository?

Weldon: It's very controversial. I support it. The House supports it. I don't think we have an alternative. But I don't think that should preclude us from allowing researchers to look into other ideas. We're moving in that direction and there are those who say this is a bad idea. But I generally think that Congress is on board because we can't just continue to keep our heads in the sand. We can't pretend that this problem will go away. It won't. So my best guess is that it will take time, but that it will go forward

Mangan: One final question from Ed Johnson.

Johnson: Back to the Russians for a moment. The Russians have been proposing to take spent fuel for storage and disposal, particularly from Asian countries. I was wondering what was the attitude of the Congress on this plan?

Weldon: Most members aren't aware of what the Russians were proposing. Velikhov was talking to me about it, as far back as two years ago, before the Duma voted on the legislation, which as you know they passed. They vetoed it twice and then they finally passed it. The Duma is very uneasy right now. The environmental community in Russia, led by people like Yabakov, and Greenpeace and others are adamantly against it. The Russian media is against it. The Congress doesn't have a feeling for this because most members don't know that Russia is really planning on establishing this kind of repository largely for financial purposes. Again, I'm not a scientist, but Velikhov is convinced that we shouldn't even call it nuclear waste. He convinced that within fifty to seventy years scientists will come up with peaceful reuses for spent nuclear fuel. So he calls it spent nuclear fuel and says that eventually we're going to find peaceful reuses of this material therefore it should be just temporary storage as opposed to burial.

Johnson: It's a resource, it's just not economical at the present time for recovery but it may well be later on.

Weldon: Right now I'd say the American Congress would probably support the Russian elected officials of the Duma and federal council. If they did not want this to happen and Congress should probably support them in that decision but if they decide that they want to do it, then Congress would probably not be opposed to it. Now our security experts would probably have to weigh in with us and tell us what kind of security problem it could present or pose, but by and large most members aren't even aware of Russia's movement to have a repository of nuclear waste for other countries. But again, we can't all put our heads in the ground. Somebody has to find some short- and long-term solutions because aboveground storage of this material many of us agree presents a bigger threat. Whether it's a terrorist coming in or an airplane, aboveground storage scattered all over a large area is certainly not a viable way to safely handle nuclear material and so we've got to do something. The matter now is on the side of quicker rather than slower because of the increased threat of terrorism and the fact that we've uncovered some plots that were initially going to be aimed at nuclear facilities.

Mangan: Well, unfortunately, our time has run out. Thank you so much for your time. We have enjoyed our discussion and your talk this morning.

Addressing Terrorism

A Summary of the Closing Plenary Session of the 43rd INMM Annual Meeting

James Lemley
Brookhaven National Laboratory, Upton, New York, U.S.A.
Chair, INMM Government Industry Liaison Committee

Amy Whitworth
National Nuclear Security Administration, Washington, D.C., U.S.A.
Vice Chair, INMM Government Industry Liaison Committee

The Government-Industry Liaison Committee had little trouble in determining the theme of the Closing Plenary Session of the 43rd INMM Annual Meeting following the events of September 11, 2001.

For everyone in the nuclear field, that day has had profound effects. Terrorism was not new in the world, but such a large-scale attack on the United States made the nuclear industry focus on how terrorist acts could potentially affect both commercial and government nuclear facilities. The GILC set about building a Closing Plenary Session that would provide information about recent acts of terrorism and outline the reaction to date in both U.S. domestic and international nuclear arenas.

To set the stage, U.S. Federal Bureau of Investigation Supervisory Special Agent Mark Whitworth outlined recent explosive terrorist events. What stood out in Whitworth's talk was the relative low level of sophistication used in the recent high-profile terrorist acts. Michael Weber, deputy director of the newly formed Nuclear Security and Incident Response organization within the U.S. Nuclear Regulatory Commission, then discussed how the NRC was addressing the changing threat environment. Weber indicated that while much had been done to address terrorism, much more work was ahead. Anita Nilsson, International Atomic Energy Agency, closed the session. She discussed what could be done to address the increased terrorist threat in a global manner and discussed the concept of a dirty bomb, a topic of considerable interest to attendees.

It was evident from the question and answer portion of the Closing Plenary Session that the Institute's membership is strongly interested in this evolving subject. Clearly, many questions remain as to how the world's nuclear industry will ultimately address the increased threat, but the GILC hopes that this Closing Plenary Session benefited the Institute's membership by providing relevant and valuable data and furthering information exchange in this area.

James Lemley, left, chair of the Government Industry Liaison Committee, and Amy Whitworth, right, vice chair of the committee, flank the three speakers at the closing plenary session of the INMM Annual Meeting, Michael Weber, Anita Nilsson, and Mark Whitworth, (left to right).

Explosive Terrorist Activities in the Recent Past

Mark Whitworth
U.S. Federal Bureau of Investigation
Summary by Mark Whitworth

Mark Whitworth is a supervisory special agent in the U. S. Federal Bureau of Investigation Laboratory in the discipline of explosives and hazardous devices. In 1992, Whitworth was transferred to Washington, D.C., where he worked counter-terrorism for several years before accepting a transfer to the Joint Terrorism Task Force (JTTF). The JTTF was an interagency task force that included members from the FBI, Metropolitan Police Department, State Department Office of Diplomatic Security, Secret Service, and U.S. Capitol Police. The JTTF was formed to investigate acts of terrorism committed in the District of Columbia. In 1997, Whitworth accepted a supervisory position in the FBI Laboratory Explosives Unit where he coordinates and conducts the FBI's training for Post-Blast Investigations. Whitworth has investigated many acts and potential acts of terrorism domestically and internationally, including the bombing at the Egyptian Embassy in Pakistan; the bombing of the Khobar Towers U.S. Air Force facility in Saudi Arabia; the bombing of an abortion clinic in

USS Cole

Alabama; TWA Flight 800 and Egypt Air Flight 990; the bombing of the American embassies in Kenya and Tanzania; and the September 11 Pentagon attack. He is the lead examiner for the bombing of the USS Cole.

Summary

Whitworth outlined the roles and responsibilities of the FBI Explosives Unit. The FBI Laboratory gained its authority to operate from Congress in 1932. Previously, the FBI used external scientists but this led to problems with confidentiality, evidence chain of custody, costs, and the availability of the scientist to testify. Lab services are available to all law enforcement agencies in the United States and are provided free of charge. The FBI Laboratory has eight sections: Electronic Surveillance Technology, Technical Operations, Wireless Communications, Scientific Analysis, Forensic Analysis, Investigative Support, Investigative Response, and Administrative Support. The Explosives Unit is in the Scientific Analysis Section and covers improvised explosive device (IED) examination, arson and explosives residue analysis, bulk explosives analysis, crime scene processing, investigative assistance, explosive reference files, forensic intercomparisons, and EXPeRT database system. IED examinations that Whitworth conducts include component exams and IED reconstructions, and coordinates examinations in residue analysis, tool marks, materials analysis, hair and fibers analysis, document examinations, latent fingerprint examinations, and courtroom charts and reconstructions.

Whitworth provided several examples of component examinations that the FBI has been involved in to include the batteries and wires from the UNABOMBER cases and timing devices used by the Puerto Rican pro-independence group FALN. The examinations provided a foundation for linking evidence to the individuals or groups committing the crimes.

Whitworth detailed several major bombing cases that the FBI investigated including the first bombing of the World Trade Center in February 1993; the April 1995 bombing of the Murrah Federal Building in Oklahoma City by Timothy McVeigh; the June 1996 bombing of the Khobar Towers in Saudi Arabia; the August 1998 bombings of the U.S. embassies in Nairobi, Kenya and Dar es Salaam, Tanzania; the October 2000 bombing of the USS Cole at a refueling dock in Aden, Yemen; and the September 11 attacks on the Pentagon and World Trade Center by members of Al Qaeda. In each of these cases, Whitworth discussed the materials and tactics used and the forensic techniques used in the investigations. His discussions were set against a backdrop of photographs and graphics.

Khobar Towers, Saudi Arabia

FBI Supervisory Special Agent Mark Whitworth discusses investigating terrorist attack sites during the Closing Plenary Session of the 43rd INMM Annual Meeting.

Whitworth noted that while large bombings receive most of the media attention due to their scale, they are relatively rare. Most bombings that occur in the United States receive little or no media coverage. The majority of bombings involve improvised explosive devices, most notably pipe bombs that are filled with black smokeless powder and have simple fusing/initiation systems.

Ensuring Nuclear Security in a Dynamic Threat Environment

Michael Weber
U.S. Nuclear Regulatory Commission, Office of Nuclear Security and Incident Response
Summary by James Lemley

Michael Weber is deputy director of the new Office of Nuclear Security and Incident Response (NSIR) in the U.S. Nuclear Regulatory Commission (NRC). NSIR was created in April 2002 by consolidating security elements from throughout the NRC. In this capacity, Weber helps manage the development of policy and oversees safeguards, security, threat assessment, and incident response associated with the civilian use of nuclear materials in the United States.

Before assuming this role, Weber was the director of the Division of Fuel Cycle Safety and Safeguards in NRC's Office of Nuclear Material Safety and Safeguards (NMSS). He is a geosciences graduate of the Pennsylvania State University and a graduate of the Office of Personnel Management's Interagency Executive Potential Program.

Summary

Introduction to NSIR

In response to the terrorist attacks of September 11, 2001, the NRC recognized that greater effectiveness and efficiency could be achieved by combining safeguards and security with incident response. The responsibilities of the new Office of Nuclear Security and Incident Response include oversight of material control and accountability, international safeguards, physical protection, threat assessment, information security, and incident response. The offices of Nuclear Material Safety and Safeguards (NMSS) and Nuclear Reactor Regulation (NRR) retain responsibilities for licensing. NSIR partners with these offices and the regions to ensure sufficient oversight of security, safeguards, and incident response activities. NSIR is working hard to enhance communications internally and with the regional offices as well as externally with Congress, the Office of Homeland Security, other federal agencies, states, licensees, and other stakeholders.

New Threat Environment

NRC has been keenly coordinating with the intelligence community and law enforcement agencies since well before the terrorist attacks last September. In the late 1970s, NRC established its design basis threats (DBT) for radiological sabotage and for theft and diversion. About every six months the staff completes a systematic review of significant terrorist, criminal, and civil unrest incidents. The purpose of these reviews is to assess the overall threat environment, as well as to identify any necessary changes to the DBTs and highlight for the commission any emerging trends in targets, tactics, weapons, or other threat attributes.

Weber noted that, despite all the rhetoric in the press, there have been no specific credible threats against nuclear facilities or activities since September 11. There have been suspicious incidents but no operational planning or attacks.

In 1994, for example, following the first bombing of the World Trade Center, NRC added vehicle bombs to the DBT for radiological sabotage. Critics of NRC pointed out that this decision was obvious but belated since vehicle bombings had occurred overseas much earlier. The United States is often accused of fighting the "last war." Weber observed that staying ahead of terrorists, criminals, disgruntled citizens, and extremists is consuming the professional attention of many INMM members and a growing portion of our intelligence and law enforcement agencies. The threat environment is very uncertain, and this complicates planning.

While America has other enemies, Al Qaeda continues to present a clear and present danger. NRC has been working closely with the intelligence community and law enforcement agencies in assessing Al Qaeda—its tactics, training, targets, and capabilities. Assessments of Al Qaeda and other enemies provide insight into what may be next. Open sources have widely reported Al Qaeda interest in nuclear targets. Noting the great irony, Weber claimed that apprehension by the public and the media about nuclear and radiological terrorism may have the unanticipated effect of reinforcing terrorist interest in nuclear targets. He pointed out that radiological dispersal devices, for example as reported in connection with the detainment of Jose Padilla (Abdullah al-Mujahir), would not achieve the terrorist objective of widespread devastation and casualties but could be successful in disrupting society, causing public concern, and imposing economic impacts.

In a comprehensive security and safeguards review launched by NRC Chair Richard A. Meserve, the commission is scrutinizing these insights and deliberating on the best approaches for revisions to the DBTs. Revisions to the DBTs and the changing threat environment provide new impetus for consideration of changes to existing security and safeguards programs.

Michael Weber, deputy director of the newly formed Nuclear Security and Incident Response organization within the U.S. Nuclear Regulatory Commission, discusses how the U.S. NRC is addressing the changing threat environment.

Security Measures

Immediately after the attacks, NRC issued a series of threat advisories to certain licensees advising them to upgrade security measures because of the great uncertainty that existed in mid-September. In developing these advisories, NRC staff also examined what other vulnerabilities could exist at licensed nuclear facilities, particularly if adversaries used weapons and tactics that went beyond those postulated in the DBTs. After all, NRC's DBTs did not anticipate the use of civilian airliners as missiles. From first-order vulnerability analyses, NRC formulated a string of measures that could be readily implemented to enhance security, if they were feasible and compatible with safety, and communicated them to licensees in early October 2001. Although the exact measures are protected safeguards information, they included actions such as increasing standoff distances to access portals, restricting access, and revising emergency procedures in response to terrorist attacks. NRC audited licensee consideration and implementation of these measures during the remainder of calendar 2001.

Shortly thereafter, NRC identified

additional interim compensatory measures (ICM) that could further enhance security at a wide range of nuclear facilities and imposed enforceable requirements at some facilities, such as power reactors, decommissioned reactors, and gaseous diffusion plants. Enhancements included increased patrols, augmented security-force capabilities, additional physical barriers, vehicle access checks at greater standoff distances, more restrictive site access controls, and enhanced coordination with local law enforcement agencies.

Additional ICMs being considered are tailored to each class of licensee and to entities that use, transport, and store significant quantities of radioactive materials. With ICMs in place, NRC is proceeding with a more deliberate and comprehensive review, including revisions to the DBTs and threat characteristics, vulnerability analyses, and regulatory improvements. The continuing vulnerability assessments will provide a more systematic and risk-informed basis for identifying and justifying regulatory improvements to the safeguards and security program over the next several months to years.

Challenges Ahead

In planning a way forward, Weber identified a series of fundamental issues that would affect security decisions by NRC and nuclear security and homeland security more broadly.

Risk avoidance vs. risk mitigation: As an independent public-service agency NRC serves the public by responding to their elected representatives in Congress. Does the public want to eliminate security risks altogether or, alternatively, to reduce them sufficiently that they do not warrant additional attention, cause undue alarm, or infringe on our civil liberties? Weber reported that NRC generally perceives public will to be the latter, as framed under the Atomic Energy Act, which specifies “adequate protection” not “absolute,” and as displayed more recently in the resumption of normal business following September 11.

Federal, state, and local roles: Licensee reliance on federal, state, and local agencies to supplement and augment licensee security forces was never more evident than in the days and weeks following September 11. If public-sector agencies are to have ongoing roles in post-9/11 security, the operationally effective allocation and coordination of responsibilities among federal, state, and local agencies will be a significant challenge.

Distinguishing public and private responsibilities: The NRC has required licensees to provide the security forces necessary to ensure sufficient protection of the public, and in most cases this meant extensive reliance on the private sector. NRC-licensed power reactors are among the most protected of private sector facilities in the United States. However, NRC’s existing regulatory framework makes it clear that licensees cannot be held accountable for designing nuclear facilities to protect against enemies of the United States (10 CFR 50.13).

So where is the threshold for public-sector responsibility? Is such a threshold pragmatic or would it be more constructive to look at security as a seamless continuum ranging from private sector for handling the smallest incidents up to U.S. military defense for threats from foreign nations? Even under shared public and private responsibility a number of practical questions will have to be addressed. How long should private-sector guards be held responsible for defending the facilities until offsite public help arrives? Are plans for offsite assistance well designed and adequately exercised? What are the obligations of private-sector guards once the cavalry arrives from offsite?

The nuclear industry compared to other infrastructure assets: Weber raised a fundamental question of whether the nuclear industry is sufficiently different that it warrants special consideration in examining the adequacy of homeland security or whether nuclear security should be subsumed in broader efforts to protect the infrastructure in general. More specifically, are the potential threats, consequences, vulnerabilities, and risks so different from other parts of the infrastructure that nuclear warrants separate and distinct consideration? Will the public ultimately support homeland security initiatives intended to provide a coherent and harmonized approach, despite perceptions that nuclear facilities pose higher risks and consequences? What should be the measures for evaluating the risks associated with sabotage or with theft or diversion and how would they apply across the infrastructure? If different criteria and metrics are used, how can decision makers best evaluate the relative risks associated with nuclear facilities and materials, versus other components of the critical infrastructure?

Openness vs. information security: If the public continues to expect the NRC to conduct business in an open, forthcoming, and meaningful process, how can NRC most effectively balance this expectation with the need to enhance security through restricting access to information? Is there a legitimate role for public stakeholders to engage NRC staff in discussion of security measures? How can these stakeholders be engaged effectively in the peer review process? If NRC continues to conduct its business in an open environment, how can NRC ensure that sensitive information released to the public does not find its way to terrorists, criminals, or other adversaries who might exploit it nefariously?

Conclusions

NRC continues to ensure security in an uncertain threat environment through advisories and interim security measures. NRC licensees remain at a high security level and are on the lookout for suspicious or threatening activities. Although there have been no specific, credible threats against licensed activities or facilities, private security forces remain vigilant against sabotage or theft. NRC continues a high level of engagement with the Office of Homeland Security, other federal and state agencies, and other entities involved in antiterrorism activities.

These measures afford NRC the time to proceed thoughtfully and deliberately with revisions to NRC's DBTs and threat characteristics. Further enhancements in security are being planned from ongoing threat revisions, vulnerability analyses, and regulatory improvements. To make progress in ensuring security in an uncertain threat environment, NRC will have to resolve vexing issues and provide scrutability and predictability in its regulatory decisions, while preserving flexibility and efficiency to accommodate future changes.

Nuclear Security—Increased International and National Efforts

Anita Nilsson
International Atomic Energy Agency
Text Provided by Anita Nilsson

Anita Nilsson joined the IAEA Department of Safeguards in 1996 as the senior coordinator. In 1999, she was appointed head of the then established Office of Physical Protection and Material Security, which carries out the IAEA's program of Security of Material. This program includes the physical protection of nuclear material and facilities, measures to combat illicit trafficking, and responses to malicious acts involving nuclear and other radioactive materials. In March 2002, the IAEA Board of Governors approved in principle a comprehensive plan of action to combat nuclear terrorism with activities that cut across several of the IAEA programs and are carried out in different departments. Nilsson was appointed as the IAEA nuclear security coordinator to coordinate all these activities and report on the results.

First of all I wish to express gratitude for the invitation to speak at the closing session of this 43rd INMM Annual Meeting.

This meeting has been colored by the events that took place on September 11, 2001. The attacks on the Twin Towers, the Pentagon and a fourth, unknown, target have triggered serious considerations of what a terrorist act involving nuclear or other radioactive materials could bring about. I will take this opportunity to reflect, much on a personal basis, on that and on what is being and can be done in particular on the international level to prevent, or to make much more difficult, nuclear terrorism.

Is Nuclear Terrorism New or Unrealistic?

The events of 9/11 have been referred to by the IAEA director general as a "wake-up call" to states to work toward effective protection of nuclear and radioactive materials. In considering the present situation, we have looked into open information sources also to recall some past events.

A notable past event took place in November 1972, when three armed men hijacked a DC-9 in the United States, demanded ransom and enhanced the threat pressure by ordering the pilot to crash the plane into the Oak Ridge National Laboratory. Fortunately, the threat was not carried through. In 1982, a missile was fired against the Super-Phoenix reactor in France and many other reports are available on threats to nuclear power plants. Reports also document threats of dispersal of radioactive materials. One example is from 1995 when Chechens placed a cesium-137 source in a public park in Moscow. Further examples are the threat to damage the Lucas Height research reactor in Australia, and the arrest in Osaka, Japan, of a man for releasing iodine-125 at a subway station. The anthrax attacks in the United States and Aum Shinrikio's use and large storage of sarin gas demonstrated the vulnerability of our society.

Over the past ten years, some 430 cases of illicit nuclear trafficking have been confirmed by states, including eighteen cases involving HEU or plutonium, three with notable quantities. Other open source reports remain unconfirmed. A preliminary analysis of the cases reveals that a majority involved a criminal element. It is impossible to know, however, for what purpose, whether financial, illegal disposal, or possible supply to terrorists. We must also bear in mind that the voluntary reporting of illicit trafficking does not necessarily cover domestic thefts or trafficking in nuclear equipment and non-nuclear material.

Anita Nilsson of the International Atomic Energy Agency speaks on what can be done to address the increased terrorist threat globally and discusses the concept of a "dirty bomb" at the Closing Plenary Session of the 43rd INMM Annual Meeting.

After September 2001, it was reported that Al Qaeda had documents and plans to use nuclear and radioactive materials in destructive actions. Recently, a man was arrested in the United States, allegedly in connection with plans to carry out a terrorist attack using a *dirty bomb*.

The attacks of September 11 showed ruthlessness and long-term planning; and they showed that terrorists recognize no limits to death and destruction that results. We can now assume, therefore, that, if available, terrorists would make use of nuclear biological chemical (NBC) weapons or other means of mass destruction.

The production or acquisition of weapons of mass destruction by terrorists, in particular nuclear devices, would depend on external support to get either the actual device or the necessary materials and technologies. As the process of enrichment or reprocessing would be too complicated to be mastered by any subnational group without state support or knowledge, the theft and smuggling of nuclear material would be a prerequisite.

The willingness of terrorists to sacrifice their own lives to achieve their aims creates a new dimension in the fight against terrorism. This triggers a revision of the equilibrium of the equation in which the risk for terrorist activities is on one side and the potential consequences on the other.

Reactive versus Proactive

The international community has been, through the events of September 11, alerted to the deadly potential of nuclear terrorism. Our awareness provides the opportunity for us to take preventive measures. We can now be *proactive* rather than *reactive*.

In this respect, let me make some reflections.

First, on the statement that nuclear security is exclusively a national concern: An attack on a nuclear facility in a country, the use of stolen nuclear material in a crude nuclear explosive device, or the use of stolen radioactive material in a dispersion device, would have global consequences. Having said that, it remains undisputable that security is and will remain an *exclusive responsibility* for each individual state. However, the far-reaching consequences of nuclear terrorism undoubtedly points to an international dimension of nuclear security.

Second, while attention in the past has been focused on the protection of nuclear material from theft, i.e. to hinder its potential use in the construction of nuclear explosive devices, we must now increase focus on the protection against sabotage. Likewise, we must now pay more attention to indirect use of nuclear material and the use of other radioactive materials. The possibility of a radiological dispersal device, a dirty bomb, cannot be ignored. While the number of fatalities from a radioactive dispersal device cannot be compared with those from even a crude nuclear explosive device, a dirty bomb nevertheless would create tremendous disruption of society. The abbreviation WMD (weapons of mass destruction), can be recast to mean weapons of mass disruption. Since disruption in itself, and not the physical damage, may be the purpose, its prevention requires specific attention. It is clear that terrorists are well aware of the economic consequences of the attack on the World Trade Center.

Third, you may recall that several years ago, a first attempt was made to damage or destroy the Twin Towers using conventional explosives brought into the building in a van. Fortunate circumstances at that time prevented a major accident. However, it did not discourage the terrorists from trying again, having identified a prestige target. It seems that in some cases terrorists mount repeat attacks until successful or defeated. In September 2001, airplanes were used as missiles. It is noteworthy that domestic flights at that time had less security compared with international flights. The terrorists took advantage of this weakness. Thus, we must identify and close the gaps in present nuclear security systems.

All of this shows that there is no room for complacency. There is only one option: to encourage, promote, and implement, which is the hardest part, a high level of security. A comprehensive approach is warranted, focusing on prevention, and including detection and response. Security must be considered, of course in a graded approach, for all nuclear applications, nuclear power reactors, fuel cycle facilities, research facilities, radioactive sources in non-nuclear industrial or medical applications or nuclear transports. The introduction and maintenance of a *security culture* is fundamental; without it the effectiveness of any measures will degrade over time.

International Undertakings

Let me now talk about international efforts that contribute to the prevention of nuclear terrorism.

The Nonproliferation Treaty remains the fundamental undertaking to prevent proliferation of nuclear weapons by states. Non-nuclear weapons states, signatory of the treaty, undertake to declare and place all their nuclear material under IAEA safeguards. As a consequence, states have systems in place to register and account for nuclear material, i.e. SSACs (state's system of accounting for and control of nuclear material). The agency's verification of the continued presence and peaceful uses of the material provides for early detection of theft. The NPT does not, however, cover subnational proliferation, namely the illegal use of nuclear material, for example, by terrorists. However, states recognized the vulnerability of nuclear material in international transport. The Convention of Physical Protection of Nuclear Material, which entered into force in 1987, contains obligations to protect nuclear material in international nuclear transport. The need for protection of nuclear material in domestic use, storage, and transport is recognized in its preambular paragraphs but there are no obligations to that extent.

During this week we have heard about the ongoing efforts to strengthen the Convention on the Physical Protection of Nuclear Material. The conceptual consensus among participating states, *inter alia*, to broaden the scope of the convention to include the protection of nuclear material in domestic use, storage and transport is a *major* step forward. However, it is disappointing that there remain technical and legal differences to be overcome before a diplomatic amendment conference can be convened.

Further, as has been repeatedly stated by the IAEA General Conference, the universal implementation of protocols additional to safeguards agreements provide yet another important contribution to the prevention of terrorism. Diversion of nuclear material, the undeclared production of material for weapons purposes will be much more difficult to pursue for states with an additional protocol in force.

All of this was recognized at the recent preparatory meeting for the 2005 NPT Review Conference where many states made statements in support of that.

For safety and security of radioactive sources the legal framework is different. There is no convention with obligations for states to maintain control and security of radioactive sources. The draft convention on the suppression of acts of nuclear terrorism, which would include nuclear as well as radioactive material, is still in draft, and little, if any, progress is noted or expected. *The IAEA Basic Safety Standards for Protection Against Ionizing Radiation and the Safety of Radiation Sources* and the more recent *Code of Conduct on the Safety and Security of Radioactive Sources* provide important safety standards but limited advice on security of these materials.

