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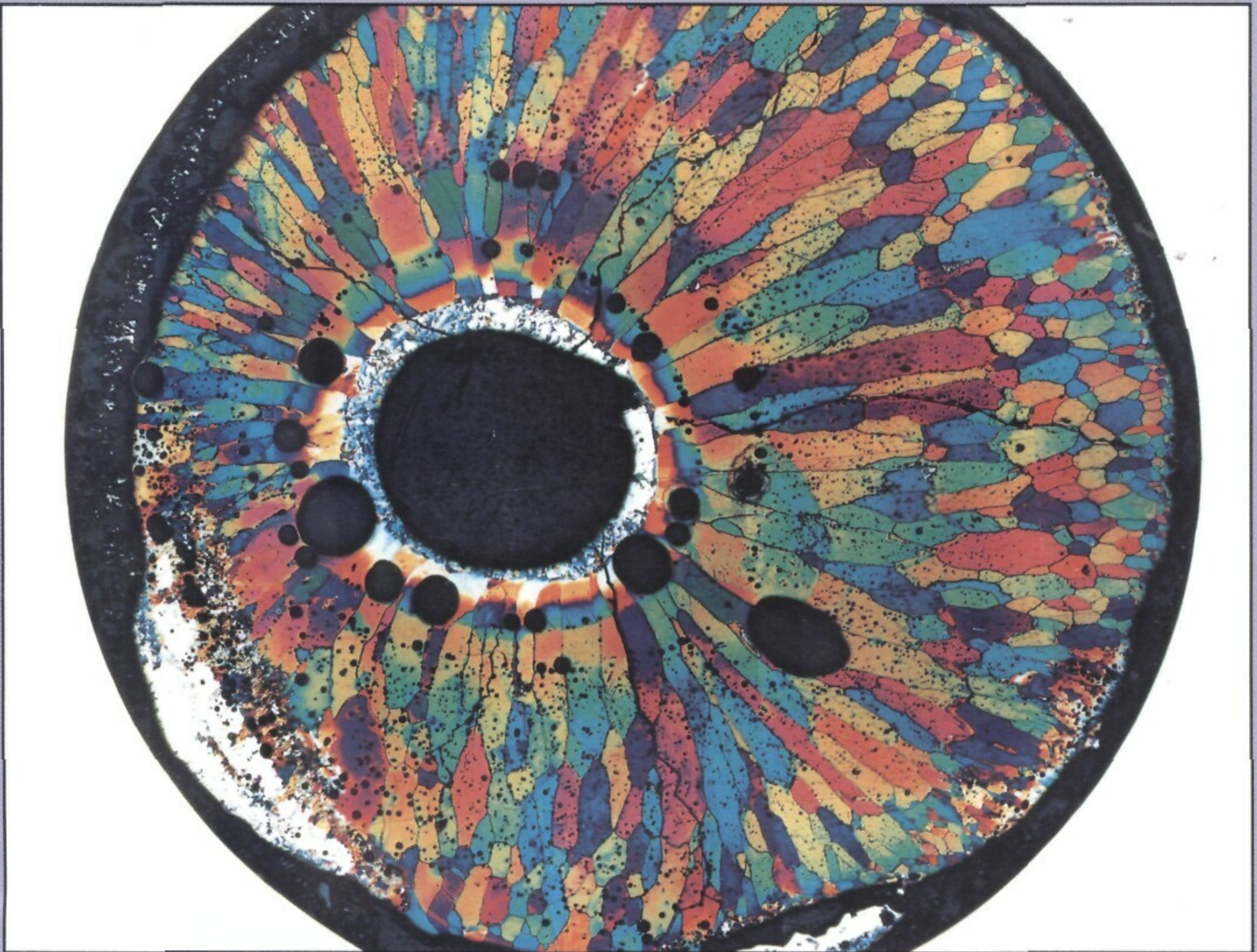

Annual Safeguards Roundtable

Guest: Dr. John Bartlett, Director, DOE Office of Civilian Radioactive Waste Management

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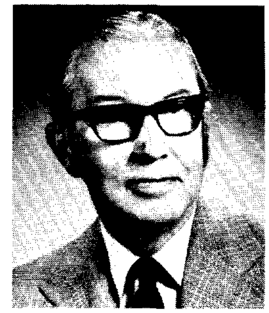
On the Cover: Transverse cross section through an irradiated sodium-bonded fuel pin. The liquid sodium was expelled from the fuel/cladding gap, and the fuel center temperature exceeded 2700K without cladding breach. Photo courtesy Los Alamos National Laboratory.

Separating papers from politics



In May of 1989, I received a letter from Helen M. Hunt which said that Paul Levinthal, president of the Nuclear Control Institute, had recently met with officials in Japan to discuss safeguards and safety aspects of Japan's commercial use of plutonium. The Nuclear Control Institute, as you may know, has published the proceedings of a symposium on nuclear terrorism and is opposed to commercial reprocessing and the use of plutonium fuels. She asked if the INMM would be interested in publishing two of the papers that had been circulated in Japan and said that "We would particularly like to receive comments from safeguards experts on the substantive issues raised in the papers."

Since this required a policy decision, I sent copies of the letter and the articles to the officers and to other members of the Institute for advice. As individuals and as an organization, we should and do analyze the effectiveness of safeguards and physical protection systems. However, as a professional organization we should not advocate political policies even if a clear majority of our members might agree on them.

The Executive Committee decided that politically oriented papers are not acceptable as technical articles. We have published an interview with Dixie Lee Ray in which she advocates the use of plutonium fuels. The technical issues raised in the papers are of concern to our organization and its members around the world. It was finally decided that a contribution of this nature might be published as a letter to the editor, along with appropriate comments.

Subsequently, I notified Ms. Hunt of this decision and, in due time, she submitted the letter to the editor which appears in this issue. She is a member of the INMM as well as a consultant for the Nuclear Control Institute, and she presented a paper on measuring nuclear waste containers at the most recent INMM annual meeting. Several of our members present their comments on the issues raised. Additional comments on these issues and on the manner in which the Institute has handled this contribution are sincerely invited.

Again I appeal to the membership for technical contributions and for comments. If the *Journal* is to serve its purpose of exchanging information and ideas, it needs the support of those who read it.

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

Whither INMM

Fellow members and friends of the INMM, in my first year as chairman, I am pleased that we have set the destination and dates of the 32nd Annual Meeting of the Institute (...for this organization). The meeting will be held July 28-31, 1991, at the Fairmont Hotel in New Orleans, Louisiana. I hope you are planning to attend. I realize that this is a time of uncertain, and perhaps, decreasing, budgets for many of us. However, the rapidly changing world situation, the increasing interest in arms control or reduction, and the recognition of the urgency to protect our environment have combined to make the need for responsible stewardship of nuclear materials — that is, nuclear materials management — even more important than ever before. And the INMM's Annual Meeting is the forum in which, typically, more than 500 of the world's leading safeguards, security , transportation and waste management professionals will gather to exchange technical information.

The Technical Program Committee already is working to make the 1991 Annual Meeting an even greater success than our 1990 meeting in Los Angeles. More than 200 technical papers are planned in sessions that include waste management, transportation, physical protection, international safeguards, containment and surveillance, materials control and accounting, measurement technology, and arms control verification. The deadline for submission of abstracts is February 1, 1991; it will be more strictly enforced this year than ever before to reduce the last minute scramble in the paper review and selection process. So, get started now — INMM needs you to share your experience and expertise.

On the lighter side: New Orleans is always a delightful setting that spouses and families should enjoy. The Fairmont is right on the edge of the French Quarter and quite near the Mississippi River. I have even heard mention (no promises, but a definite maybe) of another Monday evening on the River on one of the big sternwheelers.

The Long Range Planning Committee has recommended to the Executive Committee that INMM consider organizing itself in divisions, in part to facilitate more fully integrating elements of nuclear materials management other than safeguards and security (transportation and waste management, for example). Jim Tape is chairing an ad hoc committee to investigate this opportunity, and I expect that the Executive Committee will be considering what to propose to the membership at their next meeting in March. If you have thoughts or feelings on this, please let Jim or me know. Either of us may be reached at Los Alamos National Laboratory, MS E550, Los Alamos, New Mexico, 87544 U.S.A.

Have a good year, and I'll see you in New Orleans.

Darryl B. Smith
Los Alamos National Laboratory
Los Alamos, New Mexico U.S.A.

Japanese Facilities Pose Safeguards Concern

There are serious grounds for concern that safeguards and security for plutonium at Japanese facilities are and will be inadequate. A presentation of these grounds for concern follows, together with a suggestion for resolving the problem.

Introduction

The plutonium produced in Japanese facilities for peaceful nuclear energy use is subject to full-scope safeguards measures implemented by the International Atomic Energy Agency. In addition, in accordance with the terms of the U.S.-Japan nuclear cooperation agreement, Japan must implement certain minimal levels of physical security to protect its plutonium from theft. Nevertheless, in view of a recent Iraqi attempt to obtain nuclear bomb detonators and earlier attempts by Iraq and Libya to buy plutonium and highly enriched uranium on the black market, it appears that even rigorous application of the required protection measures might not be sufficient to assure that plutonium will not be diverted from Japanese reprocessing or fuel fabrication plants to terrorist nuclear bombs.

Japan intends to process huge quantities of plutonium at bulk handling facilities, where, because of non-reducible measurement uncertainties, materials accountancy techniques will not be capable of detecting theft of bomb quantities of plutonium. The very large flow of plutonium that is projected in Japan is one principal cause of the significant risk to the security of Japanese plutonium in the near future.

A second principal cause—which works synergistically with the first—is the Japanese lack of belief that some employees (who might be coerced or heavily bribed) might be so disloyal as to steal plutonium from the company. This lack of belief in the possibility of insider diversion creates a lack of vigilance and a pronounced unwillingness of employees to report suspicious behavior of fellow employees. Without employee vigilance, the only real obstacle to insiders attempting to divert several kilograms of plutonium would be the technical non-human safeguards and security systems, which in large bulk-handling facilities can be defeated.

Crime (even large-scale crime) does occur In Japan. Early this year Japanese officials were acutely embarrassed by a huge counterfeit-coin scheme. According to the *New York Times* [1], at least $71 million (10,300 million yen) in gold coins at the Bank of Japan were discovered (because of a slight flaw) to be counterfeit.

This elaborately executed scam was one of the world's largest counterfeiting schemes. Although the counterfeit coins were made of solid 24-carat gold (more than two tonnes total), the gold value was less than half the face value of the coins, so the counterfeiters made a very large profit! One Japanese government official asserted on television, "This isn't supposed to happen in Japan."

Technical Safeguards and Security Limitations for Large-Scale Plutonium Plants

The technical literature on safeguards and security for plutonium clearly states that a combined measurement uncertainty of 0.5% or greater is normal for plutonium fuel fabrication and reprocessing plants and is apparently not substantially reducible. In consequence, for a reprocessing plant of the (projected) scale of the Rokkasho-mura facility, conventional materials accountancy would probably not detect with high confidence the loss of 100 kilograms of plutonium in a one-year period.

Indeed, the U.S. Nuclear Regulatory Commission has noted that the yearly MUF (material unaccounted for) at Rokkasho-mura could be as high as 200-300 kilograms, without any indication being given that investigation of a possible unauthorized removal of plutonium is warranted [2]. Even if MUF usually did not exceed 100 kilograms of plutonium per year, so that a MUF greater than 150 kilograms or so in a one-year period might be investigated, there would be the possibility that several bombs worth of plutonium could be diverted from the plant in a year, without detection through material accountancy procedures.

Alternate materials accountancy techniques do not reduce the amount of plutonium that could be diverted from any particular facility in a one-year period. In particular, the method of near-real-time accountancy, for which there were initially high expectations, though able to detect very large abrupt (single event) diversions, is no better than conventional accountancy at detecting protracted diversion [3].

The Tokai-mura reprocessing plant has been operating at a capacity (<100MT/yr) roughly one-eighth or one-tenth the expected operating capacity of the Rokkasho-mura plant. A 1987 IAEA paper on field-testing of the near-real time technique at Toka-mura reveals that: (1) an abrupt loss of up to three kilograms of plutonium might not be detected, and (2) protracted losses (or diversions) cannot be distinguished from flow measurement bias. The near-real-time technique probably would not detect a protracted diversion of a few kilograms over a one- or two-month period [4]. For the Rokkasho-mura plant, one must multiply these figures several fold.

The IAEA has rejected use of one method, process monitoring, which national safeguards authorities employ as an aid in detecting loss or diversion [5]. Process monitoring comprises use of a variety of frequent or continuous measurements in various areas of a plant and a variety of analytical tools [6]. But even process monitoring has severe limitations. For example, under certain conditions, process monitoring could not detect unauthorized removal of significant quantities of concentrated plutonium nitrate solution from large storage tanks, and there appears to be no way to overcome this weakness [7].

At large plutonium plants there is apt to be a serious problem with alarms for the many surveillance and containment devices. This problem has two components: (1) If alarm thresholds are set at levels which offer reasonable probability of detection, then the rate of occurrence of false alarms is apt to be at a nuisance level, with the result that alarm thresholds might be excessively reduced or, even worse, the alarms might be deactivated. (2) If alarm thresholds are habitually set at levels substantially below nuisance level, then the probability of detection is apt to be excessively low [8].

In addition, as Dr. Hideo Kuroi of the Japan Atomic Research Institute points out, "rather frequent anomaly signals actuated by the system cause facility guards to impute all alarms to false alarms, thus ignoring them. This is the dangerous syndrome of 'The Boy Who Cried Wolf'" [9].

Another safeguards difficulty for highly automated plutonium plants is that large quantities of concentrated, rather pure, plutonium are inaccessible to inspectors. In consequence, safeguards inspectors must rely heavily on operator-supplied data in a computer. As Peter Tempus, former IAEA head of safeguards, has pointed out, "if so programmed, [a computer] can give completely honest information to facility operators and totally false information to IAEA inspectors."[10] Tamperproofing cable lines can be difficult or sometimes impossible. Inaccessibility to inspectors also facilitates unauthorized use of a "black box" between a sensor and computer, for the purpose of data alteration. Because Japanese plans include large highly automated plants, these safeguards problems could be prominent.

Of special concern, particularly for large plants because of the possibility of large diversion not detectable through materials accountancy, is that several kilograms of well-shielded plutonium could be diverted in a single standard 200-liter waste container used for laboratory waste, discarded tools, etc. After waste containers leave a material access area, the level of security may be low enough that an employee could remove an item from a container without arousing suspicion. This waste stream is a particularly available route for diverting plutonium to terrorists. It does not depend on rewiring of hardware or reprogramming of computers. Therefore, it must be regarded with especially great concern as a likely diversion path. The risk could be substantially reduced by use of small-diameter waste drums and improved waste assay techniques, which would reduce the quantity of material that could be diverted in a single container. Nevertheless, this pathway could remain risky.

Some Major Human Impediments to Enforcement of Safeguards and Security Procedures at Large-Scale Plants

There are many general human obstacles to the implementation of a reliable safeguards and security system at a large plutonium plant. One has been mentioned, namely, lack of tolerance for moderate or high false alarm rates, and consequent disregard for alarms, reduction of alarm thresholds, or deactivation of the alarms. Another is that groups of employees sometimes strike — in particular, groups of guards refuse to work for days or weeks or even months. In addition, respect for human rights, for example, privacy, can seriously interfere with the protection of plutonium from theft.

Two examples Illustrate that serious safeguards and security weaknesses can arise from human impediments. The first pertains to a nuclear facility, the second to an airport.

Last year there was a several-month guard strike involving a large number of guards at Los Alamos National Laboratory in the United States. The U.S. Department of Energy has confirmed that during this period "an uncleared individual [was] afforded entrance to the top security command post that controls access to the Laboratory's plutonium facility."[11]

The second example shows that security personnel do sometimes violate security regulations and that tragic consequences can follow. The terrorist plastic explosive device which blew up Pan Am flight 103 was reportedly permitted on board because "Pan Am had been inspecting with X-rays some bags that under regulations should have been searched by hand."[12]

Some Major Problem Areas in Japanese Safeguards and Security

The present failure of both Japanese and international inspectors to assay plutonium-contaminated waste at the Toka-mura reprocessing plant and at the PFPF fuel fabrication plant represents a major hole in safeguards for plutonium. As explained above, this waste stream is especially vulnerable to use as a diversion pathway even when it is assayed — without assay it is even much more vulnerable. Failure to assay this waste stream is not consistent with the principle "trust but verify."

Another severe safeguards hole in Japanese plutonium facilities could arise from the high degree of automation and computerization for handling plutonium and data. There could be serious safeguards weaknesses involving not only lack of inspector access, problems in tamperproofing cable, and lack of transparency of some hardware and perhaps some software—but also the ability of certain personnel to manage an automated system so as to gain access at irregular times to a site in the production line where concentrated, fairly pure plutonium can be removed.

At least for the Rokkasho-mura plant, the policy will be to "assign top priority to safety and next to reliability and economy"[13]. Safety, reliability and economy are very important, but safeguards and security are equally important and are not included among the high priority concerns. This apparent lack of focus on safeguards and security is consistent with the historical de-emphasis on physical protection in Japan. According to Dr. Kuroi, Japan's historical and geographical background "gave the Japanese the attitude that steps taken for the sake of security ought not to cost anything because any devices or measures of security are not necessary and therefore ought not to cost anything." [14]

Dr. Kuroi emphasizes a need for education and intense dialogue in Japan concerning the reasons that safeguards and security for plutonium are important. One of the present problems he describes is that " . . . the strong group consciousness [in Japanese companies] could develop a curious atmosphere to cover up any possible misbehavior of a person in the group." He relates as a particular example the case of an airline pilot who intentionally plunged a passenger plane into the sea. The co-pilot tried unsuccessfully to block the pilot's actions. Of particular relevance to the possibility of diversion by insiders is that "[m]any of the captain's colleagues had reportedly observed his curious behavior and perceived something different, but did not take any action." This cultural characteristic could work in combination with technical weaknesses in safeguards and security at large plutonium plants to create a pronounced vulnerability to diversion.

The IAEA has limited resources and limited access to plants. It cannot assume total responsibility for monitoring the efficacy of safeguards and security at a plutonium plant (especially a large highly automated plant). Efficacy of safeguards and security depends crucially on oversight by a national safeguards authority. The weaknesses cited above raise questions as to whether Japanese national oversight could be adequate.

Conclusion

In view of evidence in the past decade of a black market demand for nuclear bomb fuel and for specialized electronic nuclear bomb components, it appears that risk of diversion from large-scale Japanese plutonium plants would be excessive.

