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U.S. Policy on Nonproliferation Issues

Personally, I was interested in the message President Clinton made to the United Nations on Sept. 27. Unfortunately, I was on a plane and not able to see it live. I found the various news articles I read were not very comprehensive about the particular issue of my interest, namely non-proliferation. It was not until I received a copy of a Fact Sheet released by the White House on Sept. 27, titled "Non-proliferation and Export Control Policy," that I gained an understanding of the message the president gave. Since the core technologies and capabilities of our professional society, from both U.S. and international constituents, will play an important role in solving the worldwide non-proliferation issues, I thought it might be beneficial to highlight the Fact Sheet, which outlines the present U.S. policy in this area.

According to the White House, there are three major principles that guide the U.S. non-proliferation and export control policy:

- National security requires the United States to accord higher priority to non-proliferation and to make it an integral element of relations with other countries;
- To strengthen U.S. economic growth, democratization abroad and international stability, the United States will actively seek expanded trade and technology exchange with nations, including former adversaries, that abide by global non-proliferation norms; and
- The United States will build a new consensus—embracing the executive and legislative branches, industry and public, and friends abroad—to promote effective non-proliferation efforts and integrate U.S. non-proliferation and economic goals.

The Fact Sheet identified six key elements of the policy: fissile material; export controls; nuclear proliferation; missile proliferation; regional non-proliferation initiatives; and conventional arms transfers. Strategies were enumerated as to how the concerns for each of these elements would be pursued. Because the space allotted for this message is limited, I would like to focus on fissile material, nuclear proliferation and regional non-proliferation initiatives, recognizing that export controls, missile proliferation and conventional arms transfers are important to addressing the worldwide non-proliferation issues. Below I attempt to summarize the strategies in the Fact Sheet.

Concerning fissile material, the United States is concerned about the growing accumulation of fissile material from dismantled nuclear weapons and from civil nuclear programs. It will seek to eliminate stockpiles and subject existing stockpiles to the highest standards of safety, security and international accountability. It will submit fissile material no longer needed for deterrence to inspection by the International Atomic Energy Agency (IAEA). It will propose a multilateral convention prohibiting the production of HEU or plutonium for nuclear explosives or outside of international safeguards. It will encourage regional arrangements to constrain fissile material production in regions of instability and high non-proliferation risk. It will pursue the purchase of HEU from the former Soviet Union, and it will initiate a comprehensive review of long-term options for plutonium disposition. Although the United States does not encourage the civil use of plutonium, it will maintain its existing commitments regarding the civil use of plutonium in Western Europe and Japan.

On the subject of nuclear proliferation, the United States will make every effort to secure the indefinite extension of the Non-proliferation Treaty in 1995. It will also seek to ensure that the IAEA has the needed resources, including the ability to detect clandestine nuclear activities.

Concerning regional non-proliferation initiatives, the Fact Sheet states that non-proliferation will receive greater priority in U.S. diplomacy, to address the proliferation threat in regions of tension, such as the Korean peninsula, the Middle East and South Asia. The significant non-proliferation progress made in Latin America and South Africa will be taken into account, and efforts will be intensified to ensure that the former Soviet Union, Eastern Europe and China do not contribute to the spread of weapons of mass destruction, including delivery systems.

We believe we have postured the INMM to cover the issues, technologies and capabilities needed to help implement the policies of various countries, policies which address the worldwide non-proliferation issues. Our recent successful Annual Meeting in Scottsdale is testimony, and our next Annual Meeting should be even better. After all, it's our business.

In other news, the Japan Chapter of INMM will hold its 14th Annual Meeting in Tokyo on Nov. 9 and 10. I received a copy of the preliminary program, and congratulations have to go to our members in Japan. They are doing an excellent job.

The charters of the INMM Technical Divisions have been finalized, thanks to the diligent efforts of the division chairs. We will introduce these charters to you in the near future after we discuss it at the October meeting of

Chair's Message
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the Executive Committee.

Finally, a sincere word of thanks goes to all of you who supported the outstanding meeting we had in Scottsdale. Plans are underway for the meeting next summer, which will be in Naples, Fla., at the Registry Resort Hotel, July 17-20. One has to admire the efforts of the INMM headquarters staff in meeting the boundary conditions we impose on them. We try to alternate yearly to be east and west of the Mississippi; we need a place that will give us government *per diem*; we need a place that will give us "bennies" so the registration fee will stay low; and, we need a place big enough to not only handle the people who attend but to also accommodate the plenary session and the five or six concurrent sessions we hold. The call for papers for next year's Annual Meeting will be issued in the near future.

Should you have any comments or questions, please feel free to contact me at (505) 845-8710.

Dennis Mangan, Chair
Institute of Nuclear
Materials Management
Sandia National Laboratories
Albuquerque, New Mexico, U.S.A.

Public Education and the Future of Nuclear Energy

In this issue we have a discussion of the future of nuclear energy, and three contributed papers on three different subjects of interest to our members.

For several years, we have published in the Fall issue an interview with the speaker who introduces the Annual Meeting. This year the speaker was A. David Rossin, the past president of the American Nuclear Society (ANS). The subject of public education on nuclear energy and related issues should be of particular interest to our members. The INMM talks about this subject but we have not done much about it. The ANS in the United States and similar organizations in other countries have considerable experience in this important area. As you will see, we decided that it would make more sense for the INMM and its members to work with these professional organizations rather than to try to develop effective educational programs on our own.

In the most recent issue of the *Journal*, we published a paper by T. Shea, et al., on IAEA safeguards for reprocessing plants. In this issue, we have another paper on the subject by A.B.M.N. Islam, S.J. Johnson and W.D. Sellinschegg, all of whom are from the IAEA. This paper explains in detail how the Agency and its inspectors verify the facility data on inputs and on interim verification of the in-process inventories, and how they draw conclusions regarding the interim and annual material balance calculations. Having followed these operations for a number of years, I found this procedure to be very efficient and effective.

C.A. Rodriguez of Los Alamos and I.G. Waddoups of Sandia Laboratories contributed a joint paper on materials monitoring systems. A stimulus for these developments is the fact that the U.S. Department of Energy (DOE) will have to store large quantities of highly enriched uranium and plutonium which are now being recovered from nuclear weapons that are no longer needed. The present DOE regulations require frequent physical inventories of such material in storage. Performing such inventories is not only time consuming but, in the case of plutonium, involves exposure to gamma rays and neutrons. The monitoring systems involve continuous surveillance of the materials and of any people who may have access to them. As the article states, these procedures have been implemented at DOE storage facilities and their cost effectiveness is being demonstrated.

The third paper was submitted almost a year ago by several authors at the Idaho National Engineering Laboratory, which is actually about 60 miles east of Idaho Falls, Idaho. Their original contribution consisted of two long and very detailed papers. The reviewers and I agree that the subject should be of interest to a number of those in the INMM who are becoming involved in cleaning up radioactive contamination from previous operations. Although this is a major problem for the nuclear weapons powers, there are similar problems in any country which has had an active nuclear development program. However, we requested that the authors to present the basic concepts of their methodology in a shorter paper. Interested readers could then obtain more details from the authors. I am very grateful to them for responding so thoughtfully to our request. They have obviously spent considerable time and effort in presenting a rather complicated methodology in a few pages. I recommend the original papers to anyone who may be faced with designing a logical and defensible remediation program.

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

Committees: Bylaws

According to the bylaws, the "Secretary shall notify each member in good standing of the results of the election before Oct. 1 of each year." This notice in the *Journal* is construed as having met that obligation.

In accordance with the bylaws, the Nominating Committee selected the following individuals for officers and members at large for the Executive Committee of the INMM:

Chair: Dennis Mangan
Vice Chair: James Tape
Secretary: Vincent DeVito
Treasurer: Robert Curl
Members at large: Gary Carnival and Philip Ting.

Ballots were mailed to each of the 708 INMM members, of whom 174 returned election ballots and 161 returned ballots for the bylaws changes.

As a result of the balloting, the officers and members at large forming the Executive Committee beginning Oct. 1, 1993, are as follows:

Chair: Dennis Mangan
Vice Chair: James Tape
Secretary: Vincent DeVito
Treasurer: Robert Curl
Members at large:
Deborah Dickman (term expires 9/30/94); Tom Williams (term expires 9/30/94); Gary Carnival (term expires 9/30/95); and Philip Ting (term expires 9/30/95)
Japan Chapter: T. Haginoya
Vienna Chapter: James Larrimore
Immediate Past Chair:
Darryl Smith (9/30/94).

Write-in votes:

Chair: Obie Amacker
Vice Chair: Obie Amacker
Members at large: Obie Amacker; Tom Collopy; Barton Farley; and Ed Johnson.

The bylaw authorizing the Executive Committee to establish the level of dues for senior members (Article II, Section 3) received 158 votes *for* and 3 votes *against*. The bylaw pertaining to employees of sustaining members attending INMM-sponsored meetings at reduced rates (Article I, Section 7.B) received 156 *for* and 5 votes *against*.

Roy Cardwell
Chair, Bylaws Committee
Consultant
Lenoir City, Tennessee, U.S.A.

ANSI Standards Distribution

Members who want to be on the distribution list of the American National Standards Institute's (ANSI) Standards Forum should contact: Don Stallman, DOE Technical Standards Program, c/o Performance Assurance Project office, P.O. Box 2009, Oak Ridge, TN 37831-8065.

ANSI's Packaging and Transportation of Radioactive and Non-nuclear Hazardous Material (N.14) Committee is responsible for the preparation of standards for the packaging and transportation of fissile and radioactive materials and non-nuclear hazardous materials including waste and mixed materials, but not including movement or handling during processing and manufacturing.

The Methods of Nuclear Material Control (N.15) Committee is responsible for the preparation of standards for protection, control and accounting of special nuclear materials in all phases of the nuclear fuel cycle, including analytical procedures where necessary and special to this purpose, except that physical protection of special nuclear material within a nuclear power plant is not included.

Each standards committee comprises several subcommitteees that develop consensus standards in the Institute's assigned areas of responsibility.

Chapters: Pacific Northwest

Richland was the site of an INMM-sponsored workshop on "Long-Term SNM Storage and Inventory Extension" on April 18-21. It was well attended by contractors and federal staff from across the complex. Don Six was in charge of putting on this successful event.

The chapter continued to participate in local technical activities. Curt Colvin represented the chapter on the Tri-City Technical Council during the past year. The council routinely participates in local media, community and legislative concerns. In addition, support was provided to the annual Mid-Columbia Science Fair. This event provides junior high and high school students an opportunity to design unique science projects and compete for scholarships and other prizes. The chapter provided monetary assistance and judging for the fair.

The chapter membership survey was mailed in August. It is designed to help evaluate and plan future needs and activities for the chapter.

Debbie Dickman
Chair, Pacific Northwest Chapter
Pacific Northwest Laboratory
Richland, Washington, U.S.A.

Southeast

The Southeast Chapter is active again. An average of 15 members attended the chapter meetings on March 9 and July 12. They had an evening of mini-workshops on "The Changing Face of Nuclear Materials Management" in October. The officers are attempting to locate our records and our banner.

Paul Ebel
Chair, Southeast Chapter
BE Inc.
Barnwell, South Carolina, U.S.A.

Japan

The following people were elected for the fiscal year 1993-1994 at the 54th Executive Meeting on Sept. 4, 1992, in Tokyo.

Chair: Tohru Haginoya, Japan Space Utilization Promotion Center
Vice Chair: Kentaro Nakajima, Toshiba Corp.
Secretary: Takeshi Osabe, Japan Nuclear Fuel Co., Ltd.
Treasurer: Hiroyoshi Kurihara, Nuclear Reactor and Nuclear Fuel Development Corp.
Members at Large: Noboru Ishizuka, Japan Atomic Industry Forum; Hayao Kawamoto, Japan Nuclear Fuel Ltd.; Yuzuru Motoda, Nuclear Material Control Center; and Kouji Ikawa, Japan Atomic Energy Research Institute.

Divisions: Waste Management

The following individuals are the new officers and directors of the division:

Vice Chair: John Richardson, United Engineers & Constructors
Secretary: M.J. White, F.R. Johnson Associates, Inc.
Chair, Committee on Spent Fuel Storage: J.R. Clark, E.R. Johnson Associates, Inc.
Chair, Committee on Spent Fuel and High-Level Radioactive Waste Packaging and Disposal: John Clark, EG&G Idaho
Chair, Committee on Low-Level Radioactive Waste Packaging and Disposal: P.M. Saverot, NUSYS
Chair, Committee on Remedial Action: David Swindle, Radian Corp.

Ed Johnson
Chair, Waste Management Division
E.R. Johnson Associates Inc.
Fairfax, Virginia, U.S.A.

1993 Annual Meeting

What impact is there on the INMM and the constituency we serve by the ending of the Cold War, the restructuring of the U.S. Deaprtment of Energy (DOE) and its weapons facilities, and the decreased emphasis on advanced nuclear reactor research and demonstration? A. David Rossin, Ph.D., immediate past president of the American

A. David Rossin

Nuclear Society, discussed these issues and other significant concerns as Plenary Speaker at this year's INMM Annual Meeting in Scottsdale, Ariz. His pragmatic perspective and intimate knowledge of the nuclear community was not only informative but inspirational. The private discussion with Rossin following his presentation was even more revealing and readers are urged not to miss it. **[See page 11.]**

The Annual Meeting was a success, based on the number of papers and sessions, the attendance and the lack of complaints by attendees! There were 32 sessions this year and 209 papers; since 1988 we have been presenting more than 200 papers. There were 531 paid registrants. Eleven presented posters and 22 technical exhibitors displayed booths at the Scottsdale Princess Hotel. Most sessions were well attended with the exception of a few of the Waste Management sessions, which emphasizes the need for a concerted effort to increase participation in this area.

In spite of a generally successful meeting, we did have a downside: there was an unusually large number of last-minute withdrawals of papers after publication of the Final Program (ten days before the meeting) and even as late as the day of presentation. The Technical Program Committee and INMM headquarters staff are evaluating this information to determine what actions can be taken to minimize this disruptive occurrence.