The many sources that are thrown away or abandoned after use present a particular problem. Several radiation accidents caused by orphan sources have taken place. The recent situation with the lost sources in Georgia demonstrates the risks, health effects, and efforts needed to find and secure such sources.

Recent Progress and Looking Forward

Now, let us look at recent progress and the future.

As reported earlier this week, the IAEA Board of Governors has taken a significant step forward in approving, in principle, a program of activities to strengthen the protection against nuclear terrorism. The program consists of eight activity areas, reflecting a comprehensive approach to nuclear security. It focuses on prevention, with physical protection, nuclear material accountancy, and improved control and security of radioactive sources, and adds measures for the detection of and response to malicious acts involving these materials. Activities include security advisory services, the development and implementation of standards, guidelines and recommendations, technology and methodology development, expert services, training, and information exchange. Nuclear security information and coordination with member states and other international organizations are important elements of the program. The budget of the program was estimated to be about $11,500,000.

The IAEA, in pursuing the approved program, will provide a focal point for international efforts to improve nuclear security. The Board of Governors decided, for the time being, that the program will be funded through voluntary contributions. It is a measure of confidence and trust that to date, eleven states plus the Nuclear Threat Initiative have pledged some $7.5 million for the implementation of the program. Several other states have pledged contributions in kind such as training facilities, expertise and other valuable resources to be used in the implementation of the program.

Several states are in the process of upgrading their nuclear security systems. Some of them have requested IAEA support in assessing whether their systems meet with existing international guidelines and good practices. Some of these states also have programs that aim at providing support to other states for the upgrading of their security systems. Very significant and important resources have been and continue to be devoted to these efforts. In 2000, an estimate was made that about $500 million of national resources had been devoted to such support. These efforts continue and it is clear that significant resources are assigned to improving nuclear security. This can only be referred to as a good global security investment. For maximum impact, however, duplication of efforts should be avoided with effective targeting of activities.

It is a great pleasure to report that on June 12, 2002, officials representing the U.S. Department of Energy (DOE), the Russian Federation's Ministry for Atomic Energy (Minatom) and the IAEA established a tripartite working group on securing and managing radioactive sources. A coordinated and proactive strategy to locate, recover, secure and recycle orphan sources throughout the former Soviet Union will be established. This agreement represents the first concerted international response to the threat posed by vulnerable radioactive sources in the NIS. Funding and expertise for this initiative will be provided by DOE and Minatom.

The agency stands ready to provide coordination services to ensure effective and efficient use of the collective funds available. Analysis of available information, outcome of information exchange and feedback from security services missions such as IPPAS provide good basis for targeting efforts and for the provision of support to achieve identified improvements.

Summary

Nuclear terrorism is a global threat and the responses to it must be global in nature. The effectiveness of anti-terrorist measures will be determined by the weakest link in the system, and the implementation of these measures will benefit all states.

Much needs to be done. We are far from a global security standard that would make nuclear terrorism difficult, if not impossible, to carry out. The international community must collectively support improved nuclear security, and make the necessary commitments to combat nuclear terrorism.

This requires, *inter alia*, a consistent and coherent promotion, support and implementation of:

1. A security culture for all nuclear applications
2. The development and implementation of a comprehensive set of nuclear security standards, guidelines, and recommendations
3. Continued and strengthened international cooperation
4. Significantly improved coordination between international and national programs
5. While maintaining confidentiality of sensitive information, improved communication to general public with an aim to generate confidence that nuclear security is an issue being addressed with the required attention

Ladies and gentlemen, this concludes my remarks. This is the last item of the Annual Meeting, and I thank you for your attention and patience. I look forward, now or later, to answer any questions that you may have.

Proliferation Aspects of Plutonium Recycling

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Note: This paper appeared first in a special issue fully dedicated to the nuclear fuel cycle of the Proceedings of the French Academy of Sciences *published in 2002 by Elsevier Press. The issue contains some thirty scientific papers in English and provides a broad overview of the fuel cycle from a European perspective.*

Abstract

How serious are the proliferation risks of plutonium holdings, whether separated or still in spent fuel? Should the concern be the same for all mixtures of plutonium coming out of different reactor types and for different degrees of nuclear burnup? Should there be different categories of plutonium for verification purposes, as is the case for enriched uranium? This paper reviews the issue of plutonium utilization in nuclear weapons and explosive devices in the context of an effective and efficient verification of nuclear materials by regional and international organizations.

Plutonium recycling offers substantial benefits in an energy perspective of sustainable development, while contributing to nonproliferation through the elimination of the residual risks associated with plutonium. Before recycling, reactor-grade plutonium from light-water reactors does not lend itself easily to the assembly of explosive nuclear devices; thereafter, practically not at all. Verification systems for material security and nonproliferation should therefore adopt several categories of plutonium covering various isotopic mixtures associated with different fuel types, in order to better reflect the risks and to better focus their verification activities. The author proposes the adoption of three categories of plutonium.

Plutonium: A Resource and a Step Toward Sustainable Development

The chemical reprocessing of nuclear spent fuel leads to the separation of plutonium, a constituent that can in turn deliver much energy when re-inserted in nuclear power plants. The recycling of plutonium makes sense in terms of energy resources. Nonetheless, some people are concerned about related proliferation risks and they would prefer banning plutonium recycling altogether.

The recycling of plutonium is a mature technology with an outstanding technical, safety, and environmental record, and this for all its stages: the reprocessing of spent fuel, the fabrication of plutonium-bearing fuel elements, and their use in nuclear reactors. However, the cost of natural uranium can affect the recycling of plutonium by rendering it economically unattractive in comparison with other options, such as the indefinite storage of spent fuel at the surface, or even the underground disposal.

Despite transitory economic bottlenecks caused by low uranium prices, the recycling technology should be preserved as a technical and industrial option to allow for the future use of the large energy reserves embedded in spent fuel in the form of plutonium. Reprocessing and mixed-oxide fuel fabrication are needed technologies, if sustainable development is to remain a reality in the use of nuclear energy.

Besides economical considerations, several countries have been opposed to plutonium recycling for nonproliferation reasons. This stance goes back to the April 1977 decision of President Carter to abandon reprocessing in order to set an international example of good nonproliferation behaviour.[1] This same view was later restated in an official announcement of the American government: "The Clinton's Administration policy announced in September 1993 reaffirms the link between nonproliferation goals and concerns vis-à-vis civil plutonium reprocessing and its use in nuclear power, as emphasized by the United States in the late 1970s. …the United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes."

A reversal of the official American position is possibly underway. The energy plan announced by President Bush[2] in May 2001 leaves open the recycling option in the context of future energy needs. It states, "The United States should also consider technologies (in collaboration with international partners with highly developed fuel cycles and a record of close cooperation) to develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste-intensive, and more proliferation-resistant. … In doing so, the United States will continue to discourage the accumulation of separated plutonium worldwide."

More to the point, the Bush administration announced in early 2002 that American weapon-origin plutonium would be converted to mixed-oxide fuel for use in nuclear power plants. This decision was possibly influenced by the interim findings of a panel of the Committee on International Security and Arms Control of the U.S. National Academy of Sciences,[3] which concluded that irradiating the plutonium in MOX (mixed oxides of uranium and plutonium) in a once-through nuclear reactor fuel cycle would meet its spent-fuel standard for resistance to theft and proliferation better than the alternative. This selection could close the door to the alternative of matrix immobilization and underground burial.[4]

The civil use of plutonium in many European countries over several decades has firmly demonstrated the soundness of the technology, and has paved the way toward more efficient nuclear fuel cycles with a better utilization of the uranium resources of the earth.[5] The proponents of plutonium recycling value the universal nonproliferation objectives, and they are convinced that recycling can satisfy these objectives.

Plutonium Mixtures and Explosive Suitability

Plutonium has a positive record in the civilian applications of nuclear energy in laboratories and industry. Under proper conditions, plutonium is safe to handle. Its use is not associated with environmental pollution. Remaining toxic for long periods, it does however require long-term safe disposal; but, more important for many people, plutonium is widely perceived as a proliferation threat.

Plutonium is indeed a material of interest for the making of nuclear devices by states or by terrorist groups. Today, the security of nuclear materials must certainly remain a high priority at all levels, whether national, regional, or international. Several new factors need, however, to be taken into account to design verification systems that focus on the essentials and that make use of the available financial resources most efficiently and effectively. First, there are very large inventories of civilian spent fuel in storage. The unseparated plutonium contained in high-burnup fuel can hardly be considered of *direct use* anymore. A greater concern: a non-negligible fraction of that civilian spent fuel contains low-burnup, high-quality plutonium (in terms of weapon use) that would deserve more attention from the verification organizations. Second, there are increasing inventories of separated plutonium. As implied by President Bush, the problem today is not reprocessing as such; it is the accumulation of separated plutonium resulting therefrom. In terms of perceived proliferation risks, the Achilles' heel of reprocessing is the still insufficient recycling of plutonium in power plants in the form of MOX fuel.

These new factors call for a closer look at the proliferation risks associated with plutonium and with different plutonium mixtures from different origins. Traditionally, the suitability of a plutonium mixture for explosive devices is determined by its Pu-240 contents, as shown in Table 1.

These definitions have been widely used by scientists[6] and by weapon designers.[7] What is then the usability of the various plutonium grades for the making of explosive nuclear devices? A review of available sources—and taking into account physics and engineering factors—leads to the broad assessment shown in the last column of Table 1, an assessment spelled out in the coming sections:

Table 1. Plutonium mixtures for explosive purposes

Grades	Pu-240	Usability
Super grade (SG)	<3 percent	Best quality
Weapon grade (WG)	3–7 percent	Standard material
Fuel grade (FG)	7–18 percent	Practically usable
Reactor grade (RG)	18–30 percent	Conceivably usable
MOX grade	>30 percent	Practically unusable

Weapon grade: The standard material is easy to use, with high yields, low radiation levels, and low heat generation. Super-grade is even better.

Fuel grade: Up until the '70s, the definition of *reactor grade* started at 7 percent, and thus included what was later called *fuel grade*. At that time, no one saw any interest in fuel grade for serious weapon use due to the higher radiation and heat levels. Everything beyond weapon grade was by default labeled reactor grade. The confusion between the two definitions of what constitutes reactor grade is frequently maintained—intentionally or not—by those people who want to emphasise the risk of plutonium originating from commercial nuclear plants.

An old American test is mentioned sometimes as proof that *reactor-grade plutonium* is a suitable explosive material. In 1977, then again in 1994, the U.S. Department of Energy announced that the United States had in1962 exploded a device using reactor-grade plutonium supplied by the United Kingdom. A lively private debate ensued between the two governments,[8] since there are no records of reactor-grade plutonium as now defined being produced at the Calder Hall and Chapelcross nuclear plants before 1962 (the fuel burnup was too low). The DOE announcement of 1994 was plainly misleading.[9] In reality, the material was *fuel-grade* plutonium containing a small proportion of Pu-240, presumably around 12 percent.[10]

Fuel-grade plutonium does not qualify for a "weapon program," by the very definition of the word weapon, that is, a tool easy to handle and to store, and with a predictable impact. Nevertheless, in combination with an adequate implosion technology, fuel-grade plutonium becomes a suitable material for a potential proliferator to make a powerful *nuclear explosive device*, even if the yield would be somewhat unpredictable.

Reactor grade: More than 2,000 nuclear explosions have been carried out worldwide since 1945; none is known to have used reactor-grade plutonium (>18 percent Pu-240), none with Pu from light-water reactors). Such reactor-grade Pu can be used *in principle* to make a crude explosive device; the practical difficulties are nevertheless considerable, as pointed out below. One should, incidentally, specify the type of reactor when applying this definition: gas-cooled and heavy-water reactors operate at different burnups, and produce different mixtures of plutonium falling frequently in the fuel-grade category.

MOX grade: This is plutonium resulting from the use in a LWR of MOX fuel manufactured from LWR reactor-grade plutonium. In other words, this is the plutonium coming out of Pu recycling. MOX-grade plutonium contains so much Pu-240, and in addition so much Pu-238 (some 2 percent or more), that its handling

Table 2. Characteristics of plutonium isotopes

Isotope	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
Half-life (year)	87.7	24,100	6,560	14.4	376,000
Bare critical mass (kg)	10	10	40	10	100
Spontaneous neutrons (/kg/sec)	2,600,000	22	910,000	49	1,700,000
Decay heat (watt/kg)	560	1.9	6.8	4.2	0.1

becomes extremely difficult in terms of radiation and heat levels. The French scientist and engineer Robert Dautray, former high commissioner of the French Atomic Energy Authority (Commissariat à l'énergie atomique), and a key figure of the French nuclear weapon program, writes the following about MOX fuel:[11] "MOX brings a further benefit: this plutonium is not suitable for making weapons. One could thus bury MOX, if one so wishes, after cooling. Furthermore, the security of the repository is then simplified." As noted above, the panel of the Committee on International Security and Arms Control of the U.S. National Academy of Sciences has also reached a positive conclusion as to the resistance to theft and proliferation of MOX-grade plutonium.

Weapon usable: This is—for the sake of completeness—another expression frequently used in the United States to denounce plutonium altogether: all plutonium mixtures, except those containing more than 80 percent Pu-238, are placed on the same footing and deemed *weapon usable*.

Usability of Reactor-Origin Plutonium: Isotopic Factors

Plutonium quality plays a central role in the making of nuclear weapons and of nuclear explosive devices. While not practical for a weapon arsenal, the usability of fuel-grade plutonium for explosive devices is demonstrated by the 1962 test and thus undisputed. On the other side, several experts seem to acknowledge the *de facto* unusability of MOX-grade plutonium. Therefore, the issue is really about reactor-grade plutonium containing between 18 and 30 percent of Pu-240. Is this Pu mixture *easily usable* as some claim, or only *conceivably, theoretically usable*?

The most frequent isotopes in spent fuel are, in order, 239, 240, and 241. Pu-238 is the least frequent, but the most undesirable when its concentration begins to weigh in above a burnup of about 30 MWd/kg. The respective fundamental characteristics of the Pu isotopes are summarized in Table 2.[12]

Of main concern for the making of an explosive device are the very high figures for Pu-238 and Pu-240 of the spontaneous fission neutrons and of the decay heat (and implicitly of the radiation levels). Spontaneous neutrons can lead to a pre-initiation of the chain reaction, while heat and radiation complicate the manufacturing and the handling of the device. Pu-238 is so undesirable that some authors see too many difficulties beyond a 2 percent fraction of the total plutonium. Pu-241 creates also serious problems in handling because it decays to americium-241, which is very radioactive. Pu-242 does not help either, with its high critical mass and high rate of spontaneous neutrons.

Now, Table 3 provides some indicative figures as to the isotopic composition of discharged LWR fuel, in relation to the achieved combustion burnup.[13,14]

Then, Table 4 shows some relevant technical values for an explosive device made of various grades of plutonium.[15]

Table 4 warrants some comments. The reactor-grade Pu used in this table corresponds to a burnup of only 33 MWd/kg. Today's LWR burnups go beyond 50 MWd/kg; as a result, the device characteristics would worsen dramatically, with much more than a 100-watt heat release, a figure that some authors see as a practical limit for proper assembly. According to J. Carson Mark, the values of the column *Reactor* would lead to an equilibrium temperature of 190°C in the device, assuming a 10 cm layer of chemical high explosives (HE) around the core. He adds that "the breakdown rate of many types of HE begins to become significant above about 100°C," but that "a thermal bridge with a total cross-

Table 3. Plutonium isotopic composition of spent fuel at discharge

Isotopic contents in percent of total Pu	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
Burnup—irradiated LWR uranium oxide:					
20 MWd/kg heavy metals (Siemens)	0.7	70	18	10	1.6
33 Mwd/kg heavy metals (Mark)	1.3	60	24	9	5
33 Mwd/kg heavy metals (Siemens)	1.2	58	23	14	4
50 Mwd/kg heavy metals (Siemens)	2.7	47	26	15	9
60 Mwd/kg heavy metals (Siemens)	3.5	44	27	15	11
Burnup—irradiated LWR mixed oxide:					
33 Mwd/kg heavy metals (Mark)	1.9	40	32	18	8

Table 4. Plutonium grades and usability parameters

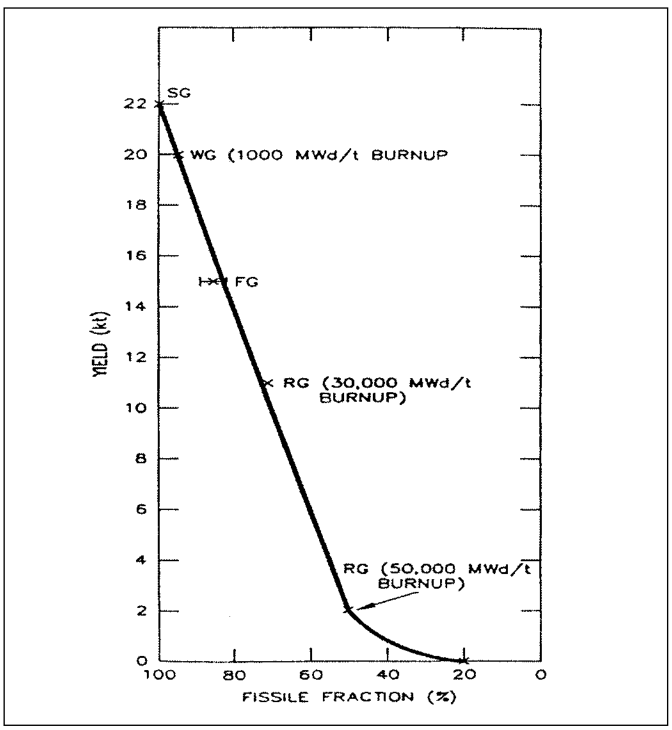
Device made with grade:	Weapon	Reactor[a]	MOX[b]
Spontaneous neutrons (/kg/sec)	66,000	360,000	570,000
Plutonium mass (kg)	3	8	>20?
Decay heat (watt/kg)	2.5	11	13.7
Heat from device (watt)	8	100	>300?

a. Assumptions: from pressurized water reactors (PWR) spent fuel with a burnup of 33 MWd/kg stored ten years prior to reprocessing
b. Assumptions: from PWR-MOX spent fuel produced from the same reactor-grade plutonium

section at the surface of the core of only one square cm could halve the temperature increase induced by the reactor-grade plutonium." Then, the physicist Mark brushes aside all practical engineering difficulties to conclude rather unexpectedly, "The difficulties of developing an effective design of the most straightforward type are not appreciably greater with reactor-grade plutonium than those that have to be met for the use of weapons-grade plutonium." The omission in Mark's paper of serious reservations as to the constructive difficulties is almost as interesting as the inclusion of the lengthy physical recapitulation about fizzle yields.

As to MOX grade, the values of Table 4 for the critical mass and for total heat release come from a simple first-order estimate; they do nevertheless illustrate the unusability view of Robert Dautray quoted above, a view further substantiated by Figure 1 below. Indeed, the recycling of plutonium eliminates—for all practical purposes—the proliferation risks associated with plutonium. The plutonium contained in, or separated from, MOX spent fuel incorporates so much of the undesirable isotopes Pu-238 and Pu-240 that the material becomes useless for a weapon and even for an explosive device. This makes a strong case for the recycling of plutonium in MOX form in terms of nonproliferation objectives.

Figure 1. Calculated yield curve



Usability of Reactor-Origin Plutonium: Technology Factors

The availability of suitable nuclear materials—in particular, of plutonium with the proper isotopic composition—is a prerequisite to bring a nuclear device to explosion. In addition, the availability of a series of technological skills is just as important, e.g. in chemical explosives, electronic devices, and mechanical tools. There are differences between the potential proliferators of concern, for instance, a state acting clandestinely under international controls, or a subnational group acting without the knowledge of the host country. A state can more easily make undetected use of national technological resources than a subnational group.

Figure 1 shows the calculated average explosive yield[16] of a nuclear device as a function of the *fissile* fraction, that is, the two valuable isotopes of a uranium or plutonium mixture, U-235 and Pu-239 (reverse abscissa with 100 percent at the left). This curve assumes the availability of the required technology, unhampered by technical constraints such as heat and radiation levels. In a sense, this curve represents an upper bound of what can be achieved with a given grade of material (and a corresponding tamper).

Various authors have attempted to assess the role of technological factors on the yield. Johan Swahn[17] has considered three levels of technological know-how applied to the making of an explosive device; he uses as a yardstick the compression velocity induced by the chemical explosion on which the nuclear yield depends: "First, we have the terrorist group or the sub-state ethnic group, perhaps with the support from a state, at level 1. These can possibly achieve a compression velocity of 500 m/sec. Second, at level 2, we have the level of know-how that the United States achieved during the Second World War during the Manhattan Project, with compression velocities of about 1,000 m/sec. The general technological level is higher nowadays, and one can today count most of the world's states, with perhaps a few exceptions in the developing world, in this category. Finally, we have level 3 at which the nuclear weapon states, but also many other industrialized states, are. The technological know-how in these states would allow the construction of a device with a compression velocity of over 2,000 m/sec." Quoting a former study of the Swedish National Defence Research Institute,[18] Swahn concluded: "1. Reactor-grade plutonium (20–30 percent Pu-240) is at compression velocities of about 500 m/sec only useful for devices of at most a kiloton yield. The function will remain uncertain. 2. Reactor-grade plutonium can at very high compression velocities (2,000 m/sec) be used in 1 kT devices with a good reliability and in 10 kT devices with limited reliability." Later American sources[19] match these values.

High compression velocity—the most critical technology factor—cannot be achieved without extensive testing of high explosives. An advanced state could do so clandestinely; a subnational group could not, without the complicity of the hosting state.

Accordingly, with a mastery of implosion technology, LWR Pu can be used *in principle* to make a crude explosive device.[20] Nevertheless, many obstacles stand in the way besides the availability of the nuclear material and the required implosion technology. Altogether, according to Alexander DeVolpi,[21] there are some ten difficulties facing a new proliferator attempting to manufacture an explosive device with reactor-grade plutonium:

Larger critical mass	Pre-initiation more likely
Larger size and weight	Risk of metallic phase changes
Longer neutron lifetime	High surface dose and temperatures
Smaller explosive yield	Chemical explosive testing required
Unpredictable yield	Forced cooling of device required

All those are major obstacles. A would-be proliferator would rather choose a less visible and less complicated technical process, for example, uranium enrichment, as done by South Africa and Iraq.

Is then the mere possession of separated reactor-grade plutonium a substantial proliferation risk? The French nuclear scientist Robert Dautray has said,[22] "We know of no scientific reference in the U.S., the United Kingdom and France—not stamped "defence secret"—that bears out rigorously and quantitatively the above assertion (to possess separated plutonium). Yet, all assertions from expert reports say '..as well-known from the open scientific literature..,' with references to each other. Such assertions ought to be qualified with accurate reservations—never spelled out—and backed up by experimental or theoretical references always absent from such reports."

Alexander DeVolpi had said earlier,[23] "A shibboleth of some current policy analysis is that all Pu is 'weapons usable.' This is a deceptive oversimplification that could result in delaying effective steps to defuse the caliber of weapon-grade Pu. Moreover, by creating an aura of futility, that portrayal provides a rationale to stall further arms reductions."

New Factors for Consideration

New categories of plutonium are needed to handle properly what are really different materials in terms of security and verification criteria. The nonproliferation and security verification systems, e.g. the International Atomic Energy Agency (IAEA) and the Euratom Inspectorate, have lumped all plutonium isotopes together and applied common verification parameters to the lump regardless of the grade. This was acceptable at the time (in the late '50s) in view of the small quantities of plutonium-bearing materials in non-nuclear weapon states. Yet, the quality and the isotopic mixture of plutonium play an essential role in defining the degree of risk of misuse. New factors now call for a revision of verification goals and criteria, such as:

Strong differentiation between plutonium grades

Even though all Pu isotopes are fissionable for the fast neutrons of an explosive device, all isotopes other than Pu-239 have a strong negative impact on the feasibility and on the yield of a device. The concentration of the useful isotope Pu-239—and those of the most undesirable, Pu-238 and Pu-240—must be recognized and taken into consideration in a well-defined verification system.

More and More High-burnup LWR Fuel

Some 1,500 metric tons of plutonium have been accumulated worldwide, about 250 metric tons of it in the military sector. In 2000, under all its safeguards agreements in non-nuclear weapon states, the IAEA had to control 726 metric tons of Pu, separated and unseparated. The cost of verification in the world and in Europe of high-burnup spent fuel is growing beyond reason. Controls of such spent fuel in future direct geological depositories would be expensive and even more senseless; less stringent controls could apply to these materials without incurring proliferation risks. Very high-burnup fuel and MOX spent fuel contain plutonium of practically no proliferation concern.

More and More Low-Burnup Civilian Spent Fuel

Low-burnup fuel contains weapon-usable plutonium that deserves more attention than has been the case so far. A growing inventory of low-burnup spent fuel is now under IAEA safeguards.[24] For LWR spent fuel, there are close to 100 kg of weapon-grade plutonium and about 5,000 kg of fuel-grade plutonium *easily* accessible through chemical processing; yet these sensitive nuclear materials are under *normal* safeguards criteria only. Additional large quantities of weapon-grade and fuel-grade plutonium are contained in spent fuel from gas-cooled and heavy water reactors. When low-burnup spent fuels are disposed of directly in geological formations, they do become—after fission product decay—authentic *bomb plutonium mines.* For such materials, reprocessing (in a mix with high-burnup fuel) should really be mandatory. John Carlson and his colleagues at the Australian Safeguards and Nonproliferation Office[25] have tried for many years to draw the attention of the world safeguards community to the problem of low-burnup fuel. They have also pointed out the *weapon-grade* quality of the plutonium produced in the blankets of fast breeder reactors (2–4 percent Pu-240), with such material available in several countries. Be it low-burnup spent fuel or blanket materials, more stringent controls than the current ones should apply to these materials.