Low-enriched uranium is much more economical than plutonium, it will be in plentiful supply well into the next century, it can be stocked at reasonable cost and it is a much lower diversion risk than plutonium. Accordingly, Japan might consider relying on uranium rather than plutonium for national energy needs.

Helen M. Hunt
Consultant on Safeguards and Security
Princeton, New Jersey

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Comments on letter to the editor by Helen M. Hunt

The preceding letter to the editor proposes that Japan should stop using plutonium fuels because "it appears that risk of diversion from large-scale Japanese plutonium plants would be excessive." The author questions the effectiveness of national safeguards and security programs intended to prevent theft or diversion of sensitive nuclear materials by "insiders" based on her impressions of Japanese interest in effective safeguards and physical protection.

As often happens in discussions of this issue, the author confuses the objectives and methods of international safeguards and national programs for protecting nuclear materials and facilities. For example, the IAEA accountancy verification goal quantity for an 800 te per year reprocessing plant is presently about 250 kilograms of plutonium per year, as is noted in the U.S. Nuclear Energy Commission's letter to Senator Glenn (reference 2). However, a national system of material control, accounting and physical protection employs the screening of employees, barriers and surveillance measures to deter, detect and respond to any attempt by authorized personnel to steal nuclear materials. While a highly automated nuclear processing facility could present some problems for the IAEA, as was noted by Peter Tempus (reference 10), Japan and other members of the IAEA are working with the Agency to resolve such problems. It is also important to recognize that highly automated facilities may present problems to a potential diverter and, in any case, employ fewer people with "hands-on" access to the material. In the design of such systems, care should be taken to ensure that the programmers and operators of the automation cannot employ it for diversion, as the letter by Ms. Hunt points out.

The author identifies some of the many issues that those who design and operate nuclear material control systems must consider, such as avoidance of excessive false alarms, strikes by security personnel, noncompliance with the rules, and removal of nuclear materials from the safeguarded area in waste containers. Many of the papers presented at the annual meetings, at technical workshops, and in the Journal address solutions to these problems.

From the paper on physical protection in Japan by Hideo Kuroi in the January 1988 issue of the Journal, and other references, Ms. Hunt concludes that the Japanese do not believe that some employees might be so disloyal as to steal plutonium, that employees in Japan would not report suspicious behavior by their fellow workers, that the Japanese do not verify the contents of waste containers before removing them from a protected area, and that safeguards and security are not top priority in Japan. We interpret Kuroi as saying that some national traditions and attitudes may facilitate the protective measures while others may conflict with them. In the latter case, the public must be educated to support the necessary protection activities. As in the U.S. and other countries, the safeguards and physical protection systems in Japan employ the screening of employees, surveillance and entry-exit searches to provide redundant control and high assurance.

Those who are interested in this subject should also read Aiming at Better Physical Protection: Physical Protection in Japan, by K. Seyama, H. Nakano and M. Kajiyoshi in the February 1990 issue of the Journal, which says, inter alia: "Physical protection is considered to be an extremely important measure associated with non-proliferation and safety."

Japan is one of a number of countries that is working with the IAEA to determine the criteria for termination of IAEA safeguards on waste discards. All agree that the waste containers should be measured by the facilities and that the Agency should have the right to verify such measurements. The February issue of the Journal contains a description of an NDA measurement system for waste drums by J. Akatsu, et al., of the Japanese Atomic Energy Research Institute.

The Japanese chapter of the INMM represents a significant fraction of the membership of the Institute. Japanese members and their colleagues make substantial contributions to our meetings and papers. INMM members in the U.S. and other countries attempt to better understand how to make international and national safeguards and physical protection programs more efficient, effective and credible worldwide. We U.S. members consider Japan to be as concerned about protecting nuclear materials from theft and sabotage and as capable of providing such protection as is the United States, the U.K., France or any other country with substantial nuclear programs.

James W. Tape
Darryl B. Smith
Los Alamos, New Mexico

We feel it is important for us to respond to the letter to the editor by Ms. Hunt.

It is unfortunate that the author made a sensitive political recommendation on the basis of misunderstanding about safeguards in general, and safeguards in Japan specifically. She quotes Dr. Kuroi to indicate a lack of concern over safeguards and in particular the insider threat in Japan. However, she ignores other sections of Kuroi's article which note that in addition to a well-developed personnel screening and training program, Japanese nuclear facilities control their entrances and exits with metal and nuclear material detectors. It would be imprudent for the Japanese to identify the location and sensitivity of specific devices at any facility. In addition, all personnel entering and leaving Japanese nuclear facilities must completely change clothing under the eyes of the guards, providing a severe challenge for the insider trying to remove kilograms of plutonium.

The author also cites as a weakness of the Japanese system the fact that plutonium in highly automated facilities is inaccessible to the IAEA inspector. In fact, it also is inaccessible to the operators and poses another challenging problem for the diverter. The Japanese, the IAEA and the United States have collaborated in developing a sophisticated automated materials control and accounting system for the automated plutonium fuel production facility at Tokai whereby the IAEA can obtain accounting data in near-real time without requiring physical access to the material. This system has been the topic of special sessions at both the 1989 and 1990 annual INMM meetings and earned the Power Reactor and Nuclear Fuels Development Corporation (PNC) The Corporate Safeguards Award for 1990 from the INMM.

In questioning the effectiveness of near-real time accounting (NRTA), the author paraphrases from an article by Barry Jones of BNFL as follows, "In particular the method of NRTA, for which there were initially high expectations, though able to detect very large abrupt (single event) diversions, is no better than conventional accountancy at detecting protracted diversion." An actual quote from the abstract of the referenced article is, "In recent papers it has been shown that Near Real Time Materials Accountancy (NRTMA) is vastly superior to conventional accountancy in the following respects:

• more timely detection of abrupt losses;
• much higher probability of detection of abrupt losses or gross accountancy errors;
• much greater control of protracted losses, biases and systematic measurement errors."

The effectiveness of NRTA for detecting abrupt or protracted diversion in reprocessing plants depends on facility design as well as safeguards system design. The facility and the NRTA system must be designed and operated to minimize errors in measured throughput and inventories, to statistically deal with measurements and to resolve anomalies.

Ms. Hunt also cited the results of a 1987 PNC-IAEA study to conclude "An abrupt loss of up to 3 kg of Pu might not be detected." The actual quote from the report states, "Using linear regression, the standard error of estimate, the ability to predict CUMUF from a knowledge of either material balance period or throughput, was never worse than + 1100 grams, and for the 1985 data was only + 900. Multiplying by 3.3 to introduce false alarm and detection probabilities suggests that any abrupt diversion larger than 3.0 - 3.5 kgs Pu would have at least a 95% probability of being detected as an anomaly requiring further investigation. Or, as the authors suggest might be a more appropriate way of looking at the data, an 8 kg abrupt diversion would have at least a 99% probability of detection, even using a false alarm rate of 0.1% or lower." The data are for a campaign reprocessing 79 MT of fuel to recover 500 kg of plutonium, or approximately 10% of the annual design capacity of Rokkasho-mura. Note also that the experiments were conducted with a retrofitted NRTA system; the system was not designed and installed prior to startup.

Ms. Hunt also makes it sound as though it is a routine operation for an insider to remove kilogram amounts of plutonium in drums of waste. Reactor grade plutonium is a prolific emitter of neutrons, through spontaneous emission and (a, n) reactions, and of gamma rays, and as such it is difficult to shield and prevent its detection with sensitive nuclear material counters. The diverter would have to carefully package the plutonium in kilograms of lead or another heavy metal to shield the gamma rays and add extensive moderators and absorbers for neutrons. The presence of extensive amounts of lead could be detected by x-raying the barrels. Most routinely used barrel counters are sensitive to grams, not kilograms, of plutonium.

We hope the above comments clarify some of the issues raised by Ms. Hunt. We believe that the Japanese nuclear industry, the Japanese national inspectorate and the international safeguards community are working together to ensure that safeguards applied to Japanese nuclear facilities are efficient and effective.

E. Arnold Hakkila
George W. Eccleston
Los Alamos, New Mexico

Technical Working Group: Radioactive Waste Management

The following summarizes the activities of the Technical Working Group (TWG) on Radioactive Waste Management for the period July through October 1990.

• The TWG organized three technical sessions for the INMM 31st Annual Meeting held in Los Angeles on July 15-18, 1990 - High-Level Waste, Greater-Than-Class C Low Level Waste and Environmental Restoration and Waste Management-Measurement Technology. Also, at the invitation of the TWG, Dr. John Bartlett, Director of the DOE Office of Civilian Radioactive Waste Management, was the speaker for the Plenary Session.

• The TWG provided INMM co-sponsor representation at the 1991 International High Level Radioactive Waste Management Conference Steering Committee meeting on October 5, 1990. The steering committee decided on the key speakers, logistics, exhibitors and program organization. The 1991 IHLRWM conference is scheduled for April 28-May 3, 1991 at Caesars Palace in Las Vegas.

• The preliminary agenda has been completed for the INMM Spent Fuel Management Seminar VIII to be held January 16-18, 1991 at Loew's L'Enfant Plaza Hotel in Washington, D.C. Five sessions are planned - DOE Spent Fuel Management Progam, Technology for Meeting Future Storage Needs I and II, From-Reactor Transporation of Spent Fuel and Special Studies in Spent Fuel Management.

• The TWG chairman participated in the discussions on the INMM organization and potential need for reorganization to better represent the current focus of the nuclear industry.

E.R. Johnson, Chairman
Oakton, Virginia U.S.A.

Committees: Long-Range Planning

Planning, Purpose and Scope

The long-range plan is intended to provide the INMM with a framework for planning activities relevant to current purpose and objectives as generally set forth in the Constitution and Bylaws of the Institute and to future needs. To date, Institute members have made a professional commitment to research and high-quality performance in the fields of nuclear materials accountancy, international safeguards, containment and surveillance, materials control, physical protection, transportation and waste management.

The Long-Range Plan is directed toward areas of nuclear materials management that are consistent with the INMM purpose as a professional society to:

•advance nuclear materials management in all its aspects and disciplines,
•promote related research,
•establish standards, consistent with professional norms,
•improve qualifications through high standards, education and recognition of those who meet such standards and
•disseminate information through meetings, professional contacts and publications.

Current Objectives

Of particular interest to the Long-Range Planning Committee are the following objectives:

1. To raise the level of awareness and recognition of all areas currently embodied in the INMM;

2. To help promote a stable financial position for the INMM to assure its continued viability; and

3. To establish additional fields of commitment that are of interest and within the expertise of the membership such as environmental restoration, nuclear safety; and arms control verification.

Current Recommendations

The Long-Range Planning Committee feels that these objectives may be met through the following recommendations and hereby submits these to the INMM Executive Committee for their consideration:

1. The INMM continue on a path of controlled growth, both in terms of total membership as well as areas of commitment.

This recommendation serves to further achievement of objectives two and three. Further expansion of the membership helps to stabilize our financial base through larger attendance at meetings and workshops and may help realize economies of scale in the costs associated with maintaining and servicing membership in the Institute. Expansion into new fields helps assure stability by countering potential downturns or fluctuations in existing fields.

2. The INMM be transformed into an organization having a divisional structure similar to that of other professional societies.

This recommendation is an outgrowth of a proposal originally submitted to the Executive Committee by Mr. Edway Johnson in a letter to the Chairman of the INMM dated 2/28/90.

This recommendation for a divisional structure serves to further achievement of objectives 1, 2 and 3. Such a structure will hopefully encourage new members to join the INMM by creating greater visibility of their interests. A divisional structure will also help to provide the infrastructure for supporting additional areas of interest for existing as well as potential new members. This may also help to diversify the traditional sources of INMM sponsorship and help make the Institute less dependent on relatively narrow industrial and governmental programs. This new structure will also help to provide an expanded forum for technical exchange in areas of importance to international cooperation.

The Long-Range Planning Committee recommends the following divisional structure to implement this recommendation.

International Safeguards Division

Encompassing primarily IAEA/ EURATOM safeguards systems including containment and surveillance methods.

National Safeguards Division

Encompassing primarily material accounting, material control and physical protection (including computer and document security, access controls, etc.).

Transportation and Waste Management Division

Encompassing primarily decommissioning, high-level and low-level waste management, remedial actions, transportation and package certification.

Other divisions may be established by designation of the Executive Committee.

The Long-Range Planning Committee recommends that each division be represented on the Executive Committee by an elected Division Chairman. Members of the INMM need not join any division. However, to qualify as a candidate for Division Chairman or other division office and to vote in division elections, a member must join that division. A nominal fee, in addition to the normal membership fee, will be levied to cover the cost of processing division elections.

3. If the INMM Executive Committee endorses the divisional structure recommendation, it should establish an ad hoc committee to prepare draft charters for each division including a statement of goals, structure and operations, membership rules and fields of interest. The ad hoc committee should also develop a plan for prompt implementation of the divisional reorganization of the Institute.

4. The INMM Executive Committee establish a Technical Working Group to review and assess the inclusion of arms control verification as a new field for INMM support.

There were two sessions on arms control verification in the 1990 Annual Meeting. These represent the first formal efforts to include this field into the Institute. Arms control verification has become increasingly visible and important in the last three years, and there is a strong inherent connection with international safeguards. In addition to being of interest to the current membership, it appears that there are few, if any, societies that provide a forum for the technical exchange of information in the arms control area. The Technical Working Group should review relevant issues in regard to this recommendation and issue a report to the Executive Committee. This should be done in a timely fashion. An issue requiring some study is the classification of arms control information by government agencies and the effect this has on the exchange of technical information.

Other Issues

The Long-Range Planning Committee discussed the Provisional Draft Charter for the INMM International Safeguards Subcommittee. The Long-Range Planning Committee endorses the formulation of this subcommittee and notes that it may form the basis for an INMM division under Recommendation two of the Long-Range Planning Committee if this recommendation is adopted.

Joseph P. Indusi, Chairman
Upton, New York U.S.A.

Ad Hoc Committee On Arms Control

Last year, at this time, the Executive Committee established an Ad Hoc Committee to consider if, and to what extent, the Institute should become involved in the subject of verification of arms control agreements. With the assistance of other interested parties, two sessions were arranged for this annual meeting on this subject.

The Ad Hoc Committee concluded that the Institute should adopt verification of arms control agreements as a field of interest along with the present fields of international and national safeguards and waste management and transportation.

To formalize this move and to provide a focus for such activity, the Ad Hoc Committee recommends that the Executive Committee establish an Arms Control Verification Committee with the following responsibilities:

(1) To solicit papers on the subject for the annual meetings and the Journal. (2) To discuss classification problems with the appropriate agencies. (3) To compile a bibliography of references on the subject. (4) To explore the feasibility of organizing workshops or topical meetings on the subject. (5) To stimulate interest and participation by others than U.S. and Soviet citizens.

William A. Higinbotham, Secretary
Leon Chapman, Safeguards Committee
John Lemming
Joe Indusi
James Tape
Dennis Mangan
Charles Pietri
Joerg Menzel
Kenneth Sanders
David Swindle

INMM Election Results

According to Article III, Section 6, of the INMM Bylaws, the "Secretary shall notify each member in good standing the results of the election by October 1, of each year." This notice in the Journal is construed as having met that obligation.

In accordance with Article III, Section 4, of the INMM Bylaws, the Nominating Committee selected and submitted to the Secretary the following candidates for Officers and Members-at-Large for the Executive Committee of the INMM:

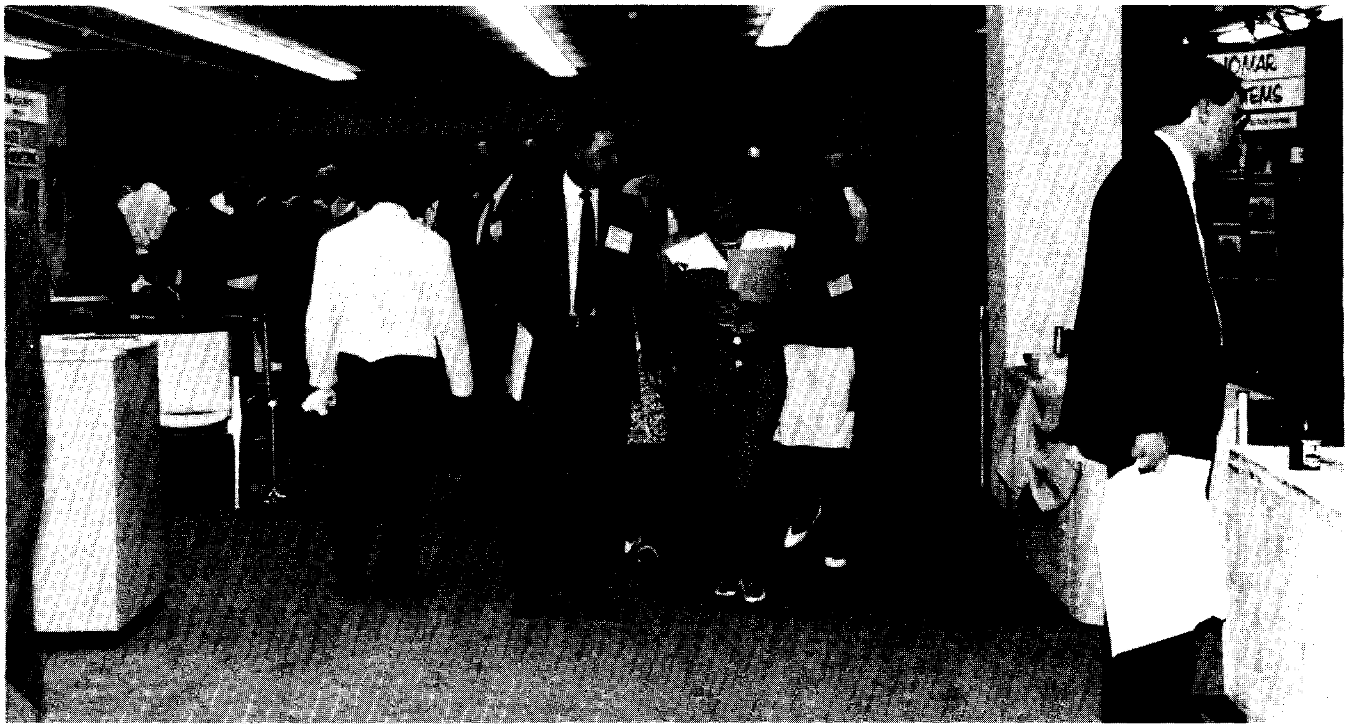
Chairman	Darryl Smith
Vice-Chairman	Dennis Mangan
Secretary	Vincent DeVito
Treasurer	Robert Curl
Members-at-Large	Obie Amacker
	Elizabeth Ten Eyck
	Ed Young

In accordance with Article III, Section 5, a ballot was mailed to each of the Institute's 816 members of which 3/4 returned ballots.

