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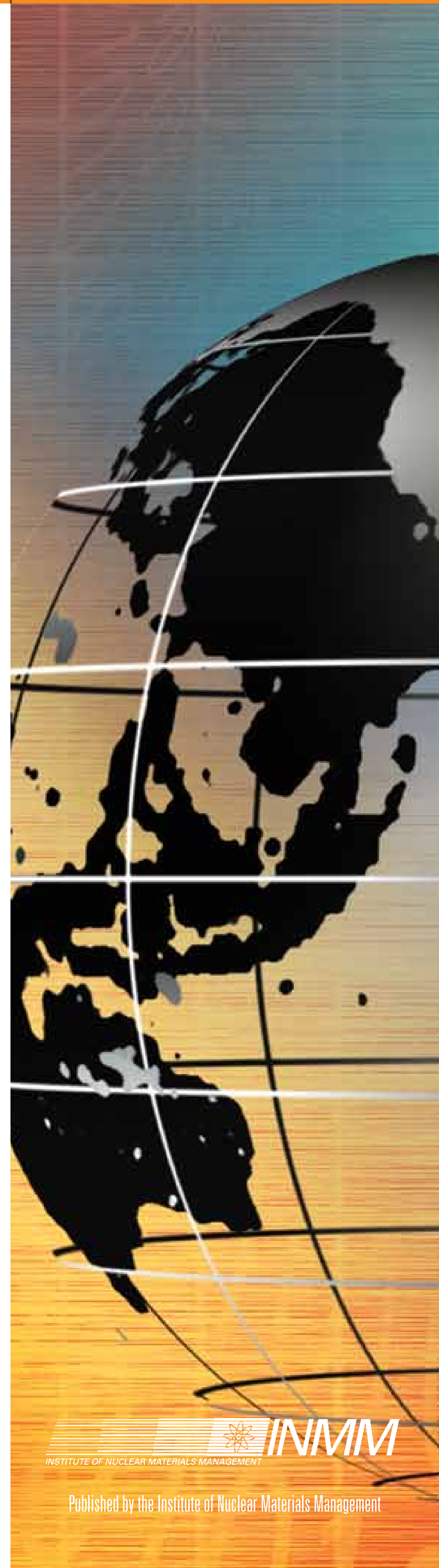

INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

INMM 52nd ANNUAL MEETING

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JNMM Journal of Nuclear Materials Management

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JNMM Journal of Nuclear Materials Management

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On the Availability of Information

By Scott Vance, President

It is with great honor that I address you for the first time as INMM president. Having been involved in INMM for more than twenty years, I have seen many individuals assume this role, and have also become personally acquainted with many of those who served before I was involved. This is very intimidating. There are many talented individuals in this organization, and to assume that I can offer similar services to the organization is humbling. In that regard, for the past two years you have had an individual in this role who cares deeply about the mission of INMM and who took the obligations of this office very seriously. It has been both a great pleasure and extremely informative to work with Steve Ortiz, and I look forward to his continued involvement on the EC as Immediate Past President.

A natural question that you may have is, "What are your goals?" I am reminded of the athlete who when asked asked the same question replied, "To not fall down and embarrass myself." Following in such a long line of talent leads me to hope that I can simply avoid embarrassing myself. Over the next two years, I want to see the Institute fully adopt the new structure that has been approved by the Executive Committee, as this structure will serve as a platform for INMM to remain relevant and vital. I also hope to significantly involve the nuclear utility community. As you know, the EC has been attempting to develop this relationship for some time, and with the resurgence in commercial generation interest, we may be able to finally achieve these goals. I also hope to represent the organization with the respect that it deserves. INMM has been assisting nuclear materials management professionals to prepare for future challenges for more than fifty-one years, and I am proud to present the achievements of INMM to anyone willing to listen.

In that regard, I was recently given the opportunity to represent INMM before an international gathering of nuclear professionals at the IAEA's Safeguards Symposium. Not only was this an impressive gathering of individuals concerned with future challenges associated with nuclear material verification, but I was encouraged to see that a significant percentage of the individuals asked to present papers were active in INMM.

I offered only brief comments to the group, but will take this opportunity to expand slightly on those. As I considered for myself the future challenges to effective nuclear verification, I realized that we may have some of the most significant future challenges of any generation that has considered this question. My basis for this statement may surprise you. I do not make the statement based on world politics, nuclear expansion, or even technological advances; I come to this conclusion based on the realization that we are at the emergence of a complete change in *attitude about the availability of information.*

To illustrate this point, consider a comparison between your parents, yourself, and your children with regard to information expectations. Like me, you may remember the emergence of e-mail and the birth of the ability to instantly send someone a request for information. While e-mail does not guarantee an immediate response, the fact that your request could be instantly transmitted was truly revolutionary. As the Internet continued to expand, often the necessity of e-mailing a request was eliminated because information could be instantaneously downloaded. The concepts of immediate communications and availability of information continue to be somewhat elusive to my parents, but they are actually hopelessly archaic to my sons' generation.

My sons now carry their smart phones and are constantly texting information to their contacts. Like my parents' attitude toward e-mail, I find texting to be more trouble than it is worth. However, my sons expect that everyone they know be constantly and instantly available. This is a complete change in attitude about information availability. My sons do not remember a time when "constant contact" was not the norm.

What does this have to do with nuclear material verification? I suggest that this represents a radical change that will impact the next generation's approach to nuclear security. This is more than just a technological advance; it is a change in expectation regarding information exchange and the acceptability of a delay. I suspect that this change in attitude will have long-term impact on all aspects of nuclear material management that we have not even considered.

I encourage you to become involved in INMM as we seek to confront these impacts and continue to encourage the proper management of nuclear materials worldwide – but do not expect me to text you a personal invitation.

As I begin my term, I would love to hear comments from you regarding how we can make your membership more valuable to you. Feel free to E-MAIL me at savance@tva.gov.

The Loss of a Highly Intelligent Gem

By Dennis Mangan
INMM Technical Editor

The *Journal* staff is sad to inform you that Steve Dupree, our assistant technical editor for many years, has passed away after a long battle with pancreatic cancer. During the last year, his involvement in the *Journal* had understandably dwindled to practicably nothing and his presence was greatly missed. He was an important contributor to the running of the *Journal*, was instrumental in the development of the peer-review process and he corresponded with our authors regarding the reviews of their papers. He also reviewed every issue of the *Journal* and was a valuable participant — he questioned authors' to the last minute, made corrections, and brought a breadth of knowledge and experience that has been highly instrumental and important in running the peer-review process.

Dupree was 68 when he died September 22, 2010, after a courageous four-year battle with pancreatic cancer. He is survived by Patricia, his wife of forty-six years, by his daughter Jessalyn Brach and her husband Jeff, and his son Jason Dupree and his wife Heather; and several grandchildren. He retired from Sandia National Laboratories after twenty-seven years as a Distinguished Member of the Technical Staff. He was named a Fellow of our institute at the 2008 Annual Meeting, an honor that he relished. (See *In Memoriam: Stephen A. Dupree* on page 4 of this issue.)

Just before Dupree's passing, Markku Koskelo of Aquila Technologies agreed to join the *Journal* team and assist in the peer-review process. He has graciously agreed to assume the role of assistant technical editor and has already begun corresponding with authors. We are excited to have him join the staff.

As is normal, this issue of the *Journal* highlights the Institute's Annual Meeting held this year in Baltimore. INMM Technical Program Committee Chair Charles Pietri unfortunately was unable to attend for health reasons and he was sorely missed. Paul Ebel and our new president, Scott Vance, were capable replacements. They were responsible for preparing the report of the 51st Annual Meeting for this issue.

Also included in this issue is the Opening Plenary speech by Gregory Jaczko, chair of the U.S. Nuclear Regulatory Commission, *Nuclear Materials: Current and Future Regulatory Challenges.* Although we did conduct the traditional Roundtable interview with Chairman Jaczko, this issue of the *Journal* does not include the transcript of the Roundtable because of mainly technical difficulties. We are very disappointed about this; we will however continue to pursue getting the transcript ready for a possible release in a future issue. The Closing Plenary Address, *Creating a Next Generation Nuclear Material Security Architecture,* presented by Kenneth Luongo, president of Partnership for Global Security, is also included in this issue. Both of these plenary speeches are interesting reading and provide some key insights.

The three technical papers included in this issue are the first and second place winners of the J. D. Williams Student Paper (Presentation) and the first place winner of the Student Paper (Poster). The first place presentation winner was Karen Miller (a student at Texas A&M and a summer intern at Los Alamos National Laboratory), with a paper entitled *The Uranium Cylinder Assay System for Enrichment Plant Safeguards,* which has always been a challenge for the measurement community. The second place presentation winner was Jamie Warburton of the University of Nevada, Las Vegas, with *Use of UV-visible Spectroscopy to Determine Solution Chemistry Under Used Nuclear Fuel Reprocessing Conditions,* which appears to be a highly complex problem. The winner of the student poster paper was J. Marcial (a student at Columbia Basin College and a summer intern at Pacific Northwest National Laboratory), with a paper titled *Effects of Quartz Particles Size and Sucrose Addition on Melting Behavior of a Melter Feed for High-Level Waste Glass,* which addresses waste vitrification processes for thee Hanford Site.

Also included in this issue is a book review by Walter Kane of Tad Daley's *Apocalypse Never,* which appears to be an interesting book.

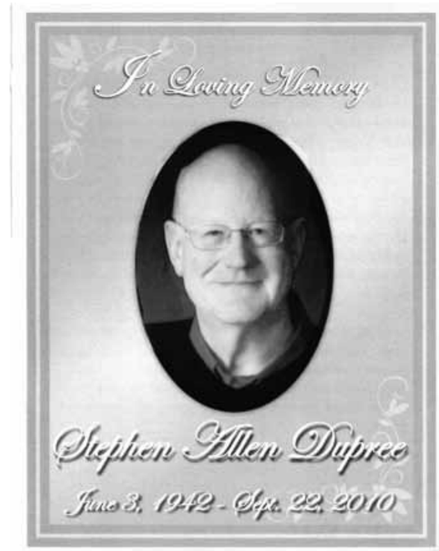
This fall issue also includes a revised format for the Industry News column. Jack Jekowski, our new Industry News Editor, has taken over the column and will be giving his take on the relevant issues in nuclear materials management. I trust you will enjoy reading Jekowski's first such article and we believe this column will become a much more widely read and discussed feature of the *Journal.* We think this is an exciting development and are thankful to Jekowski for his contributions and invaluable insights.

Should you have any questions or comments, please feel free to contact me.

JNMM *Technical Editor Dennis L. Mangan can be reached at dennismangan@comcast.net.*

In Memoriam: Stephen A. Dupree

We are greatly saddened to report the death of *JNMM* Assistant Technical Editor Steve Dupree. Steve was an invaluable part of the *Journal* management team for more than a decade. He was instrumental in developing and improving the *JNMM* peer-review process, communicated with authors, reviewed every issue of the *Journal*, and picked more than his share of nits.



He will be greatly missed by all who knew him.

In 2008, Steve was named a Fellow of the Institute of Nuclear Materials Management. Instead of a traditional obituary, we publish here the nomination letter submitted by Technical Editor Dennis Mangan, along with quotes from two of the endorsement letters that accompanied this nomination.

I am honored to nominate Steve Dupree as fellow of the Institute. He has been a member of the Institute since October 1, 1996, and has been a Senior member since July 17, 2001. He served as the secretary of our International Safeguards Technical Division from 1996 to 2005. Steve has presented many papers at the INMM Annual Meeting, served as session chair, and even flipped slides for a few Annual Meeting speakers. He has published in the *JNMM*, and since 1997 he has been and continues to be, assistant technical editor of the *Journal*. In this position, he has the responsibility to implement the peer review process of the *Journal*. His enthusiasm in leading this peer review process, plus his unbelievably broad knowledge of the technologies of our Institute has led, in my opinion, to a significant improvement in our *Journal* over the years. We would have to hunt to find an Institute member with his broad technical capabilities.

Steve received a B.A. from Rice University in 1964, an M.S. from Texas A&M University in 1965, and a Ph.D. from Purdue University in 1968.

During a forty-year career in science and engineering (initially at SAIC and then at Sandia National Laboratories) Steve has specialized in the detection, measurement, and analysis of nuclear radiation, and the application of radiation transport techniques to technical problems. He has contributed to projects involving radiation shielding, reactor safety and analysis, international safeguards, weapon system development and analysis, and national security issues. He has extensive experience in the development and use of the Monte Carlo method. Steve has worked in systems design and engineering, arms control and verification technology, remote monitoring, systems vulnerability and effectiveness, program planning and management, and strategic planning for technical organizations. He has managed both technical staff and technical projects.

While working in arms control, treaty verification, and nuclear nonproliferation Steve has collaborated with scientists and engineers in many domestic, foreign, and international organizations including DOE and DoD laboratories, the International Atomic Energy Agency, the Russian nuclear institutes, the Argentine-Brazilian nuclear monitoring agency ABACC, and the Argentine nuclear regulatory agency ARN. He served as program manager of the DOE International Remote Monitoring Project which involved cooperative technical work and demonstrations with IAEA support programs and nuclear facilities in Sweden, Finland, Japan, France, Germany, Australia, and Argentina. He was manager of the technical division at Sandia that developed the radiation detection equipment used to support verification of the Intermediate Nuclear Forces (INF) and Strategic Arms Control (START) treaties. He participated in the development of the portal and perimeter monitoring systems for both the INF and START treaties, and worked on sensor development in support of the Open Skies treaty. He was a technical expert for the U.S. delegation to the Joint Compliance and Implementation Commission under the START treaty. He served in Geneva in support of the negotiation of the protocol for use of the radiation detection equipment permitted under the START treaty. Working with the United Nations Special Commission on Iraq at their headquarters both in New York and Baghdad he developed requirements for the remote monitoring system that was used in the UNSCOM on-going monitoring and verification program in Iraq.

Although now retired (2005), Steve continues to serve the Institute in a very important position and he continues to work as a consultant in both domestic and international national security issues and problems in radiation transport and analysis.

To me, Steve is one of our outstanding "silent majorities," and again it is a honor to nominate him as a Fellow of the Institute.

Sincerely,

Dennis L Mangan
Fellow of the Institute
Technical Editor of the Journal

From the letters supporting Steve's nomination as Fellow:

From Donnie D. Glidewell
Manager, Global Security Engagement and International Safeguards Department, Sandia National Laboratories

"Dr. Dupree is a highly respected contributor to the International Safeguards community and a long-time active supporter of the Institute of Nuclear Materials Management. He was a driving force in the success of the International Remote Monitoring Project, which was instrumental in advancing the maturation of remote and unattended monitoring for International Safeguards applications, resulting in improved effectiveness of the International Atomic Energy Agency (IAEA) inspection regime while simultaneously providing substantial cost savings over on-site inspections. His early efforts, often in the face of significant skepticism, directly contributed to the worldwide use of remote and unattended monitoring that is the backbone of IAEA systems today.

Dr. Dupree is very active in the international safeguards community, with major contributions to organizations such as the European Safeguards Research and Development Association (ESARDA), as well as the INMM. As the Official United States Observer on the ESARDA Containment and Surveillance Working Group, he brought focus to the continued development of safeguards technology and enhanced technical collaborations between the European Union, the United States and Canada. This group represents numerous safeguards users (IAEA and the European Union), nuclear facility operators, and safeguards technology developers. These stakeholder groups come together to ensure that everyone understands the needs of the safeguards users and operators, and the current status of technology development. This group has not only developed a Safeguards Compendium, which is accessible by all interested stakeholders via the Internet, but has also contributed to numerous technical articles for the ESARDA Bulletin."

From John C. Matter
INMM Past President and Fellow

"Steve's technical expertise is in the field of nuclear radiation detection, measurement, and analysis. He has applied his experience in this area to support arms control, treaty verification, nuclear nonproliferation, and international safeguards. He was one of first to work on the development and application of remote monitoring to international safeguards, for what has now become an indispensable norm for the IAEA.

Steve was a long time leader of INMM's International Safeguards Division, serving several years as Secretary of that very active group with the Division chairs Cecil Sonnier and Jim Larrimore. He worked long and hard to help establish and conduct the now institutionalized joint INMM-ESARDA periodic workshops on advanced safeguards."

Memorial contributions may be made to:
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Report of the 51st Annual Meeting

By Paul Ebel and Scott Vance

The Institute of Nuclear Materials Management held the first meeting of its second half-century of existence—in other words, its 51st Annual Meeting—in the Inner Harbor of Baltimore, Maryland, USA. Known for its myriad superb restaurants and sightseeing options, Baltimore's Inner Harbor proved to be the perfect setting for an equally superb meeting. While the meeting began with some trepidation because of the unfortunate inability of Charles Pietri, our Technical Program Committee chair for the past twenty-four years, to attend, his planning and hard work prior to the meeting proved to be up to the task and once again the meeting was conducted with several improvements from previous years. And this was despite the fact that attendance and participation were both at record levels.

The setting for this year's meeting was urban rather than resort, but there are advantages to both, and the Baltimore Waterfront Marriott certainly exemplified the advantages of downtown locations. Not only was the physical setting—both the hotel and location—phenomenal, but there were many restaurants and cafes, most featuring famous Maryland seafood, within easy walking distance. The meeting-room setup was much more compact than what is normal at a resort location, so it was possible to transfer from virtually any session to any other in a few minutes. And, given the weather, it was nice to know that you did not have to go outside unless you wanted to. Many attendees commented on the exceptional facility, which enhanced the entire experience.

As usual, activities began even before the actual technical meeting. Sunday morning saw the Institute's faithful golfers brave the heat (a mere high of 92°F) and head out to Waverly Woods Golf Club. Forty-one golfers participated in the tournament this year.

Sunday afternoon, the Technical Divisions held their respective meetings to discuss their purpose, accomplishments over the past year, and sessions during the upcoming meeting. If you have not participated in a Technical Division meeting at the INMM Annual Meeting, we encourage you to consider making your travel plans for next year in a way that will allow you to do so. The real work of the Institute is accomplished through the Technical Divisions, and these annual division meetings are a great way for you to get involved in the area that interests you.

The first major event of each year's annual meeting is the President's Reception on Sunday evening. This year's reception, as is our usual practice, was held in the Exhibit Hall, allowing attendees to greet acquaintances whom are often only seen once a year at the Annual Meeting, as well as peruse the various booths highlighting those vendors who support the mission of INMM. This year's Exhibit Hall housed a total of twenty-nine vendors, three of whom were exhibiting at INMM for the first time. The reception was well attended and offered a great initiating event for the 51st Annual Meeting. The President's Reception was also the first introduction to the quality of food that the Baltimore Waterfront Marriott offered—the hors d'oeuvres were excellent, and proved to be only the beginning of exceptional food offered during the week.

Following the President's Reception was a mixer for student attendees. Responding to comments from previous meetings, a determination was made that the meeting mentor process that had been used for the past several years had been helpful to student attendees when there were fewer of them, but as the number of students grew it became less and less beneficial. Knowing that this year's student attendance would likely surpass all previous years—in fact, 148 students registered for the meeting—a different type of event was organized. All student attendees were invited to the mixer to meet other student attendees as well as other INMM members. This allowed students to discuss their interests with a variety of INMM members as well as ask any questions that they had about the Annual Meeting and careers in nuclear materials management.