Weapon-origin Pu Coming into the Civilian Cycle

If this will ever happen, the supplying countries will probably make the material available under lease only. They will also require very stringent controls, much more stringent than the current international controls.

Table 5. Verification criteria vs. plutonium grades

Categories	Pu-240 fraction	Significant quantity	Timeliness (separated)	Timeliness (unseparated)
High grade	<17 percent	8 kilograms	Two weeks	One month
Low grade	17–30 percent	16 kilograms	Three months	One year
Depleted grade	>30 percent	–	One year	–

The significant quantity is the approximate quantity of nuclear materials needed to manufacture a first nuclear device, taking into account losses in conversion and in manufacturing. Timeliness is a component of inspection goals related to the conversion time, that is the time required to convert a given nuclear material into metallic components for an explosive device.

For all these reasons, all organizations dealing with nuclear material security should initiate an in-depth review of plutonium, with the objective of categorising it in a suitable manner.

Needed: Categories of Plutonium for Verification Work

A pertinent suggestion to that effect was made in the 1996 report published by the Canberra Commission, a group of eminent personalities brought together by the government of Australia.[26] The report contains interesting ideas about the use of civilian and demilitarized fissile materials. Noting that a proper balance must be struck between the legitimate civilian use of such materials and the objectives of nuclear nonproliferation and disarmament, the commission stated that striking such a balance might be feasible. "One possibility may be to draw a distinction between plutonium of different isotopic grades and to use this distinction both for safeguards purposes and for a proscription on the separation of plutonium of an isotopic composition which makes it attractive for weapons use. ... It is an unfortunate consequence of the current practice of not differentiating between plutonium grades for safeguards purposes that special attention is not directed to plutonium having the isotopic characteristics of greatest proliferation concern. ... Therefore, there would be merit in investigating various categories of plutonium in terms of applicable safeguards measures and resulting verification costs."

In line with the advice of the Canberra Commission, this paper takes the position that nuclear materials verification systems should be designed with due consideration for the types of materials to be verified and for realistic risk assessments. Taking into account the technical factors related to the use of various kinds of plutonium for the fabrication of a nuclear explosive device, the following categories of plutonium are being proposed here:

- High grade
- Low grade
- Depleted grade

This definition of high-grade Pu is conservative and prudent; it includes, of course, the weapon-grade (<7 percent), but also almost all the intermediate category fuel grade (7–18 percent). This material comes: 1) from dismantled weapons, before and after one MOX cycle, 2) from breeder reactor blankets, and 3) from various types of power reactors, also from LWR in case of abnormally short exposure in reactor. The threshold value of 17 percent corresponds to the safety/criticality limit in large modern reprocessing plants; thus this is a convenient way of segregating materials for verification purposes. The high-grade category deserves all the attention of the verification organizations; actually, it deserves more attention than in the past. Therefore, the timeliness of such separated plutonium should be reduced from the current one month to two weeks (this should also be the case for highly-enriched uranium). The timeliness of unseparated Pu could stay at the current value to reflect the time required for chemical separation from spent fuel. This grade would then logically become the true *weapon usable* category.

Low grade, the bulk of materials to be verified, corresponds primarily to medium-high burnup LWR fuel. In view of the difficulties associated with the use of such plutonium for explosive devices, the key verification parameters should be adjusted: e.g. the significant quantity doubled with respect to weapon-usable material, the timeliness for separated material increased from one month to three months, and the timeliness for unseparated Pu (spent fuel) raised to one year—a step that the IAEA plans to adopt under integrated safeguards for the current single Pu category.

Depleted grade covers mostly Pu in irradiated LWR MOX, but also Pu from spent fuel with higher burnup, say above 50 MWd/kg. In this category, it is not only the Pu-240 content that is relevant, but also the Pu-238 whose fraction can exceed several percentage points in high-burnup fuel. As noted by Alexander DeVolpi,[27] "Yet, even without recycle, higher burnup can further degrade Pu." A Pu-238 threshold of 2 percent (in an and/or criterion) could also be added to the definition. The concept of *significant quantity* is irrelevant here. As to controls, an occasional verification of separated material (an unlikely situation) would be sufficient.

In so proposing three categories of plutonium, one can draw a limited analogy with the three broad categories of uranium:

Table 6. Verification classes

Verification class	Materials coming from:
High-grade separated	Weapon-origin, low-burnup origin
High-grade unseparated	Blanket fuel elements, low-burnup spent fuel
Low-grade separated	Fresh mixed oxide fuel made with LWR Pu
Low-grade unseparated	High-burnup LWR spent fuel
Depleted grade	Separated or not, irradiated MOX and very high-burnup fuel

highly enriched (HEU) (> 20 percent U-235), *low-enriched* (LEU) (0.71–20 percent U-235) and the *depleted natural* (≤ 0.71 percent) range. To account for the not very attractive uranium recovered from reprocessing plants, it would, incidentally, be sensible to group in a single category all uranium below say, 1.5 percent U-235. One recalls that the concern about LEU is not its usability as such, but the *distance* that separates it in terms of separation work units (SWU) from the full HEU level. At the typical research reactor enrichment of 20 percent, the distance is a good 0.9 of the full distance (5,000 SWU required for one significant quantity of 93 percent HEU); at a typical LWR enrichment of 3.5 percent, it is still 0.63; and at 1.2 percent (a value on the high side for uranium out of reprocessing), the distance is down to 0.26.

The security measures applied to nuclear materials by Euratom in the European Union and for the safeguards verifications of the IAEA in the world should therefore distinguish between five different forms of plutonium in decreasing order of concern.

In conclusion, the adoption of several categories of plutonium—as for uranium—would lead to a better perception of the link between plutonium recycling and proliferation. This would allow for a more effective and more efficient verification of nuclear materials, from both the security and safeguards viewpoints. This would strengthen the case of plutonium as a component of a sustainable development of nuclear energy. Last, but not least, it would pave the way to further nuclear disarmament initiatives.

Postscript

This paper does not question the theoretical feasibility of exploding plutonium of various categories. The emphasis lies on the practical obstacles standing in the way and on a realistic assessment of the technical difficulties to be encountered. The objective is the determination of optimum criteria for the international verification of nuclear materials. Optimizing means using the available resources effectively and efficiently, with more stringent verifications on materials of real concern, and less stringent on materials of little concern.

Since the rejection of reprocessing by the Carter administration in 1977, many American scholars and officials have repeatedly argued against reprocessing and plutonium recycle elsewhere in the world, still under the impression of the alleged *reactor-grade* nuclear test of 1962, and dogmatically bound to the questionable claim that all plutonium is *weapon usable*. In international forums, they have thus refused to contemplate a categorization of Pu and any other re-assessment of the relevant verification criteria. Behind a veil of secrecy, the opinion of weapon designers is short-handedly invoked to validate preset positions. While recognizing the need for confidentiality, the independent observer too often gains the impression of a lack of technical objectivity. To develop a more balanced technical opinion on the matter, there is a need to look—as is done in this paper—beyond the physics, at the interface between physics and engineering, in order to gain a better understanding of the real difficulties for a proliferator of using less than good quality plutonium.

In fact, physics alone is not a reliable guide to design an optimum nuclear material verification system. Other technical, economical, and even political factors must be taken into consideration to achieve the best results. Recent related issues in the field of nonproliferation and disarmament illustrate the need to balance things out:

The americium bomb: In the late '90s, the IAEA discussed potential controls over stocks of neptunium and americium, two transuranium materials that accumulate in some nonnuclear weapons countries and that are usable for explosive purposes—to different degrees. Some national representatives insisted unreasonably for identical controls on both materials, even though americium is almost as unusable as Pu-238 in terms of radiation and heat. The justification was simply that skilled weapon designers "have said they could do it." Common sense prevailed at the end, with enough other parties keen on seeing the IAEA concentrate its new efforts on neptunium, the material of real concern.

The one-kilogram plutonium bomb: Throughout the '90s, American antinuclear militants tried to convince the IAEA to change the standard significant quantity for Pu from 8 kilograms to the low figure of one kilogram. Again, the argument was that experienced American and Russian weapon designers "have said they can do it." After review, the IAEA ignored the call and kept the current figure, on the grounds that its verification mission is to detect the *first* device ever of a proliferator (and not the tenth or the fiftieth), and because miniaturization cannot be achieved without prior testing of larger devices.

Robert Dautray has his own opinion on this matter: "In this respect, the low mass values quoted by some scientific journals and by 'experts' (experts?, yes, but for what?) who sit as such in the world's highest-level scientific committees are questionable; these values suppose very specific matching conditions, difficult to fulfill, never explicitly stated, because not rigorously and quantitatively understood by these 'experts' (this is not a mere speculation of the author, but it reflects his personal experience)." [28]

Fissile Material Cut-off Treaty: Throughout the '90s, the Conference on Disarmament in Geneva tried to conclude a Fissile Material Cut-off Treaty (FMCT), a treaty that would forbid the production of nuclear materials for explosive purposes. Several states—in particular France and the United States under the Clinton administration—made valuable contributions toward such a goal. The process is now stalled for a number of reasons, in particular the excessive demands (in the FMCT context) of other states for the full disclosure of existing stockpiles.

In last analysis, the future of the FMCT will largely depend on the practicability and the cost of verifying such a treaty.

This in turn will depend on the number of installations to be inspected, a number that relates directly to the types of plutonium to be considered. If all reactor-grade plutonium in spent fuel is deemed usable for weapon purposes, then hundreds of nuclear plants and the associated fuel stores will require inspection in the states not already controlled by the IAEA (that is the five declared weapon states, and Israel, Pakistan, and India). With such a heavy financial burden, a FMCT will never happen. Agreeing on plutonium categories is a necessary prerequisite for a viable and affordable FMCT. Those who oppose Pu categories under the Nonproliferation Treaty—in particular those coming from the weapon establishment—should not give the impression that they do so in order to make a FMCT impossible from the onset, as hinted by Alexander DeVolpi in the above quotation—"a rationale to stall further arms reductions."

Whether for americium, the one-kilogram bomb, or reactor-grade plutonium under the NPT or the FMCT, the design of an optimum verification system demands a serious, honest, and all-encompassing assessment of all relevant factors. In last analysis, this is a political balancing act between the perception and reality of risks, between economical constraints and the technical capabilities of the proliferator and those of the verification agency.

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Multi-Level Variable Sampling in the Variable Mode

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Abstract

The problem of determining the optimal falsification and inspection strategies for a two-level verification system in which false alarms are possible is investigated. A solution in the form of an optimal statistical test procedure and optimal falsification strategy is presented for a special case in which one of the items to be verified is measured with a more accurate device, the others with a less accurate one. The solution is shown to be valid for sufficiently small combined falsifications of the data.

Introduction

For many years it has been the practice in verification of reported data in certain material classes to use a multi-level sampling procedure. With the aid of an exact but time-consuming method, a relatively small number of measurements are made to determine whether some data were falsified by small amounts, and an inexact but quick method is used to check if a smaller number of items have been falsified by large amounts. Hereby the inspector must take into account that the inspectee, should he wish to deliberately falsify the data, will do so in such a way as to minimize the chance of detection. In other words, the problem is one of strategy and can only be solved with game-theoretical methods.

The situation described here was treated some time ago on a heuristic basis, by, among others, Sanborn[10] and Jaech.[5] Later Avenhaus[1] showed how game-theoretical methods might be brought to bear, but because of the complexity of the calculations, restricted himself to specific examples. More recently, interest in the problem has been renewed, with Jaech[6] and Lu, et al.,[8] presenting new heuristic approaches.

In a recent contribution to this *Journal*,[4] the choice of optimal sample size for the inspector was addressed under the simplifying assumption that the first and second kind errors associated with the measurement errors could be neglected. In the present work, measurement errors are included and we consider the problem of determining the optimal falsification strategy and the corresponding optimal statistical test procedure for the inspector. Unfortunately the general case of N_i reported data in k classes, i = 1 …k, is not analytically tractable when treated from first game-theoretic principles. In order to gain insight into the structure of the problem and its solution, we consider a far simpler special case in which data are reported for two inventory items. These are thereafter verified with two different measurement methods. We then derive saddle point strategies for inspector and inspectee under the assumption that the total amount by which the data are falsified is common knowledge.

Problem Statement

We represent the inspector's measurements on the two reported items by two normally distributed random variables X_1 and X_2 having, under the null hypothesis H_0 of no data falsification, expected values and variances

$$E_0(X_1)=E_0(X_2)=0 \text{ and } \mathrm{var}(X_1)=1,\ \mathrm{var}(X_2)=\sigma^2<1.$$

Thus, without loss of generality, the first item is measured with a device with associated measurement variance normalized to one and the second item is measured with a more accurate device.

Under the alternative hypothesis H_1, the reported datum for one of the items is falsified by the amount μ_1 and that of the other item by amount μ_2, whereby

$$\mu_1 + \mu_2 = \mu > 0.$$

The overall falsification μ might for example be taken as some verification goal quantity. The inspector doesn't know beforehand which item is falsified by which amount. This can be modeled by assuming that, under the alternative hypothesis, the random variables have expected values

$$(E_1(X_1), E_1(X_2)) = \begin{cases} (\mu_1, \mu_2) \text{ with probability } 1/2 \\ (\mu_2, \mu_1) \text{ with probability } 1/2 \end{cases}.$$

The two measurements are assumed to be independent, therefore the joint density functions for X_1 and X_2 under the two hypotheses are given by

$$H_0 : f_0(x_1, x_2) = \varphi(x_1)\varphi\left(\frac{x_2}{\sigma}\right)$$

$$H_1 : f_1(x_1, x_2) = \frac{1}{2}\left[\varphi(x_1-\mu_1)\varphi\left(\frac{x_2-\mu_2}{\sigma}\right) + \varphi(x_1-\mu_2)\varphi\left(\frac{x_2-\mu_1}{\sigma}\right)\right],$$

where $\varphi(.)$ is the standard normal distribution density.

Let us now formulate our problem as a two-person, zero-sum game in which the payoff to the inspectee is the non-detection probability β for the given value of the false alarm probability α. Let Δ_α denote the (infinite) set of all possible statistical test procedures for the inspector for false alarm probability α. A game-theoretical equilibrium or saddle point is a falsification μ_1^* and a statistical test procedure δ^* that satisfy the inequalities

$$\beta(\delta^*, \mu_1) \leq \beta(\delta^*, \mu_1^*) \leq \beta(\delta, \mu_1^*) \text{ for all } \delta \in \Delta_\alpha \text{ and } \mu_1 \in [0, \mu]. \quad (1)$$

The saddle point payoff $\beta(\delta^*, \mu_1) =: \beta^*$ is referred to as the value of the game, and μ^* and δ^* are called equilibrium strategies. These strategies are a solution of the problem in the sense that the players have no incentive to deviate unilaterally from them. Moreover, playing μ^* guarantees the inspectee *at least* β^*, and playing δ^* guarantees the inspector *at worst* β^*.

A Partial Solution

According to the Neyman-Pearson Lemma, see for example reference 9, the statistical test procedure that minimizes the non-detection probability for a given false alarm probability is to reject the null hypothesis if the measured values x_1 and x_2 are in the set

$$\left\{(x_1, x_2) \,\middle|\, \frac{f_1(x_1, x_2)}{f_2(x_1, x_2)} > \frac{\lambda}{2}\right\},$$

referred to as the *critical region* of the test. The threshold $\lambda/2$ is determined by the fixed false alarm probability α, see Equation 3 below. We take α to be common knowledge (in nuclear safeguards usually 5 percent). For some specific falsification μ_1, this critical region is easily seen to be equivalent to

$$\left\{(x_1, x_2) \,\middle|\, \exp\left(x_1\mu_1 + x_2\frac{\mu_2}{\sigma^2} - A\right) + \exp\left(x_1\mu_2 + x_2\frac{\mu_1}{\sigma^2} - B\right) > \lambda\right\},$$

where the constants A and B are given by

$$A = \frac{1}{2}\left(\mu_1^2 + \frac{\mu_2^2}{\sigma^2}\right) \text{ and } B = \frac{1}{2}\left(\mu_2^2 + \frac{\mu_1^2}{\sigma^2}\right).$$

Let us choose for δ^* in 1 the Neyman-Pearson test procedure against the—as yet unknown—saddle point falsification μ_1^*. Call this test $\delta_{NP}(\mu_1^*)$. Then we must demonstrate

$$\beta(\delta_{NP}(\mu_1^*), \mu_1) \leq \beta(\delta_{NP}(\mu_1^*), \mu_1^*) \leq \beta(\delta, \mu_1^*) \text{ for all } \delta \in \Delta_\alpha \text{ and } \mu_1 \in [0, \mu]. \quad (2)$$

But we see that the right hand inequality is now satisfied by virtue of the Neyman-Pearson Lemma. It remains to find a value for μ^* which satisfies the left hand inequality. We shall now show under what condition the strategy $\mu^* = \mu/2$ satisfies 2.

The critical region for $\mu_1 = \mu/2$ is

$$\left\{(x_1, x_2) \,\middle|\, 2\exp\left(x_1\frac{\mu}{2} + x_2\frac{\mu}{2\sigma^2} - \frac{1}{2}\left(\frac{\mu^2}{4} + \frac{\mu^2}{4\sigma^2}\right)\right) > \lambda\right\}$$

or, equivalently,

$$\left\{(x_1, x_2) \,\middle|\, x_1 + \frac{x_2}{\sigma^2} > \lambda''\right\},$$

where λ'' is some function of λ, μ, and σ. We can express it in terms of the false alarm probability α as follows:

$$\alpha = \text{prob}\left(X_1 + \frac{X_2}{\sigma^2} > \lambda'' \,\middle|\, H_0\right) = 1 - \phi\left(\frac{\lambda''}{\sqrt{1 + \frac{1}{\sigma^2}}}\right),$$

where ϕ (.) is the standard normal distribution function, and from which we obtain

$$\lambda'' = \sqrt{1 + \frac{1}{\sigma^2}} \cdot U(1 - \alpha), \quad (3)$$

where U is the inverse of the function ϕ.

Evaluating the saddle point payoff in 2, i.e. with $\epsilon(X_1) = \epsilon(X_2) = \mu/2$, we obtain

$$\beta(\delta_{NP}\, \mu_1^*) = \text{prob}\left(X_1 + \frac{X_2}{\sigma^2} \leq \lambda'' \,\middle|\, H_1\right) = \phi\left(U(1-\alpha) - \frac{\mu}{2}\sqrt{1 + \frac{1}{\sigma^2}}\right).$$

For an arbitrary falsification (μ_1, μ_2) the non-detecting probability for the Neyman-Pearson test δ_{NP} is, with $\epsilon(X_1) = \mu_1$ and $\epsilon(X_2) = \mu_2$,

$$\beta(\delta_{NP}, \mu_1) = \text{prob}\left(X_1 + \frac{X_2}{\sigma^2} \leq \lambda'' \,\middle|\, H_1\right) = \frac{1}{2}\left[\phi\left(\frac{\lambda'' - \mu_1 - \frac{\mu_2}{\sigma^2}}{\sqrt{1 + \frac{1}{\sigma^2}}}\right) + \phi\left(\frac{\lambda'' - \mu_2 - \frac{\mu_1}{\sigma^2}}{\sqrt{1 + \frac{1}{\sigma^2}}}\right)\right].$$

It is convenient to define

$$\mu_1 = \frac{\mu}{2} + \varepsilon,\ \mu_2 = \frac{\mu}{2} - \varepsilon, \text{ and } \tilde{U} = U(1-\alpha) - \frac{\mu}{2}\sqrt{1 - \frac{1}{\sigma^2}}.$$

Then, with 3, we can write the left-hand inequality in 2 in the form

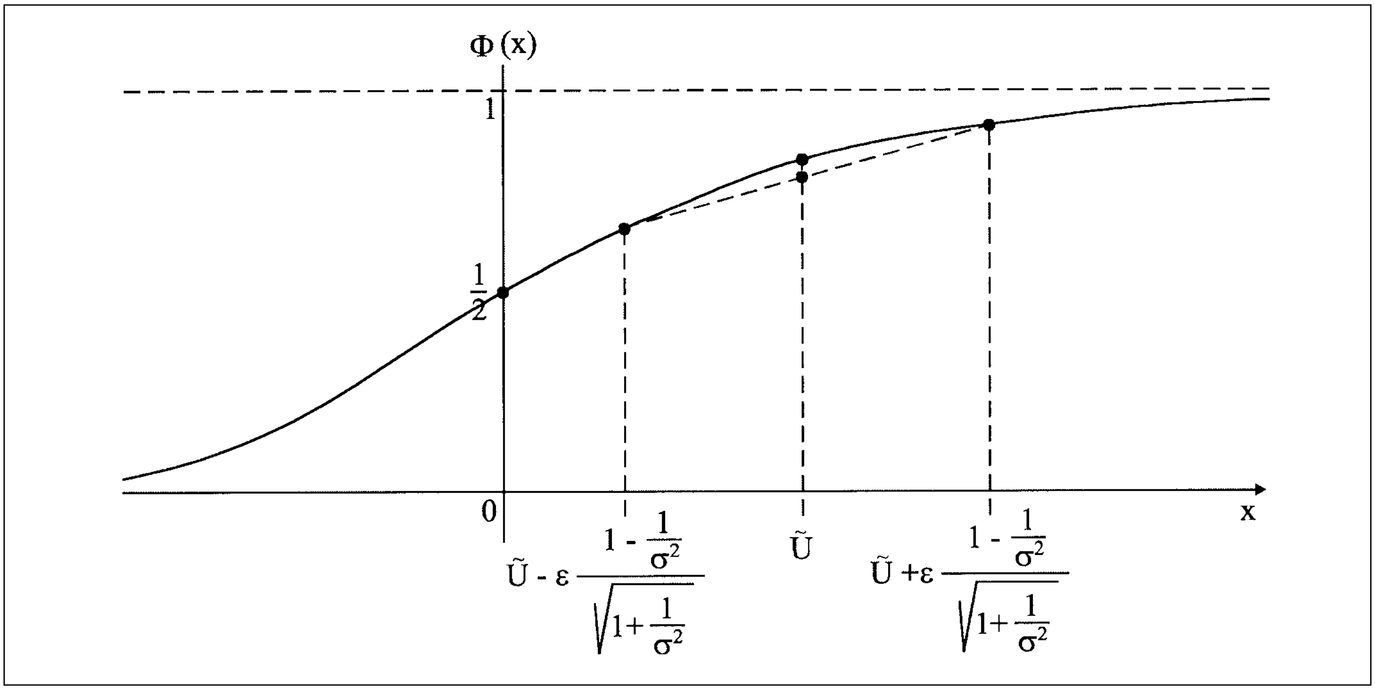
$$\frac{1}{2}\left[\phi\left(\tilde{U} - \varepsilon \cdot \frac{1 - \frac{1}{\sigma^2}}{\sqrt{1 + \frac{1}{\sigma^2}}}\right) + \phi\left(\tilde{U} + \varepsilon \cdot \frac{1 - \frac{1}{\sigma^2}}{\sqrt{1 + \frac{1}{\sigma^2}}}\right)\right] \leq \phi(\tilde{U}). \quad (4)$$

From Figure 1 we see that is satisfied provided $\tilde{U} > 0$ or, equivalently,

$$\mu < \frac{2U(1-\alpha)}{\sqrt{1 + \frac{1}{\sigma^2}}} \quad (5)$$

For $\sigma = 1$ inequality 4 is satisfied as equality. This corresponds to the special case of a more general result which says that, for N

Figure 1. Graphical representation of Equation 4.



identical items, all of which are measured with a single device, the uniform falsification strategy and the corresponding Neyman-Pearson test form a saddle point for all values of μ, see for example 3. On the other hand, when $\sigma \ll 1$, we can write condition 5 approximately as

$$\mu \leq 2\sigma U(1-\alpha).$$

Note also that requirement 5 implies that the saddle point non-detection probability will exceed 50 percent:

$$\beta(\delta_{NP}(\mu_1^*), \mu_1^*) = \phi(\tilde{U}) \geq 1/2.$$

Generalization

The question of course arises as to whether the above result can be generalized. Assume there are N identical items, N-n of which are measured with an *inaccurate* device with measurement variance 1 and the remaining n with an *accurate* device with measurement variance $\sigma^2 < 1$,

$$\mathrm{var}(X_i) = 1 \quad \text{for} \quad i = 1\ldots N-n$$
$$\mathrm{var}(X_i) = \sigma^2 \quad \text{for} \quad i = N-n+1\ldots N.$$

Since the inspector doesn't know how the items were falsified, we now have

$$(E_1(X_1)\ldots E_1(X_N)) = (\mu_{k_1}\ldots\mu_{k_N}) =: \underline{\mu}_k \text{ with probability } \frac{1}{N!}, k = 1\ldots N!$$

under the alternative hypothesis, where the index k denotes a permutation of the N items. The joint density functions under the two test hypotheses are

$$H_0 : f_0(x_1 \ldots x_N) = \prod_{i-1}^{N-n} \phi(x_1) \cdot \prod_{i=N-n+1}^{N} \phi\left(\frac{x_1}{\sigma}\right)$$

$$H_1 : f_1(x_1 \ldots x_N) = \frac{1}{N!} \sum_{k=1}^{N!} \prod_{i=1}^{N-n} \varphi(x_1 \ldots \mu_{k_i}) \cdot \prod_{i=N-n+1}^{N} \varphi\left(\frac{x_1 - \mu_{k_i}}{\sigma}\right).$$

The saddle point criteria are with $\underline{\mu} = (\mu_1, \ldots, \mu_n)$

$$\beta(\delta^*, \underline{\mu}) \leq \beta(\delta^*, \underline{\mu}^*) \leq \beta(\delta, \underline{\mu}^*) \text{ for all } \delta \in \Delta_\alpha \text{ and } \mu_i \in [0, \mu], \sum_i \mu_i = \mu \quad (6)$$