There were no petitions for candidates to be added to the ballot; however, there were write-ins.

As a result of the balloting, the Officers and Members-at-Large of the Executive Committee beginning October 1,1990 are as follows:

Chairman	Darryl Smith
Vice-Chairman	Dennis Mangan
Secretary	Vincent DeVito
Treasurer	Robert Curl
Members-at-Large	Patricia Baird *Sept. 30, 1991*
	Donald Six *Sept. 30, 1991*
	Elizabeth Ten Eyck *Sept. 30, 1992*
	Ed Young *Sept. 30, 1992*
Japan Chapter Representative	
Vienna Chapter Representative	
Past-Chairman	John Lemming



1990 INMM Annual Meeting, Los Angeles, California U.S.A.

If INMM is to maintain its leadership role in bringing noteworthy developments in safeguards, transportation and waste management activities to its membership and to the public, it needs to be proactive in looking to the many new avenues that are opening to us and strengthen areas already established within the Institute.

The Annual Meeting is one method of providing a forum for such activities. The 1990 Annual Meeting was exemplary in giving visibility to new approaches to waste management through the Plenary Session with Dr. John Bartlett, the newly appointed director of the WE Office of Civilian Radioactive Waste Management, as keynote speaker and with an innovative session on environmental restoration and waste management measurement technology. (It is notable that this session had in excess of 70 attendees, indicating an active interest in the subject and a potential growth area for us.)

Hopefully, with this kind of emphasis, we can attract more participation in the waste management sessions. The Executive Committee is taking significant steps to support this effort. It is notable that another innovative event this year was two sessions on Verification Technology in response to the apparent diminishing of the "cold war" emphasis. If verification of treaties is the way of the future, INMM certainly should be first in bringing concepts and activities to the public in an objective and professional manner. (I continue to maintain that Chemical Warfare verification roles based on safeguards experience need to be addressed by the Institute, especially in view of the Middle East situation.)

The Verification Technology sessions were very well attended, for new sessions, with more than 60 attendees in each session - some popular and traditional sessions had significantly less.

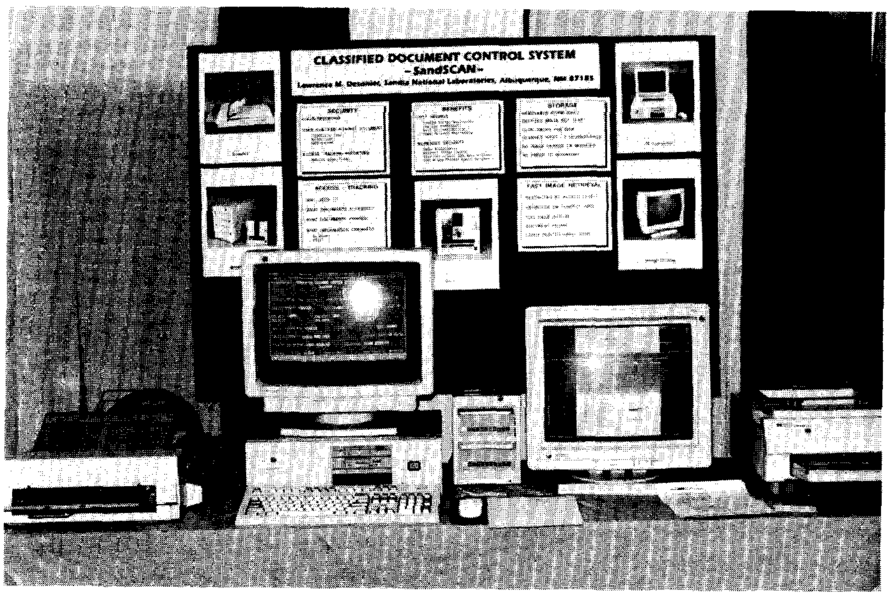
For those of you who are interested in Annual Meeting statistics, here are some meaningful ones: 29 sessions, 205 papers (11 additional papers initially submitted were withdrawn), 17 posters/demos and 27 technical exhibitors. There were 552 attendees (including families) registered and 402 meeting participants. Of the over 200 abstracts submitted to the Technical Program Committee for review, 153 were on word processing disks as requested. The conversion of these disks to working copy for the INMM headquarters staff saved many, many hours of retyping and proofreading time! This procedure for submitting abstracts will be mandatory for the 1991 Annual Meeting. (After checking with several major professional organizations, we determined that INMM is the sole user - innovator? - for such a process!) Get those abstracts in early - the deadline is February 1, 1991 - and no excuses - you

Opposite page, INMM Annual Meeting participants in the exhibit hall.

Above right, INMM Past-Chairman John Lemming passes the gavel to new Chairman Darryl Smith at the Awards Banquet.

Above, E.R. Johnson, E.R. Johnson Associates, and Joseph P. Indusi, Brookhaven National Laboratory, enjoy the Chairman's Reception.

Right, one of the displays in the posters and demonstrations session.



already know the date and location of the meeting.

Each year we begin planning the next year's Annual Meeting at the current one. We like to base our technical program on the comments we get from the meeting participants. However, this year we got about a dozen responses of which only six were written. The comments were all valid, but some were from solely personal perspectives. Again, I bring to your attention two common and traditional "complaints" by attendees: speakers not staying within their allotted time and the quality and amount of information provided by view graphs. Barb Scott, INMM headquarters, and the Technical Program Committee are preparing a speakers manual which should help - but not unless it is read and followed. Perhaps I need to talk to Joe Indusi, Brookhaven National Laboratory - I have it in writing that Joe maintained a precise schedule in his session in a way that is not ordinarily seen without the threat of actual physical violence! It was suggested that perhaps the speakers need to practice their presentations several times - are we all doing that?

Some new thoughts for next year's meeting: a Public Affairs session on the relationship of nuclear activities and the environment from the international and male-female perspectives, more verification technology sessions and greater emphasis on transportation activities. In the latter instance, the revitalized Transportation Working Group should provide considerable support.

If you enjoyed this year's program, thank the Technical Program Committee, INMM headquarters' staff, and all those others out there that worked so very hard to make it a success. They'll be at it again for 1991, and we hope to see you all in New Orleans next July.

Charles E. Pietri, Chairman
INMM Technical Program Committee
U.S. Department of Energy
Argonne, Illinois U.S.A.

Japan Chapter

The activities of the Japan Chapter of INMM for 1989-90 were highlighted by the 11th Annual Meeting and banquet.

1. Executive Committee Meeting
The five meetings of the Executive Committee of Japan Chapter (35th - 39th) were held at the NMCC headquarters in Tokyo from July 1989 to June 1990, respectively.

Topics discussed and adopted were as follows: the chapter's plan of activities for 1989-90; financial status and planning reports; the 11th annual meeting; banquet.

At the 35th Meeting, Mr. H. Kurihara was elected again as Program Chairman of the 11th Annual Meeting of the Chapter.

At the 37th Meeting, a revision of the Bylaws of Japan Chapter on the voting day for election of officers of the chapter had been proposed by the Japan Chapter and was approved by the INMM Executive Committee.

2. The 11th Annual Meeting
The 11th Annual Meeting was held in Tokyo on June 7, 1990. A total of 156 people participated in the meeting, 70 members of the Japan Chapter and 86 non-members. The program of the meeting was as follows:

Plenary Session
Chairman - M. Hirata,
Chairman of Japan Chapter
Nuclear Safety Technology Center

Opening Address
H. Kurihara, Program Chairman
Power Reactor and Nuclear Fuel Development Corp.

Chairman's Address
M. Hirata

Invited Lectures
Nuclear Regulatory Issue - Low-Level Radioactive Waste Management
K. Murakami, Nuclear Safety Bureau
Nuclear Safeguards & Non-Proliferation
R.W. Getzinger
Embassy of the United States

Requirements for Nuclear Scientists and Engineers
Today's Issue from the Public
J. Kishida, Japan Institution

The Russians
S. Ishikawa, Sumitomo Corp.

Technical Sessions
Session I. International Safeguards
Chair - R. Oyamada
Nuclear Material Control Center

Development of a Real Time Simulation System to Demonstrate Use of the Near-Real-Time Materials Accountancy (II)
H. Ihara, Y. Yamamoto, H. Nishimura, K. Ikawa - Japan Atomic Energy Research Inst., Y. Hisamatsu - BE Soft

An Analysis of Pu Behavior by Simulation Program DYNAC in Solvent Extraction Process
Y. Kojima, K. Munakata, M. Nabeshima, C. Tanaka - Sumitomo Metal Mining, Co. Ltd.

Basic Study of Safeguards System for Laser Isotope Separation Facility (II) - Quantum-mechanical Analysis of Infrared Multi-photon Dissociation of Model Molecules with Two Lasers
T. Okamoto - Univ. of Tokyo
H. Nishimura - Japan Atomic Energy Research Inst.

Development of Safeguards Approach in PPFF
K. Matsuyama, S.Inose, S. Takahshi, T. Higumas - Power Reactor and Nuclear Fuel Development Corp.

Session II. Measurement Research and Development/Accountancy Control
Chair - H. Okashita
Japan Atomic Energy Research Inst.

Method of a Process Monitoring Facilitated to Bulk Handling Facility (II)
S. Masuda, M. Kikuchi - Nuclear Material Control Center, Y. Hisamatsu - BE Soft

A Method for Estimation of Measurement Error for Paired Data and an Application Result (I) - Uranium Sample
H. Yoshida, K. Nidaiara - Nuclear Material Control Center

Rapid Determination of Plutonium for Input Accountability by Spectrophotometry Using Internal Standard

K. Abe, Y. Kuno, A. Kurosawa, S. Sato, T. Akiyama - Power Reactor and Nuclear Fuel Development Corp.

The Cherenkov Glow Observation Tests to identify FBR Spent Fuel Assemblies
Y. Fujita, M. Koyama. Y. Hashimoto - Power Reactor and Nuclear Fuel Development Corp., A. Nakaoka - Central Research Institute of Electric Power

Session III. Containment and Surveillance
Chair - H. Kawamoto
Japan Nuclear Fuel Service Corp.

Development of FCA C/S System Simulator and its Use
H. Ogawa, T. Mukaiyama - Japan Atomic Energy Research Inst.

Development of an Electronic Verifier for COBRA Seal
Y. Yamamoto, T. Mukaiyama - Japan Atomic Energy Research Inst.

Development of Compact CCTV Surveillance System "COSMOS"
T. Mukaiyama, H. Ogawa - Japan Atomic Energy Research Inst.

A Study Regarding Uncertainty and Reverification of C/S Measures
Y. Yokota, M. Kikuchi - Nuclear Material Control Center

Session IV. Generic Issues with Nuclear Deployment - Transportation, Waste Management, Security and Public Acceptance
Chair - K.Tsutsumi
Nippon Electronics Co. Ltd.

Development of an Expert System for Radioactive Material Transportation
K. Tamaoi, M. Ishitobi, Y. Shinohara - Mitsubishi Metal Corp.

Requirements for a Radioactive Waste Data Base
Y. Satp, I. Kobayashi, M. Kikuchi - Nuclear Material Control Center

Development of Nuclear Energy Security Code
T. Shimamura
Nuclear Policy Research Society
A. Suzuki - University of Tokyo
H. Ohkubo - Mitsubishi Research Inst. M. Kikuchi, Nuclear Material Control Center

Survey on Understanding on Nuclear Energy
Y. Seki, Mitsubishi Metal Corp.

Session V. Verification/Inspection
Chair - M. Kajiyoshi, Power Reactor and Nuclear Fuel Development Corp.

Above left, INMM Japan Chapter Chairman Dr. Mitsuho Hirata gives the "Chairman's Address" at the Business Meeting.

Above right, Chaiman of Japan Institution Mr. Jun'noske Kishida presented a lecture, "Today's issue from the Public."

At left, meeting participants at the exhibition.

On the Efforts (man-day) with Inspection in Uranium Fuel Fabrication Facility
T. Watanabe, T. Tanaka - Mitsubishi Nuclear Fuel Corp., Y. Seki - Mitsubishi Metal Corp.

Development of Support System for Inspection at Site Using Laptop Computer
K. Nidaira, H. Yoshida - Nuclear Material Control Center

Software Development for Practical Use of IFSS at LEU Fuel Fabrication Facility
H. Sano, S. Usui, K. Nakamura - Japan Nuclear Fuel, Co. Ltd.

Study of UNCL Application at PIV
K. Takai, H. Kai, T. Sanbe, Y. Nomura - Nuclear Fuel Industries, Ltd.

Business Meeting
Chair - T. Haginoya
Vice Chairman of Japan Chapter
Japan SpaceUtilization Promotion Center

Special Lecture
China - After the Tiananmen Incident
Y. Nakae, Ambassador/Atomic Energy Commission

Business Report
T. Osabe, Secretary

Planning Committee Report
T. Osabe
Chairman of Planning Committee

Financial Report
Y. Seki, Treasurer

Japan Chapter - Activities and Prospectives
M. Hirata

Closing Address
T. Haginoya

Exhibitions & Demonstrations
Activities of INMM Japan Chapter
The IAEA Activities - Video

Banquet
Banquet was held after the 11th Annual Meeting of the Chapter.

A copy of the Proceedings (in Japanese) of the 11th Annual Meeting of the Japan Chapter is available from the Secretary of the Japan Chapter upon request.

3. Membership
Members of the Japan Chapter as of the end of June, 1990 are 146 in total, increasing since June 1989. Members are from the following organizations:

Scientific Institution	55
University	6
Electric Utilities	7
Industries	72
Government	3
Journalist	1
Others	2

Fifth Annual INMM Safeguards Roundtable

July 1990
Los Angeles, California U.S.A.

Dr. John Bartlett
Director, Office of Civilian Radioactive Waste Management
U.S. Department of Energy
Washington, D.C.

Ben Easterling
U.S. Department of Energy
Washington, D.C.

William A. Higinbotham
Consultant, Brookhaven National Laboratory
Upton, New York
Technical Editor, JNMM

John Lemming
EG&G Mound Applied Technologies
Miamisburg, Ohio
then-Chairman, INMM

E. R. Johnson
E. R. Johnson Associates
Oakton, Virginia
Chairman, INMM Technical Working Group on Waste Management

Charles Pietri
Chicago Operations Office
U.S. Department of Energy
Argonne, Illinois
Technical Chairman, INMM Annual Meeting

Darryl B. Smith
Los Alamos National Laboratory
Los Alamos, New Mexico
then-Vice Chairman, INMM

William A. Higinbotham: What exactly are the political and technical relationships of your office and your responsibilities to the DOE (U.S. Department of Energy) responsibility for disposing of the military waste in the WIPP in New Mexico?

John Bartlett: Starting with organization, they are separate. The Office of Environmental Restoration and Waste Management addresses specifically and distinctly the waste issues associated with the defense production community. As a result of law, in terms of organization, it has no relationship with our shop. The Office of Civilian Radioactive Waste Management (OCRWM) was created explicitly to deal with the civilian waste out of the commercial power sector and is essentially chartered and missioned by the Nuclear Waste Policy Act and has been in that mode since 1982. The elevation and scoping of the effort under Leo Duffy are a product of the Admiral's initiatives. They are parallel, of course, but they're separate. The entities are separate budget items insofar as the Department is concerned.

Operationally, there are a lot of things that are similar. There are the same kinds of issues involved. The technologies to be used, the transportation issues and so forth are similar.

In terms of program interactions, there is one major area of interaction which we are fostering and that is transportation. People in Leo's shop, Larry Harmon in particular, have a lot of things that they have done that we can go to school on. And we will. They have technologies and

Dr. John Bartlett

systems concepts that we can use, and we will be interacting with them as much as possible in that arena. We also have in common an effort, under the Admiral's lead, for development of education programs. But the waste inventories that we're dealing with and the waste management issues, of course, are distinct.

Their high-level waste product, which they will make into glass will be coming to the repository.

Higinbotham: So their activity is really a preliminary demonstration. It's not going to take care of all the military waste.

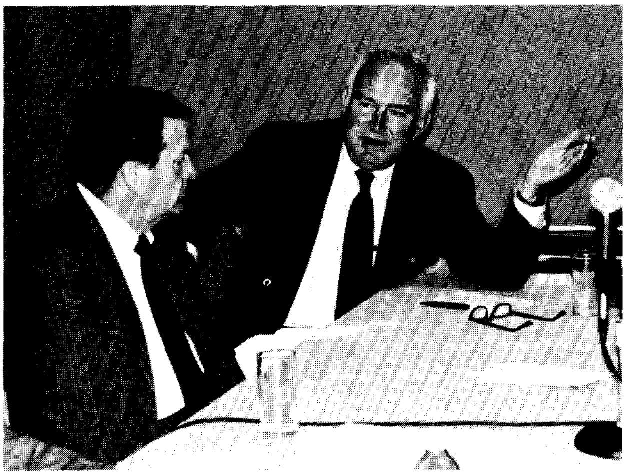
Bartlett: No.

Ben Easterling: John, if I could just add a word about the institutional interaction...Many of the political and socioeconomic problems that are associated with the building of the WIPP facility and the opening and operation of that are exactly the same types of problems that we're going to be facing down the line — already are facing — but in addition in the future we'll have a lot of the same questions and issues that they are dealing with. So we're trying to interrelate very closely with them. We have had a couple of "lessons learned" sessions with their institutional people, and I know John intends to continue that type of cooperative effort because our issues such as land withdrawl and socioeconomics are the same institutional framework that they're dealing with. There are many lessons that they are learning the hard way that possibly we can go to school on, and we intend to do that.

Higinbotham: You seem to consider the MRS (Monitored Retrievable Storage) as a very important development. The last I knew, it was tied to the time schedule for the waste disposal facility. Is there some prospect of being able to separate those so that it might come into operation earlier?

Bartlett: Indeed there is, and it is essential if we are going to meet the schedule. As it stands right now, the schedule for the MRS is the same, by law, as the schedule for the repository. There has to be action taken to separate the two one of two ways. One way, the preferred way, is if the negotiator comes up with a package that can be presented to the Congress in a timely fashion and the Congress acts favorably on that package, which automatically unlinks the two schedules. Then the MRS is ready to go on its own schedule, independent of the repository. The alternative is to have to go back and modify the end. That is, to take deliberate action to modify that schedule. We hope we won't have to do that.