The INMM Annual Meeting officially began Monday morning with a plenary speech from the Chair of the U.S. Nuclear Regulatory Commission (NRC), Gregory Jazcko (pronounced, as explained by Jazcko, "just like the yachts out in the harbor," or yachts-ko). More than 1,000 attendees were present to hear Jazcko's address, *Nuclear Materials—Current and Future Regulatory Challenges.* In his talk, Jazcko addressed both the traditional focus of the NRC's security work, safeguarding special nuclear material, as well as the more recent increased focus on source security. In regards to safeguards activities, Jazcko discussed the NRC's efforts to prevent diversion of domestic nuclear material, through physical protection measures and materials control and accounting (MC&A) programs, at not only potential new reactors, but also at new fuel cycle facilities that are actually beginning production. Some of these new facilities present some unique proliferation and protection concerns. In regards to security, he discussed the particular emphasis that has been placed on the security of radioactive sources since the September 11, 2001, attack on the United States. Finally, Jazcko discussed how imperative it is that regulators understand the need to integrate safety and security measures to ensure that they do not conflict. He challenged attendees to participate in finding appropriate solutions to questions regarding this safety-security interface.

In addition to his presentation, Jazcko participated in the *Journal's* annual Roundtable, where he responded to questions from invited participants. This was an interesting discussion, and he provided additional insights into his perspective of the role of the NRC in promoting safeguards and security, both domestically and internationally.

Following Jazcko's address, the *heart* of the INMM Annual Meeting began with the start of the concurrent sessions. As you know, it is during these concurrent sessions that the work of meeting attendees is highlighted and where valuable discussion takes place in regards to nuclear material management "best practices." This year's meeting saw a total of seventy-two concurrent sessions, a record number.

Reports from the sessions chairs, who hosted more than 530 papers presented, indicate that, once again, a great deal of valuable information was shared regarding the newest advances and future plans regarding the appropriate management of nuclear material. The Proceedings from the Annual Meeting will be released soon, and you will find it to contain information covering virtually every aspect of safeguarding, securing, protecting, detecting, accounting for, packaging, transporting and the disposition of nuclear materials. Total attendance was a record of 1,189 (compared to 1,060 for Tucson in 2009) including 148 students—another record. Of the 530 papers that were presented, forty-seven were student papers—a record breaker over the previous nineteen. Unfortunately, there were also six "no-shows." This problem continues to plague and amaze us—why anyone would not notify INMM of their intention not to present their paper? We also had sixty paper withdrawals, which was about normal and thirty-three papers were presented by other than the original author/speaker who could not personally attend the meeting.

As usual, our session chairs did an exceptional job of attempting to keep the presentations within their allotted time. This is not an easy task, and if you have never had the opportunity to be a session chair, you may not appreciate the lengths that some chairs must go to in order to maintain the schedule. We stress to the session chairs during the Speaker's Breakfasts each year that their primary task is ensuring that the presentations begin and end on the schedule that is published in the final program. This is imperative because few attendees actually sit through an entire session. Rather, most select a variety of papers throughout the session time that they desire to attend, and therefore rush from room to room in order to participate in these sessions. Because of this, it is very important that the sessions are truly "concurrent. That means that if a speaker only takes twelve minutes instead of the allotted twenty, or, even worse, a paper is removed from the program completely, the session chair must quickly figure out a way to fill this time so that the audience remains interested and the subsequent paper begins as scheduled. We offer kudos to those chairs who creatively convened panels of the speakers who were present or initiated general audience discussions in order to maintain the published schedule. There were several reports of this at this year's meeting, and we appreciate it much more than we express.

Of course, there is the occasional opposite extreme, the case where the presenter attempts to take twenty-one (or twenty-five) minutes to make their presentation. However, these are getting fewer, and, again, we appreciate the session chairs who asserted their authority and politely told presenters that their time was up. While this prevents any questions from being asked, it is again imperative that the schedule be maintained as much as possible. One tip for future session chairs—we received the report that an effective way to get a speaker to truly end their session when they had exceeded their allotted twenty minutes is to simply stand up. Apparently, while the little red light on the timer is not convincing, the session chair standing next to you at the podium conveys the message that it is time to quit in any language.

In regards to the amount of time taken by a presenter, we cannot emphasize enough that often times the most valuable information is passed during the question and answer time. Several session chairs indicated that the questions asked after the presentations either significantly clarified or expanded the points made during the actual presentation. That is how it is "supposed to work," and this is not possible unless the speaker plans on taking only about fifteen minutes of their allotted time for the actual presentation. Again, make a mental note as you prepare your presentation for next year's Annual Meeting.

From all of the reports, the new method of uploading and distributing the presentations was an absolute success. The indications are that it took a lot of stress off of the session chairs, as this process was all handled outside of the actual presentation room and transparent to the chairs. We also received several reports of incidences where the professional audio-visual crew that was staffing the Annual Meeting responded quickly to requests for assistance when things were not working correctly. One consistent comment that we have heard loud and clear is that the session chair needs to be able to see the screen; this is sometimes almost impossible simply due to the configuration of the room, but we have heard the comment and will do our best to make sure that this is accomplished at next year's venue.

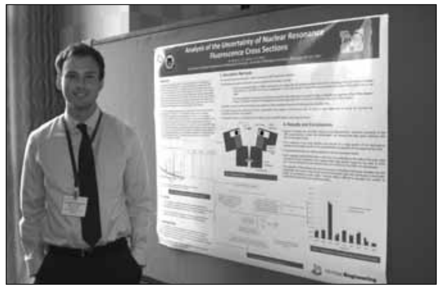
Following the first day's technical sessions, the annual reception for new members and newly-advanced Senior Members was held. This is a great opportunity for those who have joined INMM within the past year, many of whom are student members, to mingle with individuals who have recently been recognized for their commitment to INMM by advancing to the grade of Senior Member. By joining these two groups in a single recognition reception, new members can discuss the benefits of membership and opportunities for involvement with those individuals who have demonstrated by their own actions what benefits and opportunities exist.

Tuesday morning began with the traditional fun run, although many people again questioned the oxymoronic qualities of that name for the event. Nonetheless, thirty-one true running radicals braved the early morning heat and coincidental rain shower to conquer the 3K loop around the Inner Harbor. More importantly, the entry fees collected from the runners, as well as a few additional donations given during the week, resulted in INMM forwarding $700 to the Division of Pediatric Oncology at the Johns Hopkins Kimmel Cancer Center. We appreciate everyone's generosity to this organization.

In addition to the presentations, this year's meeting included the traditional Tuesday opportunity for individuals to present their latest work in the form of a poster. Unique to this year, however, was the placement of the poster session immediately outside of the exhibit hall in the ballroom foyer. This was a fantastic setting, and attendance at the poster session was very good since it was almost impossible to miss the posters as you traveled between various concurrent sessions. Twenty-eight individuals took advantage of this alternative means of highlighting their work, which gave them the opportunity to speak in more depth to those who were interested in their findings. The quality of the posters themselves continues to improve as well, and the newly updated guidelines regarding the appropriate format of posters for the Annual Meeting appears to be working, as the overall quality was very good. The presenters were there throughout the mandatory time and we did not hear any negative feedback on the process—we believe people liked it judging from the number in attendance. Unfortunately, there were two no-shows.

At 6 p.m. Tuesday evening, the Annual Business Meeting was held. Not only is this meeting open to all the membership as required by our bylaws, it is an opportunity for the Executive Committee to present the year's activities and invite any questions or discussions regarding future plans. Even though it is unfortunately often not well-attended, the Executive

Figure 1: William Wash, a student from University of Michigan, at the poster session



Committee actually looks forward to this meeting each year and hopes that more of the membership will decide to attend in future years. As a side observation, one of the most important aspects of this year's meeting was the discovery that, in future years, a phone call immediately prior to the meeting to Treasurer Bob Curl, is probably in order.

Following the Annual Business Meeting, the Reception and Annual Awards Banquet began. Once again, the hotel proved that preparation of an exceptional meal for about 700 guests is possible. The entire meal, from the salad to the final coffee service including biscotti, was as good as that available in any first class restaurant. Kudos are also due to our headquarters staff, who each year must provide the hotel with a "final count" of the number of guests expected. There is much more of an art to this process than a science, and sometimes we can be surprised by the final number; some of you may remember last year's scramble to accommodate an additional forty guests as the banquet started. This year, however, our experienced staff provided a final count that turned out to be only six individuals different from the actual attendance, truly an amazing feat.

While the meal was a hard act to follow, President Steve Ortiz had the pleasure of awarding several members with well-deserved honors. Susan Pepper was advanced to INMM Fellow, in a well-deserved recognition of her commitment to INMM and impact on the field of nuclear materials management. Vincent J. DeVito Distinguished Service Awards are designed to recognize either INMM members or nonmembers for their long-term

Figure 2: Happy times at the Annual Awards Banquet

noteworthy service to the nuclear materials management profession. Both Donnie Glidewell, Jr., and William Hopwood, Jr., were so recognized at this year's meeting. Special Service Awards focus on noteworthy contributions to the industry or INMM, and can be awarded to a person, laboratory, or business that has advanced the knowledge and professionalism of the nuclear materials management field. William Charlton was recognized not only for his significant contributions to the field of nuclear materials management in general, but also for his instrumental involvement in the formation of INMM's first student chapter at Texas A&M University. Finally, INMM's Meritorious Service Award focuses on INMM members' long-term outstanding contributions to the Institute as well as the individual's noteworthy accomplishments and contributions to the profession. This year's award ceremony not only saw this award given to Ed Johnson, but Steve Ortiz also announced that the name of the award has been officially changed to the Edway R. Johnson Meritorious Service Award. Following the awards ceremony, the dance floor was opened and the real partying began. Another important lesson for future meetings is that as the student attendance at the Annual Meeting increases, we are going to have to allow for a corresponding increase in the size of the dance floor. The number of individuals who stay after the banquet continues to increase, and it was good to see a large crowd enjoying this year's DJ. And stay tuned for next year—discussions are underway to really change the program next year. We hope to convince even more to stick around and take advantage of the after-meal festivities.

However, many of us also find (make!) time to get away from the meeting one evening for a karaoke event with John Feng, our Taiwan Power representative. Everybody gets into the act!

Figure 3: The Dancing Queens in action

Each morning before the technical sessions began, the Speaker's Breakfast offered an opportunity for speakers to meet the chair of their session and ask any last-minute questions about how the session would be conducted. Because of the new method for loading presentations onto the presentation computers, the traditional "mad rush" to get all of the papers loaded and confirm that they display properly was unnecessary. Paul Ebel once again offered a stimulating reminder to attendees about the most important aspects of giving a good presentation, and concentrated most of his training time this year on the session chairs rather than the presenters. While Charles Pietri was missed from the entire meeting, his absence from the breakfast was most profound—he normally offers a morning welcome and is able to ensure that the speakers and session chairs are awake and ready to begin their sessions. Everyone is anxious to see him back at his post at next year's meeting.

The Student Career Fair was held on Wednesday evening, and this event continues to improve and expand every year. This year's fair saw the inclusion of several Human Resources officers, and a total of twelve companies provided booths to introduce students to available careers. Rather than take any time for general announcements, this year's event was focused purely on giving participants the opportunity to talk to recruiters. Even so, time went quickly and discussions continued after the fair was officially over. This opportunity to meet company representatives who are actively hiring in the field of nuclear materials management is one of the most valuable benefits INMM offers to students who attend the Annual Meeting.

The Closing Plenary on Thursday afternoon was presented by Kenneth Luongo, president of *Partnership for Global Security,* an organization dedicated to a global effort to decrease the dangers posed by weapons of mass destruction by working for a world in which they are secured and the threat of their use is eliminated. Luongo's presentation, *Creating* a *Next Generation Nuclear Material Security Architecture,* was attended by more than 200 participants, and he offered interesting insights.

Following Luongo's presentation, Ortiz officially brought the 51st Annual Meeting to a close. By all measures, the meeting was a unqualified success, and the credit goes to incredible and thankless work by Pietri and the entire Technical Program Committee, as well as (and possibly more importantly) to all of the individuals who agreed to present their latest work related to nuclear materials management. There would be no Annual Meeting if not for their willingness to present, and the INMM Executive Committee and Annual Meeting Technical Program Committee cannot thank them enough for doing so.

An interesting comment was made during the meeting that the meeting content did not seem to include a lot of discussion regarding the intersection of technology with nuclear policy, and there was a desire to see more of this at future meetings. This comment was made just shortly before numerous individuals commented on a paper that they felt was "policy oriented and had no technical content." In fact, as always, there was a significant number of presentations that discussed very technical aspects of nuclear material management—from the design of new detection equipment to new methods for determining the isotopic content of containers. At the same time, there were numerous sessions regarding the policies that need to be enacted by governments to ensure that those who are tasked with managing nuclear material do so in a manner that prevents its loss or diversion. But, there were also numerous presentations at this year's meeting that specifically dealt with the intersection of these two—in other words, how technology can support the fulfillment of policy goals, and, conversely, the reasonableness of policy goals given the current state of technology. However, that is not to say that there could not be more of this type of discussion, and we look forward to suggestions from individuals regarding how the Annual Meeting can have additional discussions in this area.

Several times in this report, the fact that this year was a record year has been mentioned. Most importantly, there was record attendance, with 1,189 registrants. Because we have seen tremendous growth in the past few years and expect this growth to continue, we have initiated serious discussions regarding how we intend to accommodate this growth in the future. While there are many options, all of them have good and bad aspects. For instance, there is always the option of adding more concurrent sessions—but attendees complain that there are already too many competing papers that they want to attend. In addition, we are limited by the size of the host hotel on how many meeting rooms we can occupy at any one time. As discussed earlier, there were a few sessions at this year's meeting that had twelve concurrent sessions running, and that is about the maximum number that we can expect to accommodate.

Another common suggestion is that we expand the meeting to include Friday morning. This would allow for an additional set of concurrent sessions Thursday afternoon. The problem with this option is that our Annual Meeting is already one of the longest professional meetings—many are three days in length. As it is, most attendees must take at least one day of their weekend to travel to the meeting. If the meeting was expanded to Friday, full participation may require traveling on the following weekend as well. There are serious concerns that this would further degrade attendance at the final session.

Some additional options have been discussed and may offer some alternatives. One is to offer more panel sessions, where there is the opportunity for more people to participate in the discussion than can be accommodated during a typical session with each individual being given twenty minutes to present their paper. These panel sessions might be centered around a "hot-button issue" concerning a Technical Division.

Having stated all of the negative aspects of these suggestions, there is an understanding that there is no perfect option. All of the options discussed above, as well as others, are being considered. Something that would be very helpful as we plan for future meetings is to hear from those who regularly attend the meetings regarding what they see as options for accommodating additional participation at the meeting. If you have any ideas, we would love to hear them.

INMM is thankful for the leadership of Ortiz as president for the past two years—he steps down at the end of September 2010 and hands the mantle to Scott Vance.

Figure 4: Outgoing INMM President Steve Ortiz and his new bride, Patricia.

Figure 5: Incoming INMM President (October 1, 2010) Scott Vance and his charming wife, Debbie.

Now, start thinking about the 52nd INMM Annual Meeting to be held at the Desert Springs JW Marriott Resort in Palm Desert, California, USA, on July 17–21, 2011. Start planning for it now by completing your research, getting your subject approved by management in a timely manner, writing your abstract, and submitting it by February 1, 2011. Then write your paper and submit it early—certainly no later than the June 9, 2010, deadline.

IMPORTANT! We expect another record-breaking participation in 2011—be sure your abstract is submitted on time as well as your paper. Latecomers may be disappointed when the technical program fills up early. Remember, for those of you who are planning to organize a special session, you need to contact Charles Pietri at cpietri@aol.com and be prepared to attend the Technical Program Committee review meeting in March 2011. There are no exceptions!

On behalf of INMM President Scott Vance and myself, we look forward with great pleasure to your presence at the 52nd Annual Meeting next year—be there, all your colleagues will be!

Nuclear Materials: Current and Future Regulatory Challenges

Opening Plenary Speech at the Institute of Nuclear Materials Management Annual Meeting
Baltimore, Maryland USA
July 12, 2010

Gregory B. Jaczko, Chair
U.S. Nuclear Regulatory Commission

Thank you for the introduction. I am honored to be here today at the Institute of Nuclear Materials Management's 51st Annual Meeting to share my thoughts on some of the important regulatory issues before the Nuclear Regulatory Commission (NRC). For over half a century, the Institute has been dedicated to advancing safe and secure management practices and promoting professional excellence among materials management professionals. You can justifiably take great pride in the Institute's past accomplishments. I was pleased to read in the message from your Vice President Scott Vance about this organization's commitment not to rest on its laurels—to achieve even more in the next fifty years than it did in its first half century. That is exactly the kind of approach that everyone in the nuclear field—regulators, licensees, and stakeholders—should maintain as we to seek to advance our shared safety and security objectives.

Since the 9/11 attacks, the NRC and its licensees have made tremendous progress in strengthening our regulatory framework for security. The NRC created a separate new office to focus on security, incident response, and emergency planning issues; significantly increased the budget for security issues; and implemented a large number of physical security upgrades, cyber initiatives, and enhanced materials control and accounting measures. To support this work, the NRC also has coordinated with federal, state, and local agencies, as well as received support from the intelligence and law enforcement communities.

Over the past decade, all of the policy changes and increased coordination have contributed significantly to the enhanced security framework that we have today. Those changes would not have been possible without the commitment by the NRC to stay attuned to the dynamic threat environment and to implement the necessary regulatory programs in response. Despite the considerable progress that has been made toward greater security, it remains as vital as ever that both the NRC and its licensees not become complacent, and maintain a proactive approach in the future.

With that in mind, this morning I will discuss a number of important initiatives underway that reflect the Commission's continuing focus on guarding against security threats and our intention to maintain that strong focus in the future. I'll first discuss the traditional focus of our security work—safeguarding special nuclear material—and then discuss source security, an area of growing focus for the agency during the past decade.

The NRC's domestic safeguards program has two primary aims: 1) ensuring that special nuclear material within the United States is not stolen or otherwise diverted from civilian facilities for nefarious purposes; and 2) limiting the possible risk of radiological sabotage of a facility or transport. Through the agency's licensing reviews and oversight programs, the NRC is responsible for ensuring that licensees have the technical and administrative capabilities necessary to implement our security and safeguards requirements. The NRC also has important responsibilities in reviewing export and import licenses for nuclear material and equipment. In consultation with the Executive Branch, the Commission must consider whether the importing country has the technical and administrative capability, as well as the resources and regulatory structures in place, to manage the material and equipment in a safe and secure manner.

In terms of our domestic licensees, the NRC's requirements primarily take two forms—physical protection measures and material control and accounting programs. The NRC's physical protection requirements for reactors, fuel cycle facilities, and spent fuel storage facilities are based on the type of the facility, the quantity of the material, and the overall level of risk. In order to determine the adequate level of physical protection, the NRC monitors intelligence information through its threat assessment program to stay alert to the capabilities of—and threats posed—by potential adversaries. This information helps us establish the design basis threats—the threats and adversaries that these facilities are required to protect against—and determine the adequate level of physical protection.

The second pillar of the NRC's domestic safeguards programs is material control and accounting for special nuclear material. The NRC and DOE have worked together effectively to deploy a national accounting system for special nuclear materials aimed at preventing or detecting their potential loss. This database—the Nuclear Materials Management and Safeguards System—contains current and historical data on the possession, use, and shipment of this material within the United States, as well as all exports and imports of such material. These control and accounting measures help us verify that these materials have not been stolen or diverted to unauthorized users.

That is a very general view of the two main security strategies that the NRC employs to safeguard nuclear facilities and material. The specific rules and requirements that we put in place, however, have to remain responsive to the dynamic threat environment. The NRC has to ensure that its security framework remains effective as new issues emerge for existing facilities and as potential new facilities raise different challenges. The NRC remains focused as ever on the safety and security of the existing reactors and facilities, but at the same time, we also are working to ensure that we have the staff, expertise, and regulatory framework we need to assure the safety and security of potential new facilities. In the coming years, it is quite possible that the NRC will be responsible for regulating a larger number of reactors and fuel cycle facilities employing a broader range of technologies than at any point in the agency's history.