We want to determine under what conditions, if any,

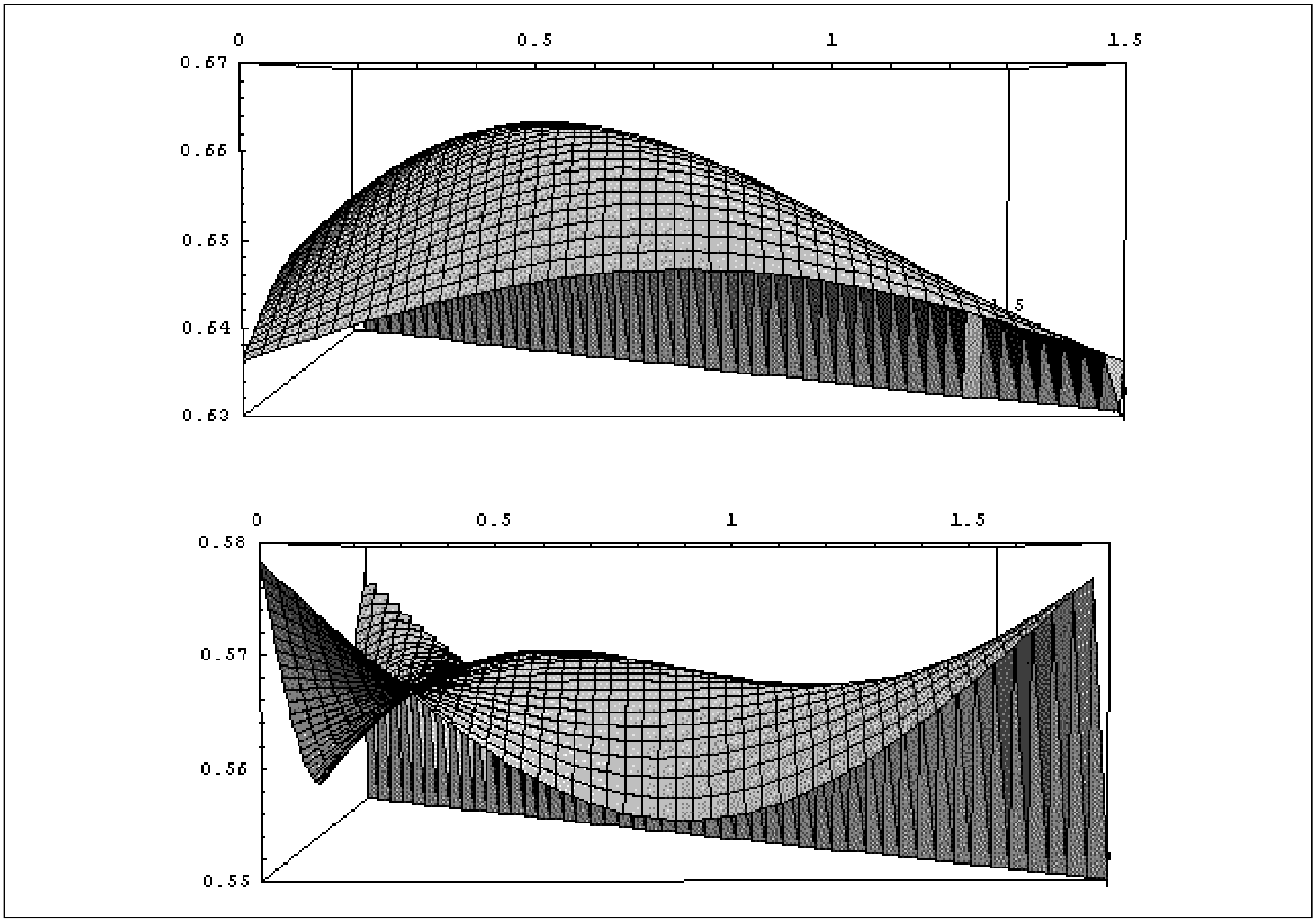
$$\underline{\mu}^* = (\mu/N \ldots \mu/N) \text{ and } \delta^* = \delta_{NP}(\underline{\mu}^*) \quad (7)$$

are saddle point strategies, whereby again the right-hand side is satisfied by virtue of the Neyman-Pearson Lemma.

The critical region for rejecting H_0 for $\delta_{NP}(\underline{\mu}^*)$ is easily seen to be

$$\left\{ (x_1, \ldots x_N) \,\middle|\, \sum_{i-1}^{N..n} x_i + \sum_{i=N-n+1}^{N} \frac{x_1}{\sigma^2} > \sqrt{N - n + \frac{n}{\sigma^2}} \cdot U(1-\alpha) \right\}. \quad (8)$$

Figure 2. The payoff $\beta(\delta^*,\underline{\mu})$ as a function of μ_1 and μ_2 for $N = 3$, $n = 1$, $a = 0.05$ and $\sigma = 0.5$, corresponding to an upper limit of 2.014 in inequality 12. The upper plot is for $\mu = 1.5$, the lower is for $\mu = 1.8$. In the first case ($\mu/3$, $\mu/3$, $\mu/3$) is a global maximum, in the second case it is only a local maximum: the global maxima occur at (μ ,0,0) and permutations thereof.



Unfortunately, demonstrating the left-hand inequality in 6 is not straightforward. To illustrate this, consider the case N = 3, n = 1. The non-detection probability for the test δ^* for an arbitrary falsification strategy $\underline{\mu} = (\mu_1, \mu_2, \mu_3)$ is given by

$$\beta(\delta^*,\underline{\mu}) = \frac{1}{3}\cdot\sum_{i-1}^{3}\phi\left(U - \frac{\mu-\mu_1\left(1-\frac{1}{\sigma^2}\right)}{\sqrt{2+\frac{1}{\sigma^2}}}\right), \tag{9}$$

where we have used the abbreviation $U := U(1-\alpha)$. Applying the Lagrange formalism, we introduce the function

$$L(\underline{\mu}) = \beta(\delta^*,\underline{\mu}) + \eta\,(\mu_1 + \mu_2 + \mu_3 - \mu),$$

where η is a Lagrange multiplier. Necessary and sufficient conditions for a *local* maximum in $\beta(\delta^*,\underline{\mu})$ at the point $\underline{\mu}'$ are

$$\left.\frac{\partial L(\underline{\mu})}{\partial \mu_i}\right|_{\underline{\mu}=\underline{\mu}'} = 0, \qquad i = 1 \ldots 3 \tag{10}$$

and the negative definiteness of the Hessian of $L(\underline{\mu})$ on the hyperplane

$$\mu_1 + \mu_2 + \mu_3 = 0 \tag{11}$$

evaluated at the point $\underline{\mu} = \underline{\mu}'$, see 7. Twofold differentiation shows

$$\frac{\partial L}{\partial \mu_i} = \frac{1}{3}\cdot\varphi\left(U - \frac{\mu-\mu_i\left(1-\frac{1}{\sigma^2}\right)}{\sqrt{2+\frac{1}{\sigma^2}}}\right)\cdot\frac{1-\frac{1}{\sigma^2}}{\sqrt{2+\frac{1}{\sigma^2}}} + \eta \text{ for } i=1 \ldots 3.$$

$$\frac{\partial^2 L}{\partial \mu_i \partial \mu_j} = \frac{1}{3}\cdot\left(-U + \frac{\mu-\mu_i\left(1-\frac{1}{\sigma^2}\right)}{\sqrt{2+\frac{1}{\sigma^2}}}\right)\cdot\varphi\left(U - \frac{\mu-\mu_i\left(1-\frac{1}{\sigma^2}\right)}{\sqrt{2+\frac{1}{\sigma^2}}}\right)\cdot\frac{\left(1-\frac{1}{\sigma^2}\right)^2}{2+\frac{1}{\sigma^2}}$$

for i = j and zero otherwise which means that the Hessian is diagonal. Therefore we get on the hyperplane 11 with 7 for N = 3

$$\underline{\mu}^T \cdot \frac{\partial^2 L(\underline{\mu}^*)}{\partial^2 \underline{\mu}} \cdot \underline{\mu} = \frac{1}{3} \cdot \frac{1-\frac{1}{\sigma^2}}{2+\frac{1}{\sigma^2}} \cdot \left(-U + \frac{\mu}{3}\sqrt{2+\frac{1}{\sigma^2}}\right) \cdot \varphi\left(U + \frac{\mu}{3}\sqrt{2+\frac{1}{\sigma^2}}\right) \cdot \sum_i \mu_i^2$$

and we see that $\underline{\mu}^*$ as given by 7 is a maximum of $\beta(\delta^*, \mu)$ provided

$$\mu < \frac{3U}{\sqrt{2+\frac{1}{\sigma^2}}} . \qquad (12)$$

This is an obvious generalization of condition 5. However we haven't demonstrated that, under condition 12, $\underline{\mu}^*$ is a *global* maximum of the non-detection probability 9, which of course is necessary for it to be a saddle point of the zero-sum game. That the uniform falsification strategy need not be a saddle point under condition 12 is demonstrated numerically in Figure 2. We have therefore to compare the local extremum of 9 at $\underline{\mu}^*$ with the values on the boundary to determine under which additional conditions it is an absolute maximum.

To this end, let us define the quantities

$$\tilde{U}_1 + U - \frac{\mu}{\sqrt{2+\frac{1}{\sigma^2}}} , \qquad \tilde{U}_2 = U - \frac{\mu}{3}\sqrt{2+\frac{1}{\sigma^2}} ,$$

$$\tilde{U}_3 = U - \frac{\mu}{2}\,\frac{1+\frac{1}{\sigma^2}}{\sqrt{2+\frac{1}{\sigma^2}}} , \qquad \tilde{U}_4 = U - \frac{\mu}{\sigma^2}\,\frac{1}{\sqrt{2+\frac{1}{\sigma^2}}} .$$

With some algebra it can be shown that

$$\tilde{U}_1 > \tilde{U}_2 > \tilde{U}_3 > \tilde{U}_4 . \qquad (13)$$

On the boundary $\mu_3=0$ the function 9 takes on the values $\beta(\delta^*, (\mu_1, \mu-\mu_1, 0))$ and it is straightforward to show that

$$\beta(\delta^*, (\mu/2, \mu/2, 0)) = \begin{cases} \max \text{ iff } \tilde{U}_3 > 0 \\ \min \text{ iff } \tilde{U}_3 < 0, \end{cases} \qquad (14)$$

with equivalent expressions for the other two boundaries $\mu_1=0$ and $\mu_2=0$. Therefore we compare the values

$$\beta(\delta^*, (\mu/3, \mu/3, \mu/3)) = \phi(\tilde{U}_2), \qquad (15)$$

$$\beta(\delta^*, (\mu/2, \mu/2, 0)) = \frac{2}{3}\,\phi(\tilde{U}_3) + \frac{1}{3}\,\phi(\tilde{U}_1), \qquad (16)$$

$$\beta(\delta^*, (\mu, 0, 0)) = \frac{1}{3}\,\phi(\tilde{U}_4) + \frac{2}{3}\,\phi(\tilde{U}_1), \qquad (17)$$

First of all, we note that

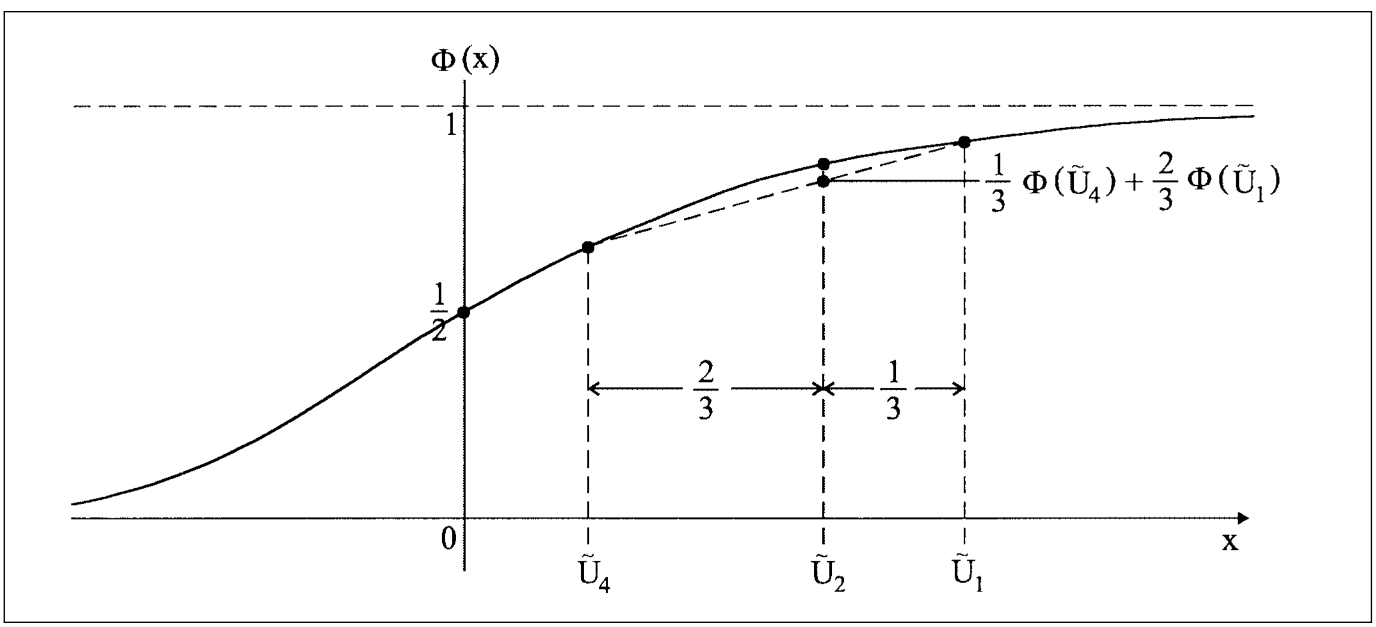
$$\tilde{U}_2 - \tilde{U}_4 = 2 \cdot (\tilde{U}_1 - \tilde{U}_2) = \frac{2}{3} \cdot \frac{\mu}{\sqrt{2+\frac{1}{\sigma^2}}} \cdot \left(\frac{1}{\sigma^2} - 1\right).$$

The situation is as shown in Figure 3, from which we conclude immediately with (15) and (17):

$$\beta(\delta^*, \underline{\mu}^*) > \beta(\delta^*, (\mu, 0, 0)) \text{ for } \tilde{U}_4 > 0,$$

and furthermore

Figure 3. Graphical representation of 15 and 17



$$\beta(\delta^*, \underline{\mu}^*) < \beta(\delta^*, (\mu,0,0)) \text{ for } \tilde{U}_2 < 0,$$

A similar argument involving the differences $\tilde{U}_1 - \tilde{U}_2$ and $\tilde{U}_2 - \tilde{U}_3$ leads to the conclusion:

$$\beta(\delta^*, \underline{\mu}^*) > \beta(\delta^*, (\mu/2, \mu/2,0)) \text{ for } \tilde{U}_2 > 0.$$

Combining these conclusions with 13 and 14, we can state that $\beta(\delta^*, \underline{\mu}^*)$ is an absolute maximum, and hence that $(\delta^*, \underline{\mu}^*)$ is a saddle point, when $\tilde{U}_4 > 0$, i.e. when

$$\mu < U \cdot \sigma^2 \sqrt{2+\frac{1}{\sigma^2}}\,. \qquad (18)$$

This is a tighter bound on μ than 12. In addition it can be shown that the strategy $(\mu,0,0)$ maximizes $\beta(\delta^*, \underline{\mu})$ for $\tilde{U}_2 < 0$. However we cannot claim this to be a saddle point since δ^* is the Neyman-Pearson test against $\underline{\mu}^*$.

We can conjecture that condition 18 generalizes to

$$\mu < U \cdot \sigma^2 \sqrt{N-1+\frac{1}{\sigma^2}} \qquad (19)$$

for $N \geq 3$ and n=1 and, however the complete generalization to any n would be a difficult task.

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An *In Situ* Safeguards Verifier for Spent CANDU-Type Fuel Bundles Stored on Stacked Trays

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Abstract

The safeguards verification of irradiated fuel bundles requires not only physically identifying them but also confirmation through spent-fuel-specific attributes. Performing such measurements *in situ* without isolating the bundles could be extremely challenging in view of the very high radiation levels that exist. This paper describes a verifier for CANDU-type spent-fuel bundles, which has been designed, developed, and used for more than a decade. The associated equipment testing for an extended period was carried out at the Karachi Nuclear Power Plant (KANUPP). The verifier or its variant in one form or other is routinely utilized for the verification of fuel bundles at other CANDU stations as well. It comprises a room temperature CdZnTe semiconductor detector embedded in a shield-collimator assembly, the electro-mechanical scanning mechanism plus the data acquisition and analysis electronics.

In addition to the hardware, the development of appropriate data acquisition software also contributed to the efficient functioning of this safeguards equipment. The working principle of the equipment and the verification methodology used for bundles of different cooling time ranges are described. As the use of this equipment involves the handling of a massive shield assembly over the irradiated fuel tray stacks in the storage bay, its inherent industrial safety features are described. Radiation safety measures for handling the contaminated components of the equipment are also outlined. In conclusion, savings in the costly inspection time affected through the development and implementation of the verifier are emphasized.

Introduction

The physical inventory verification (PIV) of spent fuel is an important requirement that needs to be carried out by the International Atomic Energy Agency (IAEA) safeguards inspectors periodically. The use of natural uranium fuel and on-power fueling intrinsic in the design of CANDU reactors means discharge of multiple numbers of safeguards sensitive fuel bundles from the reactor core into the spent fuel storage bay on a daily basis. Accordingly, the inventories of spent fuel in storage pools of such nuclear power plants have drastically increased over the years. Until the early-1980s these were individually verified away from their storage locations making use of high-resolution germanium detectors.[1] The technique, despite providing a spent-fuel specific attribute test, was limited only to the bundles of cooling time in excess of a few years because of higher detection efficiency (10 percent of 3 x 3 inch NaI detector) and the limit to which the collimator diameter could be reduced. Additionally, the method was cumbersome and time-consuming. It was therefore in the interest of the agency and the states operating these power plants that verification methods were developed that in addition to being faster and less intrusive, were also accurate. These, of necessity, would not require the movement of storage trays.

The *in situ* safeguards verifier for CANDU-type fuel bundles described in this paper makes use of a small volume cadmium-zinc-telluride (CdZnTe) semiconductor gamma ray detector. In the mid-1980s when the need arose, the detector that could best fit the desired characteristics was a miniature cadmium telluride (CdTe) semiconductor detector which had not been utilized until then for irradiated fuel measurements.[2] Due to difficulties arising as a result of a large difference between charge carrier mobility, the photo-peaks in the observed spectra were excessively broadened on the low-energy side and the detector response suffered from the disadvantages of poor resolution and low reliability. Moreover, due to the fact that in practical irradiated fuel spectroscopy most of the peaks originating from fission and activation products were located on rapidly rising Compton background of high energy lines, the spectra consisted mainly of a single high yield Cs^{137} photo-peak at 662 keV. This could still provide an attribute test provided that high count rates could be adequately processed.[3]

The rapid development of super-grade CdZnTe (CZT) detectors coupled with improved pulse processing technology in the ultra high-count rate domain in the mid-1990s allowed the verification of bundles irrespective of the cooling time constraint. The CZT material is superior because of its higher resistivity and wider band gap (1.6 eV for CdZnTe compared to 1.47 eV for CdTe). These detectors have been developed to the extent that coupled with much improved pulse processing electronics they can provide adequate fission product signatures even at short cooling times.[4] This characteristic is important for spent fuel verification where small, well-shielded detectors with good spectral performance are required to obtain spectra in the presence of a significant background of scattered gamma rays. In addition to the use of Cs^{137} for long cooling time a super-grade CZT can also be used to monitor Nb^{95}/Zr^{95} gamma emissions for the verification of bundles with short cooling times.

The development and testing of the verifier was carried out at the Karachi Nuclear Power Plant (KANUPP) under several IAEA research contracts. The agency's inspectors now routinely employ this equipment as an important safeguards verification tool. It is as such an example of a useful collaborative effort between the IAEA and one of its member states for the attainment of essential safeguards goals.

In Situ Verification Measurement Constraints

In order to understand the requirements of *in situ* verification of fuel bundles, it is necessary to describe not only the bundles but also their storage mechanism and geometry.

Fuel Bundle

The CANDU-fuel bundles, the verification of which is discussed in this paper, consist of nineteen elements (rods) assembled to form two concentric rings of six and twelve elements around a central element. These employ natural uranium dioxide in the form of pellets sheathed in zircalloy-4. Each element contains on average twenty-three pellets. Elements are equal in diameter (sheath O.D: 1.519 cm) and length (49.266 cm). These are spaced 0.119 cm from each other and held together in the above described geometrical arrangement at the end plates to which they are spot-welded. The length of assembled bundles is 49.5 cm and diameter 8.131 cm.

Spent Fuel Storage Geometry

The irradiated fuel bundles are stored horizontally on trays. Each tray, which can store up to 11 fuel bundles, measures 109.2 cm in length, 54.6 cm in width and 10.2 cm in height. The filled trays are piled on top of each other to form a stack of eighteen trays. Within the stacks the horizontal separation between the bundles varies between 3–5 mm and the vertical spacing amounts to 20 mm. About two-thirds of the face of the bundle is covered by 6.4 mm thick stainless steel side plate of the tray. The inter stack distance is ~15 cm.

Verification Principle

Based on the constraints imposed by the bundles and their storage geometry, the *in situ* verification could only be carried out by lowering the detection probe between the stacks, allowing it to see individual bundles as it traversed vertically up or down facing the bundles' end plates. To accomplish this, the detector needed to be adequately shielded against the interference effects of the surrounding bundles in densely packed storage geometry. Moreover the detector was also required to operate at ambient temperatures with no cooling and have, at the same time, an acceptable energy resolution. It was therefore exceedingly important that the design of radiation shielding for the detector was optimized considering the available space in between the tray stacks. From the viewpoint of processing of high count rates in excess of 100,000 cps, the amplifier was required to have the ability to work at extremely short pulse shaping times, ~250 ns, besides the capabilities of pulse pile-up rejection, p/z cancellation, and baseline restoration.

The shield-collimator assembly, with the detector mounted inside, is allowed to travel between the tray stacks with the detector directly viewing the bundles that need to be verified. In a single traverse, all the bundles laying at the same position on each of the eighteen trays in a stack could be verified. The scanning speed could be varied from 1 mm/s to 20 mm/s. Higher speeds of up to 70 mm/s are also available for fast insertion or withdrawal of the collimator housing. The detector signal after pulse processing is fed to a MCA, which allows selection of regions of interest (ROIs) in the spectrum followed by spectral multichannel scaling (MCS) as a function of elapsed time. The selection of dwell time in conjunction with the scanning speed determines the resolution of the MCS spectra consisting of maxima and minima as the detector passes through bundle and gap positions respectively. The counting of maxima determines the number of bundles seen by the detector. The maxima also indirectly provide the attribute test as irradiated non-fuel items would not give rise to a Cs^{137} signal in the pre-selected ROI and hence will appear only as a gap and not identified as an irradiated bundle.

For verification based on the use of Cs^{137} peak, the ROI around its characteristic 662 keV line is recorded as a function of the scanning coordinate. This method works quite well when cooling time of the bundles is longer than about one year. With shorter cooling time (< 1 year) and the associated intense gamma field, the Cs^{137} ($T_{1/2}$ = 30.2 y) peak disappears in the heavy Compton background. It was found however that the gamma rays of short-lived isotopes could be used for the verification purposes in this time domain. Recent developments in the field of small size CZT detectors have made it possible to record and use the gamma lines of such fission products. In this paper the use of the gamma lines of Nb^{95} ($T_{1/2}$=35 d)/Zr^{95} ($T_{1/2}$=64 d) for the verification of CANDU bundles with cooling time less than one year is demonstrated. They have a composite peak for 757 keV (Zr^{95}) and 765 keV (Nb^{95}) respectively, which is only a little higher in energy than the 662 keV gamma ray of Cs^{137}.

Essential Components of Verification Equipment

The development and testing of the verifier, which has come to be known as a CANDU bundle verifier for stacks (CBVS), was of an extended nature. The equipment used for the verification has now developed into a state-of-the-art verifier including a scanning mechanism and data acquisition and analysis equipment.

Scanning Mechanism

The scanning mechanism with its mechanical and electrical hardware components are shown and identified in Figure 1. Various components of the system are numbered and identified as follows:

S. No.	Identification No.	Part / Component
1.	1 & 2	Support Structure
2.	3	Movable Frame (Trolley)
3.	4	Motor Drive Unit (MDU)
4.	5	Electronic Control Unit (ECU)
5.	6	Electrical Connection Between MDU and ECU
6.	7	Rotating Mechanism
7.	8	Detector and Shield-Collimator Assembly Housing (see sectional detail)

The four-legged structure mounted on the bridge supports the frame (trolley) on which the electronic control unit (BRRT 28 Schrack, Anlagen) is mounted. The frame can be moved along the railing of the bridge as well as across the bridge. The movement along the bridge is 1.6 m and is performed making use of a pulley/roller arrangement. The movement across the bridge is 0.5 m, obtained with the help of a manually driven spindle. A bent fork shape extension of the frame is used to mount a motor drive unit (SD 5-52 Berger Lahr GmbH), which is a five-phase stepping motor for converting digital positioning directly into appropriate motor axle steps. The drive unit is connected with the electronic control unit. The ECU provides instructions to control the *speed* and initiate *start*, *stop*, *up*, and *down* actions.