Charles Pietri: There is something that I would like to explore with you a little bit. That is, what technical resources do you feel are available for you that you need? Let me relate an experience I had last fall when I attended Duffy's R&D workshop in San Francisco. I was very shocked and disappointed when I heard, "DOE does not have the resources." Now coming from a safeguards background, and with the global demilitarization and the availability of a lot of safeguards people, many of whom were at that meeting, it seems to me that we have the


From left, Ben Easterling, E.R. Johnson

resources. Whether you do sampling and surveys and such for safeguards purposes or you do it for environmental purposes or you do it for waste management purposes, there's no difference. It's just like when a statistician evaluates data it doesn't matter if it's apples, oranges or anything. Do you feel you have enough technical resources within the community?

Bartlett: That's the trick to the question and the statement: within the community. I am pretty confident. Leo was talking in terms of DOE. The Department's resources in terms of numbers of people and capabilities of people to direct, effectively, all of the resources within the community would come to bear when appropriate. The DOE is relatively under-resourced in terms of the scope of responsibility we have to direct and manage. The people are out there, with the contractors, etc. It's just a question of DOE's capability to get its arms around them and be an effective leader and manager. It is difficult.

Pietri: What sort of steps or plans are there to implement a program to do exactly what you're saying?

Bartlett: A couple of things. One is obviously staffing up. Along with any budget situation there is what I would call an "appropriate" staffing level that goes along with it. So Leo is in a mode of extensive budget growth, and along with that we will begin increasing numbers of people. The subset of that is the management and the quality. You get into issues such as grade levels and availability of SES slots to the organization in order to be able to attract and keep the quality people that you need to run these shows. So all of those are actions that are underway. They are all in the middle, in a growth mode.

Pietri: You are saying that you don't think we have a critical situation but something that we cannot resolve immediately.

Bartlett: That's right.

Higinbotham: There seems to be a problem not only with DOE but governmentwide of attracting and keeping the kind of quality people that you really need. Is it a problem of salary levels or opportunities for promotion and growth...what kind of problems are they that the government, particularly DOE, faces?

Bartlett: All of the above, Willy. Salary is a problem. It is a big problem for Leo because of all the people he needs of high caliber to run the program. They can get out there and run the programs for the contractors and get a whale of a higher salary than he can offer. The challenge is there.

Both Leo's program and ours are frontier-type programs. These inherently attract good people. The question is where do you attract them to and can you provide a circumstance within the government to keep them and have them work for the government. The angle there comes back to a practical matter: grades. Do you have enough slots of the 15 level, which is what people of that caliber need to be. So the first line of offense in order to get the capabilities you need is to get slots. Another thing that we have to rely on is the inherent attractiveness and the challenge of the work. Both of the waste programs, civilian and defense, command and should command a higher proportion of higher level people, just because of the content of the program compared with some others. But that is a tough battle to fight.

We are really talking program situations analogous to the situation at the Atomic Energy Commission back in the '40s and '50s. But to win this battle is a lot tougher.

Easterling: Another problem that we are having is the cyclical nature of the budget process and the delay on the scientific evaluation at Yucca Mountain. Carl Gertz has built up a tremendous staff of resource people who are eager to get started. And not being able to get started, good people have options, and it's very difficult to keep people enthusiastic and focused on this program.

John Lemming: You mentioned the educational programs. What are the goals and how can they be achieved?

Bartlett: The goals basically are to invest, when you look at the timeline for this program, for something like 80 years. The people who will license the repository are at best in high school. There really are two parts. The first is building a cadre of capable people to work the program. The second part is public education information. It is not hitting them over the head with it, but just so they are informed.

We are working both of those at a variety of levels. The Admiral is really big on education programs. We are

From left, William A. Higinbotham, Charles Pietri

hopping on the bandwagon and taking advantage of the climate his attitude has created to make the investment in the capability and education. We have always had some of that, but now we have the need and opportunity to expand it a lot more. The focal point at the moment is our established agreements with the University of Nevada in Las Vegas and in Reno. Each of them has several program elements that they are going to be developing. We also have a public information center in Las Vegas, and we are talking about putting another one up. We have a program which supports graduate students in the nuclear arena who focus on waste management. That is a very competitive program that has attracted some very good students over the years. We are also now looking at other conditional ways of building programs at the secondary school level, all the way down through kindergarten. The people in Reno have some really good ideas about what kinds of programs could be instituted at the secondary level, and particularly training science teachers. It is a very visible issue and they are dying to have curriculum materials that they can use. So we are developing those, too. So it is an across the board effort.

Easterling: Also in terms of adult education, we have cooperative agreements with the League of Women Voters to develop workshops and curriculum materials. Some of you may have seen a primer that they did on radioactive waste some years ago. It was an excellent small handout booklet. It was considered to be objective, and we got a lot of mileage out of that. We ordered thousands of copies and found that they were very well received. They will be updating that primer for us. The League sponsored a couple of pilot public education workshops, one in Albuquerque and one in Atlanta. Citizens were invited to two-day sessions about what nuclear waste is, what it is all about and why I should care about it. We also have a cooperative agreement with the National Congress of American Indians. The Indian community, as you can imagine, has concerns about transportation and location. Then we have one with the National Conference of State Legislators. The director of the program will address their annual conventions and answer questions from the state legislators and the Indians.

E. R. Johnson: To what extent do you believe that the monies that the department gives to the state of Nevada in the form of financial assistance contribute to their ability to fight the department in court?

Bartlett: As a matter of fact, it is very hard to tell. The General Accounting Office (GAO) is having a hard time figuring out how they are spending their money. And it genuinely is a grant. They can do anything with it that they please. They are not allowed to lobby or sue us. They have to use their own money to sue us. Other than that, there is no restriction on those monies. And it is very hard in fact to find out just how they have been spending it. In my confirmation process, I talked about the fact that, in my opinion, the states should receive 5 percent of whatever we are spending in technical evaluation for "technical oversight." So if we are spending $100 million they should get $5 million, explicitly devoted to technical oversight.


Dr. John Bartlett

Darryl Smith: When it comes to gaining access to the technology that may be available, is there a way the Institute of Nuclear Materials Management can help? Some of the divisional safeguards technologies might be useful.

Bartlett: Some of the technologies and a lot of the concepts, particularly the systems concepts and the utilization of sparse data concepts, are all actually working parts of the program. People with those kinds of skills have a role in the program. The other thing that we need in addition to that is external technical forums where the execution of that work gets subjected essentially to peer review. In other words, others have to keep this program honest. And peer approbation has to come from those outside the program. So the technical societies and the technical review board created by the Congress provide those kinds of forums, like this meeting. This is a very valuable contribution to the program.

Easterling: Often those informal reactions sometimes stimulate more formal interrelationships. These include people at the INMM (Institute of Nuclear Materials Management) Annual Meeting, the Japanese delegation, the people from the State Department, from other parts of ACDA (Arms Control and Disarmament Agency), NRC (Nuclear Regulatory Commission) and DOE. There is a community, as you all well know, of people with nuclear materials accounting and measurement backgrounds who are going to be dealing with international safeguards of high-level waste. To the extent that we can tie in to those activities now, it is in our interest to be a part of that. These kinds of sessions encourage that.

Pietri: That was one of our thoughts because INMM has paid lip service to a certain degree to waste management's perspective over the last few years. Ed has been the stalwart in promoting it, but it is great to have somebody like you here and we would like to attract others in the waste management community. We would also like to get the information out to other people who say, "Waste management, that's not my problem." You are absolutely right; in the international arena the same people who have been working in safeguards will be working in waste management, and I'm not quite sure whether they are prepared for it.

Bartlett: It is very hard for us to know where all the interfaces are and what things we have to worry about regarding those interfaces. We have to reach out and create the opportunities to find them, through interactions like this. I was aware that we had interfaces with ACDA, State Department, etc. I came to the meeting today, and now I have a card and a name. This is very valuable to me. I spoke a couple of months ago to the National Council of Radiation Control Officers, people who have the lead for radiological safety in the states. I talked with them about some of the issues of concern to them, and after the meeting a couple of people came up with key leads into transportation issues.

Higinbotham: This is sort of a common thread because technology is a very important part of all of this. Waste disposal is not the only area that is constrained to a great extent and controlled by political issues. It is also true of international...even domestic safeguards. We have to be very careful as an organization that we speak as scientists and engineers who understand the technology. We also have to be acutely aware of the political atmosphere in which all of this takes place and try to find out what ways technically competent, aware and responsible people can contribute, certainly to the technical side. We must also integrate that somehow with education and other important areas.

Johnson: A number of people have indicated the prospect of continued storage of spent fuel at reactor sites as opposed to storage at a centralized monitored retrievable storage facility. In fact, the Congress, even in the Nuclear Waste Policy Amendments Act, directed the Department to conduct a dry storage study at reactors. So it must have been in their minds as well. What is the view of the Department with respect to its responsibility to accept spent fuel from reactors and to what extent is it required or is it prudent for the Department to analyze the comparative economics of continued storage at reactors versus storage in Department facilities?

Bartlett: The mission, as assigned by Congress and for us to implement, is to accept, transport and dispose of spent fuel. I think Congress' intent as reflected by the mission is clearly not to choke the pools. The nation has a responsibility through this office to effectively manage the waste to disposal and to accomplish that in a timely fashion. I think clearly that what Congress is saying through the Waste Management Act itself and the Amendments Act is that it is our responsibility to manage it toward and accomplish the disposal effectively and not to leave it in the pools. You have 100 MRSs around now, and the system is potentially choked.

There is another aspect of that. That is that so far, with the exception of a few reactors where they have some kind of potential for having their pools full and having to take some supplemental action in terms of on-site storage, there has not been any arousal of what some call the "reactor area stakeholders" with respect to quantities of fuel stored. Under their license and under their existing storage capacity, everything is OK. But soon you get in the posture where in essence the rules of the game will be changing with the utilities' effort, either through failure of the federal government to fulfill their responsibility or their own

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policies, to expand their storage on-site, and in effect to leave it there as abandoned waste or something like that. I think you will start to see an elevation of concern on the part of the people around the reactors that that is just irresponsible management. So we move toward the direction, unilaterally, of accepting it in a timely fashion. The goal that has been set by the Secretary is that we will start acceptance in 1998. There is an issue about whether that is a legal requirement in terms of the way it was taken in the Act and the standard contract. Frankly, no one wants to raise that question as a legal issue. We just say that we have a goal. And we will march toward that goal of starting acceptance in 1998. I don't think any of us feels that it would be responsible to take an approach where we just leave the material at the reactors. It would create problems in the long haul for the reactors, and it's not fulfilling the assigned mission.

Johnson: As I recall, the Act also provides that the utilities will pay a fee for every kilowatt hour that they generate to effect full cost recovery of the storage, disposal and transportation that the department performs. We also know that within 35 or 40 years there is a likelihood that most of the existing plants will be decommissioned. To what extent does the long-term storage of spent fuel at reactors jeopardize your ability to effect full cost recovery of all of your system costs? In other words, if you have those costs after those plants have been decommissioned, how can you collect the money?

Bartlett: It's not there right now.

Higinbotham: I must say I am very puzzled by that. It seems to me that you shouldn't be spending the money as fast as you are getting it. My feeling was that the money that the utilities are paying was paying you in the future to take care of that spent fuel.

Bartlett: Yes, that should be the case. Because the basis for the fee evaluation is total life cycle cost. That looks forward all the way to the point of decommissioning all the reactors, acceptance of all the spent fuel, storage on an interim basis and, ultimately, disposal. That has a life cycle duration of upwards of 80 years and an estimated life cycle cost at this point of about $35 billion for two repositories. It is about $33 billion for one repository. Built into that is enough anticipation and accrual of interest, etc., so that the head-in fees that are paid will accrue and the funds will be available to accept and dispose of the fuel later after the shutdown.

Right now the fund has excess assets. In part because of accrual of funds toward the future and also in part because the program has not been spending it at the net rate of the nuclear waste fund. If the funds run out and we get into the situation you describe, then something has gone wrong. Either we didn't raise the fee enough to cover the life cycle cost or the government was an insufficient performer.

Johnson: But isn't it true that when the Act set the rate it was a provisional rate and, based on experience in developing deployment and operation of the Federal Waste Management System, the Department expected to adjust that fee so that it could make certain that it would achieve full cost recovery? My point is that if you experience prolonged delays in expenditures, your uncertainties are greater, and you have not had an opportunity to collect the necessary funds in the early years. That argues for early deployment of the system.

Bartlett: That among other things. It's a real incentive. The Act requires the Department to review annually the adequacy of the fee. Every year we have to publish a fee adequacy report and make a recommendation as to whether or not it should be changed.

The Department was just recently subject to reviews of the fund management by both the Inspector General and the GAO. Each of them takes their own slice of the pie in accordance with their interest. The GAO was interested in precisely the question that you are asking, whether the fee should be raised at this point in anticipation of future costs and delays. The IG was interested in the fact that 11 of the utilities elected to choose a mode of payment in which they don't pay anything until the end, when they pay a lump sum. That was available to them. The utilities who elected that are not necessarily accruing an escrow fund.

There is also the fact that defense operations within the Department have never paid any money either. The Act requires that they pay their share. So there has been money that was supposed to be coming in that is not there. And the receipt of that money is uncertain.

GAO is urging us to index the fee to the inflation rate. Our position is that there is no need to raise the fee right now, based on what we know at this point. We might anticipate having to raise it somewhat in 1992. The utilities object very strongly to the concept of indexing. They don't get to do it, why should we?

The whole thing is a picture of great uncertainty. Because of this, I want to establish a risk management policy for the fund to take into account all of these factors and establish a fundamental approach to assessment of uncertainties and their impact on revenues over life cycles, etc.

Johnson: The Act provides that the Department take title to the fuel upon delivery by the utility to the Department at the reactor location. These spent fuel materials can have future value. They have a value from the standpoint of the contained uranium and plutonium, especially in a rising market. There are radioisotopes that might find use in the future. There are precious metals contained in the fuel. There is neptunium which can be isolated and converted into americium-241 for use in fire detection equipment, and so on. While these values are not here today, they could be here tomorrow.

To what extent does the Department plan to return any prospective values to the utilities that it might find there in the future.

Bartlett: Right now that question, in my mind, is not significantly enough on the table. We need a recognition of prospective values. Closely related to that question is who owns the values as a function of time, location of the fuel, etc.

When we get into the business of negotiating an MRS facility, shouldn't an MRS host have some rights to the material. Shouldn't the utilities retain some rights? If the utilities gave title to the Department, should the Department have some rights to these values?

They are all issues at this stage. So what kind of an assessment of the prospect and rights of these things should be made? One thing that is true is that years ago, when I was at Pacific Northwest Laboratories, a lot of studies were being done on the economic feasibility of recovery and separation of a lot of these values. Every one of them showed that it was feasible. In the right economic climate, there would be an opportunity to use the precious metals, the rare earths...all of these things.

This could be an element in the package that gets negotiated with the MRS host. It is an interesting question.

Higinbotham: But the contract that the utilities signed doesn't make any promises in this area.

Bartlett: No.

Johnson: If the Department were to receive a proposal from a private organization to store materials, does it have the authority to enter into that or does it have to go out and advertise that?

Bartlett: The only requirement under the Act is for the Department to enter into contract with either the state or the Indian tribe. If a private contractor is part of the deal from the state, as far as I know it is perfectly okay. In that sense it is no different from a reactor: an investor-owned utility operates a reactor under license from the NRC and the framework of requirements imposed by the state.

Johnson: Has there been any consideration given to establishing minimum requirements for handling casks at reactors in order for you to accept the fuel? My concern here is that if a reactor operator does not have any significant capabilities and causes the federal waste management system to incur significant added expense as a result thereof, isn't that particular reactor then pushing that expense off on all the other reactors that are paying into the nuclear waste fund? And to what extent should that be limited?

Bartlett: I don't know whether we have that sort of situation. I have not had time to evaluate what the findings of the facility interface study are and to determine whether we have some real problems or not. That kind of issue might come up in the negotiation of what I call the "spent fuel acceptance system." That is going to be an interesting exercise because of the diversities that are there already. And in diversities of attitudes, the utilities get, as you might expect, pretty parochial in a hurry if their pool is choking or if they think they have rights under the "oldest fuel first" approach. Others think differently. There is certainly at this point no unanimity among the reactor owners as to what the rules should be.

So the spent fuel acceptance system will establish, I hope, on a win/win basis, the protocols that everybody can live with in the Department and the utilities with their individual circumstances.

A Measurement Control Program To Meet Desired Levels of Precision and Accuracy

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ABSTRACT

Measurement Control Programs are usually designed to test for precision and accuracy. Many instruments, however, display non-random data patterns such as biases or seasonal variations which are statistically significant but are of no practical significance. Application of the usual statistical tests can cause these instruments to be removed from service unnecessarily. It is tempting to try to overcome this problem by frequently adjusting the instrument or by arbitrarily changing the parameters of the statistical tests so that failures occur less often. This, of course, invalidates the statistical tests. In this author's opinion, the correct way to handle this problem is to identify the desired levels of precision and accuracy, and then to combine these levels with valid statistical techniques in the measurement control program. This paper describes one way to accomplish this.

1. INTRODUCTION

Section II.4, "Measurements and Measurement Control," of the U.S. Department of Energy Order 5633.3, states "The objective [of the selection and qualification of measurement methods] is to assure that measurement methods selected for use are capable of measuring the material in question to the desired levels of precision and accuracy, as approved by the cognizant operations office, and consistent with graded safeguards. To this end, each facility shall select, qualify, and validate measurement methods capable of providing the desired levels of precision and accuracy." The purpose of this paper is to describe one way in which the concept of "desired levels of precision and accuracy" may be incorporated into a measurement control program (MCP) for an instrument.

Since the terms precision and accuracy can have different meanings for different readers, these terms are defined in Section 2. In Section 3, a MCP which monitors an instrument's precision and accuracy is described. This MCP is basically one under development at the Los Alamos National Laboratory with some modifications to allow a clearer exposition.

To further simplify the presentation, it will be assumed that, unless mentioned otherwise, the instrument measurement errors are additive. This means that the measurement errors are assumed to be independent of the item's true value, u. Thus, if x is the measured value, $x = u + e$, where the measurement error, e, is independent of u. The usual alternative to an additive error model is the proportional error model where $x = u + ue$. The object of a MCP is to characterize and control e.

The precision and accuracy checks for the instrument MCP are based on the premise that a facility wants to identify and monitor statistically significant events - biases, trends, changes in variance - but does not want to remove an instrument from service unless these events are also of practical significance.

This concept of practical significance is based on the "desired levels of precision and accuracy" in the DOE Order. For each instrument, the facility assigns 'desired levels' which reflect the instrument type, its use and graded safeguards. As described in Sections 4 and 5 below, these "desired levels" are converted to control limits for use in the measurement control program. Because these limits are based, in part, on administratively set values, they are called "administrative control limits."