The potential for new reactor construction receives the lion's share of attention among much of the public and many of our stakeholders. It might surprise some to learn that new fuel cycle facilities, however, are at a far more advanced stage of development at this point. While it will be several more years before the first potential new reactor is constructed and enters operation, the NRC just last month gave its final approval to one licensee to begin operation of a new gas centrifuge enrichment facility. Additionally, two other gas centrifuge facilities, a mixed oxide facility, and a laser enrichment facility also are at various stages of development. The security concerns posed by these facilities—including the potential dual-use nature of the enrichment technologies—makes it imperative that the NRC maintain a strong focus in this area and develop the necessary resources for overseeing these new facilities.

Under the current regulatory framework, the required level of physical protection for fuel cycle facilities depends on the facility type, as well as the type and quantity of special nuclear material at the facility. This framework is based on the agency's categorization scheme for special nuclear material, which has been in place for nearly thirty years. The agency has to continually reevaluate and ensure that our approach remains effective in light of the dynamic threat environment for existing facilities and the potential expansion in the number and type of facilities. Toward that end, the Commission recently approved the development of the technical basis for a proposed rule to revise the categorization scheme. The revised approach—a material attractiveness approach—would consider additional factors in determining the risks that special nuclear material might be diverted for a nefarious purpose.

Also, just in the past year, some have raised potential proliferation concerns about the planned construction of a new laser enrichment facility. Specifically, the smaller footprint and lower energy needs of the laser enrichment technology have been the cause of concern. The proposed civilian facility is the first of its kind in the United States, and makes it distinct from anything the NRC has licensed in the past. As the agency moves forward with the licensing review of the proposed facility, the agency will proceed carefully to ensure that it is taking the right approach to not only assuring the protection of the material but also preventing the theft or diversion of information about the facility.

The potential security concerns related to special nuclear material have long been at the forefront of our security initiatives. It is safe to say, however, that in the years since September 11, we have developed a better appreciation of the potential security concerns posed by radioactive sources. The sheer number of materials licensees—approximately 3,000 NRC licensees and approximately 19,500 Agreement State licensees—creates challenges in securing these sources, as does the fact that these sources are geographically dispersed across the country, and are used for a wide variety of purposes—from treating millions of medical patients each year to the industrial functions they serve in the energy and construction industries.

The NRC chairs an interagency Radiation Source Protection and Security Task Force that evaluates and provides recommendations related to the security of radiation sources, including protection from potential terrorist threats. The interagency group is finalizing the 2010 Report to the President and Congress and looks forward to reporting on the substantial progress that we have made since our 2006 Report.

Among the key accomplishments that I expect the report to highlight is the launching last year of the National Source Tracking System (NSTS) by the NRC. The NSTS is a secure, Web-based national registry that tracks radioactive sources from the time they are manufactured or imported through the time of their disposal, decay, or export. Prior to the development of this system, there was no single U.S. source of information to verify the licensed uses, locations, quantities, and movements of these materials. Separate NRC and Agreement State systems contained information on licensees and the maximum amount of materials they were authorized to possess, but these systems did not record actual sources or their movements. By tracking more than 70,000 risk-significant sources, the NSTS system enhances our ability to detect and act upon inventory anomalies, respond to emergencies, and verify the legitimate use and transfer of sources. The greater accountability for these high-risk sources helps strengthen our national security framework. As is to be expected with any new and complicated system with thousands of users, there have been challenges along the way with day-to-day implementation. The staff right now is focused on ensuring that this system is fully and successfully implemented. Once that work is done, the Commission will be in the position to assess whether this system meets our security objectives or whether further enhancements to the system are necessary. As I visit countries around the world for international meetings, I see that we are a leader in this area, and we should remain so.

A national source tracking system provides greater source accountability, which should foster increased control by licensees. It cannot, however, ensure the physical protection of sources, which is why that also has been an area of continuing focus for the Commission. Prior to September 11 the NRC's protection requirements for sources focused on safety and preventing inadvertent or accidental exposure of these materials to workers and the public. These requirements also indirectly provided security for the material. The events of September 11, however, made the NRC take a broader look at its requirements and reevaluate what a terrorist might do to attain these materials. Through a series of orders, the Commission implemented significant enhancements to the physical protection of these materials. Last month, the Commission approved a proposed rule to codify many of these orders. This is just the latest rulemaking in a multi-year effort by the Commission to codify the post-9/11 orders. Like the past rulemakings, this one also provides the Commission an opportunity to strengthen the rules based on the lessons learned in implementing these orders, as well as to incorporate public and stakeholder input as we consider potential changes.

One material—cesium chloride—has garnered particular attention because of its use in a wide range of medical, industrial, and research applications. Approximately 550 licensees in the United States possess about 1,100 cesium chloride irradiators that contain at least a Category 2 quantity of radioactive materials. The categorization scheme for determining the risk significance of certain sources is modeled on the International Atomic Energy Agency's Code of Conduct on the Safety and Security of Radioactive Sources. In recognition of the potential security concerns posed by cesium chloride, the NRC imposes increased security controls on these sources. The Commission recently approved a draft policy statement that recognizes that the security of these risk-significant sources is an essential part of our mission and demonstrates the Commission's commitment to issuing additional security requirements if the threat environment calls for it. Through the byproduct rule that I discussed earlier, the Commission is also moving forward with a proposal to institute additional background checks and require comprehensive security programs to limit unauthorized access to Category 1 and 2 sources, including cesium chloride.

Before I close, I would like to stress—in light of the movement that we have seen, both domestically and internationally toward an increased focus on security—how critical it is to integrate the consideration and evaluation of security and safety activities. Many safety activities can have beneficial security impacts, and vice versa. There are instances in which the safety and security measures can complement and reinforce each other.

But the NRC has also seen instances in which safety and security measures do come into conflict, and can compromise the performance of the safety or security functions. The agency has seen cases in which there was a lack of communication among staff at licensed facilities that could have potentially compromised safety or security. Some examples include the placement of security barriers that diminished access to fire suppression equipment, the placement of scaffolding during maintenance activities that affected security lines of fire, and the staging of temporary equipment within security isolation zones.

It is important that regulators and licensees take an integrated approach to identifying potential conflicts and to ensuring that they do not adversely impact either safety or security. The NRC has done some good work in this area. In completing a reactor security rule last year, the Commission included a provision to require licensees to take an integrative approach to identifying possible issues and implementing the appropriate mitigative or compensatory measures.

The agency has also engaged some of these issues in the course of drafting a safety culture policy statement. Among the chief goals of this effort has been to make clear that the Commission considers security to be an important component of a positive safety culture. But we have seen disagreements about whether the importance of a security culture can best be addressed through a single joint policy statement or separate policy statements. Safety and security cultures may have some differences, such as in the role of information sharing, but it important to remember that there are also many key similarities, including a questioning attitude and a commitment to continuous improvement.

These issues do not necessarily have easy solutions. It will certainly require the hard work and sustained focus of both regulators and licensees. But I believe that it is an issue that warrants such attention to ensure that we attain the maximum safety and security gains possible from the regulations we develop. This has become more and more important in light of heightened security concerns and the increased focus on security in recent years. And as you well know, our security work is by no means complete. In addition to the important substantive issues that you will be delving into throughout this conference, I encourage you to think hard about the safety-security interface issue. We will achieve the greatest security gains if we work through discrete security issues and also consider how our proposed solutions fit within the broader regulatory framework.

Creating a Next Generation Nuclear Material Security Architecture

Kenneth Luongo
President, Partnership for Global Security

Introduction

I am very pleased to address the INMM Annual Meeting today. I consider INMM to be one of the great resources for the promotion of global nuclear material security. Its members are one of the foremost repositories of knowledge on protecting nuclear materials and ensuring that the global community can continue to safely utilize nuclear technology for peaceful and productive purposes.

This afternoon, I'd like to talk about how changes in the global environment in recent years have impacted the security structures and mechanisms that we rely on to keep nuclear and radiological materials out of the hands of terrorists. Then I'd like to offer some suggestions for how we can and should move beyond the current nuclear material security architecture to develop a more robust barrier against the devastating possibility of nuclear terrorism.

In particular, I believe that the 2010 Nuclear Security Summit should be viewed as a starting point for the development of a next generation architecture for nuclear material security. President Obama's four-year goal for securing all vulnerable nuclear material is extremely important. But this is not a four-year problem. This is a forever problem as long as dangerous nuclear materials reside on the earth. And we need to improve the barriers to the misuse of these materials.

In my view, government, civil society, and the private sector must work more closely together to counter the twenty-first century threats that are challenging today's nuclear material security and nonproliferation regimes. I think that the INMM—which incorporates all key stakeholders of this nuclear material security issue—has a vital role to play in facilitating progress on these important objectives.

Adapting to the 21st Century

I think that it important to look at this issue in perspective. We are almost twenty years past the collapse of the Soviet Union, a momentous event that woke the world up to the danger of "loose nukes." We responded very well to this new challenge by creating new programs that allowed, in particular, the United States and Russia to cooperate on nuclear material security in a number of very sensitive locations. Those programs endure today and have generated a wealth of knowledge on how former adversaries can work together on this sensitive subject.

But between 1991 and today we have had to face another game-changing phenomenon—the rising power of determined and shadowy terrorists who are intent on inflicting damage around the globe. Their ultimate weapon, there can be no doubt, would be a nuclear device. The architecture for protecting the world's growing nuclear material stockpiles needs to evolve along with this threat—and it has to some degree. But, it has not evolved enough—neither politically nor technologically.

The forces of technological and economic globalization are dramatically reshaping the nature of the nuclear threats the world faces. New dimensions of the proliferation danger are being propelled by economic integration, energy demand, technology diffusion, and the decentralization of control. The nuclear material security regime has begun to adapt to these new realities, but not as much as is necessary, and not as quickly as is needed. And, in a recent development, some efforts may be in the slow motion process of winding down. The decision of the G-8 last month not to extend the Global Partnership—while not a fatal blow—certainly was not a vote of confidence in the effort to prevent nuclear terrorism.

Since the international economy, and not international security, seems to be the prism through which most leaders view the state of the world today, I think it is important to reframe this issue and underscore the absolutely critical role that nuclear material security and nuclear nonproliferation play in supporting the global economy. Just one nuclear terrorist incident in a key city or country would likely crater the global economy. A radiological terrorist event using a high intensity source in a key population center also would do very serious economic damage. With trillions in global economic activity at stake, a few billion dollar investment in ensuring that it is not destroyed is not just prudent, it is very wise.

Globalization has fused the globe and challenged the international order. This has increased the need for more ambitious, flexible, and cooperative international security mechanisms. Governments and intergovernmental bodies alone can no longer adequately counter the twenty-first century's proliferation threats. The Nuclear Nonproliferation Treaty (NPT) is under pressure from Iran, North Korea, and global nuclear power expansion. The ad hoc mechanisms that have been created to fill the gaps in the treaty regime, by addressing emerging proliferation threats like non-state actors, have not been broadly accepted by the international community. And there are political challenges that need to be addressed with fresh ideas.

New, creative thinking is required to develop a stronger, more flexible next generation global nuclear material security strategy that is able to swiftly adapt to international developments while maintaining the broad international legitimacy and benefits enjoyed by the treaty-based regime.

The Obama administration, other international leaders, and technical and policy experts must think beyond the incremental expansion and adaptation of existing efforts and agreements and commit to work to develop a next generation suite of nuclear security and nonproliferation policies.

I would offer seven principles to frame the development of the new architecture:

- It must include a comprehensive threat assessment examining the economic consequences of a nuclear or radiological terrorist event.
- It needs to identify political leadership in the developing world that can complement that of the developed world.
- It needs to identify a baseline for security that actions and improvements can be measured against.
- It needs to embrace greater transparency of actions even if that transparency is limited to other governments and kept confidential.
- It must provide robust and multilateral funding over the long term for those in need of assistance.
- It must be flexible and inclusive, meeting the evolving threats and embracing the contributions of all stakeholders.
- It must protect the benefits of nuclear power, medicine, and other peaceful uses.

Results of the Nuclear Security Summit

In my view, the April 2010 Nuclear Security Summit should be viewed as a very useful and important starting point for a discussion on the evolution of a new nuclear material security regime, not an end in itself.

This unprecedented and successful event brought together forty-seven nations and three international organizations to discuss how to prevent nuclear terrorism by improving global nuclear material security.

There has never been such a gathering of high-level political officials to discuss the subject of preventing nuclear terrorism and securing nuclear materials. High-level political attention is essential to motivate rapid action on this important agenda.

Participants at the April Nuclear Security Summit agreed to a communiqué which highlighted the global importance of preventing nuclear terrorism and endorsed President Obama's goal of securing all vulnerable nuclear material in four years. Additionally, they underscored the importance of maintaining effective security over all nuclear materials on their territory; encouraged the conversion of reactors that use highly enriched uranium (HEU) to low-enriched uranium (LEU); and recognized the importance of the Convention on the Physical Protection of Nuclear Material and its amendment and the International Convention for the Suppression of Acts of Nuclear Terrorism as essential elements of the global nuclear security architecture. Finally, the communiqué emphasized the need for international cooperation on this agenda, including the importance of capacity building and responding to requests for assistance in order to secure these materials globally.

The work plan accompanying the communiqué focused on improving and universalizing existing nuclear security agreements and programs. In addition to the conventions mentioned in the communiqué, the work plan also notes the need to fully implement UN Security Council Resolution (UNSCR) 1540 and support the Global Initiative to Combat Nuclear Terrorism and the G-8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction. It also recognizes the continuing importance of the IAEA and its nuclear material security guidelines and activities.

The work plan further highlights the fundamental role of the nuclear industry in the nuclear security agenda, the human dimension in ensuring nuclear material security, and the importance of sharing best security practices.

Other ambitious objectives of the work plan included the consideration of the consolidation of national sites where nuclear material is stored, the removal and disposal of nuclear materials no longer needed for operational activities, and the minimization of the civil use of HEU.

However, in keeping with the need to maintain consensus on these high level objectives the work plan offers many caveats, including allowing individual nations to implement many of these objectives "as appropriate."

In addition to the work plan, twenty-nine individual countries made commitments for improving security at home, including Ukraine's decision to remove all of its remaining HEU by 2012 and the United States and Russia signing an agreement to implement the plutonium disposition agreement.

And finally, an important decision was made to hold another summit in the Republic of Korea in 2012.

All of these developments are good and positive and will further solidify the current foundation of nuclear material security. But, even if implemented completely and rapidly, they would not be sufficient to address the evolving nuclear terrorism threat.

There are three areas where I think the summit could have done more.

The first is on the funding issue. I had hoped for more international funding for the nuclear security mission. At the very least, the International Atomic Energy Agency's (IAEA) nuclear security office is in need of significant additional funding. And, just eleven weeks after President Obama called for the extension of the Global Partnership, the G-8 punted on its future.

Second, the issue of radiological material security was not afforded a high priority at the summit. While it was referenced in both the communiqué and the work plan, my understanding is that a number of countries would have liked to have seen that issue be a higher priority.

This could be on the agenda for the 2012 summit.

Finally, there were no new initiatives announced. While there may be some international fatigue with the current set of activities, they are still inadequate to the task of effectively preventing nuclear terrorism.

Why 2010 is Important

This year the international community has four unique opportunities to strengthen the defense against nuclear terrorism.

The first opportunity was April's Nuclear Security Summit. It was preceded by the new START agreement with Russia to further reduce deployed nuclear arsenals and address the legacy of the Cold War, and the Nuclear Posture Review which addresses how we will configure and use the U.S. nuclear arsenal. Taken together these were important steps that could help bolster the goals of the United States to strengthen the global effort to prevent new nuclear weapons states and enforce the NPT.

The second opportunity was the NPT Review Conference. The final conference document encouraged all states to maintain the highest possible security and physical protections standards for nuclear materials, improve national capacities for preventing nuclear smuggling and the proliferation of nuclear weapons, and implement voluntary IAEA nuclear security recommendations and related international guidance.

I would say that the first two opportunities were successes, while recognizing their limits.

The next opportunity was the joint meeting in Canada of the G-8 and G-20 nations, but unfortunately, this was a missed opportunity. The Global Partnership was established in 2002 at the G-8 summit in Kananaskis, Canada. With the summit returning to Canada this year and President Obama's call in April for an additional $10 billion in funding for the Global Partnership and an expanded substantive and geographical mandate, many experts expected the Global Partnership to be extended and expanded. However, rather than agreeing to re-shape, re-energize, and re-finance the initiative, G-8 leaders only agreed to *evaluate* its geographic expansion and new funding commitments. Additionally, the G-20 nations met in Canada on the heels of the G-8 summit, and they did not discuss security issues at all. The G-20, now solely addressing economic issues, needs to become more concerned and involved with global security issues (including nuclear dangers) that will directly affect the stability and prosperity of their nations.

The final opportunity rests with the Congress. Obama has requested a $320 million increase for international nuclear security activities in the FY11 budget, and the Congress will need to act. House and Senate authorizers were the first to move and both committees supported the requested funding for the National Nuclear Security Administration's nonproliferation programs and the Department of Defense's (DoD) Cooperative Threat Reduction (CTR) program. But the request was really not adequate to meet Obama's global nuclear security objectives, and the authorizers did not add any funding. There are darker clouds looming over the appropriations process, with key members questioning the size of the request.

Both of these examples raise the serious and enduring question of why many political leaders—both around the world and in the U.S. capitol—seem to regard the funding of nuclear material security as an expendable priority. One answer is that they do not understand the fundamental role that nuclear material security plays in global economy. My sense is that they think of nuclear issues as the responsibility of technical specialists and do not think about what the domestic and global economic consequences would be if the security system broke down and significant material leaked into the wrong hands.

The Financial Dimensions of Nuclear Security

There are two fundamental financial dimensions directly related to nuclear security. The first is the cost to prevent a terrorist nuclear event; the second is the cost to the global economy if such an event occurs. I do not know the answer to the second question except to guess that it would be huge. But I certainly hope that the U.S. government and other governments do know the answer. It would be very sobering if at the past nuclear summit or at the next one someone gave an analysis of this cost to the assembled nations. I think that would have a dramatic impact on both developed and developing nations.

The more concrete question is what it would cost to prevent this kind of an event. The answer here is more than we are currently spending.

President Obama's four-year pledge has not been backed up with the necessary funding. The current year's budget (FY10) is less than the last budget of the Bush administration. The FY11 budget request of $3.1 billion for international weapons of mass destruction (WMD) security programs (including DHS) gives a significant boost to nuclear security programs.

But, this funding doesn't much expand the scope of current efforts. It accelerates some of them, but it doesn't really expand them. There are two exceptions—the $30 million for Nuclear Security Centers of Excellence in the DoD budget and $3 million to support the implementation of UNSCR 1540 in the State Department budget. But this is partially offset by the reduction in the funding for radiological security and other activities in the budget.

There are a number of new initiatives that the administration could have proposed that would have both justified higher spending and improved the nuclear security effort. But, even if they did, would the Congress have supported them?

The real question should be whether we can afford not to aggressively finance nuclear material security. Compare the budget for locking down nuclear weapons and materials with another global challenge: climate change. In the American Recovery and Reinvestment Act of 2009 alone, over $35 billion is provided for climate change related activities—more than 12 times what we spend today on nuclear security. And nuclear security spending is only about one-third of 1 percent of the total defense budget this year.

Then consider what the world is spending on other top priorities. In 2007, $1.6 trillion was spent worldwide on defense. In 2008, $114.5 billion was spent by Organization for Economic Cooperation and Development (OECD) countries on foreign aid. These figures have likely grown in the years since and certainly dwarf the amount of funding allocated to preventing a nuclear terrorist attack.

I would argue that the Congress should be the strongest possible partner in the global nuclear security process by not only fully funding the FY11 budget request but going beyond it. Funding nuclear security today is not only a good bargain for national security, but it is also an investment in a strong and growing economy.