The shield/collimator assembly is carried up and down with the help of twin steel bands rolled on a roller pulley/winch controlled by the motor. The maximum vertical motion provided is 10 m. The shield-collimator assembly could be rotated and aligned manually before the start of a verification procedure. Many operational safety features are built into the design. Two micro-switches enable automatic stoppage of motor when the collimator either touches the pool bottom or when it reaches at the pool water surface during upward motion. The entire electro-mechanical scanning system has a TUV certification for industrial safety. The motor drive unit has a special safety device that prevents falling down of the housing through engaging of a mechanical lock when a certain falling down speed (more than 80 mm/s) is exceeded.

Shield-Collimator Assembly

The shield-collimator assembly is contained in a stainless steel housing, 1,200 x 150 x 100 mm. Being of height and width comparable to the gap between two stacks (height: 1,800 mm and minimum space between two stacks: 120 mm), it also functions as an essential guide for insertion. The weight of the housing with its tungsten alloy shield-collimator assembly was 52 kg, 37 kg in water.

The detector probe was implanted between the two blocks of tungsten shield, each of which was lined on the interior with 2 mm thick copper. The front block was provided with a 5 mm diameter collimator. The collimator diameter could be further reduced to 2.5 mm with the help of a tungsten insert tube. The detector preamplifier assembly sandwiched between the blocks of tungsten was positioned inside the stainless steel housing with the help of a lead cover plate secured by long screws such that the collimator was directly in front of the window (0.5 mm thick) provided for in the housing.

Table 1. Characteristics of CdZnTe Detector (SDP 310/Z/20 S/118) Used

S. No.	Parameters	Value
1.	Length of Cable	200 mm
2.	Diameter of Probe	8 mm
3.	Operating Voltage	+ 300 V
4.	FWHM (at 662 keV)	7.30 keV
5.	FWTM (at 662 keV)	20.10 keV
6.	Peak to Compton Ratio	4.67
7.	Peak to Valley Ratio	81.49
8.	Recording Sensitivity	0.011 mm^2
9.	Output Signal Polarity	Negative

Shield	Tungsten alloy (surrounding the detector and fixed inside the housing) and upper removable shield of lead
Dimensions	Tungsten (W) shield (100 × 145 × 100 mm); lead (Pb) shield (100 × 100 × 50 mm) From Pb shield, the CZT probe passes through a stainless steel sleeve of 50 mm length and 20 mm outer diameter into the W-shield. The probe itself is extended 90 mm into the W-shield.
Collimator	5 mm inside dia (tungsten)

Measurement System

The measurement system comprised two major components, the CZT semiconductor detector and data acquisition and analysis equipment with software.

CZT Semiconductor Detector

A CZT hemispherical detector coupled to a charge sensitive preamplifier in an integral assembly was used as also mentioned earlier, as the detector for the verifier. It could be placed in a watertight housing and connected to pulse processing/data acquisition equipment through a watertight connector and a submarine cable. Irradiated fuel gamma-ray spectrometry, as stated above, are required to have low registration efficiency while preserving their high spectroscopic performance (i.e., energy resolution ≤ 10 keV at 661.6 keV; peak-to-Compton ratio ≥ 2.5). The characteristics of the utilized CZT (SDP 310/Z/20 S/118) semiconductor detector as certified by the manufacturer are given in Table 1.

Data Acquisition and Analysis Equipment

The data acquisition and analysis equipment as shown in Figure 2 consisted of the following:

Amplifier	TENNELEC (TC-244)
MMCA	MCA-166 (GBS Elektronik)
Computer Hardware	Toshiba Libretto sub-notebook computer or equivalent
Computer Software	WinMCA (Ver 0012) with SCANDU option or WinSCAN

The output of the preamplifier was connected to the amplifier (TC-244) and on to the MMCA (Mini MCA, model MCA 166) developed at Forschungzentrum Rossendorf for the IAEA and the Euratom Inspectorate. It is a battery-powered (operates for more than eight hours on rechargeable Li-ion batteries) high performance 4 K MCA/MCS module, provided with the detector high voltage supply and an internal amplifier.

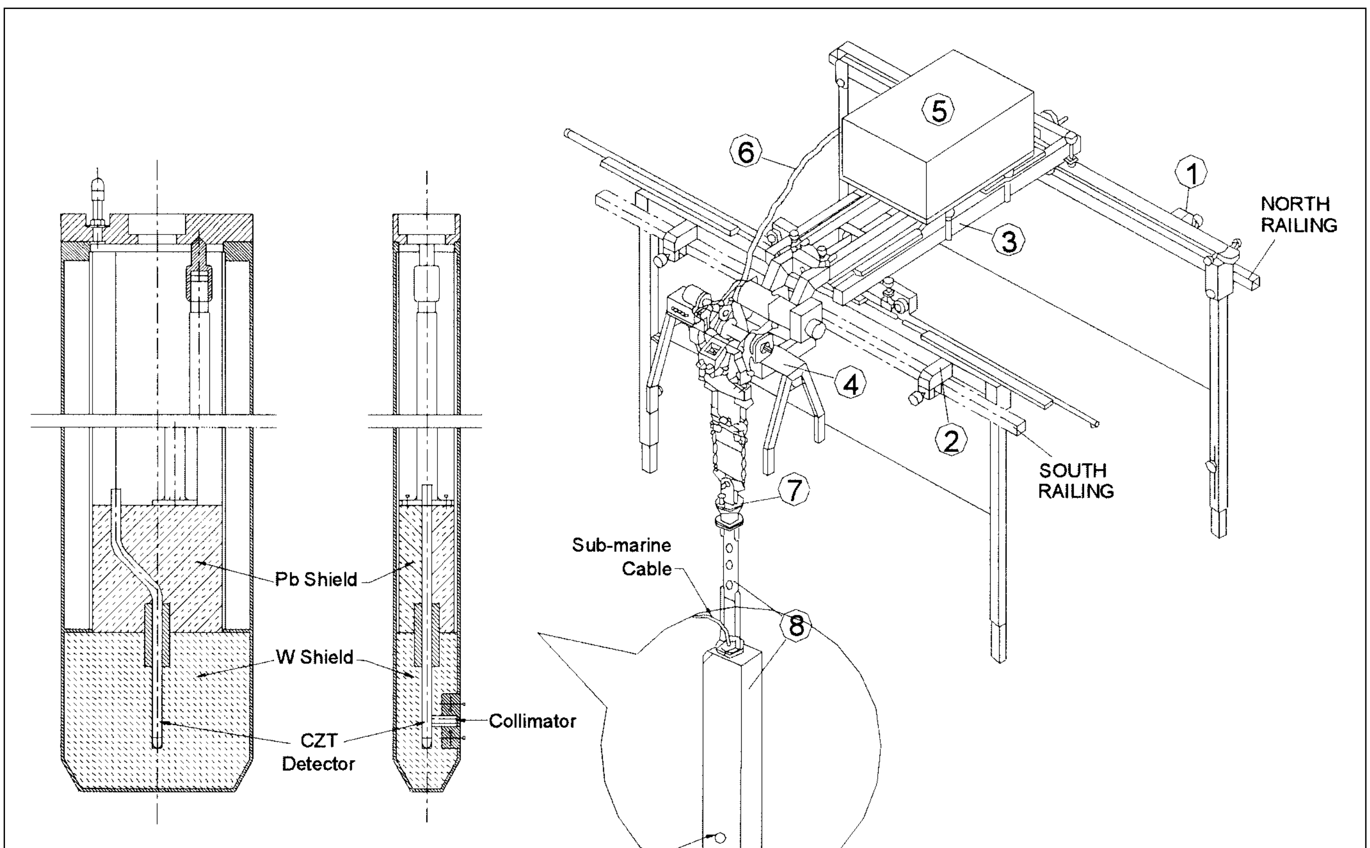
For working with shorter than 1 µs pulse shaping time using CZT detector, the internal amplifier could be readily bypassed to utilize a high-performance external amplifier. The MMCA is small (155 x 9.5 x 50 mm), its shape and size optimized for use with a HP 200LX palmtop. For the reported measurements it was, however, used with a laptop computer.

For data collection and real-time evaluation (screen plot of the peak areas of up to two ROIs in the PHA spectrum) the software WinSCAN was used (www.GBS-elektronik.de). The software allowed setup and control of the MCA, taking an amplitude spectrum, and setting of ROIs, the peak areas of which would subsequently be measured and displayed as a function of the scanning coordinant.

Verification Procedure

The CANDU bundle verifier is normally stored at the facility in

Figure 1. CANDU bundle verifier and its shield-collimator assembly



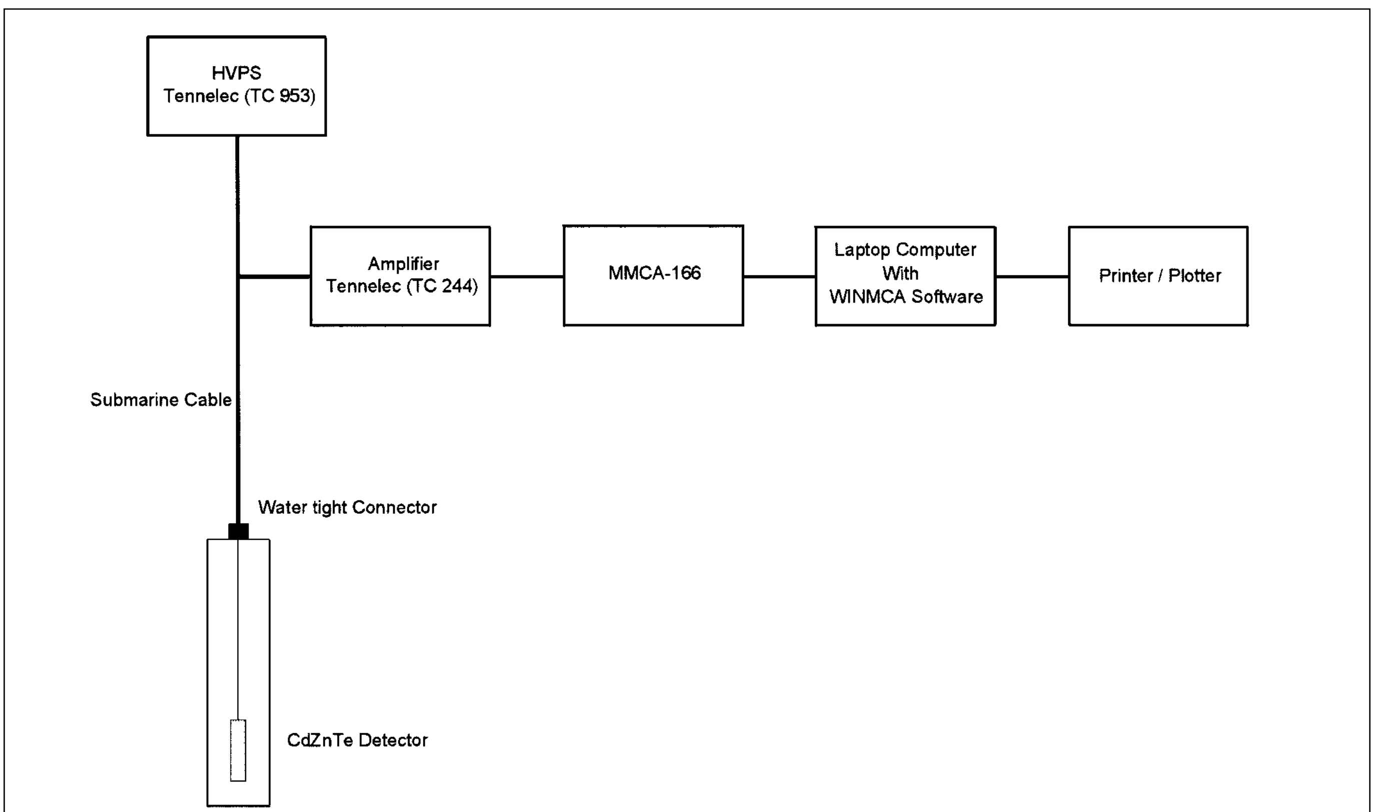
a disassembled state. Before use it is assembled and mounted on the storage bay bridge with the help of easy-to-follow instructions in the same ascending order as shown in Figure 1. Before the shield-collimator housing is lowered into the water, it is pressurized with air at a slightly higher than atmospheric pressure so that any leakage is outside and is quickly noticed through the formation of bubbles in water. While the housing is slowly lowered using a specially designed hook attached to the crane, it is also affixed to the twin steel bands that besides providing a connection between the motor drive unit and the heavy housing also take its entire load. After the load is transferred to steel bands, the hook is eased off and removed. The bridge is then moved to the desired scanning location. The housing is lowered at an appropriate speed selected from the electronic control unit. Once the housing reaches near the measurement location, it is aligned with the help of bridge movement as well as the manual X and Y motions of the trolley. The alignment is sought first to allow the housing to find the gap and second to position the collimator window so that it is in the middle of the column of bundles to be scanned. The detector voltage is applied and amplifier settings made to optimize it for high count-rate operation. If the collimator window is directly in front of a bundle then its fission product gamma ray spectrum becomes visible on the MCA screen. At this point the ROIs for multichannel scaling can be selected. The scanning is normally conducted at speeds of 1–15 mm/s depending on the cooling time of the bundles. As it is started the acquisition of measurement data is also initiated simultaneously.

The software that is used allows the pulse height and multichannel scaling spectra to be viewed in real time on the main and the small window screens respectively. Depending upon the ROIs selected, single or multiple overlapped MCS distribution could be seen developing. If the age of bundles is not known then it is instructive to select two regions of interest, one at 662 keV (Cs^{137}) for long cooling time bundles and another one at 757 keV (Zr^{95})+766 keV (Nb^{95}) for short cooling time bundles. As the detector collimator window passes the fuel and gap regions maxima and minima in the count rate distribution occur as a function of elapsed time or distance traversed by the housing. The number of maxima identifies the number of bundles present in the scanned column.

Measurement Profiles

The verification measurements making use of fission product gamma rays as well as fluorescent uranium X-rays have previously been reported.[5-6] For both the gamma- and X-ray measurements

Figure 2. Data acquisition and analysis equipment layout



the verifier equipment is strictly identical but the scanning orientation is 90° out of phase owing to prohibitively high attenuation of X-rays in the normal direction parallel to the plane of the end plate. As the storage geometry does not allow verification of all the bundles making use of uranium X-rays, it is normally not used to that end.

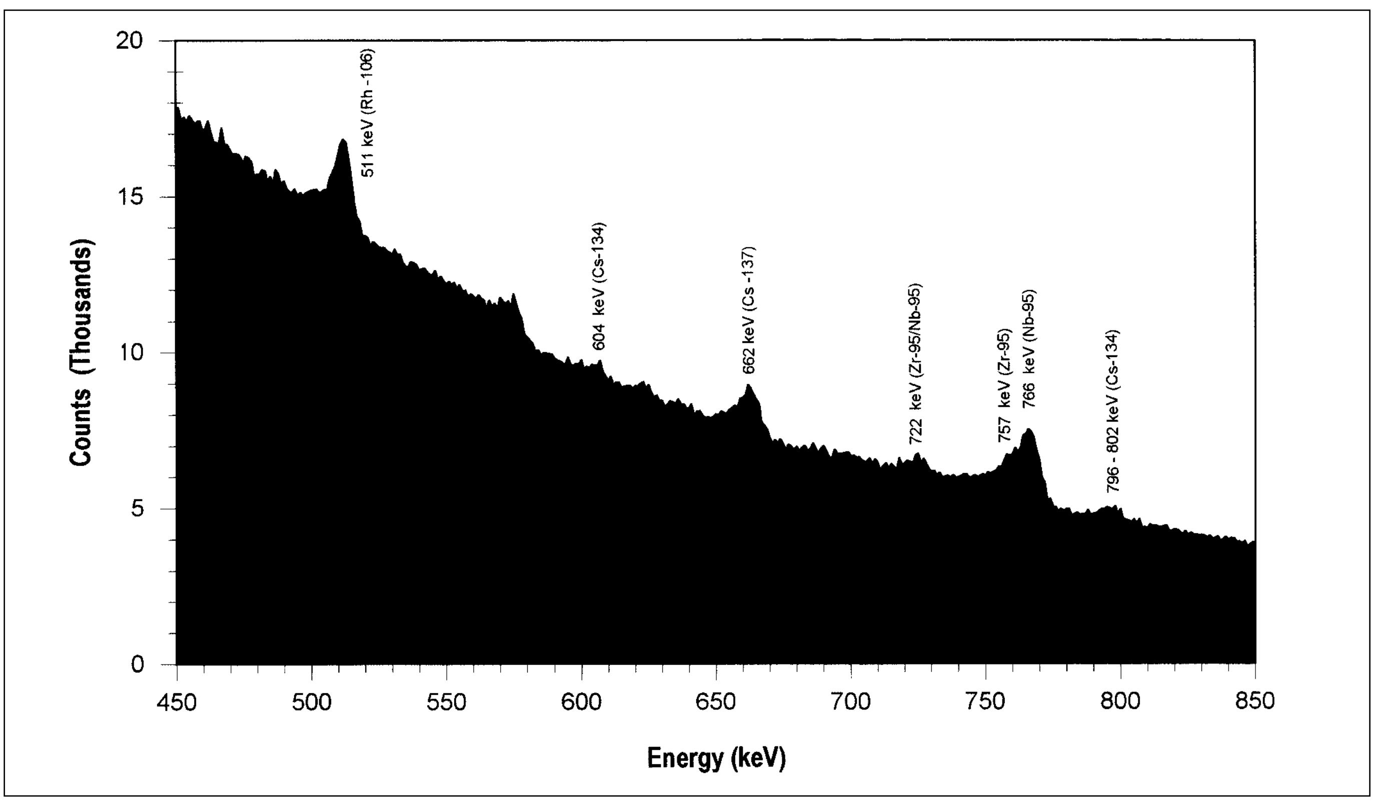
A tray stack comprising of 198 (18x11) bundles gets piled-up in forty-five to sixty days depending upon the reactor power and number of bundles discharged per day. It may accordingly contain a distribution of cooling times around a mean value to which the measurements normally refer. It is also necessary to point out that a reactor channel at KANUPP comprises eleven bundles with the eleventh bundle in out-of-core position. While the inner zone channels are fueled by one bundle, the outer zone channels are fueled by two bundles at a time. Depending upon the position occupied by a bundle at the time of initial fueling in an outer zone channel, it may discharge from the eleventh position or directly from the tenth position. If discharged from the eleventh position the bundle would undergo in-core cooling as long as it stayed in that position. On the other hand, all the bundles discharging from inner zone channels do so from the eleventh position and, accordingly, undergo cooling as long as they stayed at that position.

The verifier is currently being utilized covering the entire cooling time spectrum. The bundles of cooling time in excess of one year or more are characterized by single 662 keV gamma ray emissions from Cs^{137}. On the other extreme the short cooling time (<one month) bundles too are identifiable making use of the composite 757 keV +766 keV gamma ray of Zr^{95} and Nb^{95} respectively. The verification of such bundles is straightforward as only one ROI is required to be defined for MCS scanning. On the other hand, verification of bundles of intermediate age is more illustrative since more than one gamma line (ROI) can be observed and evaluated.

The pulse height spectrum of ~ 9-month-old bundles, as shown in Figure 3, clearly identifies the 662 keV (Cs^{137}) and 757 keV (Zr^{95})+766 keV (Nb^{95}) gamma rays. The verification profile of such fuel bundles is shown in Figure 4. The scanning was carried out from top to bottom along sixth bundle position in a given stack. The scanning speed was 1 mm/s, which required a counting time of 10 s. As seen all the bundles were quite clearly identified employing either the ROI: 1 (765 keV) or ROI: 2 (662 keV).

It is interesting to note that the bundles on the trays no. 18 (top most), 17, 16, 14, 10, 6, and 3 exhibit higher maxima for Nb^{95}/Zr^{95} counting, indicating them to be of shorter cooling times. It is understood why the bundles in trays no. 18, 17, 16, and 14 should be exhibiting such a signature as these were the ones that were discharged and piled later compared to the ones in the lower layer trays. What is not immediately obvious is why the bundles in trays 6 and 3 should also show higher count rates for

Figure 3. Response of SDP 310/Z/20 S to a ~9-month-old bundle



Nb^{95}/Zr^{95}. The only explanation is that they might have been discharged directly from the tenth bundle position of the channels involved. Similarly bundles on the remaining trays i.e., nos. 15, 13, 12, 11, 9, 8, 7, 5, 4, 2, and 1 (bottom most) show higher maxima for Cs^{137}. It is quite apparent why the bundles in trays 1, 2, 4, and 5 should show such a signature as these were the ones discharged and stored earlier. The reason as to why the bundles in trays 15, 13, 12 and 11 also show higher counting rates for Cs^{137} could be found in the fact that they might have been discharged from the eleventh positions in the respective channels and had undergone some in-core cooling. This inference was subsequently verified by referring to the bundles' irradiation history record.

Radiological Safety

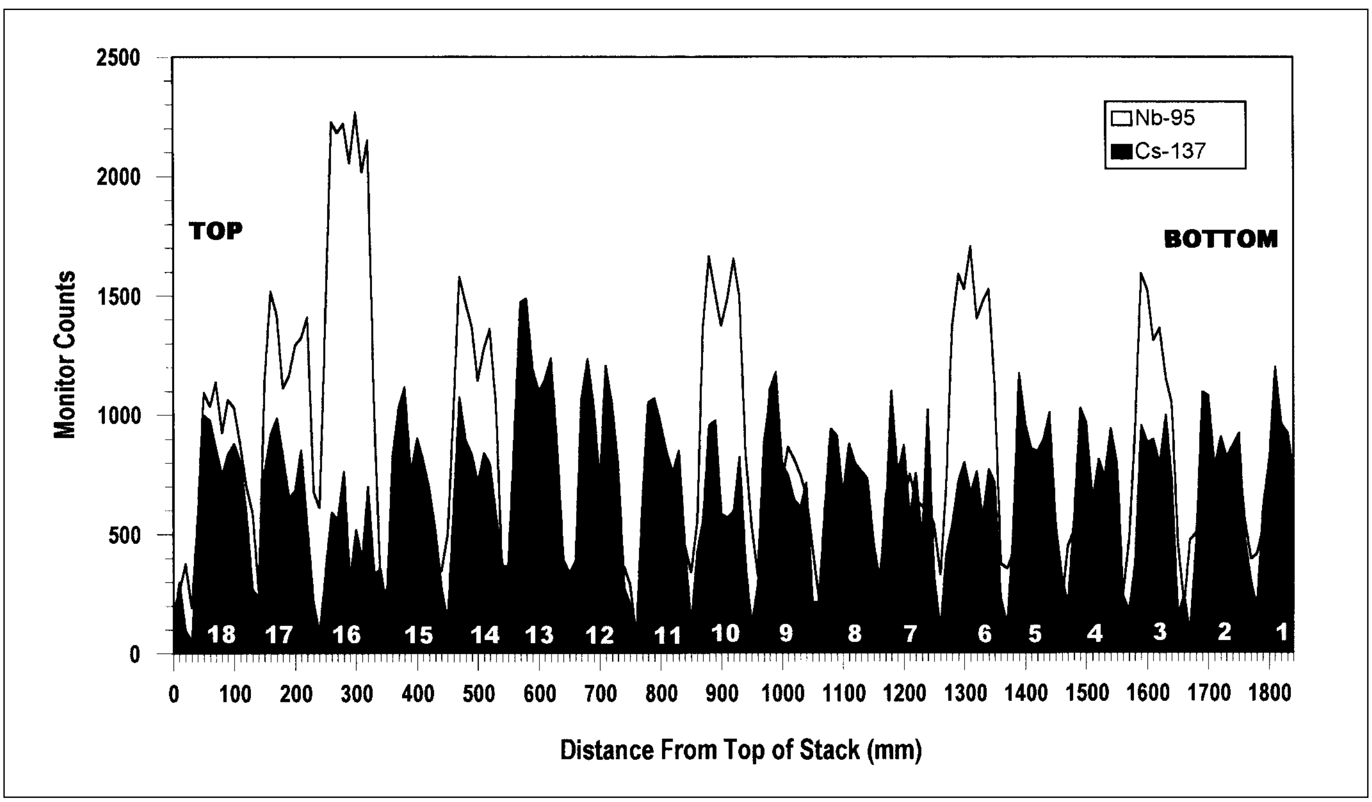
It is evident that the stainless steel housing of the detector and shield-collimator assembly along with the watertight connector and submarine cable not only remain submerged in the storage pool but often also come into contact with highly radioactive fuel bundles during a verification campaign. After their use all such components must be thoroughly decontaminated. Since the housing has a well-polished surface, it is not difficult to decontaminate it employing the documented procedures and taking all necessary precautions. The decontaminated components may subsequently be wrapped in polyethylene sheets and deposited in their respective storage boxes.

Conclusions

The equipment described in the preceding sections has been used for the verification of CANDU-fuel bundles at their storage locations for the past several years. Using this equipment, a safeguards inspector with the help of plant supporting staff is capable of verifying the representative inventory (using a random sampling plan) of the entire storage bay of more than 15,000 fuel bundles in a couple of routine working days. This includes assembling and installing the hardware as well as the essential testing of the equipment preceding the actual verification campaign.

Before the advent of this state-of-the-art equipment, the verification procedure based on high resolution LN_2 cooled germanium detectors used to occupy several inspectors working in shifts for three weeks and very considerable assistance of skilled plant personnel. The development of the above-described *in situ* verifier has led to considerable savings of expensive inspection time. Moreover, contrary to the earlier method that allowed verification of only those bundles that had undergone a considerable cooling, the present method is applicable to all bundles residing in the storage bay irrespective of the cooling time constraint. This

Figure 4. SCANDU profile of 9-month-old spent fuel bundles



is a big improvement in the attainment of the safeguards goals both from the view point of NPP operators and the IAEA. The collaborative effort between the agency and one of its member states to that end is of particular significance.