An example of the MCP for an electronic balance is given in Section 7.

2. PRECISION AND ACCURACY

Precision and accuracy are terms which have a number of meanings, and it is important to be clear which meaning is intended. There are two commonly used terms which describe reasonable extremes of meanings for precision. They are repeatability and reproducibility. Repeatability refers to the ability of an instrument to repeat a measurement under essentially the same working conditions - same operator, time, environment. Thus, repeatability is a measure of an instrument's intrinsic variability and measures the best performance of the instrument under usual operating conditions. In the case of additive measurement errors, this variability can be characterized by the standard deviation, σ_r, of measurements taken in immediate succession.

Reproducibility is at the opposite end of the spectrum with respect to included sources of variation. Reproducibility (in this paper) refers to the ability of a particular instrument to reproduce a measurement through time when the instrument is operating and operated properly. Hence, besides the intrinsic instrument variability, variability can be due to changes in operator and environment. Instrument drift, calibration, standards, etc., are included. For additive error models, the standard deviation, σ_R, of measurements taken to capture these effects can be used to characterize reproducibility.

These terms are used in basic accordance with the ASTM definitions[1] except that here reproducibility is limited to a specific instrument. In ASTM usage, reproducibility includes variation among identical instruments at different facilities. The MCP described below employs the standard deviation as a measure of precision. If the measurement errors tend to be proportional to the value of the item, the relative standard deviation should be used instead of the standard deviation to measure precision.

Some authors include precision, as well as bias, under the term accuracy: a measurement is accurate if it is both precise and unbiased. Since this can lead to confusion, separation of precision from accuracy is recommended[2,3]. Thus, in this paper, accuracy is equivalent to bias; precision is a separate concept. Accuracy, then, can be measured by the average deviation, over time, of the measured value of a standard from its assigned value. (If the assigned value of the standard has an uncertainty which is large relative to the instrument variability, it would better to use the term relative accuracy rather than accuracy.) The smaller the bias, the better the accuracy. Unfortunately, however, in any check for bias, precision must always be considered, for every measurement is affected by both the bias and the precision of the instrument. This is especially so when the bias check is performed with a single measurement. Averages of a number of repeat measurements reduce the precision effect so that the influence of the bias is more easily seen. When only a single measurement is taken the precision effect can be substantial. Consideration of precision and bias effects is evident in the definition of the administrative control limit, c, in Section 4.

Specifically then, an instrument can be said to meet the "desired levels of precision and accuracy" if the theoretical standard deviation of measurements taken in succession under essentially the same conditions (repeatability) is less than an assigned value σ_{r0}, if the theoretical standard deviation of measurements taken through time is less than an assigned value σ_{R0}, and if the absolute value of the instrument bias is less than an assigned value, b_0. The values σ_{R0}, σ_{r0} and b_0 are "the desired levels of precision and accuracy" set by the facility for each instrument.

Historical data provide measures of the actual instrument performance. For a particular instrument, let σ_r, σ_R and b represent the historical standard deviation of measurements made in succession, the standard deviation of measurements made through time, and the bias, respectively. These values are assumed to be within the desired levels described above.

The following measurement control program is designed to monitor changes from these historical values, but to alarm only when *both* the statistical and the administrative control limits are exceeded. Such an alarm results in the instrument being removed from service.

3. MEASUREMENT CONTROL PROGRAM

To simplify the discussion, the remainder of this paper concentrates on using a single standard in a MCP for an instrument where the measurement uncertainties are independent of the assay value (the additive error model case). An electronic balance is an example of an instrument which usually has additive errors. The MCP is easily modified for the use of multiple standards and for instruments where the uncertainties are proportional to the assay value. NDA instruments and chemical procedures are typical examples of the latter.

The basic MCP consists of a daily accuracy check and a once a week a precision check. These are performed by computer software immediately after the measurement data are entered. The accuracy check involves measuring a standard and comparing the observed value to the standard value. The difference between the two values is first normalized by dividing by the historical reproducibility standard deviation, σ_R. The absolute value of the result is compared to the administrative and the statistical control limits as described in the next section. A test for bias or trends using past data can be performed at this time as well. At the end of each month, an accuracy check using data from the previous12 months is performed.

The precision check consists of making a number of successive measurements of the standard. The standard deviation of the measurements is computed and compared to the administrative and statistical control limits. A second precision check using the daily accuracy check values is made monthly. The precision checks are described in Section 5.

4. ACCURACY CHECK

The purpose of the accuracy check is to ensure that the average performance of the instrument, as measured by the absolute bias, is within the desired level, b_0. To monitor for a possible bias, an accuracy check is performed daily using an appropriate standard.

The check consists of measuring a standard of assigned value u. Let x be the value obtained. The quantities dif and t are calculated

$$\text{dif} = x - u \qquad \text{and} \qquad t = \text{dif}/\sigma_R$$

where σ_R is the historical reproducibility standard deviation. (The reasons for the t calculation are twofold. First, it allows data from similar instruments to be more easily compared, and second, it tends to transform the x values into data distributed as a standard normal distribution.) For convenience, let adif =

|dif| and at = |t|. Using adif in place of dif permits use of one-sided limits in lieu of two-sided limits. If a proportional error model is appropriate, dif should be replaced by the percent relative difference and appropriate changes made elsewhere.

If the desired level of accuracy is $b_0 = 0$, no bias is to be tolerated in the instrument, and the administrative control limit is the same as the classical three-sigma statistical control limit, $3\sigma_R$. If some bias can be tolerated (i.e. $b_0 > 0$), the administrative control limit is $c = b_0 + 3\sigma_R$. In effect, c increases the statistical limits by an amount b_0. (See Figure l) Thus, if an instrument's bias is less than b_0, to allow for random variation in the measurements, adif should be less than c. If the true bias is zero, this procedure does allow the instrument variation to increase and not be detected. However, detection of increased variation is the function of the precision checks, not the function of the Accuracy Check. The precision and accuracy checks work together, not separately.

Thus, the administrative control limit combines the statistical limit with the desired level of accuracy. In either case, (i.e. $b_0 = 0$ or $b_0 > 0$) the value of adif is compared to the administrative control limit, c. If adif is less than c, the instrument passes the Accuracy Check; otherwise, the instrument is removed from service. It remains out of service until reinstated by the proper authority. Normally, a repair and/or recalibration followed by a number of repeat measurements which successfully pass the measurement control tests will be required.

If 'adif' passes the administrative control limit check, the instrument is allowed to operate. However, the data are immediately checked for statistical significance. If 'at' equals or exceeds 3.0, the result is deemed to be statistically significant but not practically significant. If 'at' is between 2 and 3, a warning limit is exceeded. In either case, the t-value serves as a flag. A cumulative sum (CUSUM) technique due to Page[4,5] is used to check for a bias or trend. The results of these checks will not cause the instrument to be immediately removed from service since the administrative control limit check has been passed. Nevertheless, the results are used for measurement control purposes. All measurement data (including t-value and CUSUM values) are stored in the permanent measurement control record for review at the end of each month (or sooner if necessary). An instrument will be removed from service should an unacceptable condition, such as a severe drift or significant bias, develop.

Summary data for the last year are plotted monthly. This provides a second level of accuracy checks and, as will be described in the next section, an additional precision check. In Figure 2, the mean and standard deviation of dif values which have been grouped by weeks have been plotted. This grouping plays the role of rational subgroups in the control chart literature, though it is not exactly the same, for grouping by weeks almost always includes more sources of variation than if the data were collected at one time. At the bottom of the figure are summary statistics for the past year. These summary statistics include estimates of the bias, the standard deviation of the individual data values (this estimates the reproducibility standard deviation), and the pooled, within-week standard deviation. The agreement between these latter two values is an indication of how well the weekly data captures the reproducibility. The daily accuracy and weekly precision check data are plotted in Figure 3. (This figure is not produced regularly, but is included here for completeness.) These figures will be discussed further in Section 7.

5. PRECISION CHECK

The purpose of the weekly precision check is to ensure that the instrument precision (repeatability), as measured by the theoretical standard deviation of n repeat measurements, does not exceed the desired level, σ_{r0}. The precision check is performed by measuring the standard n times in succession and comparing the standard deviation, s, to the statistical and administrative control limits. The statistical limits are computed based on standard statistical control chart procedures[6]. If n = 5, the statistical control limit is $1.964\sigma_r$ and the administrative control limit is $c' = 1.9640\sigma_{p0}$. (The value 1.964 comes from the standard table of control chart factors[6] and should not be confused with the value 1.96 from a standard normal distribution. If n = 2, the factor is 2.606, while for n =15 it is 1.544.) Note that the statistical limit depends on historical data through σ_r, while the administrative limit depends only on the desired level of precision (repeatability).

A procedure similar to the above accuracy check is followed. If s equals or exceeds c', the instrument is removed from service. It is returned to service only with the approval of the proper authority. If s passes the administrative control limit check, the instrument remains in service, and s is compared to the statistical warning and action limits.

For n = 5, these are $1.622\sigma_r$ and $1.964\sigma_r$. The 1.964 multiplier is the 3-sigma factor as above and the 1.622 represents the 2-sigma limit factor which is derived from the formulas used to create the standard control chart factor table. (In the notation of the factor table, the 2-sigma limit factor is $c_4 + 2*\text{sqrt}(1 - c_4 * c_4)$.) If s exceeds either of these limits, the observation is flagged. The results of these checks are stored in a permanent record and reviewed at the end of the month, or sooner, if necessary.

A check on the reproducibility standard deviation cannot be accomplished with the weekly precision check but must be done with measurements collected over a longer period of time. While not completely adequate, the five measurements taken for the accuracy checks within a week can be used for a partial check on reproducibility. (It has been observed that when an instrument is working well, and its performance is not affected by seasonal factors such as temperature or humidity, the variation of measurements within a week is close to that experienced over a year.) The standard deviation of these measurements can be computed and compared with the desired level, σ_{R0}. The check is run exactly as for the repeatability test, except that the value for σ_r is replaced by the value for reproducibility, σ_R.

6. YEARLY REVIEW OF ADMINISTRATIVE LIMITS AND HISTORICAL VALUES

At least once a year, the values used for administrative limits and historical values are reviewed for appropriateness. It is here that the value for σ_R, in particular, is checked.

7. EXAMPLE

As an example, consider the April 1989 to March 1990 measurement control (MC) data from an electronic balance in use at the Los Alamos National Laboratory. Each accuracy and precision check was performed using two standards, one having a mass of 989.72 g and the other a mass of 3982.14 g. Since the MC data from the 989.72 g standard provide a better example, the following discussion addresses that standard only. The control limits, however, apply to both standards since an additive measurement error model is assumed.

The data presentation and analysis are complicated by a change in the frequency of the accuracy checks. Through the first week of August, the checks were performed twice a week. Then, a policy of daily checks was instituted. This resulted in the change in the control limits seen in Figure 2 and the higher density of points apparent at the end of the accuracy data in Figure 3. An additional problem becomes evident upon viewing Figure 3. The balance has a one-digit readout which is obtained by truncation, not rounding. This causes the occurrence of just a few discrete observations and the lack of centering about zero. Thus, statistical tests depending on a Gaussian distribution of the data must be used carefully, if at all.

The desired levels of precision and accuracy for this balance have been set at σ_{r0}, = 0.08 g, σ_{R0} = 0.10 g and b_0 = 0.10 g. The historical values are σ_r = 0.04 g, σ_R = 0.06 g and b = 0.02 g. These are all within the desired levels. Based on these specified and realized values, statistical and administrative control limits are computed. These are given in Table I and drawn in Figures 2 and 3.

Table I. Statistical and Administrative Control Limits

		Control Limit: *Statistical*	*Administrative*	*Fig.*
Repeatability		$1.964\sigma_r = 0.08$	$1.964\sigma_{r0} = 0.16$	3
Reproducibility	(n=5)	$1.964\sigma_R = 0.12$	$1.964\sigma_{R0} = 0.20$	2
	(n=2)	$2.606\sigma_R = 0.16$	$2.606\sigma_{R0} = 0.26$	2
Accuracy	daily	$3\sigma_R = 0.18$	$b_0 + 3\sigma_R = 0.28$	3
	weekly	c15 = 0.08	b_0 + c15 = 0.18	2
		c12 = 0.13	b_0 + c12 = 0.23	2

where cl(n) = $3\sigma_R$/sqrt(n) when there are n measurements in a week.

The last lines of Table I give the control limits (cl) for the weekly averages plotted in Figure 2. The daily control limits are divided by sqrt(n) since the standard deviation of an average is the standard deviation of a single measurement divided by the square root of the number of measurements in the average[7]. The summary statistics at the bottom of Figure 2 show that there were 220 accuracy checks taken over 51 weeks. (The Laboratory is closed during Christmas week.) The overall bias was 0.017 g, which is well within the desired level. The reproducibility standard deviation σ_R was 0.077, which is larger than the 0.06 historical value but still within the desired level. This larger value is undoubtedly due to the biased values discussed below. The pooled within-week standard deviation was 0.072 g, showing that the weekly data do indeed capture most of the variation which occurs during the year.

In Figure 3, the daily accuracy check values dif = x - u and the weekly repeatability standard deviations are plotted. The values for repeatability and reproducibility standard deviations are given as 0.034 and 0.077 g, respectively. The latter value is the same as in Figure 2.

In Figures 2 and 3, it is seen that around week 28, a positive bias developed. The bias was at about 0.05 g and was not of immediate concern since it was well within the desired level of accuracy, 0.10 g. Since the accuracy check value never exceed the administrative control limit of 0.28 g, the balance was not removed from service even though the statistical action limit of 0.18 g was equaled on a number of occasions. The data from the instrument were monitored, however. During week 41, it appeared that the balance performance might be deteriorating. Although the administrative control limit was not exceeded, the balance was recalibrated in week 42.

A later inspection of the daily accuracy data showed that the observations within week 41 were not much different than the measurements in preceding weeks but that a high value was not balanced by a low value, as had happened previously. The recalibration may not have been necessary, but was precautionary.

8. CONCLUSION

The use of administrative control limits in a MCP has been shown to be useful by keeping a "bias problem" in a balance in perspective. The bias was real but never of practical significance. Ordinarily, exceeding the statistical action limit would have been cause for removing the instrument from service. The introduction of administrative control limits allowed the balance to continue in operation. Its data were monitored by using statistical control theory, and later, when it appeared that it might be necessary, the balance was indeed recalibrated. Often, a slight bias, such as observed here, is due to a short-term effect such as a period of high or low humidity. When the effect disappears, the instrument returns to its normal pattern of operation. Under this circumstance, recalibration would not have been useful.

ACKNOWLEDGMENT

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NOTATION:

σ_{r0} Desired level of precision (repeatability).
σ_{R0} Desired level of precision (reproducibility).
b_0 Desired level of accuracy.
σ_r Historical repeatability standard deviation.
σ_R Historical reproducibility standard deviation.
s Observed standard deviation of n repeat measurements.
b Historical bias.
u Standard value.
c $b_0 + 3\sigma_R$ Administrative control limit for accuracy.
c' $1.964\sigma_{r0}$ Administrative control limit for precision, n = 5.

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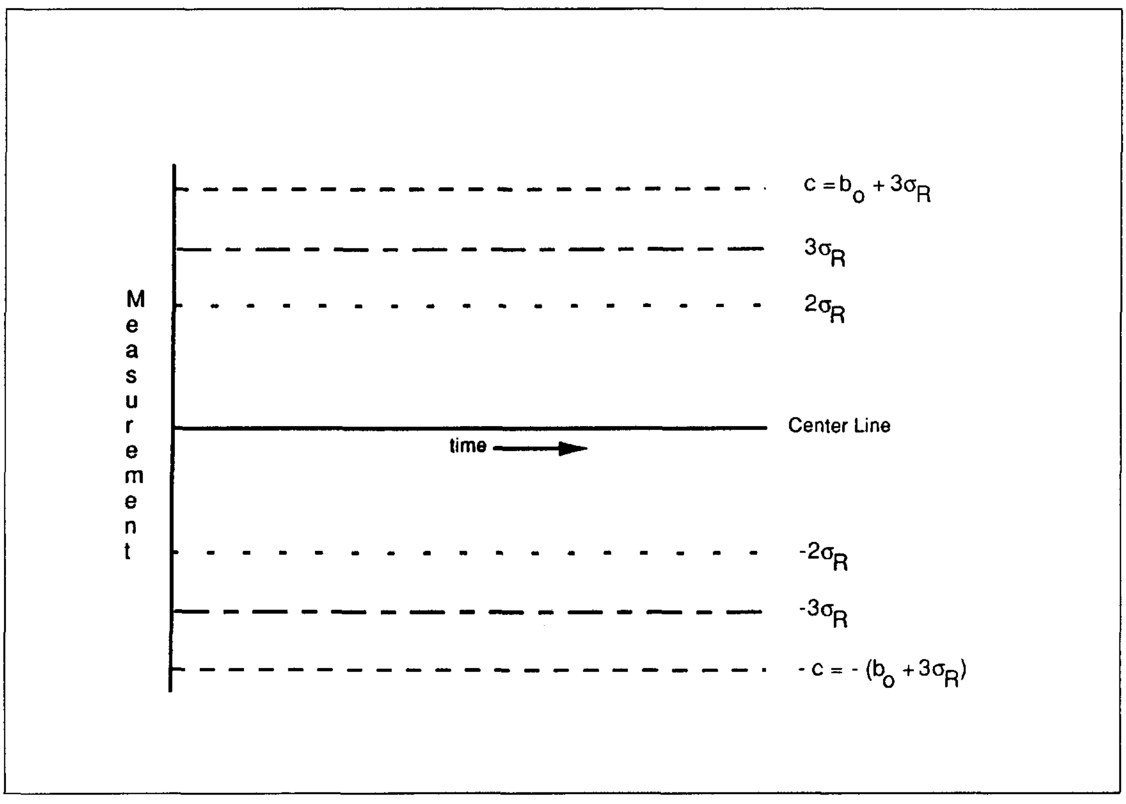
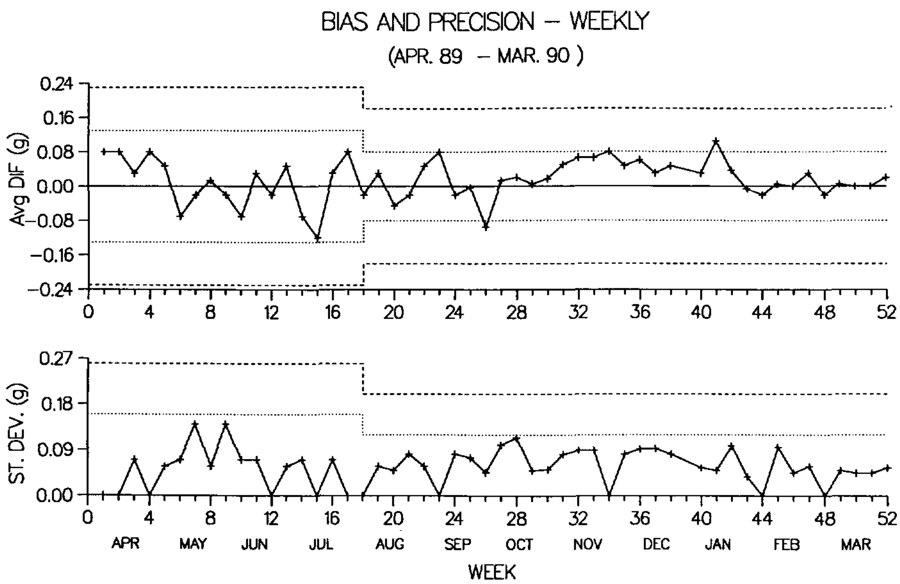
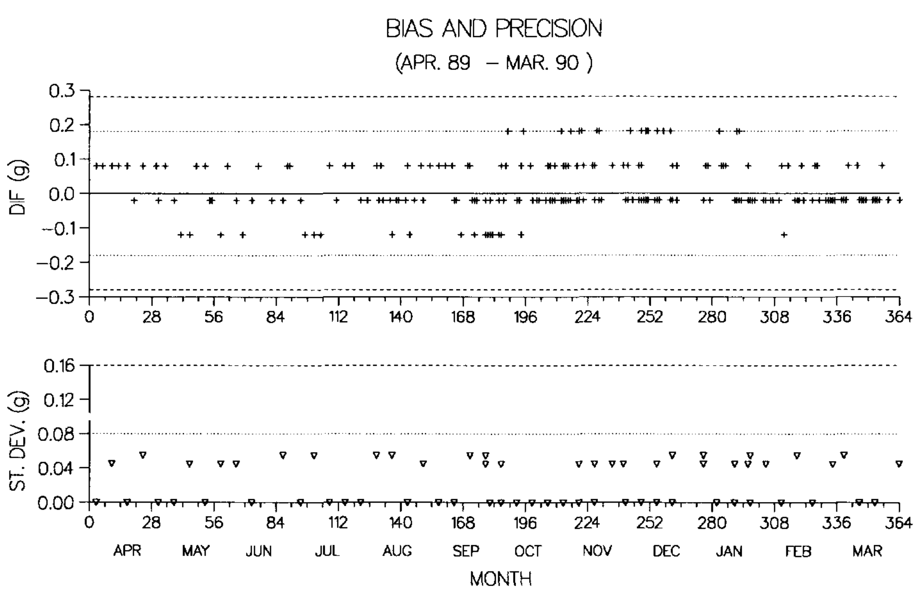