The FY11 budget, in my view, should be front loaded to ensure adequate funding for existing and new opportunities. More realistic budgets for both the International Nuclear Material Protection Cooperation (INMPC) and Global Threat Reduction Initiative (GTRI) programs are about $600-650 million in FY11 with growth up to an average of about $700-$750 million per year for FY12-15. Similarly, the DoD and U.S. State Department threat reduction budgets should grow. This would allow the programs to ramp-up their activities more effectively in support of the President's objectives.

In addition, the radiological security mission should be boosted. Large numbers of radiological sources exist in the United States, and many are in public buildings. Hundreds of thousands of these sources can be found abroad. As a result, the challenge of securing all radiological materials is significant, and it can seem too unwieldy. The Obama administration at the very least, should commit to secure all the radiological sources in public buildings, beginning with major metropolitan hospitals in the United States on an accelerated timetable. The cost for this would be about $125 million.

Further, the congressional limit on nuclear security spending in Russia and the former Soviet states is set to begin in FY12. This needs to be modified so that the Russia-focused programs can continue. This is especially important not just because the job will not have been completed in that country by that date, but also because security equipment installed at the start of this cooperation in the early and mid-1990s is nearing the end of its life expectancy and is becoming obsolete. Improvements on the original security measures, therefore, may be required.

And finally, the president and his nuclear security staff should not take the decision of the G-8 on the Global Partnership lying down. The president needs to leverage the momentum created by the Nuclear Security Summit and work to generate support for a global fund for WMD security that totals $2.5-3.0 billion per year over the next ten years. The U.S. is already paying over $1.5 billion per year of this amount. That means the rest of the G-8, its fifteen partners, and others would have to pick up $500 million to $1 billion per year. For economies that together account for over 44 percent of total global gross domestic product, that is a small investment in securing their future economic growth.

This fund would underscore the need for continued multilateral involvement in this area and make clear to recipient nations that there is a renewable WMD security investment fund that they can utilize and rely on.

Incrementally funding the fight against nuclear terrorism is a prescription for making it more likely rather than reducing its likelihood. If nuclear terrorism occurs, the cost of just the response will dwarf the cost of prevention.

The Road to the Republic of Korea 2012 Nuclear Security Summit

This leads to the opportunity that is presented by the next summit in the Republic of Korea.

Current conservative estimates of global fissile material stockpiles are 1,600 metric tons of HEU and 500 metric tons of separated plutonium. Only 50-60 kg of HEU or 8 kg of plutonium are required to make a crude nuclear bomb. And these stockpiles are growing in some unstable regions of the world.

The president's goal to secure these materials within four years was endorsed as an international objective at the April Nuclear Security Summit. But, this mission will require actions beyond forty-seven nations, beyond the current mechanisms, and beyond the South Korean summit in 2012. So, the next summit is both an important target and deadline.

The United States will certainly have to lead in this effort, but it also needs partners in this process that are as committed as the United States is. I hope that South Korea will see this as an opportunity to rise as a major player in this important global issue area, especially given the growth in prestige of their nuclear industry. But, in my view there also needs to be at least one nation in the constellation of developing nations that will be a strong political partner with the U.S. in this effort.

The responsibility for improving nuclear security extends beyond governments; both the nongovernmental community and the nuclear industry held complementary summits in Washington during the days surrounding the official Nuclear Security Summit. The coalition of nongovernmental organizations (NGO) that I co-chair, the Fissile Materials Working Group, organized the NGO event. The nuclear industry event was organized by the Nuclear Energy Institute (NEI).

The next governmental nuclear security summit raises the question of what should be done by all of the stakeholder communities over the next two years to drive the nuclear material security agenda beyond its current boundaries and to make concrete progress at that gathering.

To be most effective, it should extend beyond the 2010 summit's scope to include radiological material security issues, new funding commitments, and endorsement of new initiatives.

Here are five ideas for moving this agenda forward at the South Korean summit.

(1) A New Framework Agreement

There are at least a dozen different international agreements and initiatives providing guidance on nuclear material security. Most of these were referenced in the nuclear summit documents. In addition, each nation has its own regulations and laws. But these instruments are not tied together and adherence is often voluntary. This lack of an international framework agreement on fissile material security means there has been no organizing force to drive the agenda.

Our objective needs to be to define a cohesive future policy structure and generate international expert and political support behind it in order to persuade governments (some quite reluctant) to accept a new international order for nuclear material security.

A Fissile Material Security Framework Agreement would identify the threats to humankind from vulnerable fissile materials, especially the threats posed by terrorists, and list actions required to mitigate them. A framework agreement would allow the subject to be acknowledged at a very high political level as a global priority and then require the adherents to take specific steps to achieve the agreement's objectives.

The framework could include a number of items and usefully package them so that its norms are unified, clear, and cohesive.

For example:

- The framework could recognize all the relevant existing conventions, agreements, and Security Council resolutions, including conventions on the suppression of acts of nuclear terrorism, terrorist financing, and bombings.
- It could underscore the legitimacy of ad hoc nuclear security mechanisms such as the CTR program, the Global Partnership, the Proliferation Security Initiative, the Global Initiative to Combat Nuclear Terrorism, and others.
- It could identify a baseline standard for nuclear and radiological material security while encouraging implementation of the highest possible security standards through an intensive, global best-practices engagement process.
- It could encourage public-private partnerships in support of nuclear security and recognize the important role that the civil society sector plays in this area.
- This agreement should be universal, but it could begin with support from a coalition of the committed.

Models for the framework include prior UN Security Council Resolutions, the UN Framework Convention on Climate Change, and others.

(2) Transparency for Confidence Building

The nuclear age was born secret but we now live in an era when too much secrecy can be a liability. Security vulnerabilities have been exploited in the past and can be in the future. Transparency of countries' nuclear security measures and their improvement are very important in building international confidence.

Country reports under UNSCR 1540 offer a mechanism for sharing information and better understanding the strengths and weaknesses of security structures in countries around the world. But compliance with 1540 is very uneven, with some countries citing a lack of national resources hindering their reporting efforts.

Countries can learn a great deal from one another's experiences with securing nuclear materials and facilities. Currently, some countries are willing to share information with the IAEA—which maintains strict confidentiality—but not with the other governments or the public. Countries should be encouraged to prove to each other that they have strong security mechanisms in place, not simply make statements that must be taken on faith. The U.S. Department of Energy (DOE) offers a positive information sharing example. Each year its inspectors report on which of its facilities receive the highest marks in security. This type of transparency bolsters confidence in facility security without giving away any sensitive details.

There are a number of other mechanisms that could be considered including providing real-time information on security at specific facilities that could be transmitted to a confidential reporting center. This proposal might seem a bit extreme or even radical right now but so were other confidence building measures, like the U.S.-Russian nuclear hot line, before a crisis made it a necessity, not an option.

(3) Baseline for Nuclear Material Security

The most often-asked question from non-experts is what is the standard for nuclear material security. They are then surprised to hear that there is no one standard. Despite the detailed technical information the IAEA provides for the securing of nuclear facilities and other domestic regulations and international conventions that govern nuclear material protection, no universally accepted standard exists for securing nuclear materials and weapons. The surprise stems from the fact that they know intuitively that this is not consistent with the management of other dangerous materials.

There are reasons for why the nuclear material security system is not standardized, but the question is whether that rationale is still optimal. It is a complicated question that gets to the heart of the knowledge that many of you possess. But, it is an important issue that merits further examination in advance of the next summit. In my view, the Obama administration, in collaboration with one or more international partners, should call for the establishment of a baseline nuclear security standard to jump-start this process.

(4) Boost the IAEA

The IAEA is the central international repository of knowledge and assistance for nuclear material security and has deep international legitimacy. The Nuclear Security Summit underscored the need for the IAEA to do more. However, the IAEA's nuclear security activities are significantly underfunded. It does not have enough technical staff and is ill prepared to fulfill increased demands in the future. Expanding the formal IAEA nuclear security budget is difficult in part because developing nations will want any increase matched by an equal increase in the technical cooperation budget. But in addition to assessed contributions, the IAEA can accept voluntary contributions. The United States makes a voluntary contribution each year. These funds can be earmarked for specific security purposes without being subject to the regular board approval process.

To ensure that the IAEA has the tools and resources needed to meet twenty-first century nuclear security challenges, two actions should be taken. First, developed countries should commit to increase their voluntary IAEA contributions for the next four years and earmark the funds for nuclear security. The goal would be to match the IAEA's current annual safeguards budget of about $150 million. Second, countries should also agree to train a specific number of additional nuclear security specialists for assignment at the IAEA to fill the positions that the additional voluntary contributions would create. Strengthening the IAEA and expanding its power for nuclear and radiological security is necessary today, and this task will become even more important in the coming years.

(5) Reduce and Eliminate Fissile Materials

Of course the best way to minimize the nuclear material security burden is to reduce the amount of material, limit the number of locations where it is stored and used, and eliminate that which is excess. The nuclear security summit's work plan endorsed these objectives in the abstract, but did not delve into the details. In part that is because this work must be done on a country by country basis. But, the achievement of these objectives will be measured at the South Korean summit, so hopefully countries will take these commitments seriously.

But there are an additional two fissile material issues that should be discussed in advance of the South Korean summit. The first is the phase out and ultimate ban on the civil use of HEU. The usefulness of this material in a terrorist nuclear device is well known. The second is to limit the reprocessing of spent fuel. Here, there are no easy answers and as nuclear power grows around the globe spent fuel management headaches will increase. But, plutonium separation should not be encouraged—especially not in the United States.

Partnering with Industry on Nuclear Security

These issues of course have implications for other stakeholders besides governments, and are of particular interest to the nuclear industry. The nuclear industry needs to be more engaged in the nuclear material security discussion and the drive for better solutions.

Of course INMM has played an important role as the forum for nuclear security discussions. Its 2005 annual meeting served as the event at which the World Institute for Nuclear Security (WINS) was introduced in concept. WINS, with 350 members, is now an established nonprofit organization that provides an international forum for the nuclear industry to share best security practices, engage in public-private dialogues, and improve corporate governance structures regarding nuclear security.

WINS' goal is to encourage industry to voluntarily take a proactive role in implementing twenty-first century nuclear security structures. But the question is whether WINS alone can win the argument with private sector companies about the need for them to take a more active role in the improvement of nuclear material security. I raise this question not because of any lack of faith in the WINS staff, quite the contrary. I raise it because the Brookings Institution has recently issued a report that surveyed the nuclear industry on their views of their role in the nonproliferation regime.

The report's key finding is very instructive:

> The results of the study reveal a generally consistent industry view: the nonproliferation regime and any relevant proliferation resistant safeguards and regulations are primarily the responsibility of government and multilateral institutions, and industry is wary of any proposals that dramatically change existing laws, regulations, and institutional relationships that comprise the current nonproliferation regime.

However, as Energy Secretary Stephen Chu underscored at the Nuclear Energy Institute (NEI) summit, "even a failed detonation of a nuclear device would have a devastating impact on public trust in nuclear energy." And NEI President Marv Fertel described the industry summit as part of the ongoing nuclear security engagement by industry "to provide input to government policy, share lessons learned in this area, and ensure that we continue to operate our commercial facilities in a manner that prioritizes nuclear safety and security above all other matters."

Industry leaders, having experienced the devastating blow that the Three Mile Island accident inflicted on nuclear power thirty years ago, clearly understand the importance of robust material security for the continuation and growth of their business. But my sense is that they also are concerned about its impact on their bottom line.

One solution to this situation is to bring the key parties into more regular contact. For example, consideration should be given to the creation of a new, multidisciplinary nuclear material security "Iron Triangle." Consider the sides of this new "Iron Triangle": government institutions provide regulatory oversight and implementation capacity; civil society identifies new policy approaches to emerging challenges; and the private sector drives innovation and expansion. Government, civil society, and the private sector each play a vital role in responding to twenty-first century nuclear proliferation threats, and each offers a vital contribution the other sectors lack. But they need to work together.

The NGO- and industry-related events that took place around the official 2010 Nuclear Security Summit are examples of this conceptual triangle beginning to take a concrete form. However, despite the fact that each event was connected by content, each really existed in its own orbit and mainly served its own stakeholders. Real collaboration will require sustained engagement and attention by all parties to create a lasting structure that can collectively combat twenty-first century nuclear material security challenges.

The Brookings study had an interesting suggestion in this regard—organize a Government-Industry Conference Against Nuclear Weapons Proliferation. This was an idea that was acceptable to many of the industry respondents to the study's survey. I would argue to include non-governmental experts in such a conference as well.

I also expect that the South Korean government would welcome a continuation of the NGO and the nuclear industry summits around their official summit. It would be useful if these events were planned and coordinated in such a way as to be mutually reinforcing and beneficial to continued dialogue among the key stakeholders.

Conclusion

The Washington Nuclear Security Summit has significantly raised the public profile of the nuclear material security and nuclear terrorism prevention issues. It also has committed nations to take action to improve nuclear security. These commitments need to be implemented as rapidly as possible. But the status quo for protecting the globe against nuclear terrorism is currently inadequate and additional steps need to be taken. Right now we have many disconnected components with no cohesive and integrated driving mechanism. The key to success in driving collective and unified action on this agenda in the wake of the summit is to integrate all the necessary tools into a comprehensive, flexible, legitimate, and globally focused next generation nuclear material security framework. By setting another meeting in the Republic of Korea for 2012, there is the opportunity to fuse together the elements and the key stakeholders that will result in a next generation global nuclear material security architecture. We need to take advantage of this opportunity to tightly bolt the door against nuclear terrorism.

Thank you.

The Uranium Cylinder Assay System for Enrichment Plant Safeguards

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Abstract
Safeguarding sensitive fuel cycle technology such as uranium enrichment is a critical component in preventing the spread of nuclear weapons. A useful tool for the nuclear materials accountancy of such a plant would be an instrument that measured the uranium content of UF_6 cylinders. The Uranium Cylinder Assay System (UCAS) was designed for Japan Nuclear Fuel Limited for use in the Rokkasho Enrichment Plant in Japan for this purpose. It uses total neutron counting to determine uranium mass in UF_6 cylinders given a known enrichment. This paper describes the design of UCAS, which includes features to allow for unattended operation. It can be used on 30B and 48Y cylinders to measure depleted, natural, and enriched uranium. It can also be used to assess the amount of uranium in decommissioned equipment and waste containers. Experimental measurements have been carried out in the laboratory and these are in good agreement with the Monte Carlo modeling results.

Introduction
Safeguarding sensitive fuel cycle technology such as uranium enrichment is a critical component in preventing the spread of nuclear weapons. Independently verifiable material accountancy is a fundamental measure in detecting diversion of nuclear material. To achieve material balance over an entire enrichment plant, it is essential to know the mass and enrichment of UF_6 inside the facility as well as transferred in and out of the facility. The bulk of UF_6 moving in and out of the plant is contained in 30B and 48Y cylinders. In addition, there may be uranium by-products in waste containers and decommissioned equipment (i.e., cold traps, centrifuges, etc.).

Traditionally, the uranium mass contained in UF_6 cylinders has been determined using load cells or electronic scales. They are often used by both the operator and the inspector, making authentication difficult. These systems also require reference weights for calibration and a valid tare weight for each cylinder. A study of load cell performance conducted by URENCO UK Ltd. showed them to have reliability issues and raised concerns over the cost of realizing an authenticated system.[1]

We have developed the Uranium Cylinder Assay System (UCAS), which uses passive neutron detection to determine uranium mass in UF_6 cylinders as well as waste containers and decommissioned equipment. UCAS was designed for Japan Nuclear Fuel Limited (JNFL) for use in Rokkasho Enrichment Plant. UCAS was designed to make the measurement relatively insensitive to the position of the UF_6 within the cylinder. Two units were fabricated: (1) a fixed-geometry system for assaying 30B and 48Y cylinders on the facility's transfer trolley and (2) a mobile unit for assaying waste containers and decommissioned equipment. A mass measurement system based on passive neutron detection is an alternative that can be used in lieu of traditional load cells and electronic scales or as a redundant system to provide additional safeguards assurance.

UCAS uses total neutron counting to determine uranium mass assuming the enrichment is known. The primary source of neutrons in enriched UF_6 comes from the alpha bombardment of fluorine, where ^{234}U is the dominant alpha emitter. Because the enrichment of ^{234}U follows that of ^{235}U, total neutrons give an indirect measure of the enrichment.[2] The high penetrability of neutrons through UF_6 means that total neutrons also track the uranium mass. Thus, with a known enrichment, the uranium mass can be determined from the total neutron count rate. Conversely, total neutron counting can be used to determine enrichment given the uranium mass, but the $^{234}U/^{235}U$ ratio must also be known.[3,4]

The following sections describe the design and characterization of UCAS. All of the physics calculations were performed using Monte Carlo N-Particle Extended (MCNPX), and the characterization measurements were performed at Los Alamos National Laboratory (LANL).

Mechanical and Electrical Components
Each UCAS unit consists of four identical detector pods containing two $_3He$ tubes per pod (one upper and one lower tube). The tubes are embedded in a cylindrical block of polyethylene, which is partially wrapped in cadmium. The detector pods are enclosed in aluminum cases. A photo of one of the mobile pods is shown in

Figure 1. Photo of a mobile UCAS pod

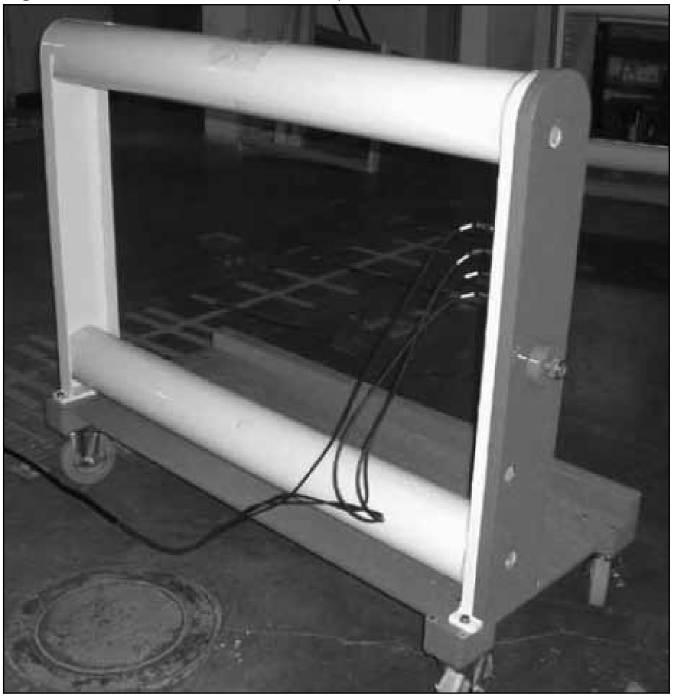
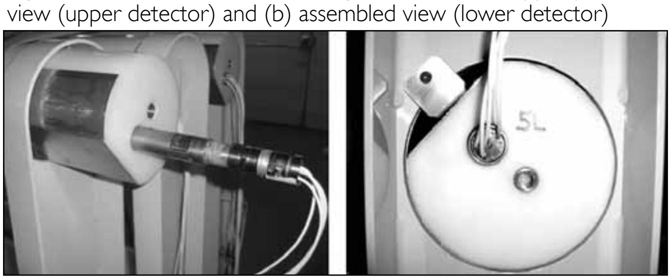


Figure 2. Detector/moderator configuration shown in (a) exploded view (upper detector) and (b) assembled view (lower detector)



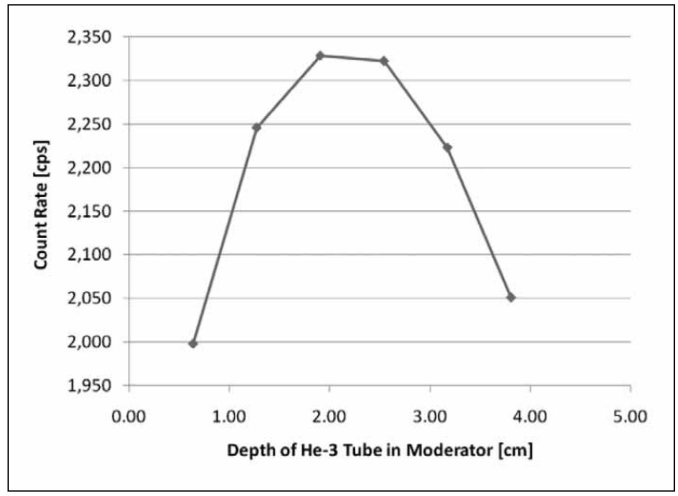
(a) (b)

Figure 1. The fixed-geometry pods are similar except that they are not bolted to a wheeled cart. Instead, a sliding mechanism will move the pods into the measurement position on the transfer trolley. Also, the cable connections for the fixed-geometry pods are inside the cover so that they can be used in unattended mode. The weight of each pod is 73 kg not including the cart.