Each year we solicit suggestions from our meeting participants on how

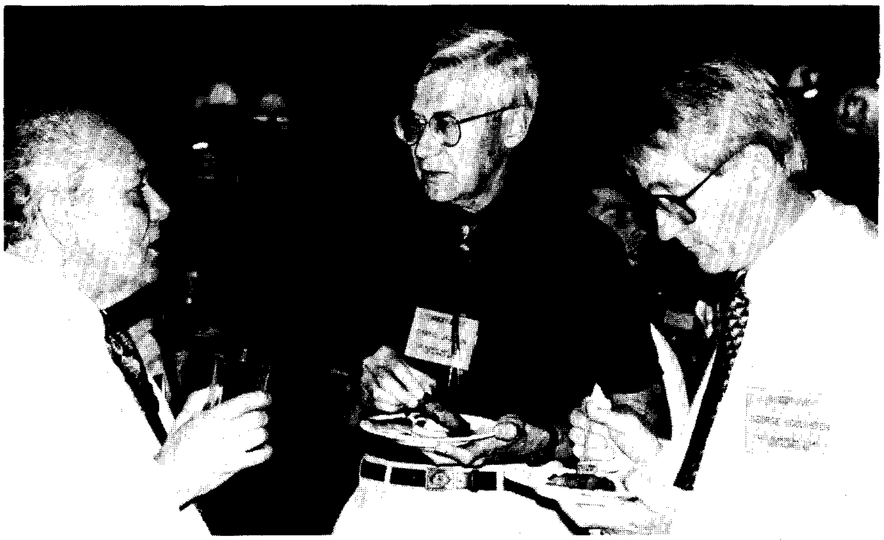
Cohu was just one of the 22 exhibitors at the conference.

to improve our Annual Meetings. Some comments under consideration are: noting the exact time for each presentation (and coffee breaks) in the Meeting Program and leaving the time allotted for withdrawn papers "open" for discussion in each session, rather than substituting the next paper. This approach may help to satisfy the most common complaint we receive: attendees want to hear papers in other sessions and the presentations must be on time as scheduled. However, this approach can present a serious problem if there are too many withdrawn papers in a session. We urgently need your comments on this approach in anticipation of next year's program. Based on your responses we will modify the Speaker's Manual accordingly.

Another idea being explored is to simplify authors' preparation of papers and reduce the Institute's production costs by using word processing disks rather than typed documents. Such information will be provided to you at an early date. Remember, the 1994 meeting is only nine months away (July 17-20) and paper abstracts are due by Feb. 1!

For this year's super meeting, thanks go to the Annual Meeting Committee, the Technical Program Committee, INMM headquarters staff, and the speakers and session chairs. We are already looking forward to next year's meeting — it should be another sparkler.

Charles Peitri, Chair
INMM Technical Program Committee
U.S. Department of Energy
Argonne, Illinois, U.S.A.



Top: (from left to right) Charles Pietri, Darryl Jackson and George Eccleston at the Chairman's Reception.

Bottom: These four gentlemen managed to get in some time on the links during their stay in Scottsdale.

1993 INMM Awards and Honors Winners

Ralph Lumb and Cecil Sonnier received 1993 Distinguished Service Awards during INMM's 34th Annual Banquet.

Ralph Lumb, a consultant with Ralph Lumb Associates, has been an integral part of the Institute ever since he participated in its formation in 1958. He became INMM's first chair, contributed to the development of certification standards and was chair of the Certification Board. He was one of the first Certified Nuclear Materials Managers and is a Certified Safeguards Specialist. He is currently a Fellow of the Institute.

Lumb received a bachelor's in chemistry and a doctorate in physical chemistry. From 1951 to 1956, he was with the U.S. Atomic Energy Commission in the divisions of production and nuclear materials management. He was responsible for the development of policy and general supervision of the technical aspects of surveillance at facilities throughout the United States for raw materials production, fuel fabrication reactor operation, fuel reprocessing and weapon component fabrication.

Lumb was a founder and president of Nuclear Surveillance and Auditing Corp. (later NUSAC Inc.). He participated in the development and implementation of management audit and review programs concerned with nuclear fuel quality assurance, nuclear material safeguards and physical protection. In 1984, he resigned from NUSAC and became a consultant providing services to upgrade material management programs.

The other recipient, Cecil Sonnier, of Sandia National Laboratory, chairs the International Safeguards Technical Division and has been involved in safeguards since 1951, when he was working at the U.S. Naval Research Laboratory, General Electric and the White Sands Missile Range. He joined Sandia in 1956.

For 20 years Sonnier has been dedicated to international safeguards. His unique contribution to this area is his effective and long-sustained performance in the coordination of U.S. development programs with those of other major industrial countries in support of the IAEA. Specifically, he has been a leader by fostering the role of containment and surveillance technology.

Charles Pietri, of the Chicago Operations Office, U.S. Department of Energy, was made a Fellow of the INMM. He is manager, Institutional Management, at the DOE, and is responsible for the oversight and coordination of management activities and is the Technology Transfer Program manager for the laboratories under contracts administered by the Chicago Operations Office. He is also a consultant to the IAEA on nuclear materials safeguards, non-proliferation and quality assurance.

Prior to his current position, Pietri was senior scientist at the DOE's New Brunswick Laboratory where he served as program manager for R&D projects. He developed and implemented a computerized laboratory information management system and designed a laboratory quality assurance program.

Pietri graduated from New York University, attended the Oak Ridge Institute of Nuclear Studies and participated in a graduate technical and management program at Rutgers University. He is the committee chair of ANSI/INMM 5.1 Analytical Chemistry Laboratory Measurement Control, Technical Program chair for the INMM Annual Meeting and a Certified Professional Chemist (National Certification Committee).

International News

In cooperation with four other companies, the IAEA is organizing an International Symposium on Safeguards in Vienna, Austria, from March 14-18, 1994. The meeting is being planned with the American Nuclear Society, European Safeguards Research and Development Association, Institute of Nuclear Materials Management and the Moscow-based Nuclear Society International.

A range of topics are scheduled for discussion. They include experience in special verification situations; strengthened and more cost-effective safeguards; safeguards for plutonium, uranium enrichment, fuel fabrication and spent fuel storage facilities; containment and surveillance technology; safeguards approaches and evaluation; and regional and national systems for accounting and control of nuclear material.

Participation in the symposium must be through designation by the government of an IAEA Member State or by an invited organization. Forms may be obtained from IAEA Conference Services or from competent official national authorities (typically the Ministry of Foreign Affairs or national atomic energy authority). Completed forms should be submitted through appropriate government channels for transmission to the IAEA.

Reprinted from the IAEA Bulletin, *September 1993.*

Eighth Annual INMM Safeguards Round Table

July 20, 1993
Scottsdale, Arizona, U.S.A.

A. David Rossin
Past President, American Nuclear Society
President, Rossin & Associates

William A. Higinbotham
Technical Editor, Journal of Nuclear Materials Management
Brookhaven National Laboratory

Joseph Indusi
Member at Large, Institute of Nuclear Materials Management
Brookhaven National Laboratory

Charles Pietri
Technical Program Committee Chair, Institute of Nuclear Materials Management
U.S. Department of Energy

Dennis Mangan
Chair, Institute of Nuclear Materials Management
Sandia National Laboratories

James Tape
Vice Chair, Institute of Nuclear Materials Management
Los Alamos National Laboratory

Laura Thomas
Communications Chair, Institute of Nuclear Materials Management
U.S. Department of Energy

Each year, INMM leaders interview the Annual Meeting plenary session speaker or speakers in a relaxed setting immediately following the plenary session. The purpose of the interview is to explore in more detail the issues presented during the plenary session and to provide Journal *readers with additional understanding regarding the issues as they affect the nuclear safeguards community.*

This year, the presence of American Nuclear Society Past President Dr. David Rossin provided for a discussion on public perception, politics and the future of the nuclear power.

JOSEPH INDUSI: It seems to me that it is sometimes better to attack than defend when dealing with adversaries of nuclear power. Have you thought about attacking other forms of energy, such as oil, coal and gas, instead of always defending nuclear?

DAVID ROSSIN: My argument is never that nuclear power is the only answer to our future energy needs. It is always that nuclear power is a part of the mix. Every energy source has its advantages and its drawbacks. Oil has drawbacks in that we import a lot of it. Gas has drawbacks in that it is a premium fuel; we ought to use it for premium purposes and allow it to be available to us for a long time. The best thing in the world is not to burn all of it in utility boilers or turbines.

Now we are talking about liquified natural gas as a fuel for automobiles. We are talking about propane for automobiles, drawing from the same resource. And of course we may end up charging batteries in the middle of the night and running gas turbines to power those batteries. We all know there are drawbacks with coal and other resources, and there is no reason not to talk about them. My point is that we are going to need electricity. And we are going to need all of those resources or we won't have reliable electricity. So it is not a matter of badmouthing them. It is a matter of trying to get people to be realistic. The idea is to show that nuclear power is as good as — or better than — the alternatives.

JAMES TAPE: What kinds of things does the American Nuclear Society (ANS) do in order to communicate with and educate the public?

ROSSIN: We are doing some things now that our membership probably wouldn't have supported a few years ago. We started a number of years ago with Public Policy Statements. Originally, we developed a mechanism for producing them that took two years. We ended up word-engineering them to the point where they were watered down, too long and too technical, even though we tried very hard to overcome that.

But the statements were useful. When somebody asked about ANS' position on something, like SNM (special nuclear materials) or reprocessing, we had a prepared statement, maybe 600 words long, with references. At least we could supply that. It was a solid statement, and we could defend it.

But producing the statements this way took much too long, and events move much too quickly for that to be an effective way of doing things. So we finally passed a rule that authorized the president of ANS to make a statement on behalf of the society. Our mechanism for doing this is to establish a peer body that is small and dedicated. We said that if the president can get the agreement of three of the five elected officers on the Board of Directors, he can go with the statement and release it. We went with three out of five because sometimes you can't reach some people or you can't get a copy of the statement to them. The mechanism works and the membership has accepted it.

Still, as president, if I tried to develop a statement and one of the other four people said "I don't like this. I am uncomfortable with it," even if I got three out of the required five votes I would back off.

In the past few months, we became aware that one of our major constituencies, the advanced reactor development program membership, might be going down the tubes. They are the backbone of our society, so when we were told that the Department of Energy nuclear power budget would be the subject of a hearing, we prepared testimony and submitted it to the House Appropriations Committee. The ground rules are simple for congressional hearing testimony: it can't be more than five pages long and you have got to get it in on time.

Amazingly, several weeks later, Congressman Phil Sharp's committee (science and technology) was looking directly at the IFR (integral fast reactor) and the actinide burning issue, and ANS got a call from a staff person, asking if we would like to testify orally at that hearing. It turned out that I had a previous commitment in Mexico that I couldn't change, so I couldn't do it. But we got Mel Koops from Lawrence Livermore National Laboratory and he did it. The two of us worked on that testimony, we had it reviewed by all five ANS officers, and it was unanimously approved. The Appropriations Committee voted the wrong way in the end, but they did it in spite of the facts, not for a lack of the facts.

The membership has not squawked about this process. We presented testimony to a panel that is looking at the long-term storage criteria for high-level waste. We did the same thing: A member of our Albuquerque section read the testimony, we got some questions back from the panel and the Fuel Cycle and Waste Management Division of ANS is preparing the answers.

So we are getting involved, but it takes initiative. You have to decide that you are going to do it. You have to show the members that there is a realistic system to prevent somebody from going off half-cocked. And you have to follow that system.

TAPE: What kind of resources do you allocate for informing the legislative branch of the government versus more general public education?

ROSSIN: Ninety-nine percent of the public information funds of ANS go toward public education, teacher workshops and things like that. The government activity is more of a volunteer effort on the part of a limited number of people. We have activated our local sections around the country, but the membership of the Institute of Nuclear Materials Management is much more focused than ours (ANS'). We are more widespread — we have 32 local sections and plant branches. We can fax them all overnight to encourage them to contact their local representatives and write to their local papers. But you never know whether something like that makes a big difference or not. Maybe it does, maybe it doesn't, but you feel foolish if you pass up the opportunity and something comes down to a couple of votes. Or, if somebody comes back to you later on and says, "We didn't hear from you." This is part of the public participation thing. Congressional staff people and others say, "Nobody told us about these arguments." Very often that is a copout because they knew damn well that we were there, and they also knew that they were taking a politicized position. But it was one that they were satisfied with, so they have no interest in coming back to us. You just can't wait for them to come to you — they have never heard of you.

We got clobbered about two years ago. Jack O'Hanion, the associate dean for engineering and research at the University of Florida, prepared some testimony on an education issue — DOE funding for education. Suddenly he gets a call and they say "We're sorry, we've got too many people. We can't use you." What are you going to do? We submitted our written testimony. Then we looked at the lineup of people they actually had, and we should have been in there. We got feedback that one of the staff people on that committee had said, "Oh, the American Nuclear Society is just another industry organization." That gave them all the excuse that they needed to bounce us out: they already had somebody "from the industry" on the panel. But we were much more representative. We had a good statement to make, but we got caught because we just didn't have a good contact.

We have a Washington representative now. We had one in the past, for a number of years — John Graham who used to write a column in *ANS News* — but he retired. About eight months ago we hired Pat Murphy, who had been on Ambassador Richard T. Kennedy's staff. Pat is a political scientist, not an engineer or a scientist, but he has a lot of experience on proliferation issues and international issues. He had never seen a nuclear power plant. He has now seen two or three, he is learning a lot and is enjoying the job. He has made a lot of contacts in Washington for us. We were very worried about getting tagged as lobbyists. This is very tricky.

CHARLES PIETRI: You are more concerned with the fact that ANS is a professional society.