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Acknowledgements

The mechanical hardware of the verifier was designed at the IAEA workshop in Vienna. Its major components were fabricated at KANUPP in Karachi. The tungsten shield-collimator assembly and its housing were both designed and fabricated at the Vienna workshop. The special purpose low-sensitivity CZT detectors used by the verifier was developed at the Ritec, Ltd., Riga, Latvia, employing the detector raw material produced by eV Products USA. The computer software used for the data acquisition and analysis was developed by GBS-Elektronik GmbH, Rossendorf, Germany. The entire equipment in its integral form was optimized and tested at the KANUPP spent fuel storage bay. The work at KANUPP was carried out under IAEA research contracts. Both the IAEA and the Pakistan Atomic Energy Commission (PAEC) were major contributors in the verifier development effort. Their assistance as and where received is gratefully acknowledged.

An Early Version of an Information Barrier

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Abstract

The term *transparency* was introduced into the safeguards lexicon in the early-1990s, and the term *information barrier* was introduced into the safeguards lexicon in the late-1990s. Although the terms might be new, the concepts are not. Both concepts have been used by the International Atomic Energy Agency (IAEA) and its inspectors since the early-1980s, but then the terms *transparency* and *information barrier* were not used. The definitions of these concepts have evolved in recent years, and both have been applied to a broader category of special nuclear material measurement problems. An information barrier uses hardware, software, and procedures or administrative controls to help obtain transparency in the measurement of sensitive material. The IAEA implemented an early information barrier concept to protect proprietary information when performing inspections of gas-centrifuge uranium enrichment facilities. This early example will be compared with the features of a current, state-of-the-art information barrier technology designed for use in nonproliferation, arms control, and dismantlement. This comparison of these two examples of an implementation of an information barrier will show that many concepts of current information barriers can be found in the concepts employed approximately twenty years ago. Predictably, current information barriers have added features that are based on advances in technology and more stringent requirements to protect more sensitive information.

Introduction

The concepts of transparency and of an information barrier were introduced in the early-1980s,[1] but the explicit terms *transparency* and *information barrier* were not used until about ten years later. The Hexapartite Safeguards Project[1] was formed in 1980 by Australia, Germany, Japan, the Netherlands, the United Kingdom, and the United States—the six technology holders of gas-centrifuge facilities—and the inspectorates of the IAEA and Euratom. The Hexapartite Safeguards Project was formed to wrestle "with the problem of how to get effective and credible safeguards at uranium-enrichment plants (specifically gas-centrifuge facilities) while protecting sensitive information and minimizing the operator's burden." At that time, the transparency and information barrier approaches were incorporated into a protocol called limited-frequency unannounced access. Today, the connotations expressed in "protecting sensitive information and minimizing the operator's burden" are used in the definitions of information barrier and transparency.

Recently, transparency is applied to monitoring regimes in the nonproliferation, arms control, and dismantlement environments. Transparency is designed to give the inspecting party assurance and confidence that the inspected party is living up to the conditions of an agreement. One definition of transparency is "measures that a country takes to build international confidence that it is abiding by treaties, agreements, or unilateral declarations while minimizing operational impact on facilities and loss of information that could negatively impact national security or result in proliferation of weapons-design information." Safeguards are generally considered to consist of intrusive measures whereas transparency measures are generally not as intrusive. Safeguards are designed to establish and maintain a material inventory. This requires precise and accurate measurements. Transparency measures generally cannot maintain or confirm material inventory and are generally not as precise and accurate.

An information barrier[2–4] is designed to prevent the release of classified or proprietary information while allowing meaningful measurements and independent conclusions. The early information barrier implemented by the IAEA in the 1980s was designed to protect proprietary information. Today's information barrier must provide the inspecting party with the confidence that the unclassified output accurately represents the classified input. The inspected party must be convinced that classified or proprietary information cannot be released to the inspecting party. An unclassified interface must be used to display, and possibly record, measurement results. The results of the classified or proprietary measurement can be reported as a simple yes or no that signifies whether the measurement result meets or fails to meet predetermined criteria. This can be accomplished by a combination of hardware, software, and administrative controls.

Recently, new information barrier concepts have been applied to support the Trilateral Initiative,[5] the Fissile Material Transparency Technology Demonstration (FMTTD),[6] and the Plutonium Production Reactor Agreement (PPRA), an agreement between the United States and the Russian Federation to confirm that Russian plutonium oxide from spent fuel in storage was reprocessed before January 1, 1997. (Measurement attributes of the plutonium oxide agreed by the parties will be used to verify the material under this agreement.) These measurement systems incorporating information barriers are tasked with preventing the release of classified information while, at the same time, allowing useful confirmatory measurements. Other examples of recent information barrier concepts can be found in references 7–14. A common feature of some of these concepts is the use of a template-matching or pattern-recognition technique to make decisions. The early example of an information barrier discussed here bases its displayed go/no-go decision on an actual determination of a single quantity.

Cascade Header Enrichment Monitor

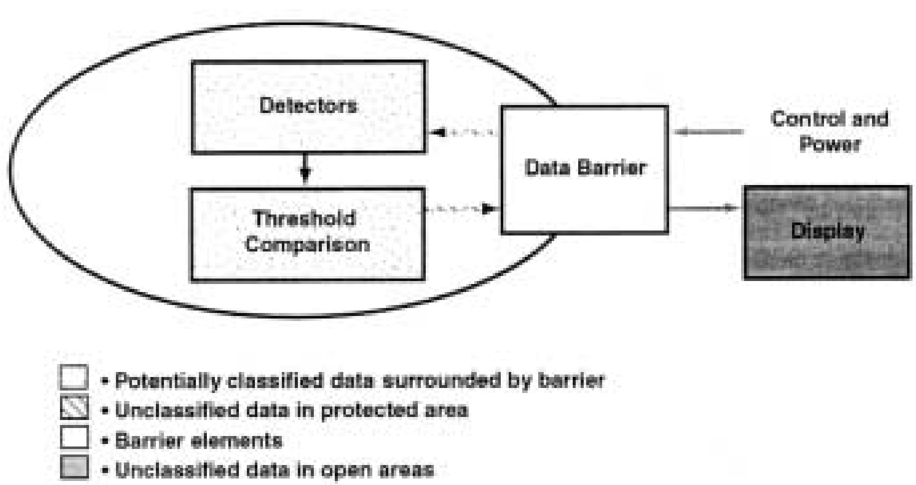
A requirement from the Hexapartite Safeguards Project for the uranium-enrichment measurement at centrifuge plants is that the nondestructive assay (NDA) measurement must only confirm the declarations of the facility operator. The measurement must be quick and result in only a go/no-go or yes/no answer that confirms only that the enrichment level is low-enriched uranium and consistent with the facility declaration. The measurement does not have high precision or accuracy, consistent with a go/no-go measurement result. Also, the characteristics of an operating centrifuge facility make a high-accuracy, high-precision, online measurement extremely difficult. The measurement algorithm uses the Sequential Probability Ratio Test,[15] a statistical test designed to make a decision in the minimum amount of time. This instrument is used on the header pipes outside the centrifuge cascade area, thus reducing the impact on the host facility and protecting the proprietary information associated with the centrifuges. This measurement has the characteristics consistent with a transparency regime. The manner in which the data are collected and presented to the IAEA inspector exhibits many features of an information barrier concept.

An IAEA-approved instrument for use during a limited-frequency unannounced access inspection is the Cascade Header Enrichment Monitor (CHEM). The CHEM[16–20] is an active/passive gamma-ray spectroscopy instrument developed in the early-1980s that verifies, online and in real time, the enrichment of the gaseous uranium hexafluoride (UF_6) in the header pipes of an operating gas-centrifuge facility. This instrument uses off-the-shelf electronic components (Davidson portable multichannel analyzer [PMCA] and a laptop computer) that are used daily by IAEA inspectors.

The result of the enrichment measurement, which could reveal proprietary information, is reported as a simple go/no-go statement. This is accomplished by a combination of hardware, software, and administrative controls as shown conceptually in Figure 1. Figure 1,[3, 4] which has been altered slightly in appearance but not in content, has been used to show many of the components of a recent information barrier and is appropriate for the CHEM. This figure shows the measurement instruments and data analysis, or threshold comparison, inside a barrier. The data analysis result is passed through a data barrier so only qualitative results are presented on the unclassified display outside the barrier.

The CHEM algorithm determines how many data are needed to make a decision based on the measurement criteria, and it makes and presents the decision. The CHEM calculates an actual enrichment of the gaseous UF_6 and then compares this enrichment with the enrichment the facility is authorized to produce. The only conclusion from the CHEM presented to the inspecting party and the inspected party is *low-enriched uranium confirmed* or *low-enriched uranium not confirmed*. If the header pipe happens to be under vacuum at the time of the measurement, the result at the conclusion of the measurement is *XRF indicates gas is consistent with vacuum*. Several procedures are taken to ensure the facility's proprietary information is not revealed to the IAEA inspector. The instrument is a go/no-go instrument, or a yes/no instrument. Only qualitative information is presented to the IAEA inspector.

Figure 1. Conceptual diagram of the first-generation information barrier



The function of the detectors and the computational analysis are performed inside the barrier. After the data barrier is applied, the unclassified results of the measurement are presented on the display.

There is no hard-copy output. At the conclusion of a measurement session, all data in the memory of the Davidson are erased, and nothing is stored in the memory of the computer. The CHEM prevents the release of proprietary information while allowing meaningful measurements and independent conclusions. The CHEM algorithm follows the concept of the information barrier presented in Figure 1.

Additionally, the CHEM[21] has two basic operating modes, *show* and *hide*. The show mode is password protected and is used to verify the enrichment calibration of the CHEM using a calibrated secondary pipe standard. The show mode is used during all the enrichment calibration activities conducted outside and completely independent of the centrifuge facility. This is the ideal mode of operation for laboratory training of IAEA inspectors because there are no classified or proprietary aspects of the measurements and calibration. While in the show mode, all intermediate and final results (all count rates and enrichment) are displayed on the computer screen. This allows the IAEA inspector to gain confidence in the operation of the instrumentation and the calculations of the algorithm.

The hide mode is used during an actual inspection in a gas-centrifuge facility by IAEA inspectors and the measurements on the cascade header pipes and is the default mode of operation. No uranium-enrichment value is displayed. No count rates are displayed. Although intermediate qualitative results are displayed on the screen of the computer, the facility-specific proprietary information remains protected. The final conclusion of the measurement (*low-enriched uranium confirmed*, or *low-enriched uranium not confirmed*, or *XRF indicates gas is consistent with vacuum*) is presented to the inspector.

Before the IAEA inspector makes the decision between show and hide, there is a *calib*, or calibrate, mode. When the calib mode is used, all features of the Davidson PMCA are accessible to the inspector to perform an energy calibration of the Davidson device.

During all measurements, whether in the show mode or the hide mode, the CRT display on the Davidson PMCA can be turned on. The controls on the Davidson PMCA that manipulate the CRT display are also active. All other control buttons on the Davidson PMCA are deactivated.

Information Barriers and Attribute-Measuring Systems

Attribute-measurement systems that incorporate information barriers are under development for measuring attributes such as mass, isotopic composition, age, and shape of classified plutonium objects. These measured values are compared to unclassified thresholds. The only output of the attribute-measurement system is a series of red or green lights that indicate whether the object failed or passed the appropriate threshold.

These systems incorporate recommendations of the Joint DOE-DOD Information Barrier Working Group (IBWG).[22] In particular, the IBWG recommends simple measurement systems that can be inspected by both the inspecting party and the inspected party and have a minimum of extraneous capabilities and a minimum of inputs and outputs. In addition to certification by the inspected party, the inspecting party must be able to authenticate these measurement systems. Stored classified data are to be minimized or eliminated.

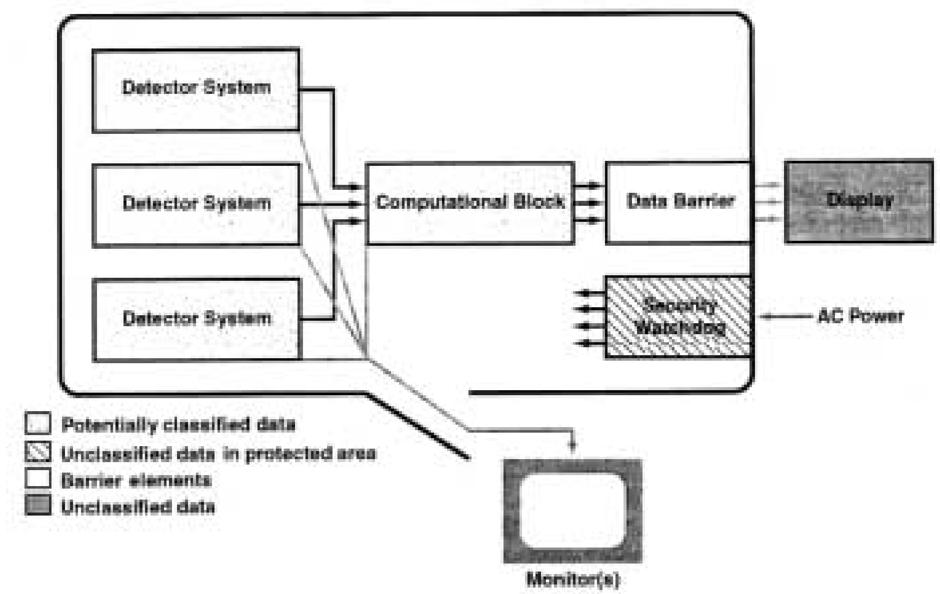
The first-generation attribute measurement system—Inspection System with Information Barrier or ISIB—designed for the Trilateral Initiative is discussed in reference 5. The second-generation system jointly developed by Russian Federation, IAEA, and U.S. technical experts (Attribute Verification Systems with Information Barriers for Plutonium with Classified Characteristics Utilizing Neutron Multiplicity Counting and Gamma Spectroscopy or AVNG) is discussed in reference 23. A similar system, measuring additional attributes (Attribute Measurement System with Information Barrier or AMS/IB) was designed for the Fissile Material Transportation Technology Demonstration (FMTTD) and is described in detail in reference 6.

As the information barrier concept has evolved during the last several years, it has become more sophisticated. A block diagram of a more recent information barrier is shown in Figure 2. Conceptually, data protection features are separated from the detector systems and computational block. Redundant layers of defense (defense-in-depth) protect the data from accidental release to the inspecting party, even if an individual element of the information barrier fails.

The actual measurement techniques used are standard NDA safeguards techniques, for example high-resolution gamma-ray spectroscopy and neutron multiplicity counting. To avoid false results, the most accurate NDA measurements possible are made, and then the resulting data are protected against possible disclosure by an information barrier. This approach is preferable to making less precise and less accurate measurements that might have a lower probability of revealing sensitive information, but that could increase the possibility of false conclusions. The normal data-collection and data-analysis algorithms are applied and results are determined. Then a barrier is applied so that only qualitative results or unclassified results are presented on the display. At the completion of a measurement, all raw data, intermediate analysis results, and any quantitative final results are erased from the volatile computer memory. There is no hard-copy output or long-term storage of classified information.

Measurement systems that incorporate an information barrier, as depicted in Figure 2, have an open mode and a secure mode. In the open mode, background, calibration, and other unclassified data can be taken and analyzed, and the quantitative results (both intermediate and final) can be studied. Such unclassified measurements increase the confidence of both the inspecting party and the inspected party that the measurement system is operating as desired. The information barrier operating in the open mode in which quantitative results can be

Figure 2. Conceptual diagram of the second-generation information barrier



The detectors are located and computational analysis is performed inside the barrier. The security watchdog supplies AC power to all other elements of the measurement system and checks for access or breaches of the information barrier. This information barrier is shown in the open mode, with monitors connected to the system. In the secure mode, the monitors are disconnected from the system, and the physical barrier is closed. There are classified data in the protected area when a classified object is measured. The data barrier is applied, and the unclassified results of the measurement are presented on the display.

studied is shown conceptually in Figure 2. In the secure mode, the monitors are disconnected from the system, and so the physical barrier is closed.

In the secure mode, only the qualitative answers yes or no are presented to the inspecting party and the inspected party. All of the unclassified measurements can be repeated in the secure mode. In addition, in the secure mode, classified data may be acquired and analyzed, but only unclassified yes/no results are displayed. No intermediate display or detailed outputs are available in the secure mode.

All equipment and instrumentation used in the measurement system are contained in electromagnetically shielded cabinets. A key feature of the information barrier is the security watchdog.[24] This module supplies AC power to all other elements of the measurement system and monitors for access or breaches of the information barrier, either intentional or inadvertent, and controls physical access to all the equipment. Any breach of the system results in the security watchdog removing power from the system, and thus removing all measurement data from the system's volatile memory.

Conclusions

The CHEM is an early example of a transparency measurement instrument that includes an information barrier to protect proprietary information consistent with the concept presented in Figure 1. It also has many of the same features of more recent and more sophisticated information barriers (Figure 2) developed to protect classified information. However, CHEM uses different terminology than that used today to discuss information barriers. The information barrier in the CHEM uses *show* and *hide* for the two operating modes. The most recent information barrier uses the terms *open* and *secure*. The displayed conclusion from the CHEM is referred to as a go/no-go or yes/no result, while the latest information barrier uses the terms yes/no or pass/fail.

The CHEM stores no information and produces no hard-copy output. The information barrier of the 1980s was designed to protect a facility's proprietary information and met all requirements of the time. The CHEM does not have all the features of current information barriers such as the security watchdog, is not as robust, and does not have any electromagnetic shielding. The latest information barrier described here evolved to both protect classified weapons-design information and allow for authentication by the inspecting parties.

Because information barriers have been developed over many years and under different measurement regimes, there are differences in how control is maintained over the instrumentation. For the IAEA, a precedent exists that they provide their own instrumentation for their inspectors to use to perform their own measurements so they know the history and can maintain continuity of control of the instrumentation. The hardware and software is under IAEA control at all times. The instrument is either being used by an inspector, or it is locked and under IAEA seal. Under the proposed nonproliferation, arms control, and dismantlement environment, one scenario under discussion would allow the inspected party to provide the instrumentation while the inspecting party would be allowed to *authenticate* the hardware and software.

There are three obvious differences between the two examples of an information barrier discussed here.

1. These two information barriers were developed over a period of about twenty years.
2. One information barrier was developed to protect only facility proprietary information. The other was developed to protect classified information.
3. The early version was implemented in the safeguards regime of the IAEA.

The latter example is being implemented in the nonproliferation, arms control, and dismantlement environment. Thus, there are obvious differences in their implementation, in the technology available, and the degree to which information is, can be, and must be protected. But there are still many similarities in the implementation and operational characteristics of information barriers in the two examples discussed. The information barrier of the 1980s provides a foundation for many of the concepts and components of information barrier systems of the future.

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Development of the Method for Characterization of Samples Containing Spontaneously Fissioning Nuclides Using Fission Products Gamma-Spectrometry

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Abstract
This paper presents some results of a study devoted to control of nuclear material samples containing spontaneously fissioning nuclides by means of γ-spectrometry. Gamma-radiation spectra of plutonium and ^{252}Cf samples were measured and analyzed. Some gamma-radiation emitters were identified, which made it possible to develop a new method for determining the mass of spontaneously fissioning material in the sample.

Table 1. Some data on californium samples

	No. 1	No. 2	No. 3
Place of fabrication	Russia	Russia	United States
Date of fabrication	August 20, 1984	August 22, 1984	January 1, 1998
Chemical form	Oxide	Oxide	Nitrate
Intensity in measurements, n/s	7.58E+05	6.44E+04	4.90E+05
Mass of ^{252}Cf mg	0.32	0.032	0.21

Introduction
Under spontaneous fission of heavy nuclides, fission products are generated and accumulated. Some fission products (short-lived nuclides) quickly reach an equilibrium concentration that is directly proportional to the amount of spontaneously fissile nuclide in a sample. Concentrations of other fission products continue to increase with time.

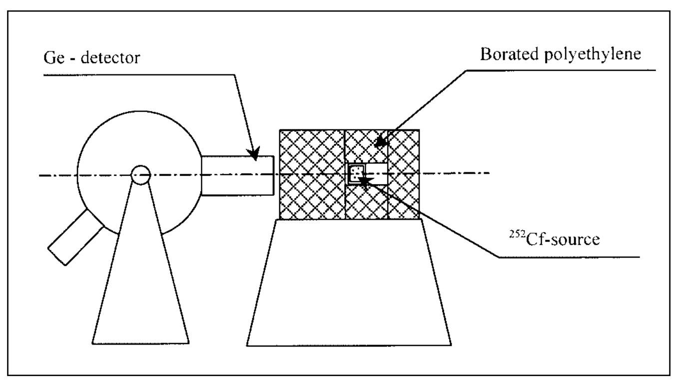
It is known that irradiated fuel in nuclear reactors also contains various fission products, and radiation from some radioactive fission products can be observed and measured by gamma-spectrometers. The gamma-spectrometric measurements of radiation emitted by fission products is complicated by the radiation background from prompt fission gamma-radiation, neutron capture radiation from samples and surrounding materials, and neutron radiation. These can degrade the performance of gamma-detectors. An additional source of radiation background is the gamma-radiation accompanying natural alpha decay that takes place in samples simultaneously with spontaneous fission.

The purpose of the present paper is to study the gamma-radiation spectra emitted by samples of spontaneously fissile nuclides (^{252}Cf, plutonium isotopes), to identify gamma lines in measured spectra that may be attributed to individual fission products, and to assess the possibility of using this information to quantitatively characterize the fissile species.

Description of Method
The study included two steps: experiments with a ^{252}Cf neutron source and experiments with plutonium samples. Gamma-radiation spectra were measured for three ^{252}Cf neutron sources (see Table 1). Californium sources were arbitrarily divided into two types: two *old* sources (fabricated in 1984) and one *young* source (fabricated in 1998). The measurements were carried out using n-type coaxial HPGe-detectors (efficiency 10 percent to 15 percent, energy resolution 1.8 keV at energy 1.33 MeV), and including various filters and shielding materials.

The experiments with ^{252}Cf neutron sources were carried out in various geometrical configurations both with and without shielding layers of borated polyethylene (thickness of polyethylene shielding was 6–18 cm). The time of the measurements was up to eighteen hours. The layout of one experiment with ^{252}Cf-source is presented in Figure 1.

Figure 1. Scheme of measurements with californium source



According to literature data presented in references 1–3, irradiation of Ge-detectors by fast neutrons with energy above 0.5 MeV can degrade the energy resolution and can damage the Ge

Table 2. Some data on plutonium samples

	Mass, g	Form	Date of fabrication	Mass fraction of isotope in plutonium, percent					
				^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu	^{241}Am*
No. 1	569.89	PuO_2	December 29, 1999	1.82	60.47	22.20	10.59	4.84	0.11
No. 2	2,954.93	PuO_2	January 27, 2000	0.12	97.2	2.72	0.061	0.010	2.1E-3
*Data at the moment of sample's fabrication									

crystal. Coaxial n-type Ge-detectors with an efficiency of 10 percent are able to withstand neutron irradiation of integral fluence up to $2 \cdot 10^8$ fast neutrons/cm^2 while similar detectors of p-type can withstand up to $4 \cdot 10^9$ fast neutrons/cm^2. Some experiments described here lasted up to 18 hours. However, no deterioration of energy resolution was observed.

The gamma-radiation spectrum of *old* ^{252}Cf-source No.1 is shown in Figure 2. One can clearly see gamma-lines of fission products (1,596.2 keV of ^{140}La, 1,435.9 keV of ^{138}Cs, 661.6 keV of ^{137}Cs), 387.9 keV line of ^{249}Cf and a peak with energy about 480 keV generated by gamma-radiation accompanying neutron capture in shielding layers of borated polyethylene.

The spectrum of the *young* source also includes peaks of ^{140}La, ^{138}Cs, etc., but the peak of ^{137}Cs is very small (see Figure 2). Therefore it appears that from the relative intensities of the ^{138}Cs and ^{137}Cs peaks the time of source fabrication can be derived, and from the relative intensities of the ^{138}Cs and ^{140}La peaks the intensity of the neutron source can be determined.

In experiments with ^{252}Cf neutron sources, gamma-radiation from some spontaneous fission products was detected, and information was obtained to assess the possibility of analogous experiments with plutonium samples.

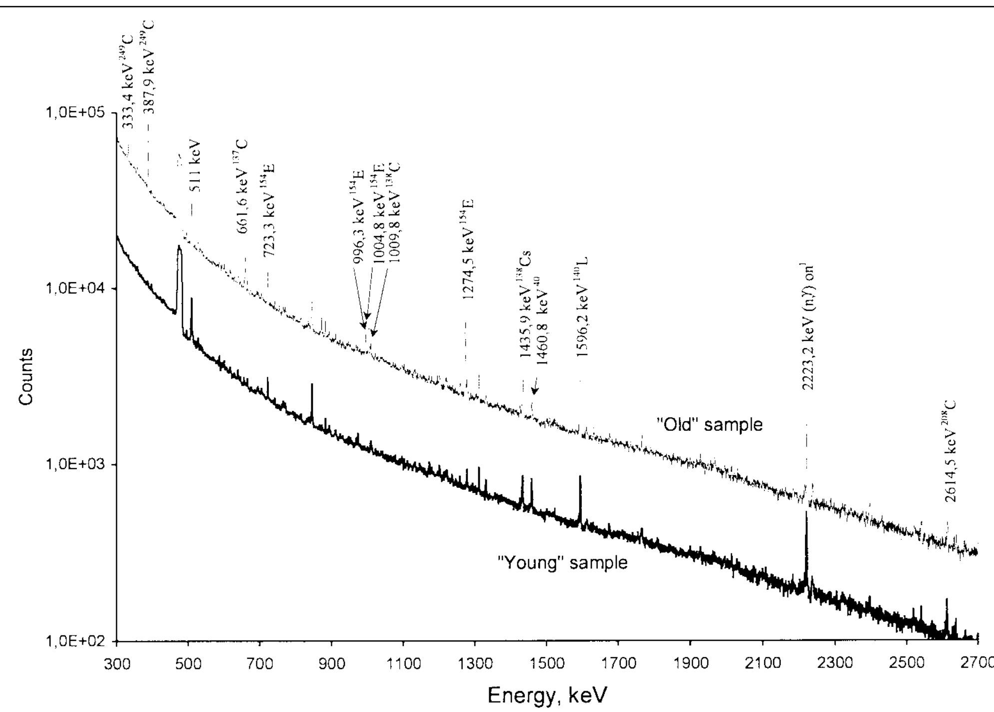
The following experiment was carried out to confirm the correctness of ^{138}Cs identification. A plutonium sample containing 96 percent ^{239}Pu was irradiated in the thermal column of a research reactor. The experiment had two goals:

- Verify the presence of other ^{138}Cs peaks beside the 1,435.9 keV line
- Determine the half life of ^{138}Cs and compare the value obtained with reference data

The measured gamma-radiation spectrum of the irradiated plutonium sample is presented in Figure 3.