With two $_{3}$He tubes per pod, there are a total of eight tubes per system. Each tube has 4 atm of $_{3}$He, an active length of 121.9 cm (48 in.), and a diameter of 2.54 cm (1 in.). The detector/moderator configuration is shown in Figure 2. Figure 2(a) shows how the detector is assembled. The cylindrical polyethylene moderator fits inside the aluminum case. The partial cadmium wrapping on the outside of the polyethylene can also be seen in the photo. The $_{3}$He tube slides into the polyethylene moderator.

Figure 2(b) shows the assembled detector/moderator configuration. The cylindrical moderator has a notch taken out of the round surface in the direction of the sample. The position of

Figure 3. Count rate as a function of $_{3}$He tube depth in the polyethylene moderator



the tube inside the moderator is optimized for maximum count rate. Figure 3 shows the count rate as a function of the depth of the tube within the polyethylene. The count rate is maximized when there is 1.9 cm (0.75 in.) of polyethylene between the outer radius of the $_{3}$He tube and the surface of the moderator. The extra polyethylene on the back side of the tube also provides shielding.

The detectors are accessed through the side cover (see Figure 1). The fixed-geometry system may be used in unattended mode, so the cable connections are inside the security cover, which can be fitted with a tamper-indicating device. The hole where the cables run out of the cover was designed to be used with the standard tamper-indicating conduit used by the IAEA. Because the mobile system will only be used in attended mode, the cable connections are on the outside of the frame for easy access. The cover also has two viewing windows that allow the operator to see the LEDs on the Precision Data Technology (PDT) preamplifiers to ensure that they are registering counts.

UCAS was designed for singles mode only, but standard shift register coincidence settings are used: 4.5 µsec pre-delay, 64 µsec gate width, and a high voltage of 1680 V. The signals from each of the eight detectors are wired separately back to an OR box and then to a JSR-15 shift register. The coincidence data can be useful for state-of-health and authentication purposes. Each system comes with a data analysis computer that uses IAEA Neutron Coincidence Counting (INCC) software (version 5.1.2 or later).

Detector Characterization

The physics calculations used to optimize the design and characterize sensitivities for UCAS were performed using MCNPX. The neutron energy spectra and source strengths for various UF_6 enrichments were calculated using another code called SOURCES. The uranium isotopics and UF_6 source strengths calculated with SOURCES are given in Tables 1 and 2.

Table 1. Uranium isotopics

Enrichment	U-234 [atom percent]	U-235 [atom percent]	U-238 [atom percent]
Depleted uranium	0.001	0.20	99.8
Natural uranium	0.0055	0.72	99.2745
2.00 percent enriched	0.01901	2.00	97.98099
3.50 percent enriched	0.0288	3.50	96.471
5.00 percent enriched	0.049827	5.00	94.950173

Table 2. UF_6 source strengths calculated with SOURCES

Enrichment	(α,n) Source Strength [n/sec–cm3]	Spontaneous Fission Source Strength [n/sec–cm3]	Total Source Strength [n/sec–cm3]
Depleted uranium	0.0574	0.0430	0.1004
Natural uranium	0.1447	0.0428	0.1875
2.00 percent enriched	0.4061	0.0423	0.4484
3.50 percent enriched	0.5974	0.0416	0.6390
5.00 percent enriched	1.0030	0.0410	1.0440

30B and 48Y Cylinders

The fixed-geometry unit will be used to assay 30B and 48Y cylinders containing feed, product, and tails. The calculated efficiency of the unit for a maximum-filled 30B cylinder containing 3.5 percent enriched UF_6 is 1.2 percent. Figures 4 and 5 show the count rates in 30B and 48Y cylinders as a function of uranium mass. In both plots, the count rate increases with increasing uranium mass.

The biggest source of uncertainty for the fixed-geometry unit is the distribution of UF_6 within the cylinder. Counting statistics should be less than 1 percent, the background is low in the transfer hall where the cylinders will be measured, and uncertainties in the calibration and $^{234}U/^{235}U$ ratio should also be relatively low compared to the source distribution term.

The distribution of UF_6 within a cylinder depends on how it was filled, the last operation made on it (e.g., sampling in liquid phase after homogenization), and the storage conditions.[5] When a cylinder is filled in liquid phase, most of the material remains in the lower part of the cylinder with a thin deposit on the upper part of the wall. When it is filled by desublimation, the solid UF_6 adheres evenly to the cylinder wall, creating an annular ring. Over time, some of the UF_6 on the upper part of the cylinder will slough off and fall to the bottom. We conducted a modeling study to assess the magnitude of the effect that source distribution has on the count rate. Based on several perturbations of UF_6 distribution within a 30B cylinder, we determined that the source distribution introduces an uncertainty of approximately 5 percent to the measurement.

Figure 4. UCAS response for a 30B cylinder containing low-enriched UF_6

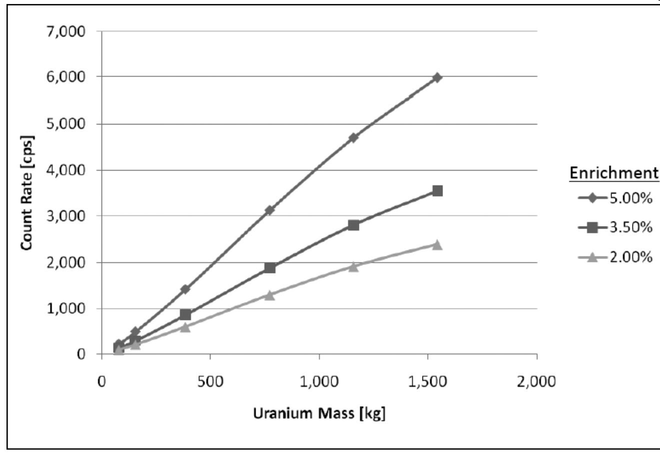
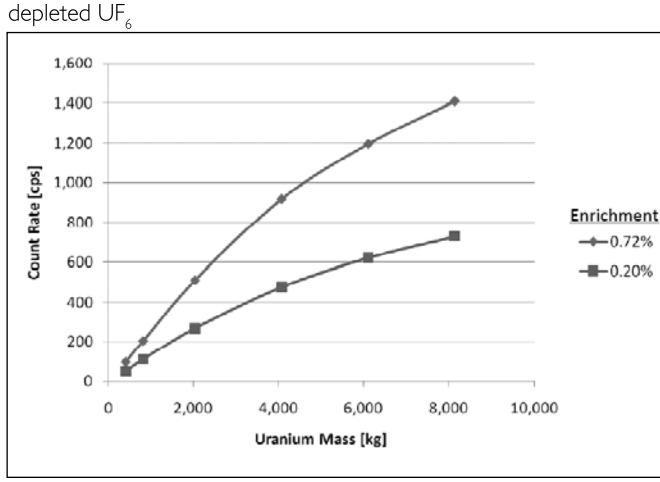


Figure 5. UCAS response for a 48Y cylinder containing natural and depleted UF_6



In addition, we calculated the minimum detectable mass (MDM) of UF_6 in 30B and 48Y cylinders. These values are given in Table 3 in terms of uranium and equivalent UF_6 mass. The MDM is calculated as 3σ above background. The background rate in the transfer hall was estimated to be 0.32 cps based on previous measurements by another instrument. The background rate was scaled based on the volume of $_3He$ in each instrument and shielding effects. The cylinder count time was assumed to be fifteen minutes.

Table 3. Minimum detectable mass for 30B and 48Y cylinders.

Container	Enrichment [percent U-235]	MDM [g U]	MDM [g UF_6]
30B cylinder	5.00	18	27
30B cylinder	3.50	30	44
30B cylinder	2.00	42	62
48Y cylinder	0.72	251	371
48Y cylinder	0.20	476	704

Waste Containers and Cold Traps

The mobile UCAS unit was designed to assay waste containers (i.e., crates and 208-liter drums) and equipment removed from the enrichment plant (i.e., cold traps). These items introduce additional measurement challenges. For waste measurements, there are uncertainty terms associated with the composition and density of the waste matrix and the uranium enrichment. For cold trap measurements, there is uncertainty in the chemical form of the uranium.

When UF_6 comes into contact with the moisture in the air, it forms UO_2F_2. For waste measurements, we assume that all of the source material is UO_2F_2. The waste containers at Rokkasho Enrichment Plant hold three categories of waste: reduced flammable, reduced resistance to flammable, and compacted incombustible. Because the waste matrix is not well characterized, each type of waste was modeled as a different mixture of iron and polyethylene at a fraction of full density. We also assume the UO_2F_2 is evenly distributed throughout the matrix. The uranium enrichment introduces another uncertainty term in waste measurements. Waste containers can contain varying enrichments, so the value is estimated from operational data.

Cold traps removed from the plant contain very little source material, but it is important to quantify that amount. The lack of source material means that counting statistics may become a significant factor in the total measurement uncertainty. The chemical form of the source material also plays into the uncertainty terms. Because the equipment has been removed from operation, it may contain a mixture of UF_6 and UO_2F_2. The INCC software allows the operator to choose the most likely combination (all UF_6, half UF_6 and half UO_2F_2, or all UO_2F_2) based on the history of the cold trap.

The additional unknowns in the waste and cold trap measurements combined with smaller uranium amounts mean that there is more uncertainty in these measurements compared to the cylinder measurements; however, MCNPX simulations give us a good understanding of how sensitive UCAS is to the uncertain parameters. Many of the uncertainties will also be better understood after the on-site calibration.

Characterization Measurements

UCAS was characterized by creating response profiles along the axial, radial, and vertical axes of the pods. This was done experimentally using a ^{252}Cf source, which was moved along each axis in 10 cm increments. The measurements were then compared to MCNPX simulations of the same test. The results are shown in Figures 6, 7, and 8. Each of the plots shows measurements from a single pod. For the radial profile case (Figure 7), the zero-point in the MCNPX simulation was 6 cm from the geometric centerline, which is why the measurement locations are shifted. As seen in the plots, there is excellent agreement between the Monte Carlo simulations and the experimental data in all three cases. These validation measurements give credibility to the MCNPX-based characterization of UCAS.

Figure 6. UCAS axial response profile—measured vs. MCNPX simulation

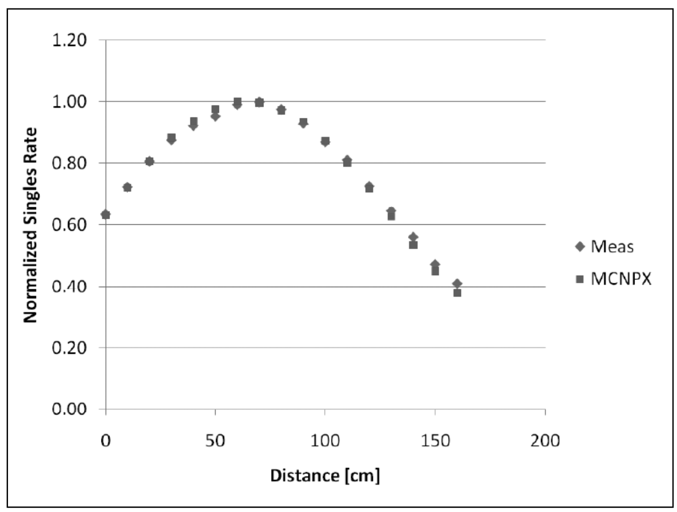


Figure 7. UCAS radial response profile—measured vs. MCNPX simulation

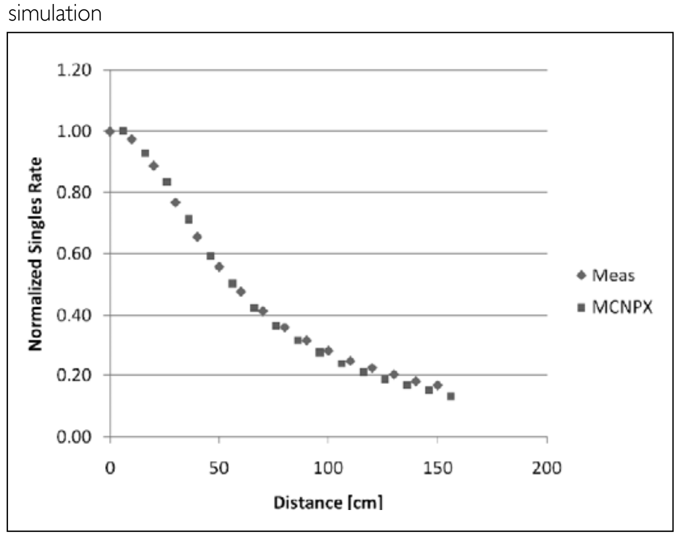
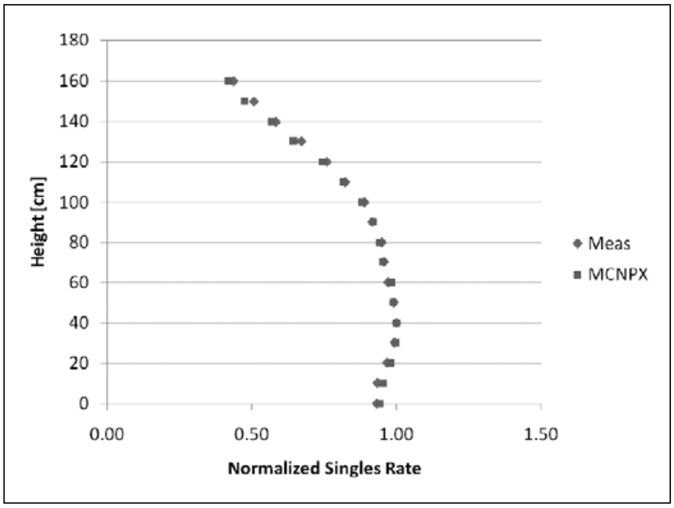


Figure 8. UCAS vertical response profile—measured vs. MCNPX simulation



Conclusions

In this paper, we have introduced a new instrument to determine uranium mass in UF_6 containers assuming a known enrichment. UCAS was designed specifically for use at Rokkasho Enrichment Plant to assay 30B and 48Y cylinders, waste containers, and equipment removed from the plant. Two units were fabricated: (1) a fixed-geometry system for product, feed, and tails cylinder measurements on the facility's transfer trolley and (2) a mobile unit for measuring other items. UCAS uses total neutron counting to determine uranium mass. The detection principle is based on the correlation between ^{234}U and ^{235}U in enriched uranium.

The detector design was optimized using MCNPX simulations. Each system consists of four pods, with two $_3He$ tubes per pod. The tubes are embedded in a polyethylene moderator that is partially covered with cadmium. Each unit uses a JSR-15 shift register and INCC software.

Modeling studies showed that the largest source of uncertainty in the cylinder measurements is the distribution of UF_6 within the cylinder. For waste measurements, the dominant uncertainty is the waste matrix, and for cold traps, it is the chemical form of the uranium. MCNPX simulations provide us with a good understanding of how these uncertainties affect the count rate. Characterization measurements made with ^{252}Cf matched MCNPX simulations very well and give credibility to the Monte Carlo modeling studies.

Future work for UCAS includes installation and calibration at Rokkasho Enrichment Plant in 2010. Because of the relatively high penetrability of neutrons through UF_6 cylinders and potential for unattended mode operation, neutron methods may also offer an alternative (or complement) to gamma-ray methods for enrichment determination. Menlove, Swinhoe, and Miller are currently studying a technique that uses total and correlated neutrons as well as the cadmium ratio to simultaneously determine uranium enrichment and mass in UF_6 containers.[6] These types of advances in nondestructive assay techniques represent important steps in independently verifiable nuclear material accountancy for enrichment plant safeguards.

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Use of UV-visible Spectroscopy to Determine Solution Chemistry Under Used Nuclear Fuel Reprocessing Conditions

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Abstract

UV-visible spectroscopy is utilized in an online fashion to directly measure concentration and speciation of special nuclear materials, such as uranium and plutonium, allowing real-time accountability and tracking for the solvent extraction processes. The implementation of UV-visible spectroscopy for concentration measurements in flowing systems has been demonstrated at labscale, and this initiative boasts great potential to simultaneously and directly monitor chemical process conditions and metal concentrations through an analysis of fundamental chemical speciation. By evaluating the impact of process conditions, such as acid concentration and flow rate, on the sensitivity of the UV-visible detection system, the process-monitoring concept can progress from a common use of instrumentation to an advanced application of fundamental spectroscopy. Ultimately, the experiments conducted pursuant to these objectives will quantitatively describe the relationship between certain UV-visible spectra and their process conditions through the exploitation of chemical speciation. Understanding this relationship is complex due to the undefined uranyl nitrate speciation, thus groundwork tasks focused on characterizing the system encompassing 0.01-1.26 M U and 0.01-8 M HNO_3. Results suggest dominant speciation changes from low (0.01 M) to high (>6 M) HNO_3, and peak shifts in the high (>1 M) uranyl system similarly imply an ingrowth of uranyl nitrate species not present at lower uranyl concentrations. Trends in uranyl molar absorptivity dependence on HNO_3 concentration across wavelengths provide a complimentary approach for investigating uranyl nitrate system behavior. Extended X-ray Absorption Fire Structure spectroscopy has been employed to elucidate uranyl nitrate speciation changes in solution, and extend nitrate solution studies to the plutonyl system. Density functional theory (DFT) calculations of the geometric and electronic structures of the lowest energy uranyl nitrate complexes indicate that the kinetic stability of the tetranitrato species is significantly lower than for other uranyl nitrate complexes, supporting experimental results in which the tetranitrato species is absent. Current efforts focus on integrating a fiber optic dip probe for UV-visible spectroscopy into a bank of centrifugal contactors to demonstrate the online process monitoring concept. Further, the sensitivity of the UV-visible system to nitrate and uranyl conditions, and expected extrapolation to plutonyl conditions, confirm the acute potential for this method of online process monitoring.

Introduction

The outline for this project was developed for the purpose of utilizing UV-visible spectroscopy in a process monitoring setting as to provide a method for confirming and tracking process chemistry. The direct application of this concept is for proliferation resistance in nuclear fuel reprocessing. Online spectrophotometric measurements at Savannah River[1] and fluorescence measurements at the CEA[2] have demonstrated the potential of this technique. Extensive background on the project and preliminary results have been presented elsewhere,[3] the advancement of the UV-visible spectroscopic research project with the addition of Extended X-ray Absorption Fine Structure (EXAFS) spectroscopy and Density Functional Theory (DFT) calculations is communicated here.