ROSSIN: We have this crazy situation where, when you really analyze public opinion, there is a hard core of anti's and there is a hard core of people who are realistic about energy ans say that you have got to have nuclear power. Then there is 70 percent or so of the public that just doesn't care about this issue. It is those 70 percent, or a good chunk of them, who can be pulled into the anti camp on an issue when things get emotional.

For example, Ralph Lumb [a consultant] was talking about the low-level waste site that was proposed in Connecticut and within days the town was in a total uproar.

INDUSI: It is the same way everywhere.

ROSSIN: That's right. In California the whole thing has just been tied up. I went to a session in Hollywood. I was asked to come and talk about nuclear energy. I found out when I got there that the whole thing was a bunch of third-level Hollywood types and none of the main people showed up. It was all about the low-level waste site, and it was part of their strategy to stop the low-level waste site. I didn't even know that was what that meeting was all about, but I sure found out when we got to the panel discussion. The guy who they had there had been running around the country helping to organize local groups against low-level waste sites. He is doing this because he became a "celebrity whistleblower." So what the EPA ended up doing with him was giving him an office, nothing to do and a full salary. He portrays himself as an EPA expert who is concerned about all of this. Not only that, but he portrays himself as "pro-nuclear." It's just that he is trying to stop every low-level waste site. That's what went on at this meeting.

WILLIAM HIGINBOTHAM: One of the points that you alluded to in your talk is that it is very important to get going with the Yucca Mountain (permanent storage facility) or whatever we are going to do to permanently dispose of high-level waste. The problems obviously aren't technical. The problem is acceptance. Now the earliest date that anybody is willing to say it might be operating by is 2010, provided that everything goes perfectly. I look ahead and I think, is it really all that big a deal? The fact is that you and I could figure out in a few seconds what the volume of spent fuel is and how many watts it will give out for the foreseeable future. To store that stuff forever is not an expensive thing. That is going to happen anyhow. Until we get something more permanent it has to be stored at the site or at an MRS (monitored retrievable storage). My feeling is that we ought to keep reminding people that it is perfectly safe.

ROSSIN: What's our problem? Our problem is that it is a political issue. Those who don't want nuclear power want to see this project kept in limbo because it's another reason to be skeptical of nuclear power. They go to a state and say "You don't want this stuff in your state." Now here is Nevada, which is all for underground testing of nuclear bombs, saying they don't want this engineered facility in their state. It is a political issue and a money issue.

INDUSI: You know that the people who live the closest to nuclear power plants, who presumably have the greatest risk, are always 90 percent pro-nuclear.

ROSSIN: Unless the plant has been a news item all along, they are always very positive. There is a very good reason for that, and it is not just financial: They know the people who work there. They are their family and neighbors and friends.

Another thing we are working on at ANS is increased visitor access to nuclear plants. As you know, it is very unappealing for a utility to run tours of the power plant itself. The security rules are stringent. Even when you can get support to meet them, it takes manpower and time, and if something goes a little bit awry when you have visitors there, you will have a noncompliance. Yet in my experience, there is nothing better for giving people confidence about these plants than taking them on a tour — even if you can just get them to a visitor center. Though if you do get them to the visitor center, they say, "Why can't we see the plant? What are you hiding?" They understand if you tell them that that the plant is a radiation area and to go there they have to take four hours of training.

But if the security requirements were reduced in several ways, which our experts say wouldn't make any difference as far as actual security, it would make it a lot easier to have visitors. I know that at Commonwealth Edison they used to have a crew of high school teachers. They were like docents — they were paid if they put in a Saturday or a Sunday as a tour guide. They were all trained and qualified. They would show visitors a movie and then take them on a one-hour tour of the plant. Now you have to have an authorized agent there and people to watch them: one plant person for every five visitors. That comes from some kind of a threat scenario that someone dreamed up 20 years ago.

HIGINBOTHAM: That's right. We talk an awful lot about public education. But the problem is that you don't have fair treatment in that kind of a set-up.

ROSSIN: No, you don't. The other thing that I have found is that when you do approach newspapers or radio or television, they say, "Well, we did nuclear power six months ago … ." There just isn't any interest. And they are right: There isn't any interest unless there is controversy or a national or local issue. It really is an uphill battle, but you have to get your members involved. You have to get people thinking that communicating is part of their job, though it may not be in the job description.

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Educating the Educators

INDUSI: Do you talk with high school teachers?

ROSSIN: We have a full-fledged program aimed at high school teachers and junior college teachers. We do the programs slightly differently depending on the availability of our people and their willingness to spend time on this. We are still learning how to do these workshops. We got DOE grants for about the past four years that help us fund these things, so there is no cost to the teachers. And we don't pay them anything, although in some cases we have been allowed to give them a mileage allowance and pay for their parking. If we have one of these major workshops, we try to get enough funding, sometimes through industry contributions, to cover some of the hotel rooms, lunches and maybe one group dinner. So there is very little out-of-pocket expense for these people. I spoke at a workshop in San Jose, Calif., and about two-thirds of the people — about 40 people —were from far enough away that they were staying at the hotel from Monday morning through Friday afternoon. I spoke on Friday morning, and these people were still turned on after four and one-half days!

One of the things you find out is how little these people know about the specifics and the subtleties of the things we are talking about. These are thoughtful, educated people, but they just plain have not heard our side of these issues; they just have not seen this stuff before. The kinds of questions that come back are basic questions: "If you can put this waste in the ground and it is going to stay there, what's the big deal? Why haven't you done it?" and "What about radiation? Why are these materials radioactive?" But they are people who are willing to learn.

One of my former MIT roommates is now a radiologist in Cleveland, Ohio. He was a nuclear engineer once. He called me up one day and said "My daughter came home from high school and said they had a speaker at their assembly and he was totally anti-nuclear and said terrible things and got everybody all excited." So my friend called the headmaster of this private school and said that he wanted equal time. That's when he called me and said, "Send me information." I sent him some material and then I didn't hear from him for three weeks or so. So I called him back and said, "Did you give that speech?" He said yes. I asked what happened. He said that in the first place, they didn't just let him give a speech, they would only do it if they could let the other guy come back and make it a debate. I said, "So how did you do?" He said, "I creamed him!"

INDUSI: I ran into the same thing. I gave a talk at a high school, and the kids don't understand, for instance, that there is a radiation background due largely to nature. They thought that any radiation would burn their skin. What I found out was that they had been briefed by someone from Greenpeace and this included photos of atomic bomb survivors.

I think that you have to avoid dealing with school boards and principals one-on-one because they always feel that they have this obligation to show another point of view. I believe that it is better to take the teachers, several at a time, and remove them from that environment and offer this as a training program. Then the school board then doesn't feel that they have to have equal time. Get the teachers off school property to an INMM meeting or an ANS meeting.

ROSSIN: We do that, too. At every national meeting we try to have a one-day workshop on Saturday. We already have the presenters coming in. You know something funny? One teacher told me that her school system was not going to approve people going to these types of training sessions because then the teachers would qualify for a higher salary!

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Reprocessing and the Future of Nuclear Power

ROSSIN: The main issue is whether or not we will have separated plutonium in this world. If you are going to reprocess or recycle, you must at some point have separated plutonium. If you can stop the existence of separated plutonium, you stop the long-term future of nuclear power. The future of nuclear power based only on mined uranium is finite, even with the relatively small number of plants that we have now, compared to the large number we thought we were going to have. You are talking about a resource that becomes pretty expensive when you have explored all the high-grade ore deposits. Maybe we have enough for 100 years or even 200 years. I just don't think that it is fair to say that civilization as we know it only has a couple of hundred more years to go. We are going to need energy, so if nuclear power is going to be there for the long haul, you have got to go to reprocessing.

Our adversaries know this. Let me give you a little history: In the couple of years before (former President Jimmy) Carter was elected, opponents of nuclear power were working very hard on a strategy that they had carefully mapped out. The strategy was to stop plutonium. Stop recycling. All of the anti-nuclear groups were aware of this. They all did their own thing; they weren't responsible to each other. So they went off in all directions, but all opposed nuclear power.

You had people like Dean Abrahamson (professor at the University of Minnesota), and Tom Cochran (the key strategist for the Natural Resources Defense Council). They enlisted anthropologist Margaret Mead. I was listening to her make this impassioned speech: "We need nuclear power. The developing world must have energy and we need nuclear power ... but we don't need plutonium." And she believed this. You hear this argument again and again: "We have plenty of uranium. We can have nuclear power. It is a transition until we get fusion or solar. But we don't need this plutonium."

They got the National Council of Churches to jump in and say, "We don't like nuclear power, but we absolutely can't have plutonium because of nuclear proliferation ... ." I got involved in that debate. In fact, I was given authorization by the head of the National Council of Churches to organize a formal debate. I worked with their staff to set it up at Riverside Church in New York. There were 1,500 people there. That was Margaret Maxey's first public appearance with us. We had three pros and three cons and three ethicists. Maxey was an ethicist, a nun and a professor at the University of Detroit. She came at this from a very middle position. But in the course of it all, she began to learn some things, decided where she came down on the issue, and then she got a little more involved. She concluded that the ethics of denying a long-term energy source were not acceptable to her.

When Carter's policy to ban reprocessing was being developed, his science advisor was shown the Los Alamos and Sandia data on the fact that they had succeeded in exploding a device with reactor-grade plutonium. What doesn't really come through is how hard they had to work to design and explode the device, and the problems they had to overcome. Nevertheless, it gave the Carter people all the evidence that they needed to say that any plutonium equalled a proliferation threat. The fact remained, however, that actual weapons makers didn't want to mess with this stuff.

But look at what they do with nuclear weapons. Every four or five years they have to be brought back in and refurbished to purify the materials. That material is many times easier to work with than reactor-grade material. Yet when you are all done, reprocessed reactor material is lousy compared to what you brought in. The whole reasoning is that in theory something could happen. So we have to drop everything and not touch this stuff because in theory something could happen. It was okay as an experiment. It showed that they could do it ... .

HIGINBOTHAM: It is very important to find out from these people what their attitude is about later on when there is very little oil left, very little gas, and the price of uranium begins to skyrocket, and with breeders we could take uranium out of the sea for thousands of years. Most of them say, "Yes, but in the meantime why do we need plutonium?" I just want them to admit that in the future we will need nuclear power and we will need breeder reactors.

ROSSIN: They won't admit that.

HIGINBOTHAM: Not publicly. But they will admit it to me. That's all I need to know.

ROSSIN: Alvin Weinberg, director of Oak Ridge National Laboratory for 25 years, had a conference on the "Second Nuclear Era." Cochran and Abrahamson were there. Weinberg started it out by saying, "Let's go on this premise: Let's say that in 40 years we will have a second nuclear era. What should it be like?" Abrahamson and Cochran said, "We will not accept that premise." They were getting ready to walk out on the meeting. The point I am making is that a lot of these people come at this with different reasons. There are some who are just looking to make a career out of it. For example, Paul Leventhal has absolutely no interest in how anything turns out other than his career. [Leventhal was a congressional staffer in the Carter policy days who started calling himself "The Nuclear Control Institute" with the sole target of stopping plutonium.]

But Cochran used to have some much deeper motives. He hates the concept of free enterprise. He hates the concept of corporate capital. I asked him about it once. His dream was to stop nuclear power. Then stop coal. Then, he said, we can stop this wasteful and destructive use of energy that is destroying the planet. "Then," he said, "we change the system."

Now, I am not saying that there are a lot of guys like Tom Cochran. This was 15 years ago. But in his view, the government should control everything. You see, people come at it from so many different directions that no one argument is going to satisfy everybody.

HIGINBOTHAM: I am as sure as I can be that there will be a great shortage of reasonably priced power. And that changes the whole situation.

ROSSIN: And the ones who are going to feel it are the ones who can afford it the least: Developing countries and poor people.

. . .

The Next Generation of Nuclear Engineers

PIETRI: Assuming that the nuclear community in the United States is no more popular in the next ten years than it is now, we are going to have a major void in engineering and scientific talent. How do we attract quality young people?

ROSSIN: We are very concerned about that. The fact is, we will still get some people into the profession, but we certainly aren't going to get the pick of the crop as we used to. Some of my nuclear engineering university friends admitted to me that over the last few years they know that a significant fraction of their enrollment is kids who wanted to take computer science but couldn't get in. These students found out that by registering for nuclear engineering they could take almost all of the same courses that they wanted to take for computer science. Then they can make their decision in their last year and transfer. It is happening. I was on a visiting committee for the University of Michigan a few years ago and the guys there told me so. I also know it was so at Berkeley.

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The Role of the Institute of Nuclear Materials Management

TAPE: I see the INMM's unique niche as focusing on nuclear materials. That is our core expertise. One of the major criticisms that has been leveled by the anti-nuclear critics is this proliferation concern. You mentioned in your talk that we need to address this issue of the usability of reactor-grade plutonium in weapons. I agree that the INMM should try to take on this role. Based on your experience with the ANS, what should we be doing as an institute to try to communicate better?

PIETRI: We have a lot of expertise, insight and perspective in our organization that doesn't seem to get out. That's a waste of resources that could be used to educate the public. The Institute just had an Executive Committee meeting and we were talking about training and education. But again, it has all been internalized. Maybe the Executive Committee has got to start talking about education in terms of educating some segment of the public.

ROSSIN: Because you are a close-knit organization with quite a breadth of understanding among your members, you can skip ahead a few years.

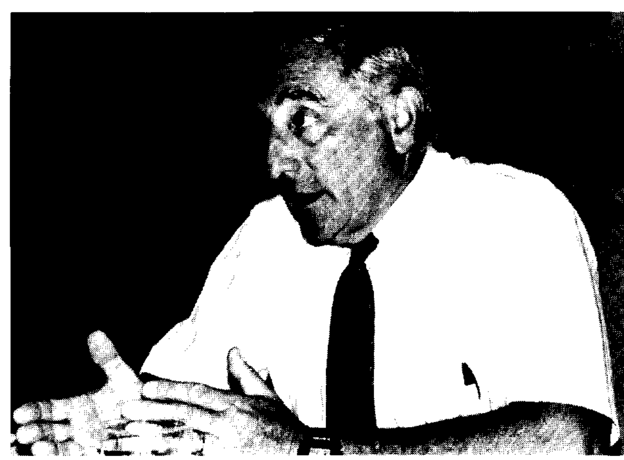
HIGINBOTHAM: Would it make sense for us to initiate some independent operations in this area or to try to cooperate the ANS, Health Physics Society or whoever is communicating at the right level or holding a workshop? We could add an expert on physical protection of nuclear materials, international safeguards, arms control and so forth. It seems to me that it makes a lot of sense for us to work on this in a cooperative way.