As it can be seen from Figure 3, the spectrum contains lines with energy 1,009.8 keV and 2,218.0 keV which belong to ^{138}Cs. To determine the half-life of ^{138}Cs, a series of consecutive measurements was carried out. The intensity of the 1,435.9 keV line decreased with a half-life of 32 minutes, which agrees well with the reference value (32.2 minutes[4]). The experiment therefore confirms

Figure 2. Radiation spectra of two 252-Cf sources: No. 1 (the old one) and No. 3 (the young one). (Measurement time: eighteen hours)



our identification of the fission product ^{138}Cs. This nuclide is generated in the fission process with a high probability (5.98 percent). The quantum yield of the 1,435.9 keV line is 76.3 percent.[4]

The next step of our investigation included measurements of gamma-radiation spectra for unirradiated plutonium samples. Spontaneous fission half-lives of even-even plutonium isotopes are nine orders of magnitude larger than that of ^{252}Cf. So, plutonium samples equivalent to ^{252}Cf in spontaneous fission rate must be larger in mass to the same degree. The mass of ^{252}Cf in the neutron sources used in the previous measurements was about 10^{-7} g. The equivalent mass of a plutonium sample would have to be several hundred grams to obtain the same spontaneous fission rate. The experiments were carried out with appropriate plutonium samples as shown in Table 2).

We would expect that spectral measurements performed on such plutonium samples, would show the presence of lines close in amplitude to the peaks observed in the spectra of ^{252}Cf sources. The self-absorption of low-energy gamma radiation from large samples will be significant. Therefore, only high-energy gamma rays will be of practical interest for determining the fission product content of such samples. The estimations showed that even in experiments with large plutonium samples (about 1,000 g in mass), up to 30 percent of the gamma-rays with energy 1,435.9 keV (^{138}Cs) generated in the volume of plutonium can reach a detector.

In the present experiments, plutonium samples were placed at a distance of 20 cm from the detector to avoid overloading the gamma-spectrometer. The detector was shielded by layers of lead (10 mm thick) and cadmium (2 mm). Such conditions are far from optimal ones. Probably, by placing the samples nearer to the detector and by increasing the thickness of the lead layer, the collection rate of useful information may be increased. Gamma-radiation spectra measured for samples No. 1 and No. 2 are presented in Figure 4.

The spectra contain some as yet unidentified peaks. Below 1 MeV we observe lines belonging to plutonium isotopes and ^{241}Am, while in the high-energy range we see lines of the fission products ^{140}La and ^{138}Cs. The 1,596.2 keV peak of ^{140}La is close to the intense 1,592.5 keV peak of ^{208}Tl (nuclide of ^{236}Pu decay chain). This significantly increases the error in the determination of the ^{140}La peak area. It should be noted that in the experiment with sample No. 2 about 330 counts were registered in the 1,435.9 keV peak, and the statistical error in the results appeared to be 5.41 percent.

Conclusions

Gamma-radiation spectra of ^{252}Cf neutron sources and plutonium samples were measured. In the energy range above 1 MeV, peaks were detected, which belong to certain fission products. These peaks can give information on the spontaneous fission rate in plutonium samples that contain the plutonium isotopes ^{238}Pu, ^{240}Pu, and ^{242}Pu. Such information can be used for determining

Figure 3. Gamma-radiation spectrum of the plutonium sample (96 percent 239-Pu) irradiated in a reactor for thirty minutes. The spectral measurements were carried out ninety minutes after irradiation.

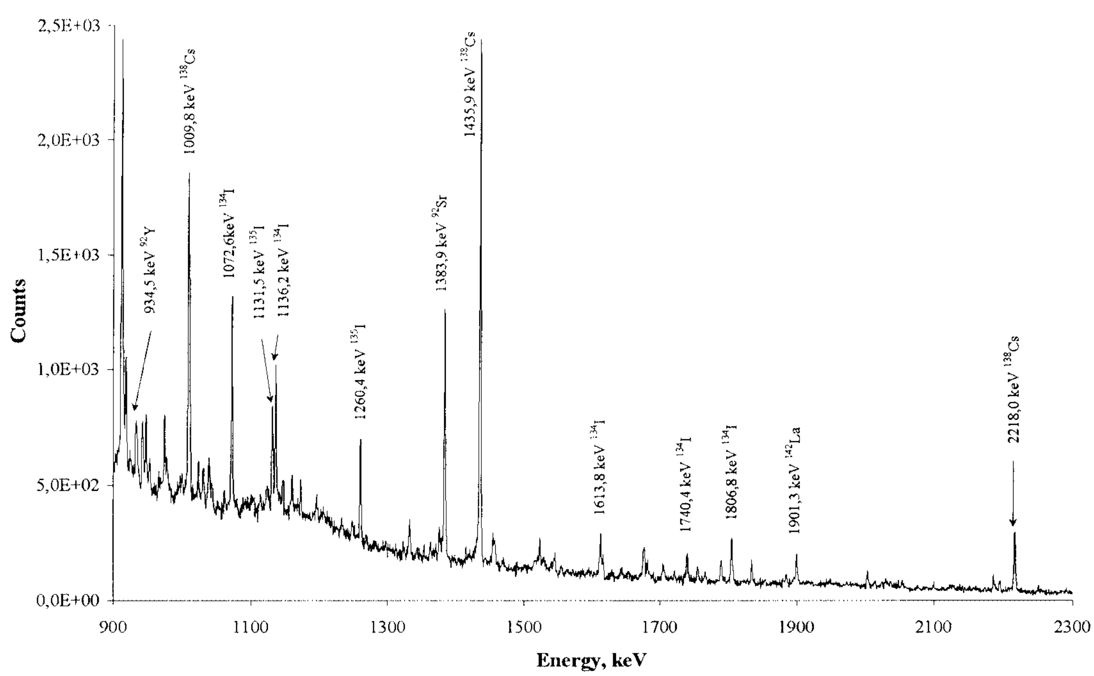
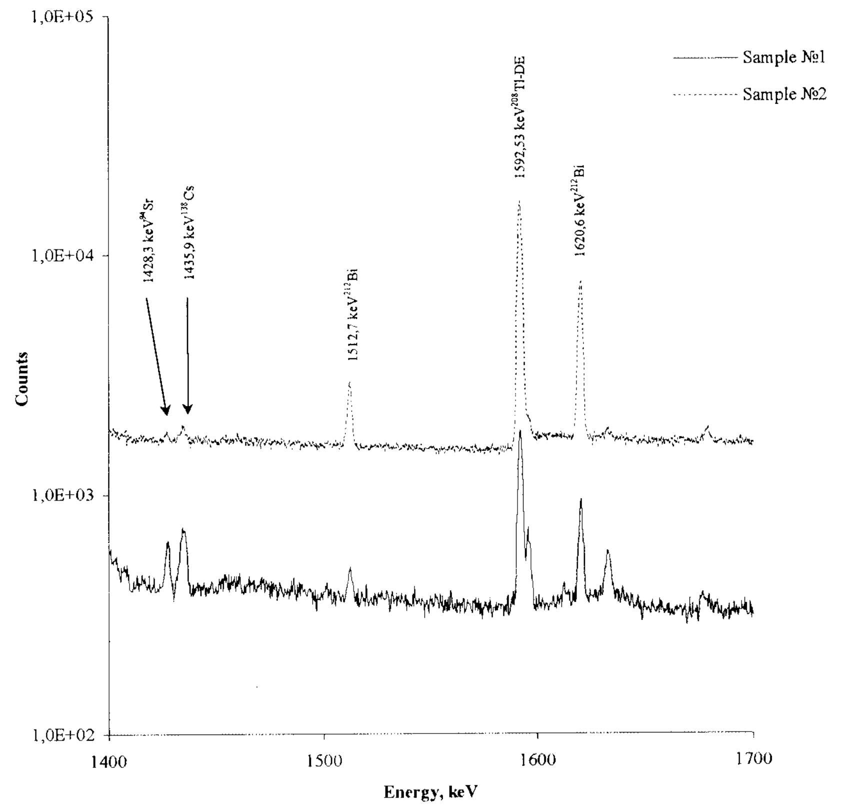


Figure 4. Radiation spectra of plutonium samples (Measurement time: 4,000 seconds)



the plutonium mass in the samples. Usually, to obtain data about plutonium mass in the samples, measurements are carried out using neutron coincidence counters.[5]

Measured gamma-radiation spectra contain peaks from plutonium isotopes that define the isotopic composition of the samples. There is a possibility of simultaneously obtaining all required data about plutonium samples (plutonium isotopic composition and plutonium quantity) from the results of one gamma-spectrometric measurement.

Complete gamma-spectrometric control can be accomplished for plutonium samples of large mass (hundreds and thousands of grams) without removing them from their containers. According to published information, such samples are the most difficult for conducting measurements by conventional techniques (calorimetry, neutron coincidence counters).

The achievable accuracy for the γ-spectrometric method and the range of its applicability will be assessed in further studies.

Measurements of spontaneous fission products might be used not only for plutonium sample control, but some other applications as well. For example, it may be used to calibrate ^{252}Cf sources and to determine their age.

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Nuclear Nonproliferation in U.S.-Russian Relations: Challenges and Opportunities

Vladimir Orlov, Roland Timerbaev, and Anton Khlopkov
Moscow: Center for Policy Studies in Russia (PIR Center), 2002. 288 pp.

By Craig Michael Johnson

It is no longer the post-Cold War, but an entirely new era—post-9/11. How Washington and Moscow should advance nonproliferation, arms control, and disarmament objectives in this new international framework is the subject of a recent study by Vladimir Orlov, Roland Timerbaev, and Anton Khlopkov of the PIR Center, a leading Russian nongovernmental think tank. While studies from U.S. institutes proliferate, U.S. readers have to a large extent been denied comparable analysis from Russians. The PIR Center's monograph *Nuclear Nonproliferation in U.S.-Russian Relations* fills this void by presenting a comprehensive review of nuclear arms control and nonproliferation issues from a Russian perspective. It emphasizes developments throughout the 1990s with an eye toward future challenges, and is invaluable for understanding the development and direction of Russian nonproliferation and arms control policy.

For readers of *JNMM*, the sections on warhead security, materials protection, control, and accounting (MPC&A), and nuclear smuggling are of special interest. Descriptions of poor morale and dilapidated infrastructure of the Ministry of Defense and Minatom are particularly disturbing. In the early 1990s, Russian officials were loath to admit there was cause for concern, but illuminating statements by senior defense officials attest to just how dangerous the situation was. As one laments, "I cannot imagine how people dealing with nuclear weapons… survive… [A] major maintaining nuclear munitions loses his conscience because of hunger."

Nuclear materials security is also addressed, reinforcing the near-universal assessment that MPC&A remains a crucial U.S.-Russian national security program. Unfortunately, the account of the program, while comprehensive, largely draws on U.S.-based reports, offering limited insight into Russian preferences. For example, on the Second Line of Defense Program, the authors note that sites where U.S. officials wanted to install equipment have not always been accepted because Russia had its own set of priorities. What these priorities might be, however, is undeveloped.

Regarding nuclear smuggling, the authors focus their umbrage on sting operations to catch smugglers and on sensationalistic media reports. They note that captured material is often described in the media as weapons-usable, when in almost every case it is not. While these charges are true, there may be cases of nuclear smuggling that have gone undetected. Thus, their recommendation that, "One should proceed on the basis that there are reasons neither for panic nor for removing the issue [securing fissile materials] from the agenda" seems too complacent. The book is more reassuring in its observation that the United States and Russia are working together at a determined pace.

In addition to analysis of nuclear security programs, there are large sections devoted to Russia's involvement in international forums, such as the 1995 and 2000 Nonproliferation Treaty Review Conferences and the 1996 Moscow Nuclear Safety Summit, and development of Russian nonproliferation policy. These portions are informative, place Russian positions in an international context, and perhaps most revealing, underscore Russian sensitivities to maintaining a leading position on the world stage. Yet grand arms control and nonproliferation summits are unlikely to command the role they once did. As President Bush alluded to in his January 2002 State of the Union address, when it comes to preventing certain nations and organizations from acquiring weapons of mass destruction, the United States may be prepared to go it alone.

How this U.S. posture will affect the U.S.-Russian nuclear partnership is not addressed in the study. While the current U.S. administration is less interested in arms control and nonproliferation summits, for nonproliferation efforts to succeed, leadership and cooperation from both the United States and Russia will be required. The partnership, however, is complicated by Washington's paradoxical view of Moscow as both nonproliferation ally and contributor to the spread of nuclear arms. Inadequate control of fissile material, questionable sales of dual-use technology, and uneven enforcement of export controls raise fears that states or terrorist organizations might acquire nuclear weapons or the technological know how from Russia's oversized and underfunded nuclear weapons complex. Yet as Washington alternately courts Moscow's help and points an accusing finger, progress in addressing these issues is strained.

PIR's analysis provides vital insights into Russia's nonproliferation policy and is an invaluable roadmap for understanding how greater U.S.-Russian nuclear cooperation might be achieved.

Craig Johnson is a research scientist with the National Security Division of Pacific Northwest National Laboratory, operated by Battelle for the U.S. Department of Energy. The opinions expressed in this review are his own. He is the author of Russia's Ministry of Atomic Energy: Programs and Developments *(PNNL, February 2000).*

Chapter Reports

Northeast Chapter

A meeting of the Northeast Chapter was held on October 18, 2001, at Brookhaven National Laboratory in Upton, New York. It featured an afternoon panel discussion on terrorist threats. The panelists were J. Indusi, A. Locke, L. Fishbone, E. R. Johnson, T. Fainberg, and R. James. Dinner followed with approximately thirty members attending. Alan Locke, former director of the Office of Analysis for Strategic, Proliferation, and Military Issues, U.S. Department of State, gave a presentation after dinner.

The chapter's Executive Committee met on January 8, 2002, at the Loew's L'Enfant Plaza Hotel in Washington, D.C.

On May 30, 2002, the chapter met again at the Forrestal Building in Washington, D.C. The speaker was David Swindle, vice president of EG&G. He discussed "Challenges to Homeland Security from Radiological Dispersion Devices." About twenty-three people attended.

A reception for the chapter members attending the INMM Annual Meeting in Orlando, Florida, was held June 24, 2002, at the Renaissance Orlando Resort.

Other Activities

The principal emphasis for the year has been to get the student paper initiative started and funded. (See page 4 for more news on this topic.) In December 2001 the chapter wrote to fifteen colleges and universities inviting them to participate in the initiative. Follow-up letters were sent in late April 2002. These letters were intended to introduce the program to university officials so that subsequent follow-up contacts could be made by chapter members.

Officers and Executive Committee Members

President: E. R. Johnson, JAI Corp.
Vice President: Susan E. Pepper, Brookhaven National Laboratory
Secretary: Teri Westerfeldt, U.S. Department of Energy
Treasurer: Bruce Moran, U.S. Nuclear Regulatory Commission
Members at Large:
Billy M. Cole, JAI Corp.
Joseph Indusi, Brookhaven National Laboratory
Martha Williams, U.S. Nuclear Regulatory Commission
Colin Carrol, Sonalysts Inc

Submitted by
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Chapter President
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Pacific Northwest Chapter

The Pacific Northwest Chapter held its winter dinner meeting February 26, 2002, in Kennewick, Washington. Gary Kodman from Battelle in Oliver Springs, Tennessee, was our guest speaker. He provided some interesting facts on statistics, applying them to both our personal lives and the world of nuclear materials management.

The chapter once again supported the U.S. Department of Energy-sponsored Regional Science Bowl for high school students with a donation and several members volunteering as officials for the event. The Science Bowl was held February 23, 2002, at WSU Tri-Cities. Hanford High School in Richland, Washington, was the local winner and went on to the National DOE Science Bowl in Washington, D.C., in May, and placed fifth in the nation. We also supported the Mid-Columbia Regional Science and Engineering Fair this spring.

The Second Annual PNW INMM Putting Contest was planned for this summer in conjunction with our summer picnic/dinner meeting. Also, the chapter is working toward hosting a local seminar here at Pacific Northwest National Laboratory in early fall 2002, providing speakers on various topics related to nuclear materials management.

Elections will be scheduled in the fall 2002. Chapter officers currently are:
President: Rod Martin, PNNL
Vice-President: Glenda Ackerman, PNNL
Secretary/Treasurer: George Westsik, Fluor Hanford Inc.
Executive Board:
Lupe Ellingson, Department of Energy-RL
Mark Killinger, PNNL
Brian Smith, PNNL (Past President)

Submitted by
Glenda Ackerman
Chapter Vice President
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Southeast Chapter

The Southeast Chapter elected new officers and members-at-large in July 2001. They are:
President: Lorilee Brownell, Wastren
Vice President: David Young, DOE-HQ
Secretary: Susan Collins
Treasurer: Edward Sadowski, Westinghouse Savannah River Co.
Members-at-large:
Jane Terrell, U.S. DOE Savannah River Site
Jerry Hickman
Berry Crain, Technical Solutions Inc.
Paul Ebel, BE Inc.

Although the chapter normally elects officers for a two-year period, additional elections will be held this summer to fill the positions of vice president and treasurer. The individuals now holding these position have either relocated outside the Southeast INMM Chapter's area or have assumed additional responsibilities that will affect their ability to function in their elected position.

The chapter has been actively meeting to address ongoing initiatives. The chapter has completed a revision of its charter to make provisions for all interested individuals who are included under the sustaining corporate membership of Westinghouse Savannah River Co. (WSRC) to participate in local chapter activities without joining INMM on an individual basis. The chapter hopes to encourage participation from all interested individuals from a variety of professional backgrounds and environments. Upon final approval of this revision by the chapter officers and members-at-large, the charter revision will be forwarded to INMM Headquarters.

The Southeast Chapter is continuing to develop plans to encourage student participation in both the Southeast Chapter and INMM activities. The chapter is working with the University of Georgia in Athens, the University of South Carolina in Aiken and in Columbia, and Augusta State University in Augusta, Georgia, to solicit interest in preparing and presenting technical papers for INMM annual meetings. The Southeast Chapter is in the process of drafting plans to use chapter funds to assist in providing financial help to chosen individuals (students and professionals) to attend the annual meeting and present technical papers.

The most recent Southeast Chapter meeting was held on May 23, 2002, at a local restaurant in Aiken, South Carolina. More than twenty-five individuals attended this dinner meeting. The guest speaker for this meeting was Jean Aragon, deputy head, Trilateral Initiative Office with the International Atomic Energy Agency. Aragon's presentation addressed "Safeguarding Plutonium at the K-Area Materials Storage (KAMS) Facility at the Savannah River Site."

Submitted by
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Southwest Chapter

The Southwest Chapter held elections in September 2001 to repopulate the chapter Executive Committee, as term limits and new job opportunities led to the departure of the chapter's president, vice president, and two members-at-large. The new Executive Committee is as follows:

President: Donnie Glidewell, Sandia National Laboratories
Vice President: Hiroshi Hoida, Los Alamos National Laboratory
Secretary/Treasurer: Lawrence Kwei, DOE/NNSA/Office of Los Alamos Site Operations
Members at Large:
Stephen Ortiz, Sandia National Laboratories
Grace Thompson, Sandia National Laboratories
Leigh Bratcher, BWXT Pantex
Robert Marshall, Los Alamos National Laboratory

The Southwest Chapter held its annual dinner meeting in Santa Fe, New Mexico, on January 10. Dr. Siegfried S. Hecker, Senior Fellow of Los Alamos National Laboratory and past laboratory director, spoke on "U.S.–Russian Cooperation in the Post - 9/11 World." His thesis is that the events of September 11, 2001, provide an opportunity to re-invigorate the U.S. relationship with the Russian Federation in global nonproliferation initiatives.

Lastly, the Southwest Chapter supported the INMM Executive Committee's student paper initiative by funding travel costs for Aaron Watson, Texas A&M University, and his professor, Paul Nelson, to attend the Annual Meeting. Watson presented "A Tool for Modeling Civil Nuclear Material Quantities in Western Europe and Japan."

Submitted by
Donnie Glidewell
Chapter President
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Committee Reports

Government-Industry Liaison Committee

Speakers for the Closing Plenary of the 43rd Annual Meeting were William Mark Whitworth, Federal Bureau of Investigation; Michael F. Weber, U.S. Nuclear Regulatory Commission; and Anita B. Nilsson, International Atomic Energy Agency. The theme of the Closing Plenary was terrorism and efforts to address terrorism post-September 11 in the nuclear environment.

The GILC met at the Orlando Renaissance immediately following the conclusion of the Annual Meeting Closing Plenary and discussed potential topics and speakers for next year's Closing Plenary as well as ideas for workshops or conferences that would benefit both government and private industry.

The current members of the Government-Industry Liaison Committee are Jim Lemley, chair, Amy Whitworth, vice chair, Peter Aucoin, Robert Behrens, Patricia Comella, Vince DeVito, Tohru Haginoya, John Matter, Bruce Moran, Anita Nilsson, Terri Olascoaga, Brian Smith, Joseph Stainback, Meggen Watt, and Mike White.

Submitted by
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Amy Whitworth
Committee Vice Chair
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Membership Committee

Individuals continue to submit membership applications, and since March, twenty-six new members have been admitted. We have

Technical Division	Ranked as 1	Ranked as 2	Ranked as 3
International Safeguards	12	0	1
Materials Control and Accountability	3	4	7
Nonproliferation and Arms Control	3	7	1
Packaging and Transportation	1	1	0
Physical Protection	3	2	0
Waste Management	1	6	5

also accepted the application of a new Sustaining Member, Gregg Protection Services.

The 2002 directory has been distributed and an electronic version of the directory has been implemented on the INMM Web site at http://www.inmm.org on the members' only area.

The review/approval process regarding application for senior membership has concluded, and eight applications were accepted during this cycle. The new Senior Members are:

Glenda Ackerman
Shirley Cox
Edward Kerr
Larry Kwei
Nancy Jo Nicholas
Susan Pepper
Glenn Vawter
Jaime Vidaurre-Henry

The table on the previous page is an indication of the interest areas indicated by the new members on their application forms. Because individuals can indicate more than one interest area (and usually do), there is not a one-to-one correspondence between the number of new members and the numbers below.

Membership Committee Meeting— Following the practice of the past several years, the Membership Committee held a meeting during the Annual Meeting. Topics addressed included the membership application review process and senior memberships.

New Member/Senior Member Reception—We also hosted our annual reception for new members and new Senior Members at the Annual Meeting.

The current Membership Committee consists of Jill Cooley, Obie Cramer, Bob Curl, Vince DeVito, Al Garrett, Michelle Romano, Larry Kwei, Nancy Jo Nicholas, Takeshi Osabe, Bruce Moran, Don Six, and Grace Thompson.

Submitted by
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Committee Chair
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Technical Division Reports

International Safeguards

During the period July 2001–June 2002, the International Safeguards Division held three meetings. The first meeting was held in connection with the 42nd Annual Meeting of the INMM in Indian Wells, California. The main topic of discussion at this meeting was "Progress Toward the Integration of INFCIRC/153 and INFCIRC/540." This was also the subject of a number of invited papers published in the Summer 2001 issue of the *JNMM*. The July meeting began with presentations by the authors of most of the *JNMM* articles. These presentations were followed by a lively discussion that showed that good progress is being made toward the "new era" for IAEA safeguards. A second topic, "International Verification Beyond NPT," was then introduced. This is a broad subject that includes important initiatives such as the expanding role of verification under the Nuclear Nonproliferation Treaty; the Trilateral Initiative jointly sponsored by the Russian Federation, the United States, and the IAEA; and the proposed Fissile Material Cutoff Treaty. The discussion indicated that there are technical questions yet to be resolved for these initiatives.

In conjunction with the quadrennial IAEA Safeguards Symposium, ISD teamed up with the Vienna Chapter of the INMM to host a dinner meeting on November 1, 2001, in Vienna. Vienna Chapter Chair Shirley Johnson and INMM President J. D. Williams welcomed seventy attendees. ISD Chair Jim Larrimore and Vice Chair Gotthard Stein led a lively discussion that included exchanges with Larry Scheinman about increasing international involvement in physical protection, and with Tom Shea on the Trilateral Initiative and the IAEA's INPRO (International Project). The informal setting fostered an excellent exchange among the attendees.

A third ISD meeting for the year was held on May 27 in conjunction with the 24th Annual ESARDA Meeting at the Congress Centre of the European Commission in Luxembourg. The general topic for the meeting was "Safeguards in Europe and the World." Rudolf Weh and Marc Cuypers presented some ideas and views on the subject and we look forward to a lively discussion.

With the summer 2002 issue of the *JNMM*, ISD continued its tradition of sponsoring the publication of a collection of articles on an important area of international safeguards. For that issue articles were solicited from authors around the world on the topic of international verification beyond NPT. In conjunction with the 43rd Annual Meeting of the INMM in Orlando, Florida, an ISD meeting was held Sunday, June 23. In addition to discussions of the summer 2002 *JNMM* articles, our topic of interest was "Progress and Issues in the Integration of Safeguards."