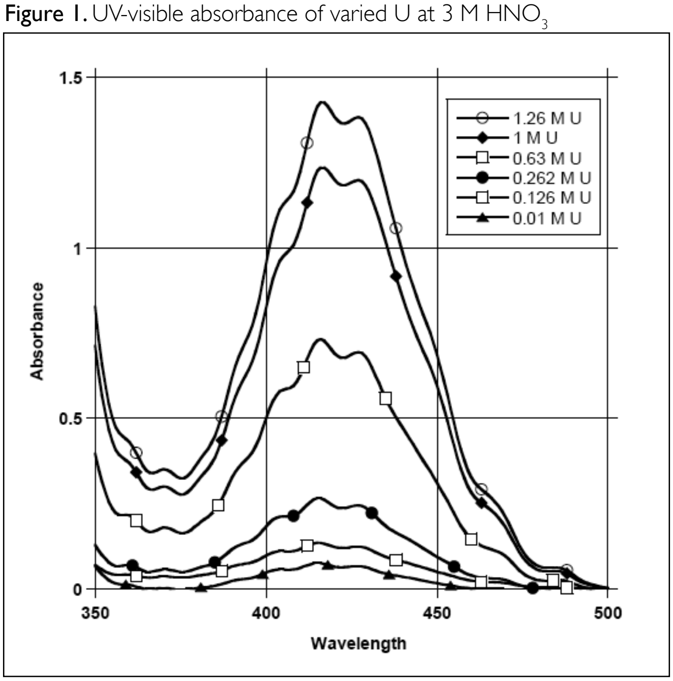
In addition to standard UV-visible spectroscopic analysis and comparison of absorption measurements, ratios of absorbance peaks can be utilized. The importance of the peak ratio comparison is that the ratio is no longer dependent on metal concentration in solution, therefore the ratios are a direct indication of the chemical speciation. Another benefit of this peak ratio method is that due to the direct relationship between changes in speciation and peak ratio differences, the technique can yield real-time feedback in process as a confirmation of chemistry or check for diversion.

An overarching project goal is to define a specific relationship between the spectroscopy of individual components of used nuclear fuel and the solution chemistry under reprocessing conditions. The spectroscopy of the dissolved used nuclear fuel is directly related to the concentrations of its components and the process conditions. As used fuel is predominantly uranium and solvent-extraction-based reprocessing generally begins with used fuel dissolution in concentrated nitric acid,[4] the uranyl nitrate system was chosen to begin spectroscopic studies. Understanding this relationship is complex due to the undefined uranyl nitrate speciation, and widespread efforts in the literature have not yielded a speciation diagram that is largely agreed upon.[5, 6] The coupling of UV-visible spectroscopy, EXAFS spectroscopy and DFT studies presented here has expanded on previous works and allowed extensive characterization of the system under consideration.

UV-visible Spectroscopy

UV-visible spectroscopic studies on the uranyl nitrate system have been reported elsewhere,[3] and a review of the results supports the conclusion that UV-visible spectroscopy can be used effectively to discriminate changes in uranyl and nitric acid concentrations in the 0.01 - 1.26 M U and 0.01 - 8 M HNO_3 system, representative of used fuel reprocessing conditions. The alterations of the characteristic uranyl UV-visible spectral shape[7] at high nitric acid can be seen in Figure 1, suggesting significant speciation changes, and peak shifts in the high uranyl system similarly imply an ingrowth of uranyl nitrate species not present at lower uranyl concentrations. The presence of the differing uranyl nitrate species is expected to substantially affect the UV-Visible absorption spectra, therefore by coupling with the additional EXAFS and DFT studies, UV-visible spectral variations can be attributed directly to specific speciation changes. Additionally, uranyl-uranyl coordination may be the basis of the UV-visible spectral shifts seen at high uranium concentrations.

Figure 1. UV-visible absorbance of varied U at 3 M HNO_3



The online capability of the UV-visible system is accomplished by inserting a fiber optic dip probe directly into the solution under investigation, and full spectrum scans can be accomplished in as little as 200 μs. Due to the rapid acquisition of data and therefore large volume of data to be examined, in addition to monitoring the raw absorbance changes over time, peak ratio measurements can be monitored as well to provide a complimentary method of process monitoring for materials accountancy.

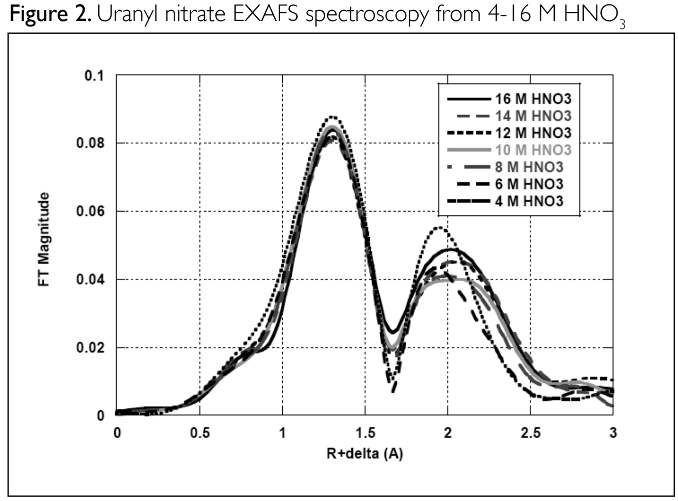
EXAFS Spectroscopy

In an effort to elucidate the uranyl nitrate speciation, fourteen samples were prepared for EXAFS analysis including 0.01 M $UO_2(NO_3)_2$ at 4, 6, 8, 10, 12, 14, and 16 M HNO_3, 0.01 M $(UO_2)_2(OH)_3$ pH adjusted to ~3.5, and 0.1 and 1.3 M UO_3 at 0.1 and 1 M $HClO_4$ and 0.1 M HNO_3.

XAFS measurements were performed at the Advanced Photon Source (APS) at the BESSRCCAT 12 BM station at Argonne National Laboratory. XAFS spectra were recorded at the U-LIII edge (17,166 eV) in fluorescence mode at room temperature using a 13 elements germanium detector with a double crystal of Si [1 1 1] used as a monochromator. A zirconium foil (Zr-K edge = 17,998 eV) was used for energy calibration. For each sample, four spectra were recorded in the k range [0 - 14] A^{-1} and averaged. Background contributions were removed using Athena software and data analysis was performed using WinXAS. The EXAFS spectra of uranyl nitrate solutions were k^3-weighted and Fourier transformations carried out in the k- range [3, 13] A^{-1}.

Fourier transform of the k3-EXAFS spectra (Figure 2) results suggest no change in speciation between 10 and 16 M HNO_3 for 0.01 M UO_2 2+, however changes can be seen across the 4-10 M HNO_3 region. Additionally, spectra indicate precipitate or colloid formation in the 0.01 M $(UO_2)_2(OH)_3$ sample, therefore this measurement will need to be repeated at a later date.

Figure 2. Uranyl nitrate EXAFS spectroscopy from 4-16 M HNO_3



The first peak seen in Figure 2 at R+Δ ~ 1.3 A is attributed to the U=O scattering in the UO_2^{2+}unit and the second peak at R+Δ ~ 2 A is attributed to the U-O scattering from coordinated nitrates (equatorial oxygens). An elongation of the U-O distance is noted with increase of the nitric acid concentration. This phenemona has already been observed in uranyl nitrate complexes and is likely to be due to the formation of a dominant pentanitrate-coordinated uranium followed by uranyl trinitrate species in increasingly concentrated nitric acid.[8] Important to note is the spectroscopic absence of the uranyl tetranitrato species. Most broadly, these U-O distance variations confirm uranyl nitrate speciation changes, however further analysis and comparison with literature values[5] are necessary to yield quantitative speciation conditions.

First-principles Calculations

First-principles all-electron scalar relativistic calculations of the total energies and optimized geometries of uranyl complexes were performed using the spin-polarized density functional theory (DFT) as implemented in the DMol3 software.[9] The exchange correlation energy was calculated using the generalized gradient approximation (GGA) with the parameterization of Perdew and Wang (PW91).[10] Double numerical basis sets including polarization functions on allatoms (DNP) were used in the calculations. The DNP basis set corresponds to a double-ζ quality basis set with *d*-type polarization functions added to atoms heavier than hydrogen. The DNP basis set is comparable to 6-31G** Gaussian basis sets[11] with a better accuracy for a similar basis set size[9]. One 5*f* polarization function and two diffuse 6*d* and 7*s* functions were included in the U basis set. In the generation of the numerical basis sets, a global orbital cutoff of 5.9 A was used. The energy tolerance in the self-consistent field calculations was set to 10^{-6} Hartree. Optimized geometries were obtained using the direct inversion in a subspace method (DIIS) with an energy convergence tolerance of 10^{-5} Hartree and a gradient convergence of $2x10^{-3}$ Hartree/A. Geometry optimization and molecular orbital analysis of the molecular complexes were performed at the Γ point. This computational approach was successfully used in previous studies of uranyl-bearing complexes.[12]

Optimized geometries and molecular orbital (MO) diagrams of the highest-lying states of the stable $UO_2^{\ 2+}$, $UO_2(H_2O)_5^{\ 2+}$, $UO_2(H_2O)_4(NO_3)^+$, $UO_2(H_2O)_2(NO_3)_2$, $UO_2(NO_3)^{3-}$, and UO2(NO3)42- complexes computed using spin-polarized density functional theory (DFT) are represented in Figure 3 and Figure 4. The calculated U-O distance in UO_2^{2+} is 1.72 A, in close agreement with previous fully relativistic results[13]. As shown in the corresponding MO diagram in Figure 3, the highest occupied MOs are formed predominantly from the mixing of O 2*p* and U 5*f* orbitals (e.g., the a_{2u} HOMO of $UO_2^{\ 2+}$ is the result of O 2*pz* and U 5*fz* 3 hybridization), while the lowest unoccupied MOs tend to be mostly composed of U 5*f* electrons (e.g., U $5f_{xyz}$ for the b2u LUMO+1 and U $5f_z({}^2_x-{}^2_y)$ for b1u LUMO+2). The calculated energy gap between frontier orbitals is 1.84 eV for UO_2^{2+}.

As depicted in Figure 4, the equilibrium structure of the pure hydrate complex adopts the C_2 point-group symmetry, while the stable mono-, di-, tri-, and tetranitrato conformers possess C_1, C_{2h}, D_{3h}, and C_{2h} symmetries, respectively. The calculated axial U-O distances are 1.77 A in $UO_2(H_2O)_5^{2+}$, and 1.79-1.80 A in the uranyl nitrate complexes, thus only a modest elongation of the axial U-O bond occurs upon complexation of uranyl in nitric acid. The calculated equatorial U-OH_2 distances are 2.48-2.52 A in $UO_2(H_2O)_{5\ 2+}$, 2.56-2.64 A in $UO_2(H_2O)_4(NO_3)$+, and 2.61 A in $UO_2(H_2O)_2(NO_3)_2$, and the equatorial U-ON distances are 2.44 A in $UO_2(H_2O)_4(NO_3)^+$, 2.50 A in $UO_2(H_2O)_2(NO_3)_2$, 2.51 A in $UO_2(NO_3)_{3-}$, and 2.45 A (η1-coordinated nitrate ligand) and 2.60 A (η2-coordinated nitrate ligand) in $UO_2(NO_3)_4^{\ 2-}$. With the exception of the tetranitrato complex where both η1- and η2-binding modes are present, the lowest-energy structures of U(VI) nitrato complexes tend to favor the η2 coordination for the nitrato chelating ligands. This result is consistent with previous DFT calculations performed at the GGA/B3LYP level of theory with the use of effective core potentials (ECP).[8]

The kinetic stability and chemical hardness of these stable structures of uranyl(VI) nitrate complexes have also been assessed in terms of energy separation between the highest occupied and the lowest unoccupied molecular orbitals (HOMO-LUMO energy gap), a larger energy gap translating in an increased stability of the molecular complex. The calculated HOMO-LUMO gaps are: 2.68 eV for $UO_2(H_2O)_5^{\ 2+}$, 2.00 eV for $UO_2(H_2O)_4(NO_3)^+$, 2.22 eV for $UO_2(H_2O)_2(NO_3)_2$, 2.33 eV for $UO_2(NO_3)_3^{\ -}$, and 1.31 eV $UO_2(NO_3)_4^{\ 2-}$. Therefore, $UO_2(H_2O)_5^{2+}$ is expected to be the most stable complex, while nitrate complexes are found to increase their stability by successive addition of one to three NO_3 ligands. Consistent with the experimental findings reported in this study—which do not show a spectral signature of $UO_2(NO_3)_4^{\ 2-}$ at room temperature—and previous *ab initio* Car-Parrinello molecular dynamics studies,[14] the $UO_2(NO_3)_4^{2-}$ is predicted to be the least stable uranyl nitrate complex.

Figure 3. Molecular orbital (MO) diagram of the highest-lying states of UO_2^{2+} calculated at the GGA/PW91 level of theory (left), with their corresponding graphical representation (right).

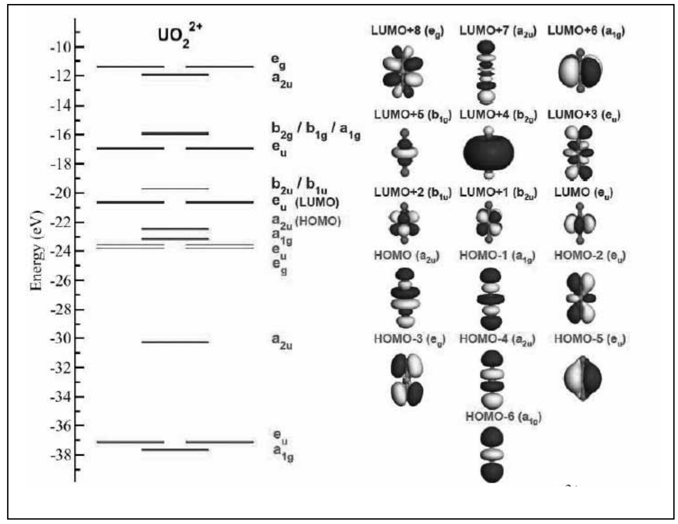
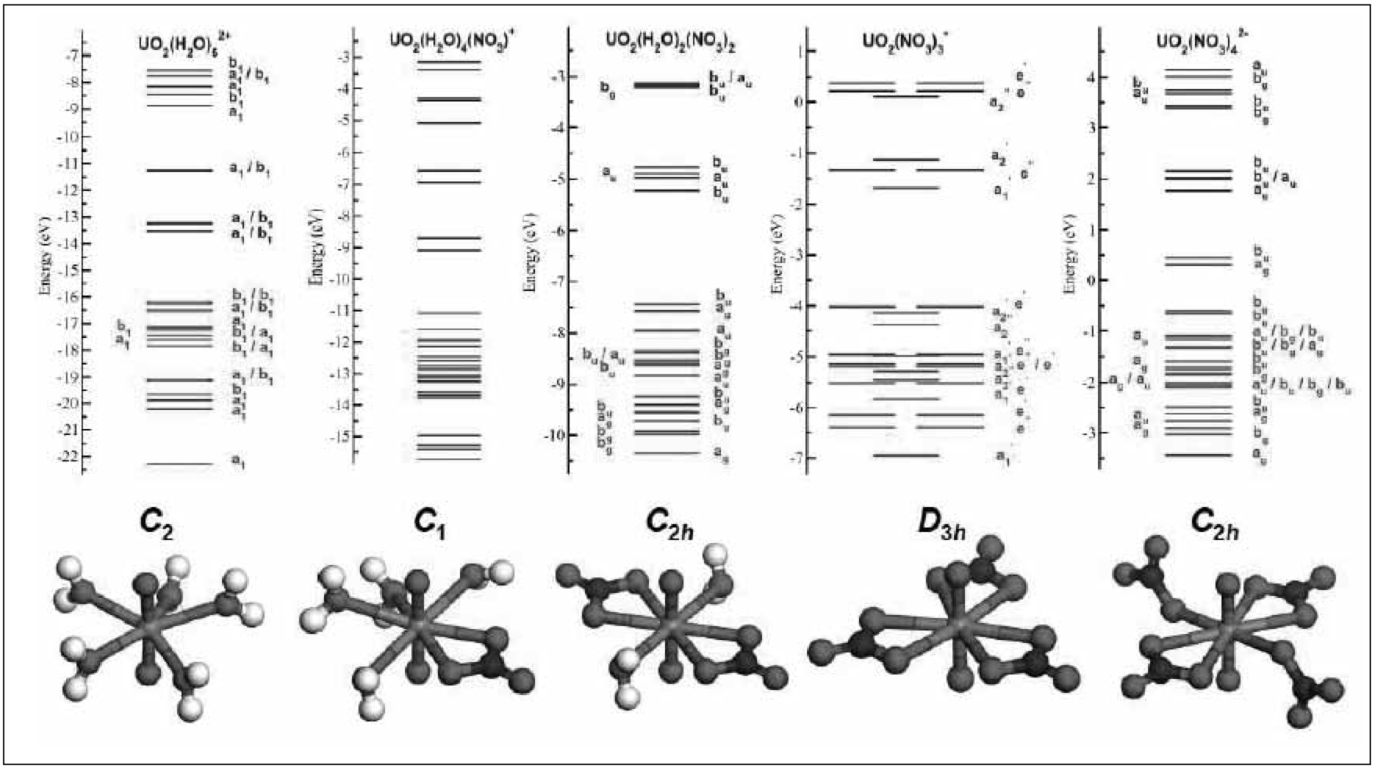


Figure 4: Molecular orbital (MO) diagrams of the highest-lying states of the $UO_2(H_2O)_5^{2+}$, $UO_2(H_2O)_4(NO_3)^+$, $UO_2(H_2O)_2(NO_3)_2$, $UO_2(NO_3)^{3-}$, and $UO_2(NO_3)_4^{2-}$ lowest-energy complexes calculated using density functional theory (top), with the corresponding relaxed geometries and symmetry point groups (bottom).



Conclusion

Online, real-time monitoring is desirable for process control and materials accountability, however previous attempts at this goal have yielded unacceptable detection limits or do not truly provide real-time results. UV-visible spectroscopy is uniquely suited to the application of process monitoring because of its very short measurement time and rapid data output, and additionally it is suited specifically for used fuel reprocessing monitoring because of its sensitivity to the uranyl nitrate speciation. Groundwork efforts focused on characterizing the uranyl nitrate system encompassing 0.01-1.26 M U and 0.01-8 M HNO_3 by UV-visible spectroscopy, EXAFS and DFT calculations. UV-visible spectroscopic results indicate dominant speciation changes from low (0.01 M) to high (>6 M) HNO_3, and peak shifts in the high (>1 M) uranyl system similarly imply an ingrowth of uranyl nitrate species not present at lower uranyl concentrations. The addition of EXAFS spectroscopy and DFT calculations build on the UV-visible spectroscopic studies, and show that due to its instability, the uranyl tetranitrato species is absent in solution. Analyses continue on spectral data and theoretical calculations as to further define the uranyl nitrate speciation under used fuel reprocessing conditions of 4-6 M HNO_3 and approximately 1.3 M U.

Overall, it is shown that solution conditions can be investigated via UV-visible spectroscopy in a manner which provides real-time monitoring of uranyl nitrate speciation changes. Ultimately, these experiments will allow a quantitative description of the relationship between certain UV-visible spectra and the process conditions under consideration. Future work includes an expansion from the pure uranyl nitrate system to one that includes plutonium, lanthanides and fission products, in an effort to better reflect real used fuel reprocessing conditions. Individual studies and then step-wise addition of these metals will allow spectroscopic changes to be attributed to specific metals. Towards this end, UV-visible spectroscopy and EXAFS spectroscopy studies are currently underway on the plutonium nitrate system.