ROSSIN: Let me make two specific suggestions: You may want to talk with the Health Physics Society — they just got a large grant, on which we teamed with them.

The second suggestion, to follow up on that, is to offer an INMM participant at future workshops held for teachers. Get one of your people to add to our expertise. Find somebody near the workshops. Chances are they can take off work for a couple of hours to go to the junior college or wherever the program is being held, give a talk, and come back without any need for extra compensation. The experience is a good one.

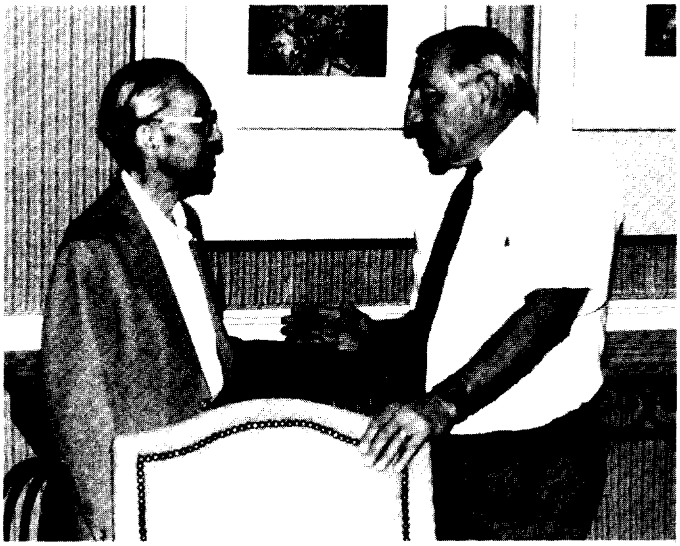
The Health Physics Society happens to be more successful [at this than ANS] because they don't have the word "nuclear" in their name. In fact, the Health Physics Society is counting on us to manage a number of these workshops under the grant that they have. And there is no reason in the world why somebody from INMM shouldn't participate in these workshops.

Also, you can write something for the public. You try to get it published anywhere: a letter to the editor, an op-ed column, a magazine article. The copier and fax machines do a great job. A cover letter says, "Here is what distinguished scientists from Los Alamos Laboratory wrote, it was published in the *Albuquerque Journal*, and I think it merits your attention." There is nothing wrong with that. It's done all the time.



A. David Rossin, past president of the American Nuclear Society, at the INMM Round Table discussion.

Rossin (left) and Joseph Indusi, INMM Member at Large.



Rossin (right) has a discussion with William Higinbotham, JNMM Technical Editor.

(left to right) Charles Pietri, INMM Technical Program Committee Chair; James Tape, INMM Vice Chair; and Dennis Mangan, INMM Chair.

Laura Thomas, INMM Communications Chair (left), and Rossin.

Meeting Timeliness Requirements in Reprocessing Plants

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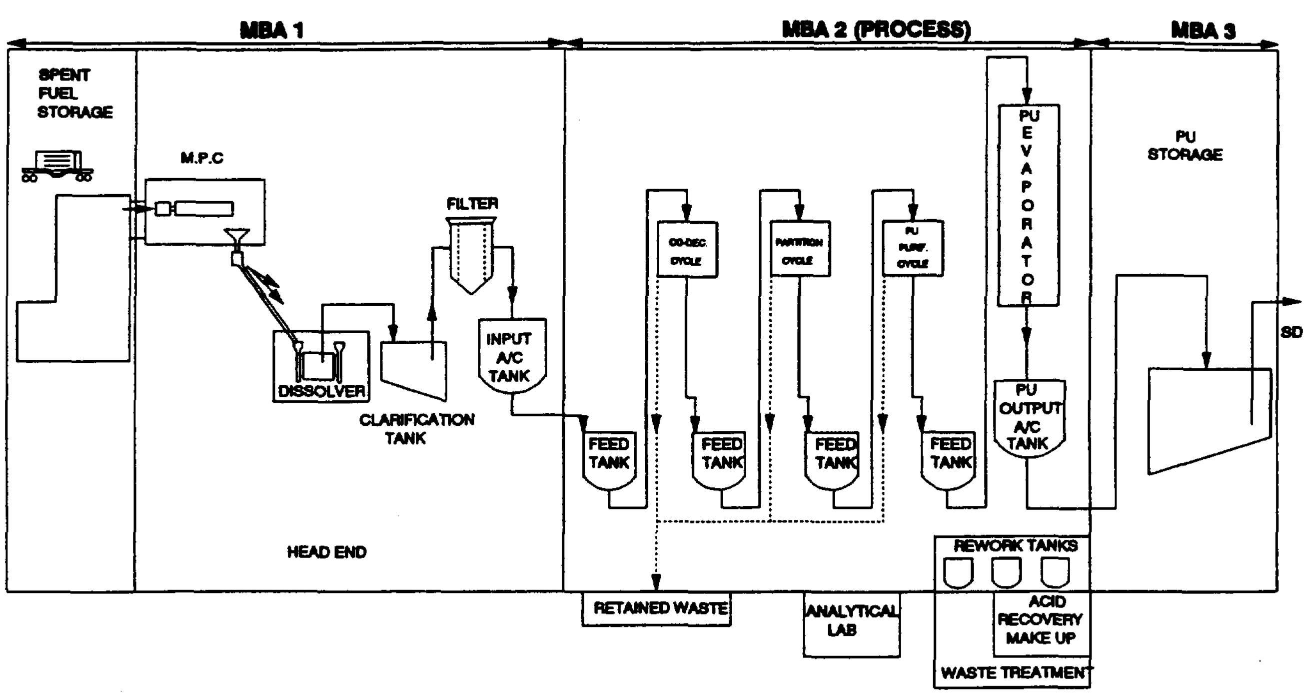
Abstract

Meeting the Agency's timeliness requirements in a reprocessing plant presents a challenge, particularly when the plant is in operation. The verification of the spent fuel pond inventory and the Pu product storage is relatively simple, employing established safeguards procedures for static inventories. However, the flow sections of a reprocessing plant require the development and management approval of facility-specific methods. These methods employ head-end batch follow-up in conjunction with density correlations and the application of near real time accountancy (NRTA). These methods have been in use since late 1990. Results attained so far are presented, with areas for improvement highlighted.

Introduction

Achievement of timeliness goals in a sensitive and complex facility, such as a reprocessing plant, requires development and implementation of facility-specific procedures. A simplified flow chart of a reprocessing plant using the PUREX flow sheet is given in Figure 1. This does not include the uranium purification and product lines because the timeliness requirement for uranium is one year; hence it does not require consideration in the monthly timeliness picture. The main inventory locations and the nature of the nuclear material at each location are summarized here:

Fig. 1: Simplified flow chart of a reprocessing plant



Location	Nature of material
Spent fuel pond	Spent fuel
Head-end (dissolver, clarification tanks and input accountability tank)	Solutions containing U, Pu and fission products
Process (feed tanks, liquid-liquid extraction contactors (e.g., mixer-settlers), evaporator, recycle tanks)	Solutions containing Pu with or without U and with or without fission products
Pu storage tanks	Pure Pu solution

The Agency's 1991-95 Safeguards Criteria[1] for timely detection in reprocessing plants requires an assurance to be provided within the timeliness period that one significant quantity (SQ) of direct-use material is not missing. The timeliness period is defined as three months plus three weeks for spent fuel and one month plus one week for in-process and product plutonium. The spent fuel, which is usually under a single containment and surveillance system, is required to be verified by successful surveillance following an initial verification by accountancy method, e.g., by item counting and NDA for gross defects through Cerenkov glow detection. The in-process material is usually verified by a facility-specific method because verification is required to be carried out without stopping the process. The product plutonium is verified by volume measurement and the concentration by NDA for gross and partial defects; in practice the NDA is done by K-edge densitometry for determining the Pu concentration. The procedures described below have been applied since late 1990 and have contributed to the achievement of the Agency's verification timeliness goal.

Verification scheme

The monthly verification is carried out at a time when contents of the Pu product evaporator are transferred to the output accountability tank. This is necessary because the evaporator (Figure 1) is a boiling tank and as such any level reading would be erroneous. At that time, called the "cut-off time," verification across the plant is carried out in the following manner:

Spent Fuel Storage

Spent fuel assemblies in a storage pond are verified through successful surveillance (the pond inventory having been verified by Cerenkov glow detection or gross gamma detection during the annual PIV and at the time of receipt into the facility).

Head-end

The inventory batches present in a head-end are identified through control room strip charts. They, however, are not verified in situ because head-end tanks (with the exception of the input accountability tank) usually are not calibrated by the Agency and solutions in these tanks are unfiltered and possibly nonhomogenous, which makes representative sampling difficult. The identified batches are followed up by monitoring control room strip charts to ensure that they flow one after the other into the input accountability tank without mixing with each other or overtaking each other. Once they arrive in the input accountability tank, volume determination and sampling for elemental analyses are carried out. Because the results of elemental analyses done at the Agency's Safeguards Analytical Laboratory (SAL) cannot be available within the timeliness period (one month plus one week), the following density correlation developed by M. Cauchetier is used to estimate the uranium concentration[2]:

$$U = \frac{d - a_o(t) - a_1(t)N - a_2N^2 - a_3N^3}{b_2(t) + b_1(t) \times \text{mole ratio}} \times 238$$

where U = uranium concentration in g/L,

d = density in g/cc,

a_o, a_1, b_1, b_2 are polynomials of the input solution at temperature t (°C),

N = free acidity (in moles [H+] per liter),

a_2, a_3 are constants, and

mole ratio = grams per mole of uranium to grams per mole of plutonium calculated for typical isotopic abundances in spent fuel.

The total Pu in the batch is then determined using the Pu/U ratio reported by the shipping reactor:

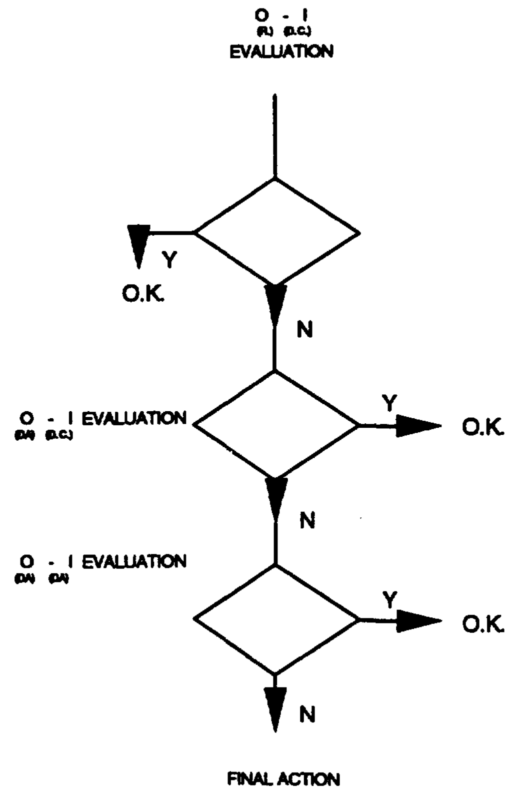
Pu (total) = Uconc × Volume × Pu/U(reactor) × Bias factor

where the bias factor has been determined for each specific reactor based on historical results from elemental analyses done at SAL.

The inspector's estimate of the Pu quantity in a batch is used in the first comparison of the operator's declaration. The analytical results from SAL are used as they become available. Conclusions are normally drawn in the following sequence (see Figure 2):

- The first comparison is made with the operator's value, which is based on the reactor's declaration. If the difference is within the limit set on the basis of historical data, then this is accepted as verification of operator's declaration. If that limit is exceeded then,
- A second comparison is made where the operator's declaration is based on the operator's chemical analysis. If this limit is exceeded,
- The third and most conclusive comparison is made where both operator and inspector values are based on chemical analyses at their respective laboratories. If this limit is exceeded, then the effect of this discrepancy on the whole population of input batches is assessed and an appropriate conclusion is drawn.

Fig. 2: Flow chart of head-end batch evaluation



In practice, most of the differences are acceptable in the first comparison, and those not within limits are usually resolved in the second comparison.