Figure 1. Administrative and Statistical Control Limits for Daily Accuracy Checks.



STANDARD	NUMBER WEEKS	N	BIAS EST.	STANDARD DEVIATION DAILY DATA	STANDARD DEVIATION POOLED WEEKLY
989.72	51	220	0.017	0.077	0.072

Figure 2. Mean and Standard Deviation of Balance Measurement Control Data Grouped by Weeks. Administrative (---) and 3-sigma (....) Control Limits.



STANDARD (g)	NUMBER WEEKS	N	BIAS EST.	STANDARD DEVIATION REPRODUCIBILITY (g)	STANDARD DEVIATION REPEATABILITY (g)
989.72	51	220	0.017	0.077	0.034

Figure 3. Precision and Accuracy Measurement Control Data. Administrative (---) and 3-sigma (....) Control Limits.

A Scheme for Randomized Inspections

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ABSTRACT

We describe a general randomized inspection scheme that satisfies initially stipulated quantitative requirements on detection probabilities and timeliness and at the same time makes more efficient use of inspection resources. The scheme reduces intrusiveness into the operations of the inspected plant and improves the effectiveness of the inspection by the unpredictability and the increased intensity of the inspections.

The same formalism is applicable to sequential inspections, inspections by strata, and inspections of facilities over a large complex, such as a country. The description has been set in the context of IAEA safeguards, where preliminary estimates show that appreciable improvements could be made. However, the methodology is applicable to a much wider class of inspections.

INTRODUCTION

Independent verifications, such as the inspections carried out by the International Atomic Energy Agency (IAEA) for nuclear material safeguards, are a technical activity aimed at the higher level objectives of assurance and deterrence. Nuclear material safeguards employ material accountancy as a measure of fundamental importance, and use containment and surveillance as important complementary measures. Material accountancy is designed to determine and verify the location, identity and quantity of nuclear material and their changes within a period of time. The records of nuclear material accountancy at a facility then are reported to the IAEA to serve as the basis of its independent inspection program.

An independent inspection program of this kind involves a variety of activities, including measurements and containment and surveillance procedures. However, the number of inspections is restricted by the limited resources available in terms of manpower (efficiency) and by the need to minimize interference with production at the facilities being surveyed[1] (intrusiveness). On the other hand, the inspections must give a consistent view of the material being examined (standardization) and assure effective realization of the stated aims (effectiveness).

These constraints stimulated investigation of several variations of the possible inspection regimes and of containment and surveillance methods which might be used, in particular, the notion of randomized inspection strategies.

This paper describes an inspection scheme which addresses this question of randomization. While the ideas and procedures described are general ones, for the purposes of exposition they are set in the context of IAEA safeguards which have a well-defined and familiar structure. However, the concepts and methodology are applicable to arms control and other types of inspections.

Subject to established values of the quantitative criteria, such as detection probabilities for diversions and postulated (*a priori*) mean inspection frequencies, the randomized strategy inspection methods we describe can contribute directly to the goals cited in the paragraph above, *viz.*,

• greater efficiency because of the better use of inspection resources,
• reduced intrusiveness, because of the type of inspection schemes proposed, and
• improved effectiveness, because of the increased deterrent effect of randomized, unpredictable inspection times and the increased intensity of inspection.

SAFEGUARDS CRITERIA AND RANDOMIZED INSPECTIONS

The IAEA has been investigating the randomization of inspections as a means of optimizing their increasingly limited resources. Markin (1988 and 1989) discussed the random allocation of inspection resources among facilities and the various strata of material. Fishbone and Nagele 1990 considered several practical aspects of randomized inspections, including confidentiality, detection probability, and the problems of associated logistics. The implementation of short-notice, random inspections (SNRI) is being tested at the General

Electric (GE) low-enriched uranium (LEU) fuel fabrication facility (Eberhard and Kessler, 1990). Canty, Stein and Avenhaus (1988) examined the relation between measurement error, false alarm rate and randomized inspections. Previously, Gordon and Sanborn (1984) examined some aspects of randomization of flow verifications for enrichment plants. In particular, they emphasized the importance of pre-declaration of flow and inventory in randomized inspection schemes.

In this paper, the IAEA Safeguards Criteria for the period 1991-1995 (the Criteria), which will govern the implementation and evaluation of the attainment of inspection goals by the IAEA, are used as the baseline to consider randomized inspections. We propose and examine a randomized scheme which can, at a minimum, satisfy the Criteria and reduce the required IAEA inspection resources. We note that the Criteria can be satisfied, even though flow verification is incomplete because of short material-residence time. Incomplete flow verification reduces the effectiveness of the IAEA safeguards, since some of the material is not safeguarded. The proposed randomized inspection scheme can improve the completeness and timeliness of flow verifications.

The scheme differs from earlier ones in that it is based on the requirements for timeliness and detection probability specified in the Criteria and thus will satisfy the Criteria without reducing the effectiveness of safeguards. The key to the scheme is the observation that current safeguards practices are designed to achieve different levels of *a priori* detection probabilities for diversions of certain amounts of various types of material.

In the proposed scheme, an inspection has two stages: (i) a randomized scheme for deciding whether an actual inspection is to be carried out, followed by (ii) an enhanced sampling program for the inspections which are conducted.

This combination will achieve the same overall probability of detection as the conventional scheme. When the inspectors go to a facility, they will make more measurements than in the current scheme. On other occasions, they will remain at headquarters; nevertheless, the scheme will attain the same overall detection probability. The potential savings in resources come from the omitted inspections and their associated overhead, including travel, opening and closing meetings, health and safety procedures, and instrument preparations. On the other hand, there will be increased inspection when inspectors do go to the facilities. We believe that the decrease in effort from omitted trips will exceed the increase in effort during the inspections that are performed. (For example, about 30% of the trips to an LEU fabrication and conversion facility may be saved as against about a 20% increase in sample size to be measured when inspections are performed.)

It is important to emphasize that in this scheme the onset of an actual inspection is determined randomly, before any requirement for timeliness or other interim scheduling. The overall inspection goal is attained because the onset of an inspection is randomly determined *a priori*, and the relevant sampling plan for that inspection is designed to satisfy the Criteria in a timely manner. We also point out that the current IAEA verification scheme is a special case of the new, more general scheme proposed; it is one particular way of satisfying the Criteria, but it is not the only way.

In addition, we will show that the proposed scheme not only achieves the detection probability goal at each inspection but is also able to detect the diversion of a goal quantity of material distributed randomly throughout the year.

SAFEGUARDS CRITERIA

In this section, we review the IAEA Safeguards Criteria relevant to randomized inspections. Since the Criteria will be used to govern the implementation of safeguards activities in the field and the evaluation of inspection goal attainment by the IAEA, the Criteria serve as necessary and sufficient conditions for satisfactory safeguards. Our discussion will concentrate on the Criteria for LEU conversion and fabrication facilities. Such LEU facilities are good candidates for considering randomized inspections because of the large material flows, the short residence time of the materials and the relatively low goal for detection probability in the Criteria. However, the validity of the principles discussed in this note is not limited to LEU facilities. For example, power reactor facilities with fresh mixed oxide (MOX) or spent fuel also will be good candidates for such randomized inspections. Because of the short timeliness requirement when fresh MOX or spent fuel is present, many interim inspections are required (11 per year when fresh MOX fuel is present, 4 per year with only spent fuel). Although the decrease in inspection effort per reactor may be small, the total potential savings for the IAEA may be appreciable, since there are many power reactors operating under IAEA safeguards.

The Criteria stipulate that for LEU conversion and fabrication facilities there is one physical inventory verification (PIV) per year and 5 interim inspections on a bimonthly basis to verify material transfers to and from the facility. (For some other types of facilities, interim inspections are performed to satisfy the timeliness requirements.) During an inspection, LEU is verified with medium detection probability (about 50%) for gross, partial or bias defects (depending on the type of material) for the diversion of an accountancy verification goal (AVG) quantity of the material. The AVG is, in turn, related to the significant quantity (SQ) or the expected accountancy capability for the material at the facility. This inspection serves the IAEA safeguards objective for "...the timely detection of diversion of significant quantities of nuclear material...and deterrence of such diversion by the risk of early detection."

Operationally, the detection probability requirement is translated mathematically into a sample size requirement via:

$$n = N(1 - \beta^{1/m}) \qquad (1)$$

where N is the total number of items of interest at the inspection, m is the number of defective items making up an

SQ, 1 - ß is the detection probability as required in the Criteria, and n is the number of items that must be verified to satisfy the Criteria. Implicit in this formula is the assumption that if a defective item is included in the sample, it will be detected. It has been shown that for inspections in which sample sizes are calculated according to this formula, the scheme can also detect the diversion of 1 SQ distributed throughout the year with the same detection probability, 1 - ß.

THE BASIC RANDOMIZED INSPECTION SCHEME

First, the overall required detection probability 1 - ß remains the same (medium detection probability, about 50%). The timeliness requirement, or interim inspection schedule, is also preserved. A few days before the scheduled inspection, inspectors will decide if the actual inspection will be carried out, with probability p, $0 < p \leq 1$. (As shown below, p must lie between 1 - ß and 1, and a different value can be selected for each scheduled inspection.) After p is selected by the inspectors, they then use a random number generator which generates random numbers uniformly between 0 and 1. If the random number obtained is less than or equal to p, the scheduled inspection will actually be carried out; if it is greater than p, the actual inspection will be omitted.

Let n' be the number of random samples selected for verification during the inspections actually carried out, N the total number of items in the population and m the number of defective items making up 1 SQ. The total non-detection probability, B, for the randomized inspection scheme can then be expressed as:

$$B = 1 - p + p \frac{{}_{N-m}C_{n'}}{{}_{N}C_{n'}} \qquad (2)$$

where $_{N}C_{n}$ is the number of combinations of N items taken n at a time. The non-detection probability, B, at this inspection is the sum of two terms:

(i) the probability that the inspection is not carried out, 1 - p, and

(ii) the product of the probability that the actual inspection is carried out and the probability that none of the defective items is included in the n' samples. For the IAEA inspections, B is required to be less than values of p as specified in the Criteria. The exact sample size in this scheme can then be calculated from Eq. 2.

After a variable transformation,

$$ß' = \frac{ß + p - 1}{p} = 1 - \frac{1 - ß}{p} \qquad (3)$$

one sees that, analogous to the derivation of the original sample size formula, (Eq. 1), the sample size in the randomized inspection scheme can be approximated by:

$$n' = N(1 - ß'^{1/m}) \qquad (4)$$

Thus, in this scheme the sample size depends on the probability of actually carrying out an inspection, p. The higher the p, the smaller the sample size. When p = 1, the formula reduces to the original IAEA formula, Eq. 1, as it should when all the scheduled inspections are carried out. However, in the new, more general scheme, not all the scheduled inspections need be carried out. Instead, whether a scheduled inspection is to be actually carried out is determined randomly before the inspection, with a probability p for actually carrying out the inspection. The cost of this scheme is that when an inspection is actually carried out, more items than in the original approach must be sampled for verification. This will most likely be counter-balanced by the benefits from carrying out fewer actual inspections.

It can be seen from Eq. 2 that p must be greater than 1 - ß. Thus, if one would like to have a 1 - ß detection probability, then p (the probability for carrying out an inspection) must be at least 1 - ß. Within this constraint, inspectors are free to choose a different p at each scheduled inspection.

The basic randomized inspection scheme described above can be carried out easily, and it will, on the average, reduce the resources required for IAEA inspections. A fraction 1 - p of the scheduled inspections may not be carried out, at a cost of some additional sampling effort at the fraction p of the scheduled inspections which are carried out. This latter fractional increase of inspection effort will be (at most) pf, where f is the fractional increase in sampling effort. Under most circumstances, the net effect should save resources for the IAEA[2]: the average fractional net savings become

$$(1 - p) - pf = 1 - p(1 + f).$$

The definitions and relations contained in Eq. 3 above have a useful physical interpretation. Just as p and 1 - p = D represent the originally stipulated non-detection and detection probabilities, respectively, so do p (given by Eq. 3) and

$$D' = 1 - ß' = \frac{1 - ß}{p}$$

represent the "effective" non-detection and detection probabilities, respectively, in the randomized inspection scheme described here.

DISTRIBUTED DIVERSIONS

The randomized inspection scheme satisfies the Criteria at each inspection. A desirable feature of the current IAEA scheme is its ability to detect with the same probability 1-ß, a diversion of 1 SQ distributed throughout the year. We show below that the proposed randomized inspection scheme preserves this feature.

In the case of the proposed randomized inspection scheme, the sample size, n_i', at the i-th inspection with total population N_i is:

$$n_i = N_i(1 - B_i'^{1/m}) \quad (5)$$

where, again $ß_i' = (ß + p_i - 1)/pj$, and $p_i \geq 1 - ß$. It follows that

$$1-\frac{n_i'}{N_i} + ß_i'^{1/m} \quad (6)$$

When the sample size is determined as described, and when the total number of defective items is m_i (instead of m) during this inspection period, the non-detection probability, B_i, for the i-th inspection can be expressed as

$$B_i = 1-p_i+p_i \prod_{j=1}^{m_i} (1- \frac{n_i'}{N_i-j+1}) \quad (7)$$

$$< 1-p^i+p^i \prod_{j=1}^{m_i} (1- \frac{n_i'}{N_i})$$

$$= 1-p_i+p_i ß_i'^{m/m}$$

$$\leq (1- p_i+p_i ß_i')^{m_i/m} \quad \text{(Sanborn 1982, Lemma 3)}$$

$$= ß^{m_i/m}$$

Summing over all the inspections with

$$\sum_{i=1}^{T} m_i = m$$

(where T is the total number of inspections) yields the total non-detection probability

$$B = \prod_{i=1}^{T} B^i < \prod_{i=1}^{T} ß^{m_i/m} = ß$$

Thus the proposed randomized inspection scheme could also detect the diversion of 1 SQ distributed randomly throughout the year, with the same probability, 1-ß.

ESTIMATE OF SAVINGS

We can estimate the savings in the following way. For each facility, the expected number of inspection trips not undertaken is the product of total number of inspections scheduled, T, times the probability of not conducting the inspection, 1-p. For now we assume that the application of the randomized scheme is limited to interim inspections only, while the PIV is still carried out as usual; this is a conservative approach. Let the inspection man-days (MDI) per interim inspection be d and the fraction of time spent on measurements during an interim inspection be q. Then the expected savings per year for this scheme is at least

$$S = [1 - p - pq (\frac{n'-1}{n})] Td \quad (8)$$

where n' and n are the samples sizes calculated according to Eqs. 4 and 1, respectively, for a total population N. The savings depend on the value of p. The limit on p is $p \geq 1$-ß. The estimates can be calculated for each type of facility, and the savings for the IAEA as a whole then can be estimated by summing Eq. 8 over all facilities under safeguards.

Any value of $p \geq 1$-ß will do. However, if p = 1-ß, then at least N-m+1 items need to be measured to ensure that at least one defect will be detected. This approach might not be desirable under some circumstances (e.g., many small items). To get a feeling of the estimated savings, the following estimates were calculated with

$$p = \sqrt{1-ß} \quad (9)$$

and

$$p = (1-ß)^{0.9} \quad (10)$$

respectively; both equations satisfy the requirement that p is not less than 1-ß.

For LEU facilities or light water reactors (LWR) with spent fuels, about 30% of the scheduled inspection trips may be omitted when Eq. 9 is used to determine the probability of carrying out an inspection, while for each of the inspections actually carried out, the sampling fraction is increased from approximately 50% to 70%. When Eq. 10 is used, about 45% of the inspection trips may be omitted, while the sampling fraction is increased from about 50% to 93%.

Thus, the estimated savings in total inspection resources for large-scale LEU conversion and fabrication facilities are about 12% to 20%, and for LWRs with spent fuel but without fresh MOX the savings are between 20% and 30%. Since there are about 100 LWRs and 8 LEU facilities, the total savings are about 250 man-days for LWRs and 60 man-days for LEU facilities. The savings would allow IAEA more opportunities for interim inspections, and thus, more complete coverage of flow verifications.