Acknowledgements

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Effects of Quartz Particle Size and Sucrose Addition on Melting Behavior of a Melter Feed for High-Level Waste Glass

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Abstract
The behavior of melter feed (a mixture of nuclear waste and glass-forming additives) during waste-glass processing has a significant impact on the rate of the vitrification process. We studied the effects of silica particle size and sucrose addition on the volumetric expansion (foaming) of a high-alumina feed and the rate of dissolution of silica particles in feed samples heated at 5°C/min up to 1,200°C. The initial size of quartz particles in feed ranged from 5 to 195 μm. The fraction of the sucrose added ranged from 0 to 0.20 g per g glass. Extensive foaming occurred only in feeds with 5-μm quartz particles; particles ≥150 μm formed clusters. Particles of 5 μm completely dissolved by 900°C whereas particles ≥150 μm did not fully dissolve even when the temperature reached 1,200°C. Sucrose addition had virtually zero impact on both foaming and the dissolution of silica particles.

Introduction
More than 100 sites in the United States are currently tasked with the storage of nuclear waste. The largest is the Hanford Site located in southeastern Washington State with 177 subterranean tanks containing over fifty-million gallons of nuclear waste from plutonium production from 1944 through 1987.[1] This waste will be vitrified at the Hanford Tank Waste Treatment and Immobilization Plant. In the vitrification process, feed is charged into a melter and converted into glass to be ultimately stored in a permanent repository. The duration of waste-site cleanups by the vitrification process depends on the rate of melting, i.e., on the rate of the feed-to-glass conversion. Foaming associated with the melting process and the rate of dissolution of quartz particles (silica being the major glass-forming additive) are assumed to be important factors that influence the rate of melting.

Previous studies on foaming of high-alumina feed demonstrated that varying the makeup of a melter feed has a significant impact on foaming.[2] The volume of feeds that contained 5-μm quartz particles substantially increased because of foaming. The extent of foaming decreased as the particle size of quartz increased.[2] Moreover, samples containing quartz particles 195 μm formed agglomerates at temperatures above 900°C that only slowly dissolved in the melt.[3]

This study continues previous work on the feed-melting process,[3] specifically on the effects of the size of silica particles on the formation of nuclear-waste glasses to determine a suitable range of silica particle sizes that causes neither excessive foaming nor undesirable agglomeration. Apart from varying the silica-particle size, carbon was added in the form of sucrose. Sucrose has been used to accelerate the rate of melting.[4] In this study, we have observed its impact on feed foaming and quartz dissolution.

Experimental
Table 1 lists the compositions of the three feeds tested. The baseline feed, A0, was formulated for high-alumina waste.[2] It contains hydroxides, nitrates, and carbonates. The other two feeds were modified by using glass-forming additives in the form of nitrate salts. In the A0-AN1 feed, the content of carbonates is limited to that coming from the waste. No carbonate is present in the A0-AN2 feed.

Quartz was crushed and sieved to obtain various particle sizes. Figure 1 presents four quartz particle sizes used for testing. The A0 feeds were tested with 5-, 75-, and 195-μm particles of quartz. The A0-AN1 feeds were tested with silica particles of 5-, 45-, 75-, 150-, and 195-μm and with an addition of 0.16 g of sucrose per 1 g of glass. All A0-AN2 feeds contained 75-μm quartz and had varying sucrose additions of 0.08, 0.12, 0.16, and 0.20 g per g of glass. The particle sizes and the sucrose masses are listed in Table 2. Feeds containing sucrose are labeled by the carbon-nitrogen atomic ratio in the feed. Feed slurries were wet-mixed in 5-l beakers, stirred with heat until solid, and dried in an oven set to 105°C overnight.

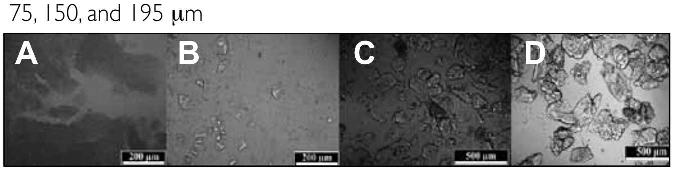
Cylindrical pellets 1.25 cm wide and 0.5 cm tall prepared from 1.50-g feed samples were pressed at ~7 MPa and ramp heated at 5°C/min from room temperature to 1,000°C. Images of the pellet profile were captured through a window in the furnace wall. These images were analyzed on Adobe Photoshop PS3 to obtain the pellet profile as a function of temperature.

For heat treatments, 10-g samples were added to platinum-rhodium boxes, weighed, and ramp heated at 5°C/min in a furnace. Samples were removed at 100-degree intervals from 400°C to 1,200°C. After cooling, heat-treated samples were removed from the crucibles and divided for optical micrographs and X-ray diffractometry (XRD). Thin sections for optical microscopy could

Table 1. Feed compositions in g per 1 kg of glass

	A0	A0-AN 1	A0-AN 2
$Al(OH)_3$	367.49	367.49	367.49
$Bi(OH)_3$	12.80	12.80	12.80
$Ca(NO_3)_2 \cdot 4H_2O$	0.00	210.56	210.56
CaO	60.79	10.79	10.79
$Fe(H_2PO_2)_3$	12.42	12.42	12.42
$Fe(OH)_3$	73.82	73.82	73.82
$H3BO_3$	269.83	269.83	269.83
KNO_3	3.04	3.04	3.04
Li_2CO_3	88.30	4.22	0.00
$LiNO_3$	0.00	156.90	164.78
$Mg(OH)_2$	1.69	1.69	1.69
$Na_2C_2O_4$	0.00	1.26	1.26
$Na_2C_2O_4 \cdot 3H_2O$	1.76	0.00	0.00
Na_2CrO_4	11.13	11.13	11.13
Na_2SO_4	3.55	3.55	3.55
NaF	14.78	14.78	14.78
$NaNO_2$	3.37	3.37	3.37
$NaNO_3$	0.00	112.97	112.97
NaOH	99.41	46.30	46.30
$Ni(NO_3)_2 \cdot 6H_2O$	0.00	0.00	15.58
$NiCO_3$	6.36	6.36	0.00
$Pb(NO_3)_2$	6.08	6.08	6.08
SiO_2	305.05	305.05	305.05
$Zn(NO_3)_2 \cdot 4H_2O$	2.67	2.67	2.67
$Zr(OH)_4 \cdot xH_2O$	5.49	5.49	5.49
Total	1349.82	1642.55	1655.43

Figure 1. Microscopic images of quartz particles from left to right: 5, 75, 150, and 195 μm



only be prepared with fused samples, which typically formed at temperatures exceeding 700°C. For examination by XRD, samples were mixed with 5 mass percent of CaF2 as an internal standard and crushed in a tungsten-carbide mill. Figure 2 shows a series of XRD scans from the 45-μm A0-AN1 feed to demonstrate the changes taking place in samples as a function of temperature. XRD scans were analyzed for content of crystalline phases by the programs JADE 6 and RIQAS 7. The pink peaks (A) belong to the internal standard. The content of quartz (B) decreases rapidly after 800°C. Spinel (C) is present even at 1,200°C. Sodalite (the blue peaks, D) dissolved at <1,100°C.

The relative fraction of undissolved quartz, s, determined

Table 2. Feed variables

Feed ID(a)	Sucrose Per 1 kg Glass, g	Quartz Particle Size, μm
A0-5	0.00	5
A0-75	0.00	75
A0-195	0.00	195
A0 AN1-5 (1.00)	157.58	5
A0 AN1-45 (1.00)	157.58	45
A0 AN1-75 (1.00)	157.58	75
A0 AN1-150 (1.00)	157.58	150
A0 AN1-195 (1.00)	157.58	195
A0 AN2-75 (0.00)	0.00	75
A0 AN2-75 (0.50)	81.41	75
A0 AN2-75 (0.75)	122.39	75
A0 AN2-75 (1.00)	163.36	75
A0 AN2-75 (1.25)	204.33	75

(a) Feed type-Particle size in μm (carbon-to-nitrogen molar ratio)

from XRD analysis was calculated as s = xs/xs0, where xs is the fraction of solid silica per mass of glass, and xs0 is the total silica fraction. The ad hoc arctangent function,

$$s = \frac{s_{-\infty} + s_{+\infty}}{\pi} - \frac{s_{-\infty} - s_{+\infty}}{2} \arctan \frac{T - T_0}{T_1} \qquad (1)$$

was fitted to data to guide the eye,[3] where s-∞, s+∞, *T1*, and *T0* are constant parameters.

Results

Figure 3 shows photographs of expanding pellets of A0-AN1 and A0-AN2 feeds. Note the 1-cm segment of Pt wire used as a size gauge.

Figure 4A displays foaming curves for feeds with varying quartz particle sizes (as obtained from averaging two trials with A0-AN1 pellets). Solid lines represent A0 feeds and broken lines the A0-AN1 feeds. Feeds with 5-μm quartz continuously expanded to foam, the A0 feed from 700°C to 900°C and the A0-AN1 feed from 800°C to 850°C. The foam collapsed as the temperature increased. Both A0 and A0-AN1 feeds with 75-μm quartz initially shrank from 700°C to 800°C, then expanded to approximately the initial profile area at 900°C, and finally collapsed by 1000°C. The A0 feed with 195-μm quartz shrank rapidly after 800°C, reaching a minimum profile area at 850°C. In A0-AN1, the use of 195-μm quartz particles resulted in gradual pellet shrinking from 700°C to 800°C followed by rapid shrinking until a minimum was reached at 875°C.

Expansion resulting from trapped gases as a result of feed reactions is often referred to as primary foaming, whereas secondary foaming is caused by gases from redox reactions.[5] Unlike

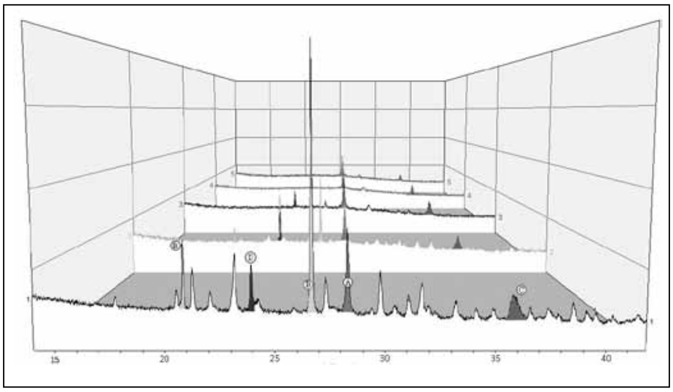


Figure 2. X-ray diffraction patterns of A0-AN1 45 (1.00) from 800°C (1) to 1,200°C (5)

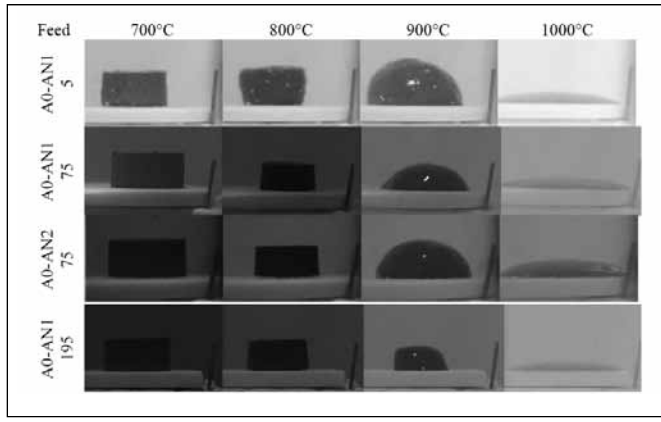


Figure 3. Photographic images of A0-AN1 feeds with 5-, 75-, and 195-—m quartz particles and A0-AN2 feed with 75-—m quartz particles

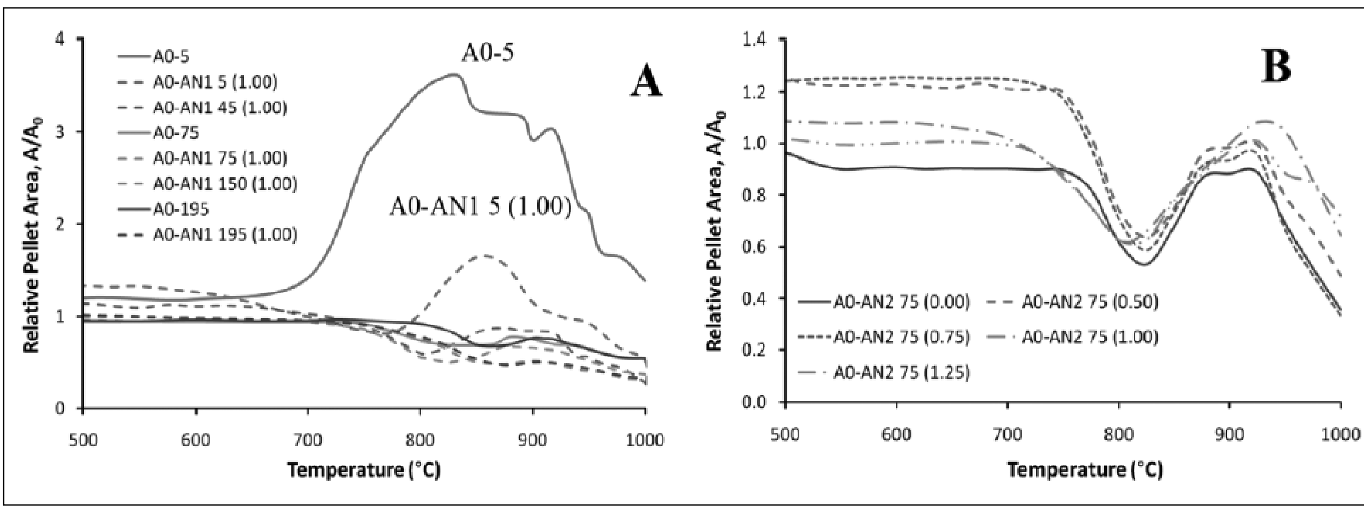


Figure 4. The effect of quartz-particle size on pellet expansion in A0 and A0-AN1 feeds (A) and the effect of sucrose addition on pellet expansion in A0-AN2 (B)

feeds with 5-μm quartz, feeds with larger quartz particles did not exhibit primary foaming because a high-viscosity melt formed only after reaction gases evolved. Secondary foaming occurred at temperatures >800°C. Figure 4B shows that foaming in A0-AN2 feeds was not significantly affected by the carbon content.

Figure 5A presents the dissolution of silica in A0 feed (solid points and lines) and A0-AN1 feeds (open points and dashed lines). The lines were fitted using Equation 1. Quartz particles in A0-AN1 feeds reached the same extent of dissolution as A0 feeds at temperatures up to 100°C higher. The quartz particles ≤75 μm fully dissolved below 1,100°C. The fraction of dissolving quartz particles in A0-AN2 feeds is shown in Figure 5B. The sucrose addition was the only variable and had no noticeable effect on the dissolution of quartz. Therefore, a single line was fitted to data. Table 3 lists the dissolution coefficients defined by Equation 1.

Figure 6 shows optical micrographs of feeds. At 900°C, feeds with quartz ≤75 μm formed a connected glass melt that trapped gases and formed cavities as wide as 5 mm on the sample bottom. The motion of the bubbles as they escaped at high temperatures homogenized the melt. Feeds containing particles >75 μm appeared uniform at temperatures < 900°C with quartz evenly dispersed throughout the sample (particles appear as dark spots on samples in first row). At higher temperatures, the dissolution of these large particles formed dark regions of high-viscosity silica melt. Bubbles isolated in this region coalesced and eventually forced particles into large clusters. These clusters survived beyond 1,200°C.

Discussion

Both primary and secondary foaming may insulate feed from external heat by reducing the rate of heat transfer and thus may reduce the rate of melting in a large-scale melter.[2,5]

Volume expansion results and quartz dissolution data have demonstrated that foaming is primarily influenced by the fraction of silica dissolved. Noticeable foaming occurred when the

Figure 5. The effect of particle size on the dissolution of quartz in A0 and A0-AN1 feeds (A) and the effect of sucrose addition on the dissolution of quartz in A0-AN2 (B)

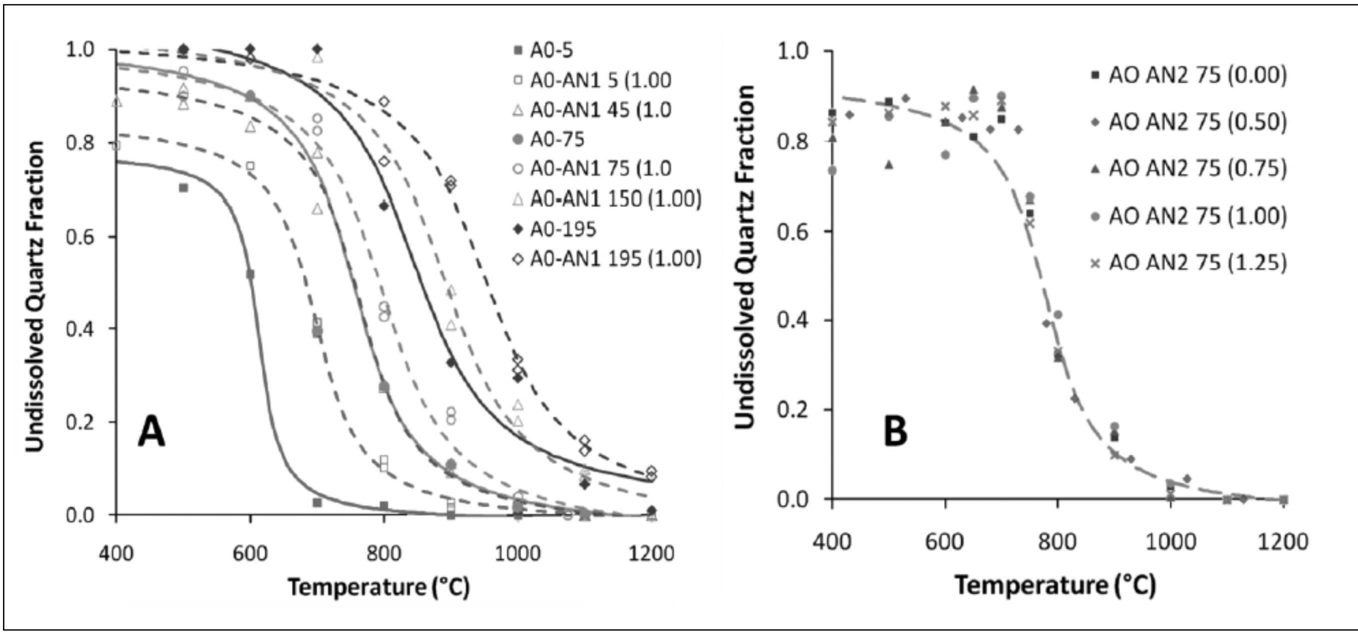
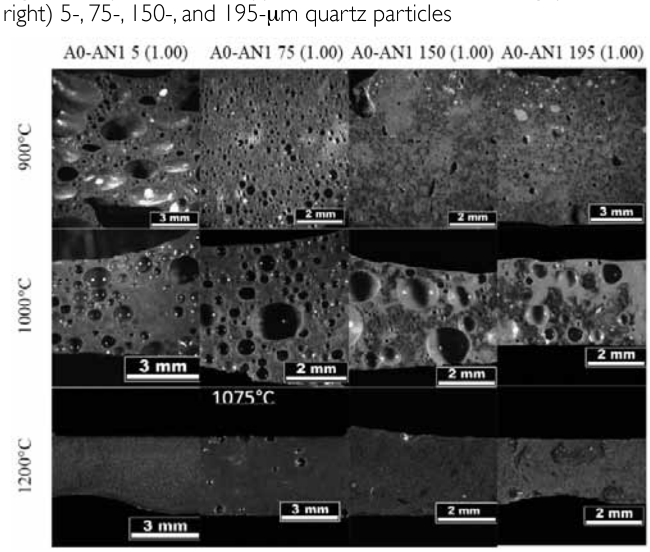


Table 3. Dissolution coefficients(a)

Composition	A0-AN1					A0-AN2	A0		
Quartz particle size, —m	5	45	75	150	195	75	5	75	95
Sucrose addition, g per 1 kg of glass	157					163	0.000		
s+∞	-0.033	-0.051	-0.071	-0.060	-0.037	-0.052	-0.020	-0.056	-0.015
s-∞	0.866	0.971	1.026	1.071	1.051	0.952	0.788	1.031	1.103
T1	49	60	76	86	89	64	23	64	89
T0	698	763	798	891	951	778	613	756	845

(a) Dissolution coefficients are defined by Equation (1).