Process

About one hour prior to the cut-off time the operator provides a preliminary declaration of the expected inventory distribution in the process tanks and in the contactors. Based on this, the inspector calculates the number of samples to be taken for authenticating the operator-declared values. At the cut-off time, level, density and temperature readings of selected process tanks are noted and samples are taken. Based on these data, the operator provides a final declaration once his laboratory analyses are completed. A monthly material balance as part of NRTA is calculated and the statistical package called PROSA (Program for Statistical Analysis) developed at Karlsruhe[3] is then applied. Examples of statistical analyses are shown in Charts 1A-1D. In these charts, material balance periods (MBPs) 1 and 5 represent the starts of campaigns, MBP 3 indicates end of a campaign, MBP 4 represents shutdown for a physical inventory verification (PIV) and MBPs 2, 6, 7 and 8 represent campaign months. It can be seen from Chart 1A that in this example there is always an apparent positive MUF at the start of a campaign (MBPs 1 and 5) as the system is charged and a correspondingly negative MUF at the end of a campaign (MBP 3) as

Chart 1A: Process MBA MUF values and 2δ -limits

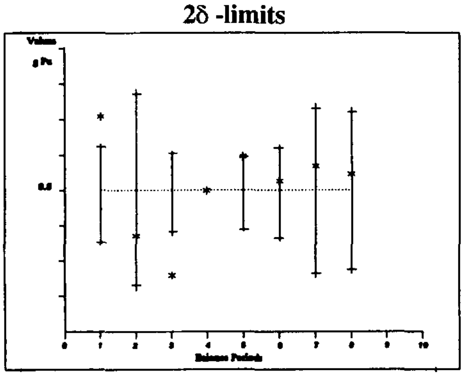


Chart 1B: Process MBA CUMUF values and 2δ-limits

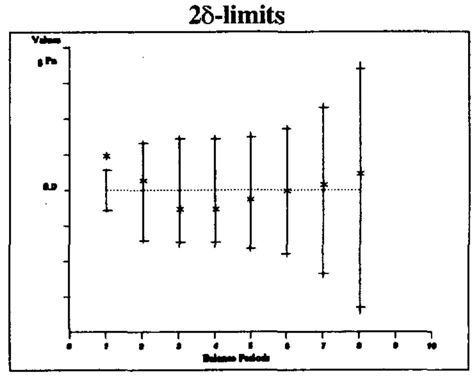


Chart 1C: Process MBA CUMUF test

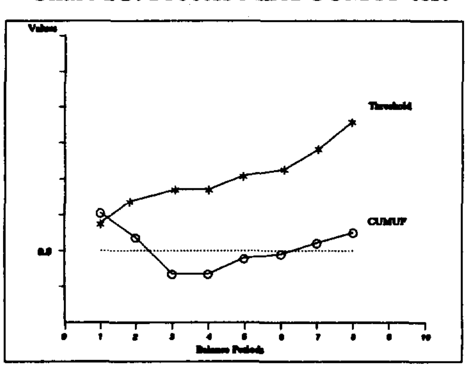
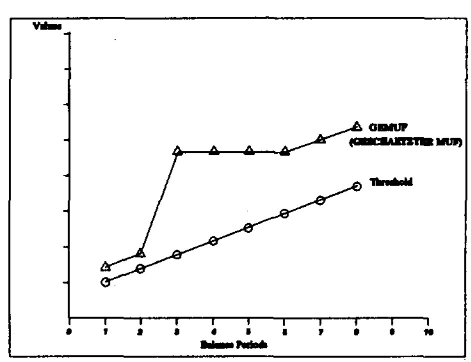


Chart 1D: Process MBA GEMUF test



the system is cleaned out. The reason for these is discussed under "Engineering Hold-up Estimate in the Process Area" in this paper.

In the CUMUF test (see Chart 1C), a threshold is calculated using a 5% false alarm probability. As long as the CUMUF test value is within the threshold, it is concluded that all material declared by the operator is accounted for.

A more sensitive NRTA verification test called the GEMUF test is also applied (other tests are possible with the existing software but are not required for the scale of current operating facilities). GEMUF stands for *Geschaetzter* MUF or estimated MUF. It is based on the principle that for every known diversion pattern there is one best test. In the absence of knowledge about an operator's diversion pattern, it is assumed that the sequence of monthly MUFs is an indicator of the underlying diversion pattern and a best test is set up against it. From Chart 1D it can be seen that the GEMUF test value is outside the threshold. A possible reason for this is explained under "Engineering Hold-up Estimate in the Process Area."

Pu Product Storage

The amount of plutonium in storage tanks is verified by volume measurement and by determination of Pu concentration by K-edge densitometry. This in itself is sufficient for the timeliness requirement. However, an NRTA analysis based on PROSA is applied here also in view of the demonstrated capability of NRTA to identify anomalies. Examples of statistical analyses for a storage MBA are given in Charts 2A-2D.

It can be seen from Chart 2A that in this example there are five apparent MUFs exceeding control limits. Results such as these could be caused by an inaccurate declaration by the operator or inaccurate estimations of unmeasurable holdups.

Combined Process and Storage Evaluation

An NRTA evaluation is also carried out for a combined process and storage area which eliminates the problems otherwise associated with inter-MBA transfers. The results are similar to the example presented for a storage area (see Charts 2A-2D) because of the dominance of the larger MUFs encountered in this area.

Engineering Hold-up Estimate in the Process Area

Although it is the intention of the Agency to verify all the material declared by the operator, in reality there are cases where either the nature of material or its location do not lend themselves for direct verification. Under such situations, it becomes necessary to gain assurance of the estimate of material by other means, e.g., through computer modeling or engineering analysis. The inventory in the contactors is a case in point, for which both operator's declaration and the Agency's verification are based on modeling and analysis. Another such case occurs for the Pu solutions found in the miscellaneous piping, in the metering pots which are used when solutions are transferred from one vessel to another, in the oxidation columns, etc. If not declared, this hold-up can significantly contribute to MUF. A positive MUF at the start of a campaign and a negative MUF at the end of a campaign

Chart 2A: Storage MBA MUF values and 2δ-limits

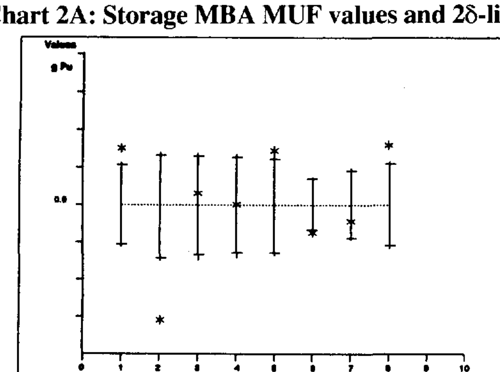


Chart 2B: Storage MBA CUMUF values

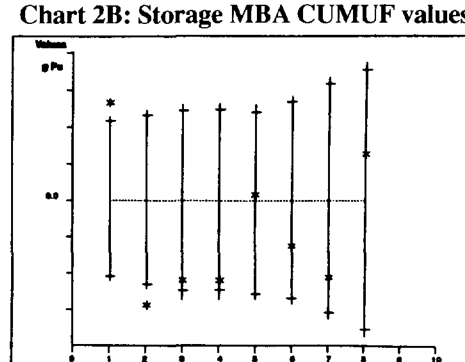


Chart 2C: Storage MBA CUMUF test

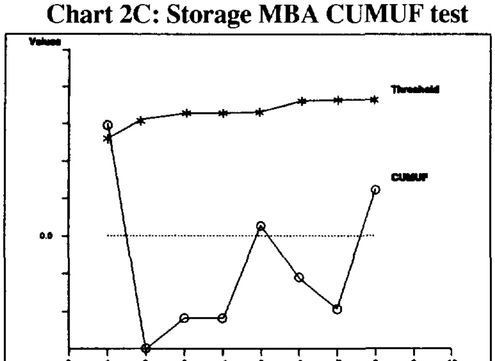
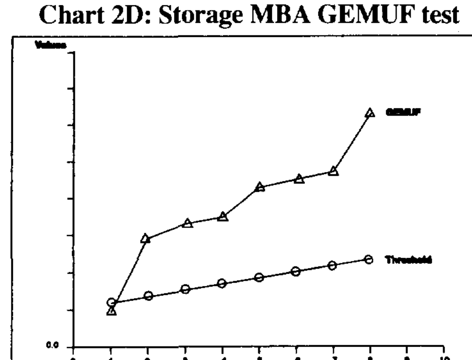


Chart 2D: Storage MBA GEMUF test



can be caused by this undeclared hold-up. A study was therefore carried out to see how the NRTA analyses behave if this hold-up is included as part of the inventory during plant operation. Examples of these results are presented in Charts 3A-3D and Charts 3A'-3D', where the former represents a case with no hold-up and the latter represents a case with hold-up added.

The results of this study can be summarized as follows:

- The MUFs for the MBPs at the start and at the end of a campaign become smaller when the hold-up is added. The MUFs for other campaign months (MBPs) are not affected because the same quantity is added both to the beginning and the ending inventory (see Charts 3A and 3A').
- The pattern for cumulation of MUF(CUMUF)-values remains the same but there is a negative shift when the hold-up is added (see Charts 3B and 3B') indicating the possible existence of an overall negative bias in the measurement system.
- The CUMUF test values are lower, within the threshold and well behaved when the hold-up is added (see Charts 3C and 3C').
- The GEMUF test shows the most significant improvement when the hold-up is added. In the test sequence shown, the GEMUF test values were always beyond the threshold with no hold-up added (see Chart 3D). However, with hold-up added (see Chart 3D') it is noted to be well within the threshold at the beginning. It starts to increase, however, at the 9th MBP because of a known problem, namely inter-MBA transfers, and correctly highlights that problem.
- It also illustrates how unmeasured portions of the process inventory can be estimated and be included in the overall verification.

Verification During Shutdown

The Agency's timeliness verification requirements also apply when a reprocessing plant is shutdown, but the verification activities differ. During shutdown of the plant, verification is relatively simple, because there is usually no material present in the head-end and no material movements in the process area (MUF = 0). NRTA, however, is still applied to the process and storage areas to maintain a historical data file. In the process area, most plutonium inventory is present in one or two tanks, which are sampled and analyzed for authenticating operator's declared values.

The spent fuel pond and the Pu product storage are verified as described earlier.

Conclusions

Although the current NRTA approach can provide adequate assurance, it can only be as good as the data used. Estimates

Chart 3A: Process MBA

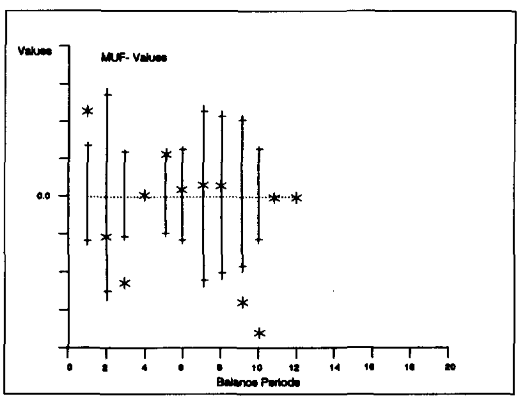


Chart 3B: Process MBA

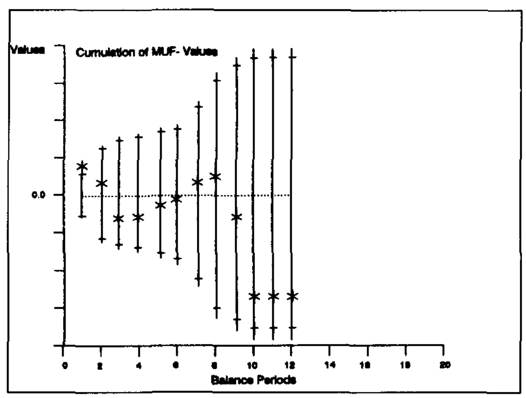


Chart 3A': Process MBA — with hold-up added

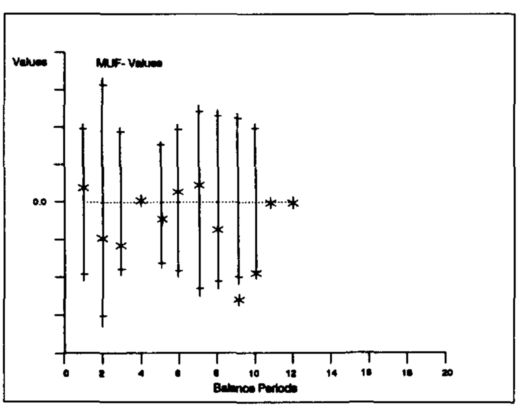
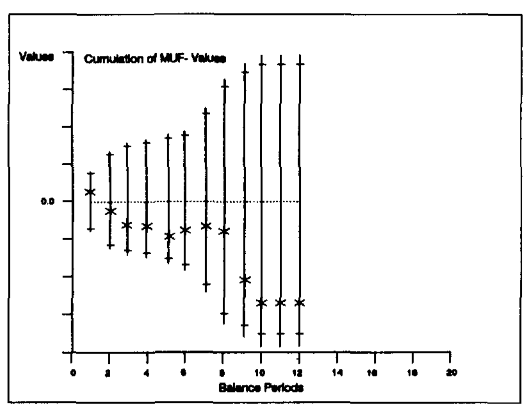


Chart 3B': Process MBA — with hold-up added



of the hold-up in the process MBA, when adequately checked (e.g., through engineering analysis and included in the NRTA analyses), help to make the system more sensitive for detecting losses or diversion. Moreover, a thorough understanding of how data for each inventory point are calculated is necessary in order to understand the behavior of the system. A thorough evaluation of the error estimates of volume measurement and concentration determination is necessary in order to set up a system which is sensitive enough to detect diversion but not too sensitive as to raise superfluous false alarms. The current NRTA analyses is capable of providing assurance against losses or diversion. The NRTA scheme in conjunction with verification of head-end solution by the density correlation method satisfies the Agency's timeliness requirements for existing reprocessing plants. The current NRTA applications have laid the basis for further improvements and are expected to help in application of NRTA in large scale reprocessing plants to come under Agency Safeguards in the foreseeable future.