Another possible formula for the selection of p_i is

$$p_i = (1- ß)^{(1-N_i/N)} \quad (11)$$

The model fits the criterion that $p_i \geq 1$-ß. Here, the more material available for inspection, the higher the probability for actually carrying out that inspection, hence the smaller the sample size required during that inspection.

SELECTION OF STRATA OR FACILITIES

In some situations, it might be preferable to select a few strata for verification instead of verifying all of them. The methodology presented here can be readily extended to such applications. Consider first the current IAEA regime where all inspections are actually carried out; this corresponds to $p = 1$ in Eq. 2.

However, instead of selecting n (Eq. 2 with $p = 1$) samples from all strata for verification, each strata is assigned a probability q for verification. Then n_q samples need to be chosen from the strata randomly selected for verification with probability q. The non-detection probability for each stratum can be expressed as

$$B_q = 1 - q + q \frac{{}_{N-m}C_{n_q}}{{}_{N}C_{n_q}}$$

Since B_q is required to be less than ß, n_q can be approximated by:

$$n_q = N(1-ß_q^{\,1/m}) \qquad (12)$$

where

$$ß_q = \frac{ß-1+q}{q} \qquad \text{with } q \geq 1-ß.$$

The random selection of strata for verification is also applicable in the basic randomization scheme. The only modification required is to substitute ß' for ß in the definition of $ß_q$.

The basic randomization scheme also can be applied to the randomization over facilities (e.g., within a country), in order to select facilities for actual inspections, in a manner similar to the randomization over material. The formalism is exactly the same as that described above.

SUMMARY

To summarize, our approach has the following features:

- it satisfies the stipulated quantitative criteria for detection probability and timeliness;
- it uses the inspection resources more efficiently by decreasing the indirect (overhead) costs, while intensifying the actual inspections[3];
- it reduces interference with plant operations because of the lower frequency of actual plant inspections; and
- it has an increased deterrence on potential diversions because the inspection times are unpredictable.

FOOTNOTES

[1] Such as power and research reactors; bulk-handling plants involving uranium enrichment, spent fuel reprocessing and fresh fuel fabrication; and spent fuel and nuclear waste storage facilities.

[2] Since $f \leq \frac{1-p}{p}$ in all practical cases.

[3] This allows additional effort on flow verifications, which may have been incomplete because of short nuclear material residence times.

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International Safeguards Aspects of Spent Fuel in Permanent Geological Repositories

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1. INTRODUCTION

The practice of not reprocessing spent fuel (the "once-through" cycle) poses one of the requirements of spent fuel management. States which decide not to reprocess spent fuel for recovery of the contained plutonium intend to dispose of the fuel in a geologic repository after appropriate conditioning. Storage facilities at reactors and away-from-reactor facilities will be required for storing and cooling the fuel until suitable repositories are available. In several States, reprocessing of spent fuel is neither envisaged nor considered to be economical. Recent developments make the disposal of spent fuel in geologic repositories more attractive than previously believed, thus introducing new challenges to safeguards. The nuclear community has expressed concern about the pressing need to address issues of long-term safeguards for the disposal of spent fuel in geologic repositories.[1,2] The IAEA must develop safeguards requirements and methodology for geologic disposal facilities for spent fuel and formulate a safeguards policy before such facilities enter into operation.

2. THE ISSUE OF TERMINATION OF SAFEGUARDS

A fundamental consideration in the disposal of spent fuel is whether conditions can be met for termination of safeguards on the material or whether safeguards must be continued indefinitely. The criteria for termination of safeguards are in paragraph 26(c) of INFCIRC/66/Rev. 1 [3] and 11 of INFCIRC/153 [4]. On the basis of requirements prescribed therein, safeguards can be terminated upon determination by the Agency that the material has been consumed or diluted in such a way that it is no longer usable for any nuclear activities or has become practicably irrecoverable. An opinion does exist that spent fuel which is stored in geologic formation becomes practicably irrecoverable due to lack of access to the material. However, in the event that safeguarded nuclear material cannot be considered to be practicably irrecoverable, the State and the Agency may apply appropriate safeguards measures.

It has been suggested that there should be more precisely defined technical criteria based on the "consumed," "diluted" or "practicably irrecoverable" attributes which could accommodate spent fuel withdrawn from the nuclear fuel cycle. Spent fuel in storage facilities either at the reactor site or away-from-the-reactors which is used for interim storing, cooling and conditioning until suitable repositories are available does not meet the requirement of being "practicably irrecoverable." Spent fuel placed in any form of interim and retrievable storage facilities remains accessible, and therefore nuclear material therein is recoverable. The situation is not so candid with the permanent repositories such as geologic formations and engineered containment structures. The basic requirement of the permanent repository is to dispose of the spent fuel in a way which isolates it from the biosphere, specifically including accidental access by man. On the other hand, spent fuel which has been stored for a long time after discharge from the reactor becomes more easily recoverable, as radioactivity decreases considerably after several decades and plutonium extraction becomes more feasible.

In the future, spent fuel could become a unique source of some vital element, such as rhodium. Geologic repositories would therefore contain large quantities of plutonium and other potentially valuable elements. Changes in institutional and social systems may provide incentives for recovery of spent fuel for energy generation as well as sources for other minerals. The possibility exists for the recovery of nuclear material throughout the operation and following closure of a permanent geologic repository and any country which emplaces spent fuel can at any given time retrieve it. The same technology and skill are required for emplacement as well as retrieval. Should a State be willing to divert material there is no conceivable way of making the material contained in fuel elements and deposited in a permanent storage facility irrecoverable.

At this point, we are confronted with a very fundamental question, i.e., to what extent should safeguards for spent fuel be continued? One possibility is to continue safeguards even long after the final disposal facility is decommissioned. This view is strongly opposed by others who maintain that it is impractical to suggest that safeguards be continued ad infinitum.

3. RECOMMENDATIONS OF ADVISORY GROUP MEETING

The IAEA recently took the initiative in view of various technical, social and political concerns to develop an international consensus on the future policy of safeguards for spent fuel placed in permanent geologic repositories. An Advisory Group Meeting[5] on safeguards related to final disposal of nuclear material in waste and spent fuel, held at IAEA Headquarters in September 1988, was attended by 43 representatives from 17 Member States and a multinational organization (EURATOM). During the course of this meeting, the basic issue of whether mere placement of spent fuel in a geologic repository, or perhaps some added characteristic of the repository or degree and method of conditioning, would make the spent fuel practicably irrecoverable to meet the criteria mentioned in the safeguards agreement was discussed at length by the advisors. It is natural that recommendations made during this meeting will be instrumental in formulating a safeguards policy for spent fuel placed in a geologic repository. These recommendations are paraphrased below.

- Spent fuel does not qualify as being practicably irrecoverable at any point prior to, or following, placement in a geologic repository, or even after closure of the repository and the IAEA should not terminate safeguards on spent fuel.
- For the stages involving fuels in reactors, away-from-reactor stores and up to the start of conditioning of the fuel, the material could be safeguarded by using adaptations of existing safeguards measures.
- The process, starting with conditioning of the fuel and ending with the final placing in the repository, raises new safeguards problems. These arise from the possible dismantling and consolidation of the original fuel assemblies, the placing in a disposal container, and placing of the container in the repository. This would require increased reliance upon containment and surveillance (C/S) and other monitoring systems. If the safeguards system fails to provide the assurance required, under most circumstances it will not be possible to re-establish the inventory by re-measurement. In order to provide a wide variety of C/S and monitoring systems, R & D should be started with high priority following the necessary systems study. In order to facilitate the application of C/S measures, early consultations should take place between the State/designer and the Agency.
- Spent fuel could be considered to be virtually inaccessible for physical verification when a particular area or drift in an operating repository is backfilled, and when all operations in the repository are completed and the repository is closed.
- There are technical and legal problems that have to be solved before implementing safeguards for a closed repository.

The Agency must develop a safeguards approach for such repositories while operational and after closure and for their associated conditioning facilities prior to the commissioning of such facilities.

4. STATUS OF SAFEGUARDS FOR SPENT FUEL

The Agency's basic safeguards approach for reactor fuel assemblies is one of item accountancy. It is based on the principle that the integrity of the individual items can be assured, either because fuel assembly tampering would be sufficiently difficult so that it can be considered unlikely or because safeguards measures are implemented to verify or confirm their integrity. Nuclear material content is based on fabrication measurement data and adjusted based on calculation of production and loss during irradiation. Nuclear material content is assumed to be traceable as long as item integrity is maintained.

The success of item accountancy as a safeguards approach is critically dependent on the Agency being able to implement measures which provide an acceptable assurance of continued item integrity. Safeguards measures include the use of a combination of containment and surveillance devices which provide the required assurance of fuel integrity and the monitoring of shipments of fuel. The use of item accountancy has been further complicated by recent technological developments, namely, increasing use of rod exchange and expansion of reactor storage pool capacities with high-density storage racks, consolidation of fuel rods, double stacking of fuel assemblies, and the use of special storage baskets or multi-element bottles to accommodate an increasing number of spent fuel assemblies. Currently used methods are not capable of verifying the loading of irradiated fuel shipping containers, fuel assembly dismantling and reconstitution, or the removal of individual spent fuel rods or small numbers of such rods in light weight shielding.

These problems have raised questions about the adequacy of safeguards measures based on item accountancy. More recently, the alternative of re-verifying integrity by NDA measurement has been given increased attention. However, it is important to note that relying on C/S measures to confirm integrity or using NDA measures to re-verify integrity poses certain practical difficulties.

Similar safeguards problems have been encountered for away-from-reactor wet and dry storage facilities. The capacity of wet storage facilities, design features and the extended time for storing create further problems as verification prospects are severely restricted. Even if NDA possibilities exist it will be prohibitively time consuming due to the large number of spent fuel elements. Spent fuel stored in special storage baskets or multi-element bottles causes serious problems even for item counting and identification. The inaccessibility of the spent fuel assemblies prevents direct periodic verification.

Currently, dry storage technology has been developed for storing spent fuel as an alternative to wet-type stores. Verification of the contents of each shipping container can be performed only during loading. Continuity of knowledge of the inaccessible fuel stored in such containers can be achieved only by C/S measures. Normally such dry storage has no provision to open these containers, so it is not possible to verify the inventory except at an unloading facility. Safeguards verification is based on item counting and identification of containers, application of seals, and containment and surveillance.

The problem to be recognized is that spent fuel will arrive at a preparation facility or a permanent storage repository with a presumption that the integrity has been preserved, but with an important question as to whether this is fact. If diversion has occurred and has not been detected at the time of disposal, then it will never be detected, because the Agency never will have another verification opportunity.

5. DILEMMA OF SAFEGUARDS FOR GEOLOGIC REPOSITORY

There are several stages through which irradiated fuel will pass before being placed in a permanent geologic repository. Each of these stages has its own unique safeguards problem to resolve in order to accomplish acceptable assurance of non-diversion of nuclear material.

5.1 Conditioning Facility

Spent fuel can only be disposed of in accordance with criteria prescribed by the State. This involves immobilization or conditioning of the fuel assemblies carried out either in off-site or on-site conditioning plants[2]. These operations are generally carried out under dry conditions. After arrival at the conditioning facility, spent fuel is transferred to a hot cell where it is disassembled. The disassembled components are then put into containers which meet final disposal requirements. In some cases, it may be necessary to cut the components into pieces. The important concern here is the need to provide assurance that the fuel assemblies have retained their integrity on arrival at the conditioning facility. The major impact on safeguards is the loss of identity of the fuel assembly as a discrete item for accountancy. The material handling operation which changes the content of spent fuel due to such operations should be followed by measures to verify the nuclear material content. Effective safeguards depend on the accounting practices to verify the content and composition of the material placed into final disposal.

Procedures must be developed to ensure that all irradiated fuel components are accounted for and that the content of all nuclear material placed into final disposal is accurately stated. Additional provisions must be developed to allow IAEA inspectors to verify that the nuclear material placed into final disposal is as declared by the operator. New measurement methods and surveillance techniques may be necessary.

5.2 Active Repository

A geologic repository[9,10] is similar to a mine and is expected to consist of access corridors and disposal caverns, excavated deep within the geologic formation. Various supporting facilities are built on the surface of the repository. Shafts provide access to the disposal caverns (drifts). At least three separate types of shafts are envisaged to ensure optimum usable. These are: a canister transportation shaft, a personnel and ventilation intake shaft, and a ventilation exhaust shaft. The underground facilities at the repository may be designed to allow further excavation of new caverns, receipt and transport of spent fuel, emplacement and back-filling of the disposal caverns. Mining operations may be performed on a continuous basis. Following excavation of the caverns, vertical access and emplacement shafts are opened. Spent fuel arrives at the repository from the conditioning plant in containers which are prepared for final disposal in surface facilities. The containers are lowered through a shaft to the disposal level, transported to the disposal cavern and placed in the emplacement shafts. All operations are expected to be remotely controlled. After the canister has been emplaced, the void space will be back-filled with low-permeability material.

When the repository has been filled with design capacity and all the room has been back-filled, final decomissioning would begin with the back-filling of all corridors and mine level openings. All shafts would be sealed to restore the formation integrity to a condition comparable to that which originally existed.

The considerations important to safeguards of a repository are the identification of individual canisters that enter the repository, tracing the canisters to their final emplacement and verification that they remain there until the drift is closed and repository is sealed.

No permanent repository currently exists or is likely to be in operation soon. Some States are actively considering the construction of final repositories to be built early in the next century. In the meantime, extensive research and development work are being pursued by many countries for the final design. It is essential that international agreement be achieved at an early date regarding the safeguards measures to be applied at such repositories.

5.3 Closed Repository

Continuation of safeguards following closure of a repository would likely be based on the use of C/S measures. Safeguards measures should be designed to confirm that the containment provided by the geologic matrix of the repository has not been compromised. Periodic inspections may be required to verify the condition of the accessible tamper-indicating devices and of the detection equipment. Visual inspection of the area surrounding the repository site to verify that no tunnelling or mining activities have been conducted might also be necessary.

Repositories are expected to be located in areas which are not tectonically active. It is unlikely that any permanent disposal facility will be loaded to capacity, back-filled and sealed before the middle of the next century, and the nature of safeguards requirements at that time cannot be predicted.

6. SCOPE OF ALTERNATIVE SAFEGUARDS APPROACH

The objective of safeguards is the timely detection of the diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or for purposes unknown. Material accountancy has been identified as a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures. The basic premise of the permanent repository is that the spent fuel is disposed of in a way which isolates it from the biosphere, specifically including accidental access by man. The final disposal of spent fuel requires consideration of the safeguards measures which might be applied; material accountancy would simply not be possible. Since the spent fuel will be rendered inaccessible, physical inventory verifications could not be performed.

However, the inspections outlined in paragraphs 74-75 of INFCIRC/153[4] do not exclude the "use of other objective methods which have been demonstrated to be technically feasible" in conjunction with surveillance and containment. The application of these "objective methods" could contribute to the development of a safeguards approach for spent fuel placed in geologic repositories.

7. SAFEGUARDS FOR DIFFICULT-TO-ACCESS INVENTORY

The current safeguards methodology[6] for long-term storage of irradiated fuel in a difficult-to-access area is based on a modified C/S system explicitly foreseen in INFCIRC/153[4]. This concept can be applied for fuel packed in discrete containers which are welded or which have an individual closure mechanism which cannot be opened for verification purposes and/or the average time needed to move items to the nearest convenient measurement location is greater than four hours using normal fuel-handling equipment and operating procedure. Prior to placing the fuel in difficult-to-access storage, the usual accountancy verification requirements to determine gross and partial defects must be applied. The safeguards objective is achieved by maintaining continuity of knowledge by successful use of dual C/S systems containing devices operating in a redundant and independent mode and based on different physical principles. For each diversion path, at least two conclusive, positive results and no conclusive, negative results must be achieved. Once these conditions are met and the fuel is under successful C/S, inventory verification by accountancy measures is waived. However, reverification of design features at appropriate frequencies to confirm that the difficult-to-access conditions have not changed is essential.

The C/S system used in such difficult-to-access facilities must be extremely reliable, and there must be a high confidence level that the information provided is correct. Any alarm will require appropriate follow-up actions. In the event of C/S failure, even for spent fuel stored at a reactor, the requirement for reverification of nuclear material inventory can be costly in terms of effort for access and may be regarded as very intrusive by the operator. Resolution of alarms generated would pose a major problem, and reverification may or may not ultimately provide conclusive results on non-diversion.

The important element of success of this approach depends on the design of reliable C/S systems which must produce conclusive positive results. The design specifications of a C/S system[7] must conform with the principle formulated by the Standing Advisory Group on Safeguards Implementation (SAGSI)[8]; i.e., if C/S measures providing sufficient assurance against circumvention or defeat by any realistic means were available, remeasurement of material under such C/S would not be necessary. Such a system should consist of devices operating in a redundant and independent mode based on different physical principles which have acceptably high standards of integrity and performance and which can be authenticated. Acceptable C/S means that a C/S system as a whole is accepted as a means of maintaining continuity of knowledge over a period of time at a confidence level comparable to that achieved during a previous material verification.

The development, evaluation and selection of C/S safeguards equipment are expected to be an iterative process. Functional requirements such as quantitative and qualitative design specifications covering reliability, availability, tamper resistance and vulnerability, false alarm probability, detection probability, authentication, and other requirements must be fulfilled. Performance specifications (i.e. a set of requirements with which a C/S system must comply) will be derived from these functional requirements. The Agency, national safeguards authorities, the developer of safeguards equipment and the nuclear facility operator must be involved in development evaluation and periodic review of functional requirements and performance specifications.

The underlying concept of difficult-to-access inventories can be extrapolated to include permanent geologic repositories taking into consideration their design and physical characteristics. The aforementioned, together with properly designed multiple C/S systems and other measures, are expected to be of major importance in the implementation of safeguards at geologic repositories for spent fuel.

8. CONCLUSION

In conclusion, the planned disposal of irradiated nuclear fuel in geologic repositories demands a fundamental systems analysis of alternative safeguards possibilities as a basis for defining the R & D programs needed to explore specific safeguards measures and concepts. This analysis should include a review of safeguards-relevant design information for spent fuel repositories with the objective of identifying and understanding features which might contribute to safeguards; exploring alternative safeguards possibilities for feasibility, potential effectiveness, cost, intrusiveness, etc. in order to meet effectiveness; and outlining the R & D effort required for implementation. In addressing these requirements, the Agency has initiated discussions on the possibility of a multinational effort under Member State Support Programs.