2002 has been another active year for international safeguards and for the ISD.

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Materials Control and Accountability

The Materials Control and Accountability Technical Division is now under the leadership of Ed Sadowski, of Westinghouse Savannah River Co. Sadowski has been an active member of INMM and a knowledgeable contributor to the MC&A Technical Division for many years. He will certainly be a thoughtful and creative leader for the division.

The past year has been an exciting and productive one for the MC&A Technical Division. At last July's INMM Annual Meeting at Indian Wells California, eighty-seven MC&A technical papers were presented. It was rewarding to see a growing number of non-safeguards presentations relating to planning, management, and disposition of nuclear materials. Of course there were continuing important developments in more traditional concerns of MC&A, such as measurements, accounting systems, and policy.

The 43rd Annual Meeting in Orlando garnered approximately the same number of papers on MC&A topics as last year's meeting. Once again, there was an increase in non-traditional topics, including "Reconfiguration of Nuclear Facilities," "Integrated Nuclear Material Management Systems," and "Developments in Environmental Measurements and Sampling." The environmental sampling session reflects an increasing awareness of MC&A in the context of international nuclear safeguards. This is especially important in light of current events. The sessions on integrated nuclear material management and reconfiguration of nuclear facilities illustrate a level of maturation of MC&A programs and technologies that enable MC&A data to be used, not just for safeguards purposes, but also for management decisions relating to nuclear facilities and nuclear material inventories.

The technical division meeting was held Sunday, June 23. The incoming chair of the MC&A Technical Division, Ed Sadowski, was introduced to division members and oversaw the meeting.

Submitted by
Dennis Brandt
Outgoing Division Chair

Nonproliferation and Arms Control

As previously reported, we have formed three standing committees, and each of these committees has been charged with coming up with ideas for workshops on topical issues related to their charters. At this year's annual division meeting, each of the standing committee chairs introduced their committees to the membership and invited participation in their work.

We have communicated to the division members that one of the functions of the INMM divisions is to conduct workshops. These workshops serve as a method of outreach for the institute, and provide a service to the divisions' constituencies. Through the conduct of workshops we are able to engage the expertise of the division's membership with experts in related fields, to enhance the knowledge and understanding of both. Our divisional goal is to hold a workshop at least once a year. With three standing committees now at work, this goal should be easier to achieve.

This summer we again had a full slate of sessions at the Annual Meeting. One special session will be devoted to proliferation-resistant fuel cycles. Others include one on the cooperative program of Material Protection Control and Accounting (MPC&A) between the United States and Russia, and additional sessions on a variety of arms control and nonproliferation topics.

Submitted by
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Packaging and Transportation

Billy Cole announced his retirement and stepped down as chair of the Packaging and Transportation Technical Division. We wish him luck and many thanks for the recognized contributions he made. During his tenure, Cole was instrumental in growing the division and he left it in very good shape.

Ken Sorenson, Sandia National Laboratories, assumed the role of chair in April 2002. He looks forward to promoting the importance of packaging and transportation issues. Briefly, Sorenson has been involved in the packaging and transportation of nuclear materials for the past fourteen years. He has participated in or managed a variety of tasks, including studies associated with material mechanical behavior, safety of transport of nuclear materials by sea, and risk/sabotage analyses associated with the transport of nuclear materials. He has served on the ASME-NUPACK committee for twelve years and is currently on the editorial board of the *International Journal of Radioactive Materials Transport.* In his present position, Sorenson is the manager of the Transportation Risk and Packaging Department at Sandia National Laboratories.

The efforts of the Packaging and Transportation Division to encourage PATRAM participants to also participate in the Annual Meeting appears to have been very successful, as there are two strong P&T sessions scheduled for the Annual Meeting, up from only two or three papers last year. The division continues to anticipate a strong INMM role in future PATRAM meetings.

Submitted by
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Physical Protection

This year has been an interesting one in the area of physical protection. The events of September 11 reminded everyone how important it is to protect our nuclear assets against terrorist threats. The events of September 11 also had a significant impact on all who work in the area of physical protection. The industry has been busy redefining the threat that facilities should protect against. As the threat is defined, facilities are conducting analyses of how well they are mitigating this threat and then are upgrading their physical security systems as necessary. Once upgrades are in place, facilities must reanalyze to determine if the upgrades are addressing the threat. The September 11 tragedy was a wake-up call for the entire world. The nuclear industry was well ahead of others, as far as protection of its assets. Other industries are taking note of what has been done in the protection of nuclear assets and applying these same principles to areas such as water, chemical plants, and information infrastructure.

One would think that the September 11 events would have opened the doors for training in the area of physical protection, but in fact, the doors have become more controlled. The information provided in training sessions of physical protection is more focused on specific customers and their needs. There is a greater reluctance (understandably so) to provide training in this area in an open forum. Not only is training more controlled, but also information on security that could previously be found on the Internet has been removed from many sites.

These events have had an impact on the Physical Protection Technical Division of INMM. The Physical Protection Technical Division planned to conduct a three- or four-day workshop in spring 2002 on vulnerability assessment methodology. We also planned to conduct a special session at the 2002 Annual Meeting in the area of vulnerability assessment. We planned to follow the Annual Meeting with a one-day workshop on vulnerability assessment conducted by Jim Blankenship, Sandia National Laboratories, and Paul Ebel, BE Inc. We felt that good discussion on this topic could be generated on Friday if the VA technical paper session were held on Thursday. The two workshops were canceled because of national political concerns over the larger issue of what material is being taught. These workshops may be rescheduled at a later date.

Even though the workshops were canceled, two sessions on analytical tools are included at the Annual Meeting. We received several papers that discuss methodology and work in vulnerability assessment. Following the incidents of September 11, there have been major requests for support in this area throughout government and industry. These sessions should be of interest to many attending this year's meeting.

The Physical Protection Technical Division decided to call for papers in two other focus areas. One area is the detection of nuclear materials that may be transportable by terrorists. Technology to detect nuclear materials could be applied to access control points such as airports and shipping ports for detection of carry-on items, or it could be applied to access control points for cargo sent by air, sea, or ground transportation. There were several good papers addressing technology that could be applied in this area.

A second focus area is technology or systems that can be applied to identify potential terrorist movement within a country. This technology or these systems could be applied wherever transactions take place, i.e., purchasing airline tickets, entering/exiting a country, movement within a country, or phone calls. Technologies or systems that may be applicable are biometrics, data mining, video, or profiling. We did not receive many papers in this area, but it may be because no one was really thinking about this too much prior to September 11. I imagine there will be a lot more technology development in this area next year.

The Physical Protection Technical Division sessions at the INMM Annual Meeting continue to grow. We went from four sessions last year to six sessions this year. Security is a very important aspect of nuclear materials management. The nuclear industry understands that synergy between physical security and material control and accountability of nuclear material provides the management system that is both safe and secure. Nuclear materials management cannot be complete without addressing both control and accountability, and security.

Submitted by
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Waste Management

The Waste Management Division held its 19th Spent Fuel Management Seminar at Loew's L'Enfant Plaza Hotel in Washington, D.C., January 9–11, 2002. A total of 130 participants attended the meeting with representation from utilities, vendors, government and international agencies, regulators, national laboratories, and consultants. Attendees were from Austria, France, Germany, Japan, Russia, Spain, the United Kingdom, and the United States. There were a number of representatives of the press in attendance at the meeting and news reports of activities at the seminar were widespread, including *Nuclear Fuel Flashes* and the *Las Vegas Review Journal*.

Arrangements have been completed for Spent Fuel Management Seminar XX to be held at Loew's L'Enfant Plaza Hotel in Washington, D.C. on January 15–17, 2003.

The WMD provided two papers from the INMM Spent Fuel Management Seminar XIX for publication in the *Journal*.

The division chair developed and submitted recommendations regarding strategic planning for INMM. He also participated in the Technical Program Committee meeting on March 5, 2002, in Reno, Nevada.

Six sessions dealing with spent fuel management, waste measurements, and packaging and transportation were organized for the 43rd INMM Annual Meeting in Orlando.

Preliminary plans are being made to hold an international spent fuel management seminar in Japan in May or June 2003.

Submitted by
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News for and about INMM Members

INMM Member Named to High-Level IAEA Post
Another Honored for Contributions to Standards Development

By Scott Vance
INMM Membership Committee Chair

What a great opportunity the Annual Meeting is for members to meet together and discuss the nuclear materials management issues *du jour!* If you were unable to attend this year, I encourage you to begin planning right now to attend next year's meeting. But more importantly, I encourage those of you who did attend but aren't yet members to consider joining. Since you attend the Annual Meeting, you are already familiar with many of the benefits that INMM membership holds—but you are missing out on the reduced registration fees. Remember, to take advantage of these member rates, you must be an INMM member for at least three months before the meeting. So join now and enjoy the discount when registration rolls around for next year's meeting.

As you can see from page 70–71 of this issue, we had forty members join since our last issue. We welcome our newest members, and remind you that if you need to contact a member who has recently joined and isn't listed in the printed membership directory, try locating them through the online directory at http://www.inmm.org. Available only to INMM members, the online directory is an excellent, up-to-date resource.

New Assignment for Kim

One of our long-time members, **Byung-Koo Kim**, was recently assigned as director of technical cooperation for East Asia, Africa, and the Pacific at the International Atomic Energy Agency in Vienna. Kim served as president of the Korean Chapter for many years, and was instrumental in its growth and vitality. With Kim's new assignment, the Korean Chapter is now under the capable direction of Hyun-Soo Park. We wish both of these men all our best, and predict that you will hear Kim's name again as he assumes his responsibilities at the IAEA. We have come to deeply respect his abilities, and know that he will capably represent the international community on issues related to nuclear materials management.

ASTM Honors INMM Senior Member

Another long-time INMM member, **Wanda G. Mitchell**, was recently chosen to receive a 2002 ASTM Award of Merit and the accompanying title of Fellow. This is the highest ASTM recognition for individual contributions to standards activities. Mitchell is a Senior Member of INMM, and serves as the director of the U.S. Department of Energy's New Brunswick Laboratory in Argonne, Illinois. In conveying this award, the ASTM Committee on Nuclear Fuel Cycle cited Mitchell's distinguished leadership in the development of consensus analytical test methods used in the U.S. program for accountability of nuclear materials. Mitchell serves on a number of subcommittees and has been recognized in the past with an Achievement Award and the Harlan J. Anderson Award. Congratulations to Mitchell for this most recent recognition of her contributions to the field of nuclear materials management.

Three Honored with Resolutions

At the Annual Meeting, we took the opportunity to recognize some long-time members and associates of the INMM who we lost this past year. While it is always difficult to realize that a friend that has graced the halls of the Annual Meeting for many years will not return, we are honored to take the opportunity to publicly recognize what they have meant to this organization and what they have personally meant to many of us as friends. This year, Resolutions of Respect were read for **Harley Toy**, **John Arendt**, and **Jean DeVito**. Our hearts and thoughts go out to the families of these dear friends, and, as the inscription reads on each Resolution of Respect, we hope that they are "comforted by the memory of their many worthy deeds, accomplishments, and contributions to our profession and to their communities throughout their lifetimes."

As a special note, the Resolution of Respect for Mr. Toy has been given to Battelle Columbus. The executor of Mr. Toy's estate expressed his belief that Mr. Toy would have wanted it kept there, since Battelle was a big part of his life and was always supportive of his participation in INMM. Doug Trout delivered the resolution to the corporate communications department at the King Avenue facility in Columbus, where it will be placed in a display case.

Stay in Touch

As always, if you have any news about an INMM member, including yourself, be sure to keep your colleagues informed by contacting either me at scott.vance@shawpittman.com or our *JNMM* Managing Editor Patricia Sullivan at psullivan@inmm.org. Please include photographs when possible.

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Aldis Maureen Riddell

Aldis Maureen Riddell died Tuesday, May 28, 2002, in her sleep. Miss Riddell worked on the Hanford Site for twenty-nine years, primarily in nuclear materials control and accounting, including more than twenty-six years with the NMMSS system. Miss Riddell proudly owned Hanford's nearly nonexistent NMMSS error rate. It was her passion to drive it to zero, and she was eager to tell others about her accomplishment.

Miss Riddell was born in Alberta, Canada, and was raised in Richland, Washington, by her adoptive parents, Pat and Vi Riddell, now deceased. She was active in the Richland Assembly of God Church, where she sang alto in the choir. She was a soloist for many years.

Miss Riddell is survived by her long-time companion, Dottie Ross, her nephew Chad Riddell, and her birth mother, Marge Clem.

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Energy Employees Compensation Program Accepting Claims

Some workers at U.S. Department of Energy facilities, at an atomic weapons complex employer, or with a company under contract with the DOE and designated as a beryllium vendor may be eligible for benefits under the Energy Employees Occupation Illness Compensation Program.

The federal act creating the program went into effect on July 31, 2001, and can provide financial and medical benefits to workers in the nation's atomic weapons programs who may have been exposed to radiation and toxic substances and have become ill as a result. Workers, or their eligible survivors, who worked as an employee, contractor, or subcontractor may be eligible for benefits. The federal portion of the program is administered by the U.S. Department of Labor and was enacted to provide compensation to workers with beryllium disease, silicosis, or cancer. A lump-sum payment of $150,000 and medical benefits for the covered disease may be received by employees, or their survivors, whose claims are approved.

Uranium workers who received compensation under Section 5 of the Radiation Exposure Compensation Act are eligible for an additional $50,000 in compensation.

For more information or to file a claim, contact the Energy Employees Compensation Resource Center at 800/861-8608.

INEEL Gets Extra $5 Million to Jump-Start New Nuclear R & D Mission Objectives

In a speech to employees at the U.S. Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL) in June, U.S. Secretary of Energy Spencer Abraham announced a major mission realignment for the lab, establishing the site as the nation's leading center of nuclear energy research and development. Abraham announced that INEEL would receive an additional $5 million in funding to jump-start the transition of the site from Environmental Management to the Office of Nuclear Energy.

The laboratory, which has been managed by the department's environmental management program, will be reassigned to the Office of Nuclear Energy, Science and Technology, where it will become a major contributor to initiatives such as Generation IV nuclear energy systems and advanced, proliferation-resistant fuel cycle technology.

"INEEL will be the epicenter of our efforts to expand nuclear energy as a reliable, affordable and clean energy source for our nation's energy future," Abraham said. "While environmental cleanup remains a priority for us at Idaho, the importance of advanced, safe nuclear energy for the future demands that we return the Idaho labs to their core mission of nuclear technology research, development and demonstration."

DOE Inks Agreement to Ensure Domestic Uranium Enrichment Capacity Is Maintained

The U.S. Department of Energy signed an agreement with the United States Enrichment Corp. (USEC, Inc.) in June that will ensure America's domestic uranium enrichment capacity is maintained and that nuclear materials from Russia will be delivered to the United States.

The uranium delivered to the U.S. will be derived from highly enriched uranium from dismantled Russian nuclear weapons, thereby reducing the inventory of highly enriched uranium in Russia.

The agreement establishes the future development viability and opportunity for both Portsmouth, Ohio, and Paducah, Kentucky, facilities, including as candidate sites for new technology enrichment capabilities as USEC must maintain any of its leased facilities in a manner that permits their future use as a site where new enrichment technology can be performed.

Under the agreement, USEC will take delivery of Russian weapons-derived uranium, deploy a new advanced technology enrichment plant at Portsmouth (by 2010) or Paducah (by 2011), and maintain production of enriched uranium at the Paducah Gaseous Diffusion Plant at a level of 3.5 million SWU per year. This production level can be reduced only after USEC is within six months of completing deployments of new enrichment technology with a productive capacity of 3.5 million SWU.

The agreement also calls for USEC to continue operating the shipping and transfer facility located in Portsmouth for an additional fifteen months to remove technetium from a portion of USEC's uranium inventory.

DOE Issues $3 Million Solicitation for Early Site Permit License Project

The U.S. Department of Energy is proceeding with the next phase of the Nuclear Power 2010 initiative, moving to establish public-private partnerships to share in the cost of selecting U.S. sites for new nuclear plants and for submitting formal applications to the Nuclear Regulatory Commission (NRC) for early site approval.

Successful demonstration of NRC's licensing and evaluation process is a major milestone for developing new nuclear power plants in the United States by the end of the decade.

Under the Nuclear Power 2010 initiative, the DOE proposes to match industry investments of as much as $48.5 million over the next two years to explore sites that can host new nuclear plants; demonstrate key NRC processes designed to make licensing of new plants more efficient, effective, and predictable; and conduct research needed to make the safest and most advanced nuclear plant technologies available in the United States.

NRC established the Early Site Permit process in 1989 for utilities to complete the site evaluation component of nuclear power plant licensing before a decision is made to build a plant. Once issued, the ESP is valid for ten to twenty years and can be used in conjunction with a subsequent combined operating license application to enable the efficient licensing of a nuclear power plant.

More information on the Nuclear Power 2010 initiative and related activities, can be found on the DOE's nuclear energy Web site at http://www.nuclear.gov.

DOE and Idaho Reach Agreement on Pit 9 Cleanup

The U.S. Department of Energy (DOE) announced in April that it has reached a settlement and agreement with the state of Idaho that will significantly speed up the process and reduce the costs of retrieving buried waste from the Department's Pit 9 area at the Idaho National Engineering and Environmental Laboratory (INEEL). In addition, the DOE announced that it has reached an agreement to move forward with a comprehensive technical study of cleanup options for the entire eighty-eight-acre subsurface disposal area at INEEL.

The settlement with the state of Idaho and the U.S. Environmental Protection Agency establishes a $5 million reserve fund that could be tapped by the regulators if DOE fails to meet future commitments on the Pit 9 buried waste retrieval demonstration project. DOE also agreed to pay Idaho $800,000 for likely delays under the previous Pit 9 cleanup schedule.

Under the agreement, DOE will excavate eighty to one hundred cubic yards of buried transuranic waste in the one-acre Pit 9 by October 31, 2004.

The new glove box excavator approach in Pit 9 will allow DOE to complete the excavation demonstration sixty-seven months faster and at 37 percent less cost than was envisioned under the schedule for the old design submitted by DOE to its regulators. Probing work that INEEL scientists and engineers have performed in Pit 9 in recent years to locate and verify areas of contamination supported the decision of DOE and its regulators to use the simpler excavator design, which will be faster from the start of construction to completion of retrieval.

The agreement also sets out a new process and schedule for conducting the remedial investigation and feasibility study of alternatives for cleaning up the entire subsurface disposal area. The new schedule allows for full consideration of the data and operational experience gained from the Pit 9 demonstration project—and will thoroughly evaluate a full range of cleanup options, including removal of buried waste. The cleanup decision is expected to be made in 2007.

NNSA Labs Complete First 3D Simulations of Complete Nuclear Weapon Explosions

Scientists at Lawrence Livermore and Los Alamos national laboratories completed two of the largest computer simulations ever attempted, the first full-system three-dimensional simulation of a nuclear weapon explosion.

The simulations signify the completion of an important milestone in the maturing of NNSA's Stockpile Stewardship program, which is responsible for maintaining the safety, security, and reliability of the United States' nuclear deterrent. Both calculations ran on the ASCI White machine—the world's fastest and most capable supercomputer—at Lawrence Livermore National Laboratory in Livermore, California.

Two years ago, Los Alamos and Livermore scientists completed the first three-dimensional simulations of, respectively, a weapon secondary and a weapon primary, the two stages of modern nuclear weapons. The new simulations build on the experience gained in those achievements to enable simulations of a weapon's complete operation.

Two code teams used different successful approaches to meeting the milestone requirement and both completed their simulations more than two months ahead of schedule. A laboratory-sponsored external review panel of physicists and computer scientists conducted a detailed, independent review of the computational methods and results of these simulations and affirmed the success of both approaches.

This latest achievement is part of the NNSA's Advanced Simulation and Computing (ASCI) effort, which involves NNSA employees, teams from Lawrence Livermore, Los Alamos, and Sandia national laboratories and key partners from the U.S. computer industry.

The first phase of the program focused on development of computers of unprecedented speed and capacity. Now it also sponsors development of new multiple-physics simulation codes needed to identify, diagnose, and correct potential concerns about the aging U.S. nuclear stockpile.

In Brief

Westinghouse to Supply Ukraine with Nuclear Fuel

The Yuzhna Nuclear Power Station in southern Ukraine will begin experimental use of six Westinghouse supplied nuclear fuel cartridges next year, reports say. If the tests prove successful, the U.S. energy giant could be supplying Ukraine with up to forty-two fuel cartridges.

ORTEC Gets Patent for Cooling System

Advanced Measurement Technology, Inc., a division of AMETEK Inc., Paoli, Pennsylvania, announced that it has received a patent for a low-cost liquid nitrogen-free cooling system for high purity germanium (HPGe) gamma-ray detectors.

The newly patented system consists of the ORTEC X-Cooler mechanical cooler and the ORTEC PopTop HPGe detector capsule. The X-Cooler allows the use of commercial off-the-shelf components to reliably achieve the cooling necessary for the operation of the HPG3.

For more information, visit http://www.ortec-online.com/cool.

U.S. to Resume Production of Warhead Triggers

In June, the U.S. Department of Energy announced plans to resume production of plutonium pits used to trigger nuclear warheads. A manufacturing plant, which will cost $2.2 billion to $4.4 billion, depending on capacity, is being designed, a National Nuclear Security Administration statement said.

The plant would start production by 2020. Site selection was scheduled to begin in September.

Currently, the DOE uses refurbished triggers taken from disassembled warheads.

Gotthard Stein

JNMM Associate Editor, INMM International Safeguards Technical Division Vice Chair
INMM Member Since: 1999
Technical Division Affiliation: International Safeguards

Forums such as the INMM can be catalysts for the further development of international safeguards. That's one of the reasons many people, including Gotthard Stein, deputy director of Systems Analysis and Technology Evaluation at the Research Centre Juelich in Germany, are INMM members.

Stein's prime interest is international safeguards. He serves as vice chair of the INMM International Safeguards Technical Division and is an associate editor for international safeguards for the *Journal of Nuclear Materials Management.*

Stein's work focuses on the development of verification technologies, systems analysis for nonproliferation strategies, climate change, and sustainable development and energy. He is also a member of SAGSI (Standing Advisory Group Safeguards Implementation) of the International Atomic Energy Agency.

Stein, who has a Ph.D. in nuclear physics from the University of Bonn, says that climate change calls for a new role for nuclear energy and the development of safe and proliferation-resistant nuclear technology is extremely important in this context. "More research and effort is needed to bring nuclear energy up to a compatible level with the concept of sustainability," he says.

According to Stein, "The new protocol INFCIRC/540 strengthens the effectiveness and efficiency of safeguards and has opened the door for a lot of new technological and institutional innovations. Satellite imagery and environmental monitoring are examples. International safeguards is never static but driven by strong technical and political innovations. To adapt these processes to safeguards research is essential. But since this complex field involves not only technical but also sociopolitical factors, the appropriate research networks have to be interdisciplinary and multi- or internationally oriented."

Stein joined INMM when he took on the role of an associate editor of the *JNMM* in 1999. He is a long-time member of the Europe Safeguards Research and Development Association (ESARDA), a member of the ESARDA Steering and Executive Committee, and he served as ESARDA chairman in 1995. (For more information on ESARDA, see the ESARDA Web site at http://www.jrc.cec.eu.int/esarda/.)

During his tenure on the *JNMM* editorial board, Stein has been deeply involved in the establishment of the *Journal's* peer-review process. He calls the peer-review process "a quantum jump that will enhance the quality of the *Journal* drastically." As part of his duties as an associate editor, Stein helps manage papers through the peer-review process, inviting reviewers, and working with Assistant Technical Editor Stephen Dupree.

Peer review continues to improve the quality of the papers submitted to the *Journal*, even as the *Journal's* peer-review process is refined, Stein says. "Nuclear materials management has many facets and is of an interdisciplinary nature. INMM now offers the authors of scientific papers a reliable forum for publication. The quantity and quality of papers will increase with the broader acceptance of the *JNMM* as a peer-reviewed journal," Stein says.

In addition to his work at the Research Centre Juelich, Stein is a lecturer at the University of Bonn, Polytechnical University Aachen, and is a visiting professor at King's College in London. His teaching focuses on technology and society, and sustainable development and energy.

October 14–18, 2002
Safe Decommissioning for Nuclear Activities: Assuring the Safe Termination of Practices Involving Radioactive Materials
Pro Arte Hotel Berlin, Berlin, Germany
Sponsor: International Atomic Energy Agency
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October 14–18, 2002
Tripartite Seminar on Assessment of Nuclear Materials Content and Inventory in By-product Streams
Obninsk, Russia
Hosts: Ministry for Atomic Energy of Russian Federation and State Research Center of Russian Federation, IPPE
Sponsors: Minatom, U.S. Department of Energy, Joint Research Centre of European Commission, Supported by Obninsk Chapter of INMM
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October 16–18, 2002
Americas Nuclear Energy Symposium (ANES 2002)
The Biltmore Hotel, Miami, Florida, U.S.A.
Sponsor: Department of Energy and American Nuclear Society
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November 4–8, 2002
International Symposium on Nuclear Power Plant Life Management
Budapest, Hungary
Sponsor: International Atomic Energy Agency
Host: Government of Hungary through the Hungarian Nuclear Society
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November 10–14, 2002
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December 2–6, 2002
International Conference on Safety Culture in Nuclear Installations
Rio de Janeiro, Brazil
Sponsor: International Atomic Energy Agency
Host: Government of Brazil in cooperation with Eletrobras Termonuclear S.A. - Eletronuclear and Industrias Nucleares Brasileiras
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January 15–17, 2003
INMM Spent Fuel Management Seminar XX
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May 18–22, 2003
ESTECH 2003, the 49th Annual Technical Meeting of the IEST
Phoenix Civic Plaza and Hyatt Regency Hotel, Phoenix, Arizona, U.S.A.
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