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Chart 3C: Process MBA

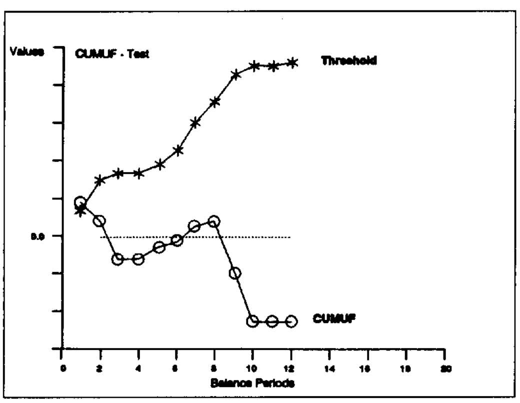


Chart 3D: Process MBA

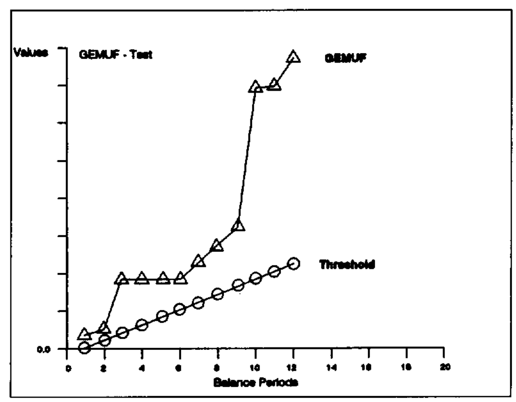


Chart 3C': Process MBA with hold-up added

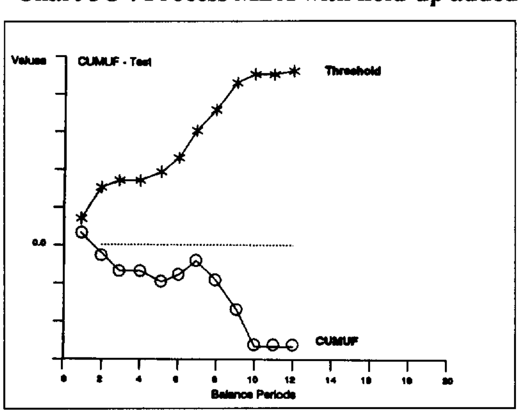
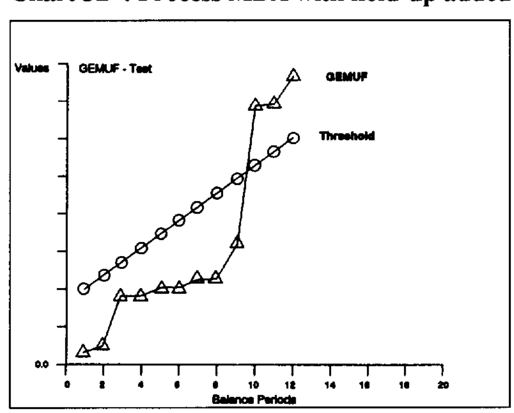


Chart 3D': Process MBA with hold-up added



Safeguards Experience with Materials Monitoring Systems

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Abstract

The U.S. government requires that personnel-intensive physical inventories be conducted on nuclear materials. The use of technology to replace or complement these inventories can significantly reduce the number of required, manual physical inventories while increasing assurance that material is where it should be. This paper presents an overview of two such systems developed by Los Alamos National Laboratory and Sandia National Laboratories/New Mexico which have been installed and evaluated at several U.S. Department of Energy (DOE) facilities.

I. Introduction

The DOE mission is changing because of reductions in the nuclear weapons inventories of the United States and the states of the former Soviet Union. In this changing climate, where long-term storage of materials is being emphasized and concern is increasing about personnel exposure and the operational costs of long-term storage facilities, the DOE is encouraging the use of alternative approaches, systems and technologies for reducing the frequency and impact of physical inventories.

Technology development efforts at Sandia National Laboratories and Los Alamos National Laboratory focused on nuclear safeguards applications have produced two such systems.[1-3] Both systems are in advanced design stages and have been installed at DOE sites for alpha test and evaluation. The Sandia Personnel and Material Tracking (PAMTRAK) system provides modular subsystems which track personnel and material. The Los Alamos Experimental Inventory Verification System (EIVSystem) provides video-based monitoring and detects change in areas under surveillance by a system of cameras.

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DOE sites using PAMTRAK and the EIVSystem for material monitoring ensure the integrity of parts or special nuclear material (SNM) in storage. These systems can reduce the frequency of manual physical inventories by providing greater assurance that materials are intact and secure; these systems also reduce operating costs by minimizing the radiation exposure to personnel, even though storage quantities increase. Because of these savings in costs and exposure, more DOE facilities are becoming interested in such systems.

II. PAMTRAK

PAMTRAK consists of a host and three subsystems: entry control, personnel tracking and material monitoring. A facility can configure PAMTRAK to use any combination or any number of material monitoring, personnel tracking or entry control subsystems with the PAMTRAK host subsystem.

The PAMTRAK host subsystem consists of a host computer, system terminal, a number of barcode readers, a serial printer for reporting alarms and a laser printer for printing barcodes and reports. The PAMTRAK host receives authorized access and movement information from the users (via the system terminal and barcode readers) and from the other subsystems. It uses this information to maintain an internal representation of the state of the facility and compares the state with the rules specified for the facility. Any time the state of the facility violates the rules, PAMTRAK reports an alarm. When PAMTRAK reports an alarm, it displays the alarm on the monitor, prints it, logs it, sounds a horn, and, if appropriate, sends it to another system.

A. Entry Control Subsystem

The entry control subsystem consists of one or more positive identity verifiers (PIVs). PIV is the general term for a device that uses some physical characteristic to identify a person. PAMTRAK uses a hand geometry unit; however, there are units that measure different physical characteristics. Each PIV communicates with the PAMTRAK host via a serial communications link. The PIV reports successful and unsuccessful identification attempts as well as tampers to the PAMTRAK host. A PIV can also control physical barriers such as doors or turnstiles.

B. Personnel Tracking Subsystem

The personnel tracking subsystem consists of a set of battery-powered, electrostatic proximity tags worn by the users, a number of exciter/receiver antenna pairs, an antenna reader for each exciter/receiver antenna pair and a tag control unit (TCU). Indala Corp. of San Jose, Calif., developed and manufactured the tags, antennas and antenna readers. Sandia designed and developed the TCU.

There are two types of antenna pairs: long range and short range. Long-range antennas reliably detect up to six tags simultaneously when they are within approximately 8 to 10 feet of the exciter antenna. Authorized personnel install the long-range exciter/receiver antenna pairs in strategic locations throughout the facility. As users move about the facility, the antennas detect the tags that they are wearing and report the users' locations (via the antenna readers and TCU) to the PAMTRAK host. The PAMTRAK host uses this information to report unauthorized access to restricted areas and to enforce facility rules (such as the two-person rule). Short-range antennas can only read tags from 6 inches, and PAMTRAK only requires that they detect one tag at a time. PAMTRAK uses the short-range antennas with the entry control subsystem to assign tags to users when they enter the facility.

The TCU is an IBM-compatible personal computer (PC) which can stand alone or be a subsystem of PAMTRAK. The TCU gathers data, records events within a facility, stores these data in files on the controller's hard disk, and downloads the data for review or permanent storage. Each TCU can handle up to 30 antenna pairs. Access to the TCU's control menus and base operating system is protected by built-in security.

C. Material Monitoring Subsystem

The material monitoring subsystem consists of a number of wireless, battery-powered, electronic devices called WATCHs (Wireless Alarm Transmission of Container Handling), at least one WATCH receiver, and a WATCH controller unit (WCU). Inovonics Corp. in Boulder, Colo., manufactures the WATCHs and receivers. Sandia designed and developed the WCU. WATCHs transmit status messages via radio frequency (rf) to the WATCH receivers.

The WATCHs detect and report movement, tampering and low batteries. Each WATCH contains a switch that generates a tamper signal when it is opened. It also periodically sends state-of-health (SOH) messages so PAMTRAK can detect attempts to shield or destroy a WATCH. There are two types of WATCH. The first type senses and reports motion through adjustable mercury switches that detect small movements of the WATCH. The second type reports the closure of a balanced magnetic switch (BMS). Motion WATCHs on material report unauthorized attempts to move the material. BMS WATCHs attached to doors report unauthorized attempts to enter rooms.

The WCU is an IBM-compatible PC that can stand alone or be a subsystem of PAMTRAK system. The WCU gathers data, records events within a facility, stores these data in files on the controller's hard disk and downloads the data for review or permanent storage. Each WCU can handle up to 256 WATCHs. Access to the WCU's control menus and base operating system is protected by built-in security.

III. Experimental Inventory Verification System

The EIVSystem uses image processing technology to acquire "basis" information about materials being monitored; from this basis, change detection, image processing and image analysis methods are applied to detect changes, or *events,* in the monitored area. Detected events can be analyzed to determine their safeguards significance, retained for the historical record or ongoing analysis, and used to trigger alarms that bring the event to the immediate attention of operations or protection personnel.

A. Hardware

The EIVSystem is designed to run on commercially available computer systems to provide maximum performance, reliability, and maintainability while taking advantage of the newest designs in the rapidly developing computer industry. A typical configuration of the EIVSystem consists of a Sun Microsystems SPARCstation 10-host computer (with a single cpu) equipped with system and data disks, CD-ROM, up to 512Mb of random access memory and a tape unit for archiving data. For high-performance applications, the EIVSystem can take advantage of multiprocessor options that allow true parallel processing. Data capacity can vary from one to five gigabytes, depending on the system application. Camera inputs can vary from two NTSC format inputs and one S-video input to 16 NTSC inputs and eight S-video inputs.

B. Software Features

The EIVSystem software has been developed specifically for nuclear safeguards applications by the Safeguards Systems Group at Los Alamos. The current model of the EIVSystem includes an X-Window-based user interface featuring "point-and-click" selection for all system functions, a C2 operating system plus additional mandatory and discretionary access controls, a system administration tool, an event logger, a camera controller, a data disk controller, a report generation tool, an interactive image-analysis tool and an alarm manager.

1. Operating System. The C2-level operating system provides overall computer security features for the host computer, while EIVSystem-specific mandatory and discretionary access controls provide security for the application software itself. Although networked installations of this type of equipment are rare within the DOE complex, secure RPC, a secure networking protocol, provides state-of-the art features for validating users and processes.

2. Camera Configuration. The camera configuration mechanism allows the user to interactively create a graphic model of the surveillance area and place cameras in the model relative to their actual location. Each camera is then interactively configured by assigning values for various parameters. These parameters may include thresholds, firing order, detection sensitivities, and camera types (e.g., detection or video). The camera controller is used to activate the surveillance once the camera configuration is complete.

3. Data Storage. The user controls the data disk through the EIVSystem user interface; the user is isolated from the host computer's operating system. Data can be archived to tape from the system's 1.05 gigabyte data disk(s) once it has been reviewed, leaving the system ready to accept new surveillance data. The EIVSystem also automatically archives data to tape. At configured intervals, the system will automatically copy all new data onto a 5-gigabyte, 8-mm backup tape.

4. Event Logging and Presentation. Event logging is used to record the actions of users who have successfully logged into the surveillance system as well as to record events detected by the system's image processing software. The EIVSystem report generation tool allows the user to produce formatted versions of system logs in DOS or UNIX files that can also be printed directly from the system user interface. The system will generate access, error, operation and alarm logs, as well as logs consisting of statistical information such as "How many alarms this month?" or "How many system log-ins in this period?" A report feature allows the use of site-specific report templates for producing periodic reports summarizing system performance.

5. Data Analysis. For data analysis and viewing live video, the EIVSystem provides an interactive image analysis tool. Difference data collected over a period of time are presented to the user in chronological order for review. For example, if vault doors were opened four times during a month to perform alarm checks, the collected data would include time-stamped images representing these vault accesses. Where a detected event triggered the collection of video data, the video data are presented to the user in an animation sequence that can be replayed at a user-selectable speed. Image data can also be manually differenced using the image tool, providing the ability to verify correct functioning of system image processing software or to analyze total change from one date to another. The gross change in an area could be analyzed, for example, by comparing a June 1 image with an August 1 image.

6. Alarm Management. The alarm manager provides an interface to the particular alarm mechanism configured into the EIVSystem installation. A system configured for data gathering only would interface to alarm and event logs. For systems that are configured with audible and visible alarms, the alarm manager would provide on, off and reset functions, or the alarm manager may activate the alarm relay when the EIVSystem is installed to interface with existing facility alarm systems.

C. EIVSystem Application

The EIVSystem is under test at two DOE sites to reduce the frequency of physical inventories. In this application, basis imagery is recorded for each vault camera and the EIVSystem is activated with the vault doors secured. The vault is then continually monitored until the cameras are deactivated by an authorized user. In secure mode, the EIVSystem expects no entry to the area and will record an alarm upon detecting events such as entry by facility personnel (Figure 1). In access mode, the EIVSystem would expect to detect the opening of the door and would record the above entry data but would not produce an alarm.

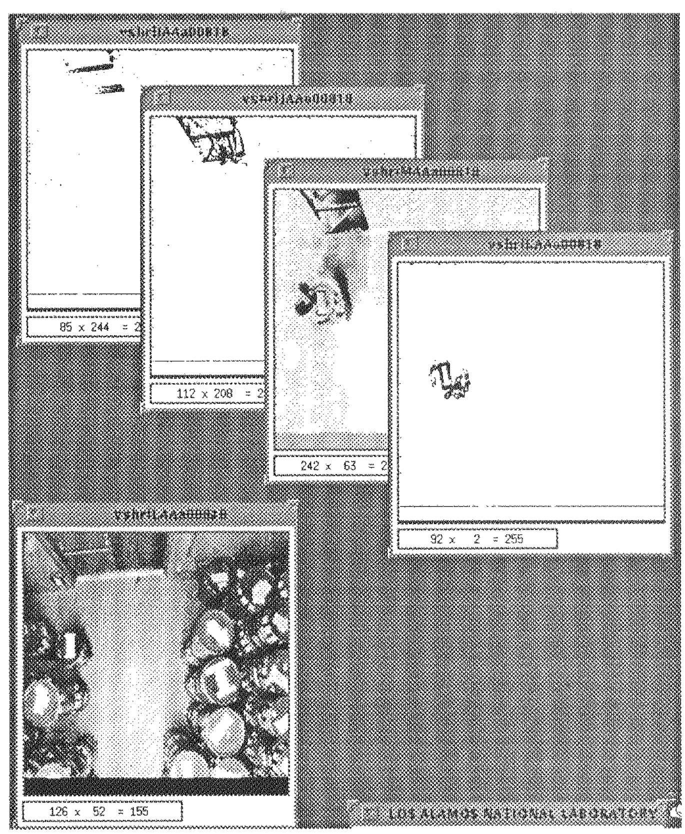

Figure 1. In this sequence of data, the vault door (top left) is opened, a human enters carrying an object, places the new object in the vault, and leaves the area. The new object is shown as a difference (lower right).