Figure 6. Optical microscopy of A0-AN1 feeds containing (from left to right) 5-, 75-, 150-, and 195-μm quartz particles



fraction of solid quartz was reduced below 0.2 before 800°C (see Figures 4A and 5A). The use of fast-reacting 5-μm quartz particles, or "silica flour," resulted in a large volumetric expansion of samples at 900°C (Figures 3 and 4A). As Figure 5A illustrates, small particles completely dissolved by 1,000°C and, as seen in Figure 6, the melt appears homogeneous at temperatures >1,000°C.

Feeds with ≥75-μm quartz particles produce little primary foam and produced a limited amount of secondary foam (Figure 4). Silica particles remained still undissolved at 1,000°C, and a high-viscosity melt surrounded the dissolving particles within the diffusion layers,[3] while bubbles escaped through a low-viscosity bulk melt (Figure 6). However, inhomogeneities from the clustering of large particles may persist and, if not dispersed in the melter, may affect the glass corrosion resistance.

Since the sugar addition has little effect on both the dissolution of silica and foaming, no effects of sucrose addition on the rate of melting are expected beyond the melt-accelerating impact of the exothermic reaction of sucrose with nitrates.

Comparing the behavior of the baseline feed and the nitrate-modified feeds indicates that nitrate salts somewhat hinder the dissolution of quartz particles and reduce foaming. Further investigation is needed to ascertain the mechanism behind this trend.

Conclusions

Feeds with 5-µm quartz particles produced excessive foaming. Particles of ≥150 µm in size formed slowly dissolving clusters. Particle sizes of 45 to 75 µm appear to be optimum for processing. Adding sucrose to feeds containing nitrate (known to accelerate melting) has no adverse effect on foaming or quartz dissolution. Quartz dissolved somewhat faster in feeds containing both carbonates and nitrates than in fully nitrated feeds.

Acknowledgements

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Book Review

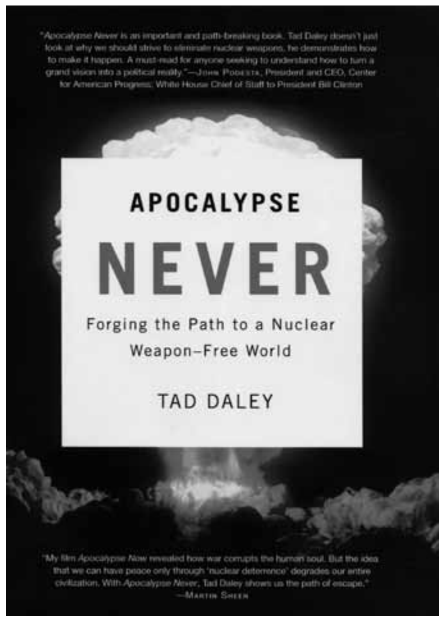
by Walter Kane

Apocalypse Never
Forging the Path to a Nuclear Weapon-Free World
Author: Tad Daley
ISBN: 978-0-8135-4661-2

The core mission of our profession is to minimize the risk of nuclear proliferation and its inevitable consequences. Accordingly, Tad Daley's new work *Apocalypse Never* should be of considerable interest to our community. The principal ideas are:

- The enormous destructive power of nuclear weapons and the risk of their use.
- The evolution of conventional weapons that has rendered nuclear weapons unnecessary.
- It is necessary, and possible, to create international entities that can promote and monitor nuclear disarmament.
- It will be necessary to create a popular movement here and in other countries to give the necessary impetus for this process to take place.

The first chapter discusses what is already well known to thinking individuals—the enormous destructive power of nuclear weapons—the Mike Device, the first hydrogen bomb, had an explosive yield nearly 1,000 times greater than those that devastated Hiroshima and Nagasaki—and there are thousands of these devices in the arsenals of the nuclear weapons states. Later chapters discuss what is less well known, the occasions when the sound judgment of one or a few individuals prevented the mutual annihilation of the citizens of Russia and the United States, not only during the Cuban missile crisis but on other occasions when, according to the "launch on warning" policy, if a fleet of incoming missiles was detected, a retaliatory strike would be launched before the



enemy missiles reached their target. On several occasions, both in Russia and the United States, computer malfunctions or the misinterpretation of radar signals led to false alarms, and it was only the common sense of individuals that prevented total disaster. This policy was totally unnecessary, since both sides had nuclear missile submarines that are essentially invulnerable.

The next thesis is also crucial—that the power, accuracy, and number of our conventional weapons today render nuclear warheads totally unnecessary. Nuclear weapons are thus unnecessary for self-defense by the United States or other major powers.

Given that nuclear weapons are both dangerous and unnecessary, we arrive at the question of how they should be eliminated universally. The existing Nuclear Nonproliferation Treat (NPT) is a step in this direction but it goes only part of the way. The NPT creates a two-tier system of weapon and non-weapon states, with duties for each group. The weapon states agree not to attack a non-weapon state with nuclear devices and to eventually eliminate their weapons (no party to the treaty has done this but several countries, including South Africa and Libya, have cancelled their weapons programs) while the non-weapon states agree not to acquire weapons. What is needed is a treaty binding on every state requiring the total elimination of weapons stockpiles, with totally intrusive inspection and enforcement provisions. Along with this treaty there should be a strong universal collective security system that will convince individual governments that they do not require nuclear arms for self-defense. In addition there must be provision for proper monitoring of fuel cycle facilities including enrichment, fuel fabrication, and reprocessing plants. Former IAEA Director General Mohamed el-Baradei has proposed that all these facilities be placed under an international agency with appropriate safeguards and security in place.

The question remains concerning the appropriate paths to this regime. There are already precedents in the arms control regime—the START and Intermediate-Range Nuclear Forces treaties and the Chemical Weapons and Biological Weapons Conventions, for example. The author proposes that Article 8 of the NPT, which provides for a conference with the aim of extending the treaty, and Article 109 of the UN Charter would be appropriate pathways. Clearly the final agreement must be veto-proof.

Finally, there must be strong popular support for this undertaking. There are many precedents in the United States in this area—the abolition of slavery, women's suffrage, and the Civil Rights Movement are examples. The public should understand that in reality, "their lives may depend on it." It is very important here to enlist the idealism and energy of young people, and create a strong popular movement.

While the principal ideas put forth in *Apocalypse Never* should have considerable utility in addressing what has been an extremely dangerous situation for the past sixty-five years, in the last chapters the author digresses into areas that do not contribute further to that goal. For example, he is justifiably proud of his father's service in flying B-29s over Japan. Accordingly, the author asserts that these raids were about to bring about the surrender of Japan, and thus U.S. President Harry Truman's decision to end the conflict with the use of nuclear weapons was unnecessary. At the end of 1944 German cities and industrial base were in ruins after years of bombing raids, but the Germans were able to launch a massive ground attack in the Ardennes, which, by the time it was beaten back, led to the greatest engagement ever fought by the U.S. Army. In the Okinawa campaign U.S. forces suffered terrible casualties (including two general officers) and the Japanese military and civilians even more. There was no indication at this time of an imminent surrender, and Okinawa gave a clear prediction of the enormous human cost of an invasion. At that time this reviewer, a very young soldier and recent graduate of an infantry replacement training center, was in a training program whose purpose was clearly to provide several hundred thousand *fillers* for the divisions taking part in the invasion. If Truman had made that choice it is unlikely that your reviewer would be here penning these words.

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Taking the Long View in a Time of Great Uncertainty

By Jack Jekowski
Industry News Editor

In this issue of the *JNMM* we introduce a new format to the Industry News column that examines the global nuclear security environment in the context of INMM's evolving mission, and extrapolates on current events that would impact future paths for the Institute. This new format was suggested by *JNMM* Technical Editor Dennis Mangan, who saw the value of future visioning, driven in part by the efforts of Ken Sorenson and the INMM Organizational Strategic Planning Working Group[1] (OSPWG) to perform an "Externalities Analysis" this past year as they examined the adequacy of the Institute's organizational structure and made recommendations to improve its effectiveness.

In this column we hope to further stimulate strategic discussions on externalities among INMM members, and to raise the awareness of members to the outside events that influence the work of the Institute, encouraging them to "connect the dots" and take a "long view" of the future. This future visioning exercise will also provide the leadership and members of the Institute insight into where their own efforts might best be invested, and should help the Institute itself continue its long history of contributing to making the world a safer place. This process also has the potential to help leadership and members feel more comfortable about decisions they may make in an uncertain future because they have rehearsed the "what ifs" enough to be able to make intelligent decisions when dramatic events occur that portend global change or danger.

Where Do We Start?

The Externalities Analysis that was performed by the OSPWG examined a wide range of external influences impacting the Institute's strategic environment, including *International Activities* (UN/IAEA); *Intergovernmental and International Non-Governmental Activities; International Regional Activities;* and *U.S. Activities.* The result of this several-month analysis was summarized into the following set of observations that were presented to the INMM Executive Committee in December 2009, and subsequently included in the briefings to the Sunday Technical Division meetings at the INMM 51st Annual Meeting to provide a backdrop for recommended organizational changes:

Externalities Analysis—Observations

- The concern over nuclear materials management is global.
- There is a strong emphasis on treaty ratification and verification.
- There is strong U.S. engagement to minimize proliferation risk while encouraging commercial expansion of nuclear power.
- There are four major forces driving the future of nuclear materials management:
  - Concern over terrorism since 9/11
  - Dramatic reduction in the nuclear weapons stockpile
  - Concern over a growing number of potential nuclear-weapons-capable countries acquiring nuclear materials/capabilities
  - Dramatic increase in commercial nuclear fuel cycle development
- The current INMM technical divisions seem to address the majority of these externalities.
- However, changes are recommended to strengthen the overall technical division portfolio in light of these externalities, particularly as they relate to the commercial fuel cycle.

Understanding the complex environment of the twenty-first century is the first step by the Institute to take command of its own destiny during a period of great uncertainty; and as the new organizational structure proposed by the OSPWG is implemented there will be an on-going effort to monitor these externalities to ensure that the changes are effective and appropriate.

We are Indeed in Historic Times

The dramatic events of the new millennium, driven by the nightmare of September 11, 2001, and reaching a crescendo today with the current threats of nuclear terrorism and the proliferation of nuclear weapon technologies, bookmark the fact that we live in historic times. It is easy to respond to the question today: "What keeps you awake at night?"

These events in the first decade have set the stage for the significant national security policy changes proposed by President Obama, including proposed dramatic reductions of the world's nuclear stockpiles, less reliance on nuclear deterrence as an element of the U.S. national security strategy, and sharing nuclear technologies for peaceful uses. Supported internationally by many countries and organizations, these new policies portend a much different path for humanity in the twenty-first century than many envisioned. The orchestration of the Obama administration's nuclear policy will undoubtedly be looked back upon by historians as a model for using the influence of the U.S. presidency to change the future path for the world. The message has been clear since the president's historic speech in Prague on April 5, 2009: this presidency will mark a turning point in human history for weapons of mass destruction. A mapping of the administration's national security timeline[2] reveals the consistency of the message and the resolve of this president to that goal:

- January 20, 2009 – President Obama sworn in as the 44th president of the United States
- April 5, 2009 – The historic speech in Prague outlining the president's nuclear weapons agenda
- September 24, 2009 – President Obama chairs the U.N. Security Council – UNSC Resolution 1887 approved – aligned with the president's nuclear weapons agenda.
- December 10, 2009 – President Obama receives the Nobel Peace Prize for his efforts to begin moving to a world without nuclear weapons.[3]
- December 17, 2009 – U.S. signs a "123" agreement with the United Arab Emirates to share nuclear reactor technologies.
- February 1, 2010 – Release of the Quadrennial Defense Review (QDR), reducing the U.S. reliance on the nuclear stockpile.
- April 6, 2010 – Release of the Nuclear Posture Review (NPR), further detailing the goal of reducing the U.S. reliance on the nuclear stockpile.
- April 8, 2010 – START Treaty signed in Prague—almost one year since the date of the historic speech on nuclear policy—taking U.S. and Russian stockpiles to lower levels
- April 12-13, 2010 – President Obama's International Nuclear Security Summit—issuance of a communiqué that reinforces the core message of the president's nuclear weapons agenda
- May 3-28, 2010 – Nuclear Nonproliferation Treaty (NPT) Review Conference—reinforcing many of the president's international objectives for reducing nuclear weapons stockpiles in a consensus document.
- May 27, 2010 – Release of the U.S. National Security Strategy (NSS)—reinforcing the goal of a world without nuclear weapons, emphasizing that our national strategy "must take a long view," and creating the imperative for a new "international order."

Some believe these historic events will provide new hope for global harmony as more and more world leaders align with the president's objective to create a new "international order."[4] Others grow more and more concerned the world will be thrown back to a pre-nuclear era of global warfare, costing millions of lives. We cannot predict what the future will be, but through the power of strategic discussions we have an opportunity to "connect the dots" and peer into the future along different paths, speculating on "what might be." By spending quality time in strategic discussions to examine these future worlds, we can then develop the actions that will allow us to adapt to, or, perhaps, even change that future.

Further Reductions in Nuclear Stockpiles

There is much discussion, now that we have started down this road, about further unilateral reductions to the U.S. nuclear stockpile. In the spring 2010 issue of *Strategic Studies Quarterly* (Vol. 4, No. 1),[5] an article titled "Remembrance of Things Past: The Enduring Value of Nuclear Weapons" speculates on the reduction of the stockpile to 311 weapons while still providing adequate deterrence for all known nation-state threats. To achieve such dramatic levels of reduction, as some suggest by 2025,[6] will require the U.S. National Nuclear Security Administration to make a significant mission re-alignment to address current resource limitations (for example the dismantlement and storage capacity at Pantex and the transportation capacity of the U.S. Secure Transportation Asset, the Office of Secure Transportation.

The Key to Making It All Work—Nuclear Forensics?

As deterrence strategies change for nation states in this new world, perhaps leading to further reductions in nuclear stockpiles, and even multilateral nuclear arms control treaties, the world's attention must turn to how the world deals with non-state or rogue state threats. Much has been written in the past few years about nuclear forensics, a technical term applied to "the examination and evaluation of discovered or seized nuclear materials and devices or, in cases of nuclear explosions or radiological dispersals, of detonation signals, and post-detonation debris."[7] The ability to conduct nuclear forensics is critical to deterring, limiting, and responding to nuclear terrorism.

Where Do We Go from Here?

There are many questions to be asked as we travel this uncertain path to the future:

- How will the world deal with the untenable situations in Iran and DPRK?
- What happens if other nation-states similarly pursue nuclear weapons?
- How are other nations responding to President Obama's global nuclear initiatives—what impact will those responses have on the INMM?
- What will be the worldwide response to the first terrorist nuclear event (either nuclear or dispersal)?
- Can nuclear forensics provide the deterrence needed to prevent terrorist attacks?
- Will unilateral reductions in the U.S. stockpile influence the decision of other nuclear weapons states to further reduce their own stockpiles?
- What is the evolving role of the United Nations and the International Atomic Energy Agency in the new "international order" proposed by President Barack Obama?
- What scientific, technological, and policy innovations can INMM promote to make the world a safer place?

We encourage *JNMM* readers to actively participate in these strategic discussions, and to provide your thoughts and ideas to the Institute's leadership. With your feedback we hope to explore these and other questions in future columns, addressing the critical uncertainties that lie ahead for the world and the possible paths to the future based on those uncertainties. The important question to be asked of the Institute: "What should INMM's role be in a world defined by the new 'international order,' and how should we be preparing today to fill that role in the future?"

Jack Jekowski is a principal partner with Innovative Technology Partnerships, LLC (ITP), a national security consulting and services company that provides support to the U. S. Department of Energy, the U.S. National Nuclear Security Administration, the national laboratories and other federal and commercial customers. Jekowski has had a forty-five-year career in the Nuclear Security Enterprise (NSE), starting with "Doc" Edgerton of EG&G, Inc. as a co-op student in 1965, and continuing today in his work with ITP. His specialty area is scenario planning, a strategic planning tool that has been more widely used in the federal government since the tragic events of September 11, 2001. Jekowski studied the art of scenario planning from the "Master"—Peter Schwartz of Global Business Network (http://www.gbn.com). Schwartz' epic work "The Art of the Long View," is the seed for this column—developing the insight and perspectives to take a long view of the future even when faced with great uncertainties by "connecting the dots." Jekowski assisted the INMM Organizational Strategic Planning Working Group as they worked during the past year to examine the adequacy of the current organizational structure of the Institute by enriching the data set used to interpret the dramatic events in today's world and where they might lead.

Comment?
To comment or offer suggestions for future columns, contact Jekowski at jpjekowski@aol.com. Material concerning the future of the U.S. NSE can also be found under the "What's New" tab of Jekowski's company Web site, http://www.itpnm.com, including presentations he has made on the NSE the past five years to the annual INMM Southwest Chapter technical meeting.

End Notes

1. The OSPWG membership included: Ken Sorenson (chair), Obie Amacker, Jeff Jay, Ed Johnson, Jim Larrimore, Teressa McKinney, and Steve Ortiz, as well as many other members of the Institute who contributed to the effort in various ways.
2. See http://www.itpnm.com/whats-new-archives/criticialuncertainty-timelinegeneric8-31-10.pdf for a visual depiction of the national security timeline of the Obama administration and critical uncertainties that lie ahead.
3. "The Norwegian Nobel Committee has decided that the Nobel Peace Prize for 2009 is to be awarded to President Barack Obama for his extraordinary efforts to strengthen international diplomacy and cooperation between peoples. The Committee has attached special importance to Obama's vision of and work for a world without nuclear weapons." http://nobelprize.org/nobel_prizes/peace/laureates/2009/press.html
4. Speech by President Obama to the commencement of the U.S. Military Academy at West Point, May 22, 2010: "So we have to shape an international order that can meet the challenges of our generation...The international order we seek is one that can resolve the challenges of our time..." quoting excerpts from the National Security Strategy that was released the following week.
5. See http://www.au.af.mil/au/ssq/2010/spring/spring10.pdf This article was authored by James Wood Forsyth Jr., a professor at the USAF School of Advanced Air and Space Studies; Col. B. Chance Saltzman, chief, Strategic Plans and Policy Division, USAF HQ; and Gary Schaub, an assistant professor at the Air War College. A video report on the article was aired on CNN's Fareed Zakari at's Sunday News program, *Global Public Square* (GPS) August 29, 2010—see http://www.cnn.com/video/#/video/us/2010/08/29/gps.what.world.nuclear.cnn
6. *Eliminating Nuclear Threats: A Practical Guide for Global Policymakers*—Report of the International Commission on Nuclear Nonproliferation and Disarmament, Canberra, Australia: Paragon 2009, see: http://www.icnnd.org/reference/reports/ent/index.html
7. *Nuclear Forensics: A Capability at Risk,* Committee on Nuclear Forensics, National Research Council, National Academies Press, http://www.nap.edu/catalog.php?record_id=12966

February 6–9, 2011
CONTE 2011
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July 17–21, 2011
52nd INMM Annual Meeting
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[1]http://www.ortec-online.com/download.asbx?AttributeFileId=0b1f5761-c46b-4901-91ac-e0b810655b6a

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