IV. Systems Test and Evaluation

A. PAMTRAK

1. Allied Signal. In 1989, DOE, Sandia and Allied-Signal Aerospace Co. entered into a cooperative program to enhance protection of sensitive and classified parts and material at the Allied-Signal facility in Kansas City. The program consisted of three phases.

In Phase I, Sandia evaluated the material security program at the Allied-Signal plant, produced a report recommending the installation of a real-time personnel and material tracking system, and submitted it to DOE for review. During Phase II, DOE funded the design and development of PAMTRAK by Sandia to implement the upgrades. Phase III evaluated PAMTRAK's effectiveness in protecting sensitive parts and material. All phases were completed in July 1992.

The PAMTRAK host and its three subsystems were installed in Department 58 of the Allied-Signal plant. Allied-Signal personnel volunteered to test PAMTRAK and provide Sandia with feedback on its hardware and software operations, impact on operations and ease of use.

The material monitoring subsystem performed extremely well. The Allied-Signal personnel thought that programming the WATCHs with the Inovonics portable programmer was difficult for a nontechnical system manager. Since that time, we have made the necessary modifications so the PAMTRAK host can directly program the WATCHs.

The personnel tracking subsystem had two deficiencies. The tags did not have a tamper-indicating necklace attached. Consequently, an authorized user could remove the tag and give it to an unauthorized user. Also, the signal strength or range of the exciter/receiver antenna pair varied from pair to pair. Some exciter antennas were so strong that their fields overlapped with others, whereas other pairs were so weak a user had to be within 2 feet of the exciter for the tag to be read. Allied-Signal personnel thought the entry control subsystem and barcode readers could be more user-friendly and so did we. The users wanted less interaction with the PIV when entering the facility and clearer prompts when interacting with the barcode readers. We are planning to interface pen computers to PAMTRAK. The pen computers will run a graphical user interface that PAMTRAK uses at the system terminal. Therefore, users will have an option other than the barcode readers.

2. Kirtland Underground Munitions Storage Complex. We have installed 61 WATCHs, two WATCH receivers and a WCU inside one vault, and 38 WATCHs in another vault at the Kirtland Underground Munitions Storage Complex (KUMSC). These vaults are a good test bed for the WATCH subsystem. We expect the system to reduce physical inventory requirements for SNM at KUMSC if it functions as designed and DOE approves its use.

3. Savannah River Site. The DOE Savannah River Field Office and Westinghouse Savannah River Co. are funding installation and site-specific modifications to PAMTRAK and its material monitoring system. The goal of this project is to produce a reliable, real-time, material monitoring system for the vault at Savannah River Site (SRS). There are four phases to this project, and we have begun Phase III.

a. Background. During Phase I, we determined how well the rf components of the material monitoring subsystem functioned in the SRS vault. SRS personnel installed 25 WATCHs and two receivers in the vault. The receiver output went to an IBM-compatible PC with data logging software that time-flagged all WATCH transmissions received. SRS personnel gathered data and moved the WATCHs as we requested. The data indicated that the receiver did not always receive the expected SOH from a WATCH, and we assumed that rf collisions caused these nonreports. As the number of WATCHs in the vault increases, the probability of a false nonreport alarm increases because of the rf collisions.

Two solutions to this problem existed. The first was to increase the supervisory period; however, the total number of WATCHs to be installed in the vault is relatively large. The second was to modify the WATCH software to randomize the transmission of the supervisory report to reduce the probability of collisions. The first method was unacceptable; therefore, we decided to modify the WATCH software.

Phase II provided hands-on experience to SRS personnel with the PAMTRAK host and material monitoring subsystem consisting of a WCU, four WATCH receivers and several motion WATCHs. We developed the WATCH randomization software, SRS personnel selected the sensitivity of the motion sensors for the WATCHs, and Inovonics Corp. produced the WATCHs. We have received the WATCHs and have completed most of the testing. Please refer to Section 6 for the preliminary results of these tests.

b. Current Efforts. Phase III began July 1, 1993, and will allow SRS personnel to evaluate the PAMTRAK host and material monitoring subsystems. SRS personnel want to monitor the system for several months to determine its operational impact, failure frequency, false alarms and other possible problems. If this phase goes well, SRS personnel may want to install PAMTRAK and its material monitoring system in other vaults at the site. After this phase, Sandia will make any necessary modifications to the system that SRS personnel deem necessary.

4. Argonne National Laboratories–West

a. Background. In the late 1980s, the DOE community needed an integrated material monitoring and materials control and accounting system. In response to this need, Sandiaand Los Alamos jointly developed the Argonne Unified Safeguards System (ARGUS). Argonne National Laboratories–West (ANLW) provided the operational and test environment for ARGUS and its evaluation. ARGUS consisted of three subsystems: personal computer-dynamic materials accounting (PC-DYMAC), wireless alarm transmission of container handling (WATCH) and mobile accountability verification inventory station (MAVIS). These subsystems are coordinated through the computer-augmented materials access (CAMA) system. Sandia developed the WATCH and MAVIS subsystems and CAMA. These subsystems perform the material monitoring functions by providing continuous surveillance of material not involved in the manufacturing process.

b. Current Efforts. Since the ARGUS project, we have been working to increase the effectiveness of the WATCH subsystem and designing and implementing a generic personnel and material tracking system. Because of these reasons, we and ANLW personnel thought it would be the best use of time and resources to substitute PAMTRAK and its material monitoring subsystem for the WATCH, MAVIS and CAMA subsystems. There are five phases to this project. Phase I was to obtain approval of the project plan by DOE/ Office of Safeguards and Security. Phase II provides "hands-on" experience for ANLW personnel with the PAMTRAK host and its material monitoring system. Currently, we are in this phase. The PAMTRAK host, WCU, two WATCH receivers and a small number of motion WATCHs have been installed at ANLW. During Phase III, we will interface PAMTRAK to PC-DYMAC. The fuel handlers will use PAMTRAK for a specific test and evaluation period. Phases IV and V will incorporate entry control and personnel tracking.

B. Experimental Inventory Verification System

1. Test and Evaluation at Idaho Nuclear Engineering Laboratory (INEL). An early prototype model of the EIVSystem was installed in a vault at INEL in July 1991. This system was installed primarily to test the image processing algorithms and to enable us to become familiar with the functions and features that would make this a valuable tool in an operations environment. Running the EIVSystem for individual 30-day periods, we were able to verify the image processing and change detection algorithms and begin to get some feel for environmental factors (such as lighting) and reliability factors (such as camera life). Routine operation of the system by ICPP safeguards personnel also provided valuable input about the user interface and data review functions.

Since 1991 we have upgraded the software and hardware in the INEL vault system many times. Today's implementation of the EIVSystem reflects several changes in hardware which were made to increase the computer processing speed and hardware reliability. For example, processing speed has improved from 30 seconds per image to a current rate of 4 seconds. We expect to reduce this to 2 seconds per image in the near future with minor tuning and enhancements to software and hardware. The INEL vault hosted an EIVSystem performance test over last summer to verify, validate and document the performance of the materials monitoring system. During the course of this test, the INEL vault will be permanently outfitted with a full complement of cameras and made ready for routine operation of the EIVSystem as an alternative measure designed to reduce the frequency and impact of physical inventories.

2. System Installation at SRS. The EIVSystem is currently being installed at the SRS vault to test and evaluate the system and concept. Recognizing the potential for substantial cost savings through alternatives to manual physical inventories of material, the Separations Area management will monitor a performance test of the EIVSystem lasting several months. (This test will be concurrent with testing at the INEL vault.) The test will determine if and where such systems will be of value in existing and future long-term storage facilities. At the SRS vault, the Sandia WATCH system will also be installed and tested.

To date, the EIVSystem host computer has been installed and configured with a pretest version of software and is operated in demonstration mode only. Several cameras and a complete bundle of fiber optic wires have been installed. The full complement of cameras will be installed when the vault storage rack has been constructed. When complete, the SRS vault EIVSystem will include an estimated 18 cameras and a single host computer and will interface through an alarm relay with the Sandia PAMTRAK system.

3. Current Efforts. Several new features of the EIVSystem are under development including compressed video recording, region of interest processing and database integration. For some applications of the EIVSystem, software will be configured such that a detected event will trigger the video recording system, storing compressed video data until the detected activity ceases. For example, a process area being monitored may contain instruments whose readings are recorded daily. When entry to this area is detected, the video recording is activated. When personnel leave the area, the video and difference data are stored for later review. The video data provide a concise record of only the access period, saving storage media and simplifying the review process, while the difference data show if any sensitive items in the area may have been disturbed during an otherwise authorized access.

The EIVSystem region of interest feature, currently under development, will provide additional flexibility in monitoring an area for safeguards events. Using the region of interest feature while configuring individual cameras will allow the user to define red, yellow and green zones within the camera's domain. Any entry or penetration into a red zone will generate an audible and visible alarm or could trigger video recording at a high frame rate. An entry into a yellow zone may trigger a soft alarm and video recording at a lesser frame rate, while entry into a green zone, where we expect occasional activity, will only generate a time-stamped data entry showing that access has occurred.

Database integration with the EIVSystem will allow information relevant to the stored materials to be accessed through the EIVSystem user interface. In some cases this information will be shared with existing facility databases, and in others the information may be local only to the EIVSystem. Access to the database will be through a graphical model of the vault and its contents. Users will "point and click" using the mouse device to access ever-increasing detail about the vault and its contents. Integrating this feature with the Los Alamos developed LANMAS (local area network materials accounting system) is being studied.

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Cheryl Rodriguez came to Los Alamos National Laboratory in 1987. Since then, she has been involved in nuclear safeguards and computer security development with the safeguards systems group. She is developing image processing and video technologies for nuclear safeguards applications.

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A Performance-Based Methodology for Rating Remediation Systems*

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■

Abstract
A methodology for evaluating and rating candidate remediation systems has been developed within the Buried Waste Integrated Demonstration (BWID) Systems Analysis Project at the Idaho National Engineering Laboratory (INEL). Called the performance-based technology selection filter (PBTSF), the methodology provides a formalized process to score systems based upon performance measures, and regulatory and technical requirements. The results are auditable and can be validated with field data.

I. Introduction
The mission of the BWID Systems Analysis Project is to identify and evaluate systems for the cradle-to-grave remediation of the Transuranic (TRU)-Contaminated Waste Pits and Trenches located within the Subsurface Disposal Area (SDA) of the INEL Radioactive Waste Management Complex (RWMC). There are three distinct objectives of the Project:

- Direct U.S. Department of Energy (DOE) resources to develop technically sound and cost-effective systems for the complete remediation of DOE buried waste sites;
- Guide the selection and technical justification for the development and demonstration of technologies within the BWID Program; and
- Identify system technology gaps and define quantitative performance requirements for technologies associated with the remediation of DOE Complex buried wastes.

The BWID Program will use the results of the Systems Analysis in conjunction with identified DOE Complex buried waste needs to develop a long-term strategy for improving buried waste remediation capabilities throughout the DOE system.

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Initial activities within the BWID Systems Analysis Project involved identifying configuration options capable of remediating the TRU-Contaminated Waste Pits and Trenches at the INEL. A configuration option is a top-level block diagram of a cradle-to-grave remediation system. The current focus of the BWID Systems Analysis Project is to conduct a rigorous evaluation of six retrieve and thermal treatment configuration options presented in an earlier report.[1]

Each block within a configuration option performs a function within a system and is referred to as a *functional subelement.* A *technology process option* is the term used in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to describe a configuration option that has specific technologies or requirements defined for all of its functional subelements. The terms *system* and *technology process option* are used synonymously in the BWID Systems Analysis Project.

The performance-based technology selection filter (PBTSF) is a tool within the BWID Systems Analysis which evaluates and rates the candidate systems and their enabling technologies. The PBTSF uses two components during its application. One component screens candidate systems against a set of previously defined system requirements. The second component executes trade-off studies that rate systems against performance measures based on CERCLA screening criteria, allowing direct comparison between various systems. This in turn allows direct calculation of the relative benefit of various technologies, even when embedded in disparate systems.

II. System Requirements
System requirements are defined in the PBTSF as a set of top-level, end-to-end constraints that guide the development and selection of viable remediation systems from a population of candidate remediation systems. The selection of a remediation system is constrained by requirements such as waste/site characteristics, applicable or relevant and appro-

priate requirements (ARARs), and institutional/programmatic requirements set forth by the U.S. Environmental Protection Agency (EPA), U.S. DOE, the State of Idaho, and the BWID Program. The system requirements, which are presented in a previous report,[2] have been generated from a combination of technical and regulatory sources including:

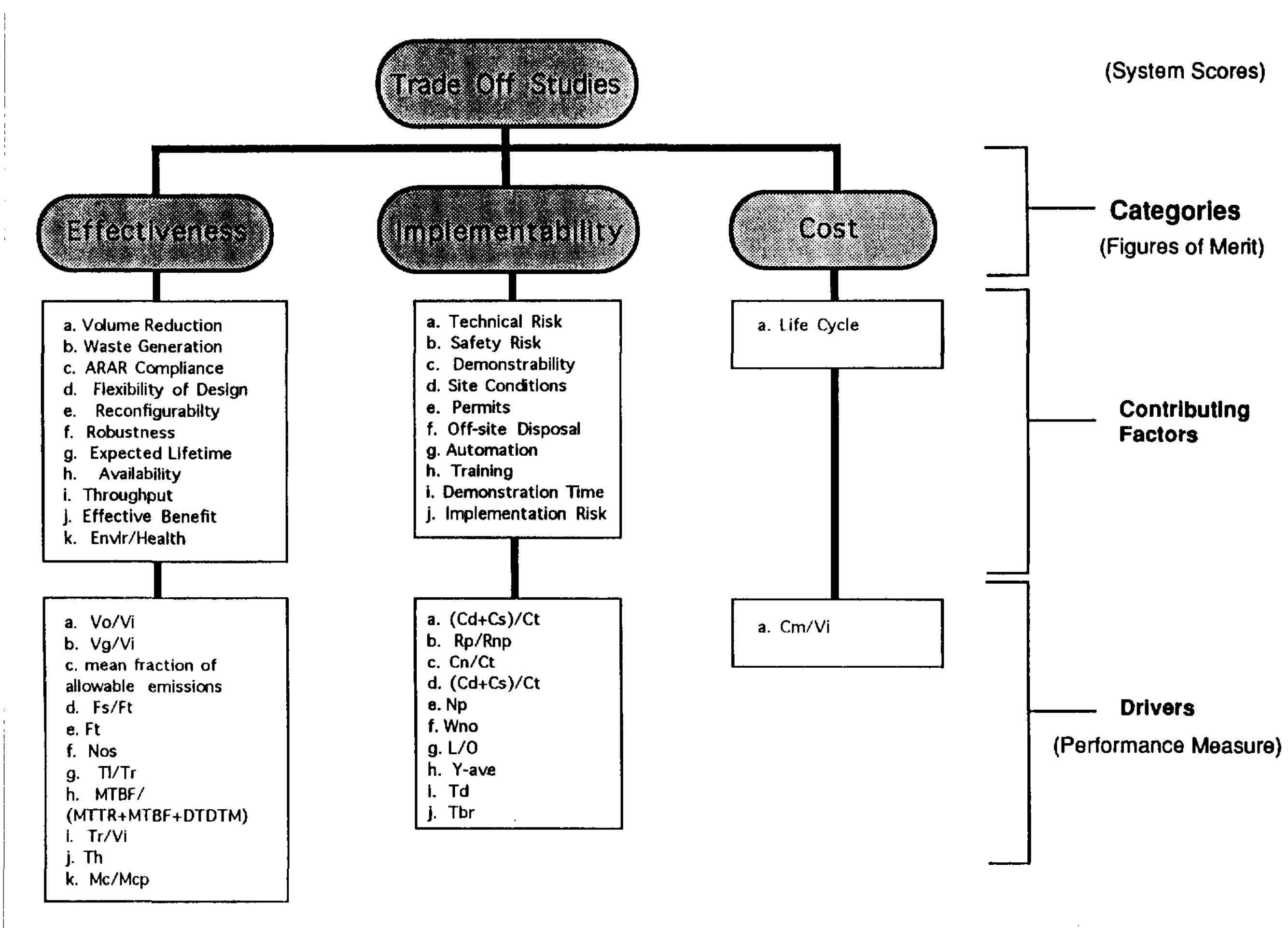
- Programmatic requirements:
  Federal Facility Agreement and Consent Order (FFA/CO) (EPA, DOE and the State of Idaho)[3]; BWID Demonstration Plan[4]
- Input requirements:
  Historical and technical characterization of the INEL SDA[5]
- Output requirements:
  INEL RWMC Low-Level Waste Acceptance Criteria[6]; INEL Transuranic Waste Acceptance Criteria.[7]

III. Trade-off Studies

Since the INEL is designated as a Superfund site, it is appropriate to consult CERCLA to guide the evaluation and rating of systems for remediating the TRU-Contaminated Waste Pits and Trenches at the INEL. CERCLA provides the framework for evaluating end-to-end technology process options (systems) during a feasibility study. The primary objective of a feasibility study is to "ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can be presented to a decision-maker and an appropriate remedy selected."[3] A report etitled "Guidance on Feasibility Studies Under CERCLA EPA/540/G-85/003" and a revision titled "Guidance for Conducting Feasibility Studies Under CERCLA EPA/540/G-89/004" identify three categories of criteria that should be considered while evaluating technology process options: effectiveness, implementability and cost. These documents provide the basis for conducting the PBTSF trade-off studies.

Twenty-two performance measures have been identified that reflect the text or the implied meaning of the text associated with each evaluation criterion in the EPA guidance documents (see Figure 1). Formulas were developed to generate numerical scores associated with each performance measure. These indicate, in a quantitative manner, how well a technology process option performs relative to each performance measure. Inputs to the formulas are various sys-

Fig. 1: CERCLA derivation of performance measures



tem technical and institutional performance characteristics of the technology process option and are referred to as performance data. The following example illustrates the terminology associated with and performance measures used within the PBTSF trade-off studies:

Example:

Criteria Category:	Effectiveness
Contributing Factor:	Volume Reduction
Formula:	$E1 = 1 - V_o/V_i$
Performance Measure:	E1
Performance Data:	V_o = Volume (m^3) of output material from the process
	V_i = Volume (m^3) of waste matrix, overburden, and horizontal plume as defined in the input system requirements.

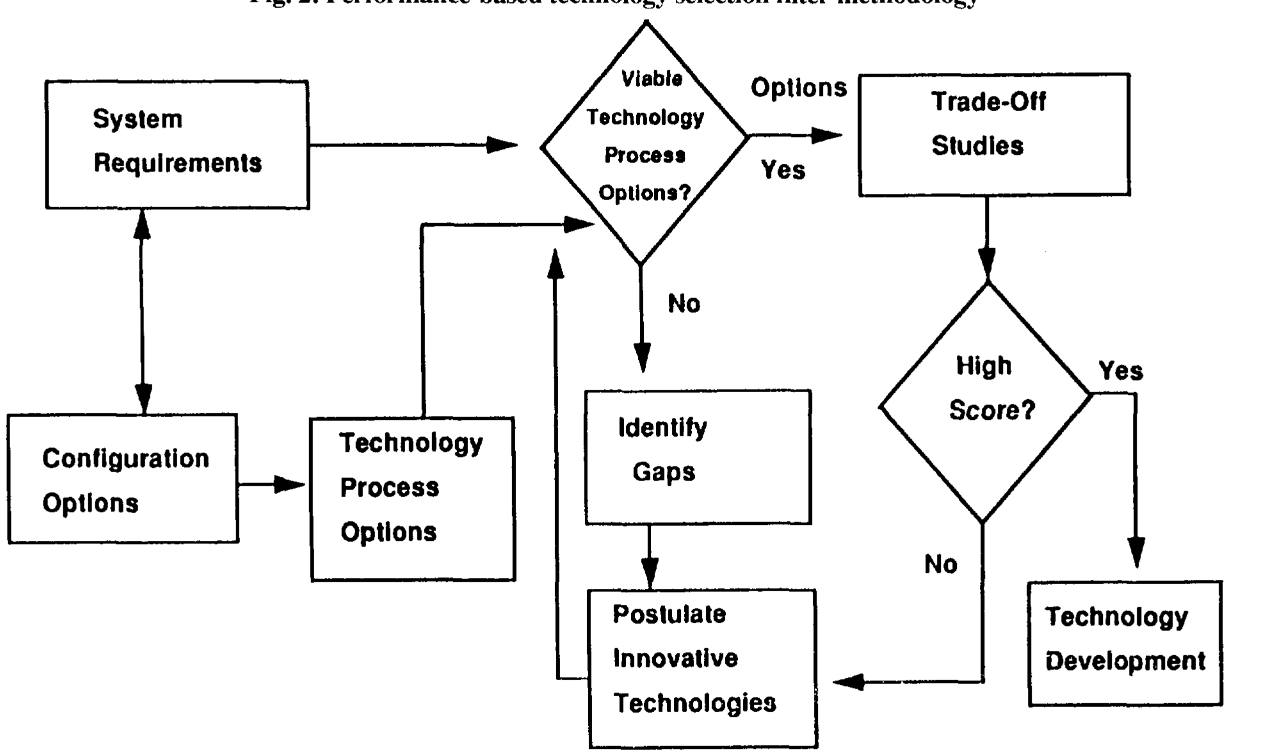
Sources of performance data include manufacturers, proposers, lessons learned from technology demonstrations, and input requirements. When a system or technology has not been demonstrated, performance data must be estimated and the uncertainty associated with the estimate identified. Technical experts will be requested to review all performance data to ensure their validity. All input performance data, actual or estimated, will be documented for further reference.

Performance data used to calculate performance measures may be collected at the system or technology level. If the performance data are collected at the technology level, the data must be combined or "rolled-up" to generate system-level performance data. For the performance measure weights to be meaningful, the performance measures must all produce scores that are on an equivalent scale. The performance measures were derived as either probabilities or ratios. Since the probabilities are naturally bounded between 0 and 1, the ratios were constructed such that under anticipated performance data, they also evaluate to a score between 0 and 1. There are cases where the probability or ratio evaluates such that 0 is "better" than 1. This problem is corrected by subtracting the probability or ratio from 1, so that all performance measures yield a score between 0 and 1 with 1 being the better score.

Linearly averaging all performance measures that contribute to a criteria category (effectiveness, implementability or cost) generates a number which is defined as the final value or *figure-of-merit.* If desired, different weighting factors can be applied to each of the performance measures. This may be used to reflect the relative levels of importance of some measures over others. An overall score for a technology process option is calculated by averaging the three figures of merit for effectiveness, implementability and cost. Again, different weights can be applied to each of the three categories. Note that CERCLA does not address the relative weighting of the parts that make up each category, nor does it address the relative weights of the categories to each other. The PBTSF trade-off study calculations can be executed using software that will run on a personal computer.

Excerpts of the text from the EPA guidance documents

Fig. 2: Performance-based technology selection filter methodology



that provide the basis for each performance measure factor, an explanation of performance data used in each formula, and a description of how performance data and performance measure error are propagated is provided in a previous report.[2]

IV. Overall PBTSF Operation

Figure 2 illustrates the sequence of steps followed in the PBTSF to rate competing technology process options and generate specific technology development requirements. This section provides a detailed description of the various elements shown in Figure 2 as being performed in the BWID Systems Analysis Project.

Initially, generic configuration options are developed that provide a description of a remediation system at a functional subelement level. Many possible technology process options may reflect the same configuration option and differ only in performance characteristics of certain subelements. An example might be a melting and incineration configuration option analyzed with several different metal shredders. Though each technology process option would have the same block diagram, its end-to-end performance characteristics will reflect the specific shredder technology. Candidate configuration options will be evaluated from a scientific/engineering standpoint to determine future consideration. Reasons for evaluating particular configuration options will be fully documented for future reference.

Specific technologies or performance requirements are defined for each functional subelement within a configuration option to develop technology process options. Technical experts will be consulted to provide and screen technology lists that are considered for each functional subelement. Again, reasons for considering technologies within a particular functional subelement will be fully documented for future reference.

Technology process options are formally assessed to determine if they meet system requirements. The results of applying the system requirements matrix will indicate explicitly which technology process options are or are not meeting system requirements and why. Those systems that do meet requirements are then addressed by the trade-off study function. The output of the trade-off study function is a score for each technology process option (also called a rating) that indicates how well the technology process options rate against the CERCLA-based formulas discussed in Section 3.

Technology process options that do not meet functional requirements are examined to determine where performance must be improved or, more specifically, what performance aspects of various functional subelements must be improved. An example might be a technical process candidate generating a waste form that cannot meet output requirements. Performance requirements are then defined at the subelement level such that system requirements can be met. Note that there may be one or more subelements that are responsible for a technology process option not meeting requirements. Thus, performance requirements may be identified for more than one subelement within a technology process option. These gaps, defined by performance requirements, may be filled by existing technologies that were not initially considered, or postulated innovative technologies. This process is called identification of technology gaps.

Postulated innovative technologies, as defined by their performance measures, are inserted into technology process options that do not meet system requirements, and the option is then reevaluated against the requirements matrix. If the technology process option meets all system requirements, it is then scored via trade-off studies, and its overall performance compared to scores of other technology process options. A score lower than other existing systems indicates that the postulated innovative technology will not benefit the process and that new and higher performance requirements must be met to fill the technology gap.

This process can be iterated until a technology process option with a postulated technology generates a high system score. The assumed technology performance parameters then become requirements for technology development. Note, again, that requirements that the technology must meet are directly related to the score the technology process option must attain in order to compare favorably with existing technology process options that require little, if any further development.

V. Conclusion

The BWID PBTSF is a systems tool with the purpose to provide a framework and formal methodology for selection and rating of technology process options and their enabling technologies. It also provides a closed-form approach to identify technology gaps and the requirements to fill those gaps. The PBTSF trade-off study function has been demonstrated at an actual remediation conducted in the state of Oregon. The remediation involved the in situ stabilization, retrieval, packaging, transportation and disposal of two sludge ponds. Results from this demonstration are presented in a previously published report.[8]

There are five primary attributes of the BWID PBTSF. These are:

- Technology process options and their enabling technologies are rated and selected based on performance measures;
- Selection and ratings are based solely on institutional and technical requirements and are documentable and traceable;
- Rating and selection is performed on complete systems;
- Performance measures expressly define direct technology development; and
- The methodology can be adapted for evaluating remedial alternatives for any CERCLA or non-CERCLA site.

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November 1–5, 1993
Third International Symposium on Stabilization/Solidification of Hazardous, Radioactive, and Mixed Wastes, Williamsburg, VA. *Sponsor:* American Society for Testing and Materials' Committee D-34 on Waste Management, with other organizations. *Contact:* Michael Gilliam, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6202; phone (615) 574-6820.

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International Low-Level Waste Conference, Monterey Hyatt Hotel, Monterey, CA. *Sponsor:* Electric Power Research Institute. *Contact:* Carol Hornibrook, EPRI; phone (415) 855-2022.

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1993 Fall Meeting of the Materials Research Society, Symposium V: Scientific Basis for Nuclear Waste Management XVII, Boston Marriott Hotel and Westin Hotel/Copley Place, Boston, MA. *Contact:* MRS, 9800 McKnight Rd., Pittsburgh, PA 15237; phone (412) 367-3003; fax (412) 367-4373.

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Spent Fuel Seminar XI, Loew's L'Enfant Plaza, Washington, D.C. *Contact*: Kathleen Sweeney, INMM Headquarters, 60 Revere Dr., Suite 500, Northbrook, IL 60062; phone (708) 480-9573.

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