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Since 1986, Dr. Khlebnikov has been the Head of the System Studies Section, Department of Safeguards, International Atomic Energy Agency (IAEA). In 1976, he earned a Ph.D. in Physical Chemistry from the State Research Institute of Rare Metals in Moscow. Prior to joining the Department of Safeguards, Dr. Khlebnikov was the Head of the Safeguards Laboratory at the Central Research Institute of Atomic Information in Moscow. He was responsible for the Laboratory's systems analysis activities including: non-proliferation issues, international safeguards systems design and state systems of accounting for and control of nuclear material.

Dr. Khlebnikov has more than 40 publications, including papers presented during the third and sixth ESARDA Symposia in 1981 and 1984 respectively, the IAEA Safeguards Symposium in 1982, the 1989 and 1990 INMM meetings and the 1989 and 1990 ANS meetings. He co-authored a book entitled "International Control Systems in the Field of Atomic Energy Utilization" which was published in Moscow in 1986. He has been active in safeguards and non-proliferation activities for over 10 years.

Nuclear Materials Control and Accountability Training: Future Challenge

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ABSTRACT

Education and training efforts are expanding in the field of Nuclear Materials Control and Accountability. There are some opportunities and very specific needs relative to MC&A education and training. This paper identifies these opportunities and needs and enlists the support of others in improving our training programs.

INTRODUCTION

The 31st Annual Institute of Nuclear Materials Meeting July 15 - 18, 1990 at the Los Angeles Biltmore Hotel hosted a session on Education, Training and Technology Transfer. The session overviewed the current ongoing Nuclear Materials Control and Accountability (MC&A) training efforts of the U.S. Department of Energy (DOE). The papers addressed MC&A training by a contractor at a DOE nuclear facility, by a support service contractor at DOE nuclear facilities, and by the DOE Central Training Academy. The proper instructor attitude and prescriptions for successful teaching were also covered. The session was very successful and will be offered again next year in New Orleans.

MC&A TRAINING NEEDS

Recent changes in the DOE regulations have re-emphasized the need for training. It is important we train both new employees and retrain current employees. Formal training and structured on-the-job training are a continuing need for people in today's complex MC&A positions.

Recent events have stimulated a nationwide call for quality in the work place. There is a switch from a classic "efficiency-oriented" to a "quality-oriented" approach to management and operations. Among other things, the quality approach has required a relentless commitment to organization wide learning and training.

Because of the growing number of Safeguards and Security requirements, there is need for more people in the MC&A field. A larger pool of MC&A trained and qualified personnel is needed to provide the depth of staff necessary for efficient replacement of staff and for cyclical work demand.

A critical MC&A staff resource problem is partially caused today by the weak MC&A position identities and by the lack of management's understanding of the MC&A professional position requirements. The career paths for MC&A professionals are not well established or understood. There often is the appearance that the career path is a dead end. It is not possible to recruit the best talent for dead-end jobs or jobs that appear so. So to fill our MC&A positions we have been faced with having to coerce the budget/finance professional or the program scientist out of their respective fields to work in MC&A. This situation should and can be changed. This will be accomplished by the analysis, standardization and documentation of the MC&A professional positions.

The MC&A field also suffers from not having accomplished a job task analysis of the MC&A positions. A good job task analysis is the basis for identifying the job requirements and designing the MC&A training program. Today's training in MC&A is largely determined by a few people who are doing separate training tasks. An overall MC&A training plan and site specific training plans should be developed. The DOE Training Policy Advisory Committee and Safeguards Working Group are addressing some of these needs.

CURRENT MC&A TRAINING APPROACHES

On-the-job training in the past has been the mainstay of MC&A training. However, OJT was been largely informal and lacked training structure and documentation. In all but a few organizations, formal training of the staff in Nuclear Materials Control and Accountability (MC&A) has been limited. In addition to the limited amount of training, the training has been very site specific (Material Custodian & Handling) or tailored to very job specific needs such as Nuclear Materials Management and Safeguards System (NMMSS) or Non-Destructive Assay (NDA) measurements. A few more generic MC&A courses are offered by the DOE Central Training Academy.

WHAT MC&A COURSES ARE CURRENTLY SUCCESSFUL?

The Nuclear Materials Management and Safeguards System (NMMSS) and Non-Destructive Assay (NDA) measurements courses are the first that come to mind. These are courses designed to meet the specific needs in one area for accountants and another for scientific members of the MC&A staffs.

Other courses being taught include:

- Accounting
- Auditing
- Measurement
- Statistics
- Train-The-Trainer for Material Handlers, Custodians and Tamper-Indication Device (TID) Applicators
- Safeguards & Security Orientation and Overview
- ASSESS - effectiveness assessment methodology.

These courses have had a limited number of attendees and do not cover all areas of interest to meet the overall MC&A training needs.

WHAT COURSES ARE STILL NEEDED?

There is a need for more MC&A courses. There is also a need for mobile courses that can be given at specific sites for a larger group that is unable to travel to a central location to receive the training.

Some of the courses that could be offered include:

- Performance Testing
- Nuclear Material Process
- Nuclear Materials Control
- SAS Integration MC&A for Supervisors
- SAS Planning
- Chemical Analysis

Another issue is that there is an insufficient number of qualified and available MC&A instructors to carry the necessary teaching load. The cadre of MC&A instructors needs to be enlarged.

There is a need for stronger national direction in the MC&A training area. A DOE training doctrine has recently been published as well as a draft DOE Order on Safeguards and Security Training System. The organizational structure for training oversight has also been recently identified. The Central Training Academy is an excellent organization and has very fine facilities. Their role is expanding to further assist the HQ-DOE training area. The national leadership and direction for MC&A training and education are also improving.

WHAT CAN WE AS A PROFESSION DO?

First, I believe that the family of positions customarily deemed necessary for a competent MC&A organization should be identified. These few generic positions should be titled the same at all facilities. Today there are numerous titles for the jobs in MC&A as one goes from site to site. Basically, the knowledge required is the same at all sites and includes accounting, chemistry, physics, statistics, computers and management. The term "Accumstat" was once thought of as a general title for the MC&A position, but a "know all/be all" person in this field is not practical.

The MC&A positions also require a working knowledge of nuclear materials, process plant operations and the nuclear fuel cycle. The common qualifications for the entry level positions should be identified and documented. From this beginning, there can be a detailed job-task analysis on each of the positions. Since there are so many duties in each position of the MC&A organization, a job-task analysis will help to identify the important nature of the job and the training necessary for attaining the journeyman level. The career path should then be carefully spelled out and tracked from entry level to management level.

It should be better understood where we should expect our MC&A talent to come from and where they can be expected to advance to in the system. Once this is understood, it becomes the basis for a good recruitment and training program. The training program must cover the special requirements of the MC&A program in a time span such that a person can readily achieve the journeyman level in the MC&A field.

It is important that more in the MC&A profession work toward developing training materials and encourage others to teach. The new people in our nuclear facilities who are wishing to do the very best for themselves and the organization deserve the best opportunity to learn about the nuclear fuel cycle and the profession of MC&A.

WHAT CAN YOU DO?

Make your commitment to provide quality education to others and help to improve the quality of work in our field.

A. Train others.

B. Assist those who choose to instruct others; Develop training materials.

C Look for added value on the job when instruction is given such as: team building, leadership development, issue identification, opportunity development, feedback, personal esteem & confidence building, and resource building.

Plan for implementation of training courses and work on the overall and site-specific MC&A training plans.

Harold Ransom is a private consultant in the Safeguards & Security Field. He has developed and taught numerous courses in the SAS area and was chairperson for the Education, Training and Technology Transfer Session for the 1990 INMM Annual Conference. He recently retired after 24 years at the DOE Central Training Academy as an adjunct instructor.

NPT: Problems & Prospects

Twenty Years of the Non-Proliferation Treaty: Implementation and Prospects
by Jozef Goldblat
International Peace Research Institute
Oslo, 1990, 162 pages (paperbound)

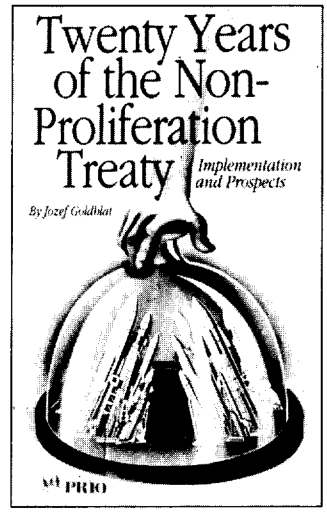
The appearance of the book *Twenty Years of the Non-Proliferation Treaty: Implementation and Prospects*, by Jozef Goldblat, is timely in several respects. The Fourth Conference to review the implementation of the Treaty took place in August of last year, and in 1995, according to Article X of the Treaty, the parties must decide whether to extend it or, alternatively, to give it indefinite duration. The groundwork for that important decision has been laid during the 1990 conference.

The Nuclear Non-Proliferation Treaty (NPT), which has now been in force for 20 years, constitutes the most comprehensive multilateral arms control agreement in existence. With the fundamental transformation of East-West relations and the restructuring of the world political order, the Treaty and the International Atomic Energy Agency (IAEA), which administers the safeguards regime required by the Treaty, are important examples and precedents for the new norms and institutions which must be created in the near future to take advantage of the opportunities which now exist to further global security.

While preserving the virtue of brevity, the book provides a balanced and comprehensive review of topics that are currently of concern in the area of international safeguards and others that are more closely related to concerns in the arms control area. In addition, it provides, in the appendix, a useful collection of source documents, including, *inter alia*, the text of the NPT, the treaties of Tlatelolco and Rarotonga, the statute of the IAEA, the IAEA Model Safeguards Agreement, and the Convention on the Physical Protection of Nuclear Material.

The first half of the text is devoted to a discussion of the successes and failures of the non-proliferation regime over the last two decades and to current, new problems that have emerged. These include the proliferation of nuclear-capable missiles in the Third World, plans of certain non-nuclear weapons states to acquire nuclear-powered submarines, the emergence of new suppliers of nuclear technology, and evidence that certain threshold states have now acquired, or are about to acquire, nuclear weapon capabilities. Other issues well-known to safeguards practitioners are discussed, including the growth and dissemination of enrichment technologies (in particular the AVLIS laser enrichment technology), new reprocessing plants and heavy water production facilities, and the accumulation of large stockpiles of plutonium from the reprocessing of spent fuel.

The activities of the so-called nuclear threshold countries - India/Pakistan, Argentina/Brazil, Israel and South Africa, are treated in some detail. The sense of this section may be summarized as follows: India is believed to possess a fully developed infrastructure capable of producing up to 15 weapons per year; the Pakistani program, while not as mature, is believed to possess the capacity to produce enriched uranium sufficient for one to four explosive devices each year. Significantly, the two countries have concluded an agreement not to cause destruction or damage to each other's nuclear installations and facilities. One feature of this agreement is the exchange of information on the exact location of all relevant installations and facilities. The current situation in South America is considerably more encouraging. While both Argentina and Brazil oppose the NPT on the grounds that it is discriminatory in that it tends to preserve the international nuclear status quo, and they possess advanced nuclear programs, there is no solid evidence that



either country has embarked on, or is committed to, a nuclear weapons program. Existing conditions, including increased scientific, technical and economic cooperation between Argentina and Brazil, the movement away from military regimes toward more democratic political systems, and severe financial stringency provide strong disincentives to nuclear proliferation in the area. Conversely, information that has been made public in recent years on Israel's nuclear program, in particular, the operation for more than two decades of an unsafeguarded reactor and a reprocessing plant, lead to the inescapable conclusion that the state of Israel now possesses a substantial nuclear stockpile. The situation in South Africa is, by comparison, ambiguous. The existence there of an unsafeguarded enrichment plant, and evidence, a decade ago, of the preparation (and dismantlement, after discovery) of a nuclear test site in the Kalahari Desert, testify to both the capability to produce and the intention to test nuclear explosive devices. From information in the public domain, however, it cannot be asserted with certainty that such devices have actually been produced. There thus now exist seven and possibly eight nuclear weapons states. Significantly, none of those which have recently crossed the threshold are signatories of the NPT.

There is a brief discussion of the new, and important, Convention on the Physical Protection of Nuclear Material, which went into force in 1987. With the increased accumulation of nuclear materials in transit and in storage, especially plutonium recovered from spent fuel, the protection of this material will be a major concern for the foreseeable future. There is an evident need for further international cooperation in this area and an upgrading of the quality and effectiveness of existing systems.

Another section deals with an important new arms control concern, that of the rapidly developing ability of many countries to produce or acquire missiles capable of delivering nuclear warheads or chemical warfare agents over considerable distances. Countries already in this category include India, with short-range (150-240 km) and intermediate range (2500 km) missiles capable of carrying a payload of one ton; Pakistan, with short-range missiles with a 500 kilogram payload; and Argentina, Brazil, Israel, and South Africa, with medium or intermediate range missiles capable of delivering substantial payloads. The inherent inaccuracy of these delivery systems provides a strong incentive to employ them to deliver either nuclear warheads or chemical weapons, neither of which require accurate targeting to function as weapons of mass destruction. In 1987, in response to these developments, seven governments, Britain, Canada, France, West Germany, Italy, Japan and the United States, adopted identical guidelines (The Missile Control Technology Regime (MCTR)) to control the transfer of equipment and technology which could make a contribution to missile systems capable of delivering a nuclear weapon. Several categories of items are controlled, ranging from complete rocket systems, to complete sub-systems, to individual components employed in such systems. While the adoption of the MCTR represents an important first step in attempts to control the spread of ballistic missile technology, it will be only partially effective as long as a number of potential suppliers (especially China and the Soviet Union) have not subscribed to it. At the present time, it is a realistic expectation that a number of additional countries will acquire ballistic missiles during the coming decade.

The section on the disarmament obligations of the NPT is particularly timely in view of recent progress on nuclear arms reductions—the U. S.-Soviet INF treaty eliminating all ground-launched missiles with a range of 500 to 5000 km and recent progress in the ongoing Strategic Arms Reduction Talks (START) which will reduce substantially the number of warheads on strategic delivery systems. These reductions represent the first real progress relative to the commitment undertaken by the nuclear weapons states 20 years ago when the NPT went into effect, i.e. "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control." This progress should begin to dispel the perception held by many non-weapons states that the implementation of the NPT has, so far, been one-sided in that it places severe restrictions upon their nuclear energy programs while failing to limit the accumulation of nuclear stockpiles by the weapons states. A second part of this section discusses proposals for bans on nuclear testing, the production of nuclear materials, and the conferences and negotiations that have been held concerning them.

Other sections address the security assurances given to non-weapons states, nuclear-weapons free countries and zones, and previous NPT review conferences.

A final section is devoted to a summary, conclusions and recommendations for measures that might be adopted. Some of the most important of these (in the reviewer's eyes) are:

- The threshold countries should be persuaded by the parties to the NPT — through a combination of political and economic incentives — to join the NPT or a regional denuclearization agreement.
- NPT parties should tighten and possibly render uniform their nuclear export legislation and improve their licensing procedures and the quality of customs control, as well as the exchange of information regarding dubious industrial and commercial activities.
- All non-nuclear weapon parties to the NPT, even those which are not yet engaged in significant nuclear activities, should conclude safeguards agreements with the IAEA, as stipulated by the Treaty. NPT parties should cease supplying nuclear material and equipment to non-nuclear weapon states refusing to accept full-scope international safeguards.
- All NPT parties should join the 1980 Convention on the Physical Protection of Nuclear Material regarding international transport. Levels of physical protection of nuclear material in domestic use, transit and storage, as well as of nuclear facilities, should also be incorporated in an international treaty.
- To contain ballistic missile proliferation more effectively, the Missile Technology Control Regime should be subscribed to by all suppliers of missiles.
- The idea of setting up an international plutonium storage (IPS) should be revived to deal with the stocks of readily accessible weapon-usable fissile material.

The reader will find *Twenty Years of the Non-Proliferation Treaty* to be a useful and comprehensive review of the current status of the non-proliferation regime and its problems and prospects during the next decade.

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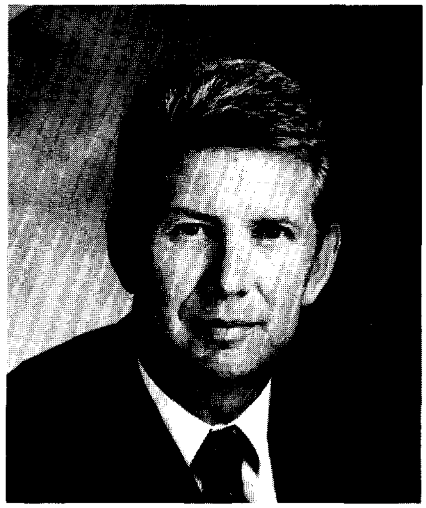
LeRoy confirmed as waste negotiator

David H. Leroy, 43, was confirmed by the U.S. Senate in August, 1990 as the first United States Nuclear Waste Negotiator after receiving a presidential appointment by President George Bush.

LeRoy has served as Acting Governor of Idaho; Idaho Lt. Governor; Idaho Attorney General; ADA County Prosecuting Attorney; Founder and Chairman, National Caucus of Republican Lt. Governors; Chairman, National Conference of Lt. Governors; Chairman, National Association of Attorneys General, Western Conference; and Chairman, National Association of Attorneys General, Energy Committee.



David H. LeRoy

PNC receives award from the Institute of Nuclear Material Management

On July 17,1990 at the 31st Annual Meeting of the Institute of Nuclear Management (INMM) in Los Angeles, PNC received an award in recognition of outstanding efforts in the technical development of safeguards.

PNC has a long history of utilizing plutonium for peaceful purposes, as well as contributing to the development of safeguards techniques and encouraging international cooperation in safeguards.

Power Reactor & Nuclear Fuel Development Corporation (PNC) began its relationship with safeguards in 1966, when its Plutonium Fuel Development facility took delivery of 260 grams of plutonium from the United States. That relationship has expanded in quantity, form and content, with the advancement of plutonium fuel facilities and the commissioning of a reprocessing plant, an enrichment plant and other facilities.

Along with the above-mentioned development activities, PNC has established and maintained a material accounting system as a fundamental measure for safeguards in each facility and accumulated valuable knowledge in the implementation of such safeguards.

To pursue safeguards research and development for these facilities, PNC joined various international programs prior to the operation.

Two such international colloquia, the Tokai Advanced Safeguards Technology Exercise (TASTEX), a joint study project by Japan, the United States, France and the International Atomic Energy Agency (IAEA) for finding a safeguards regime suitable for reprocessing facilities, and the Hexapartite Safeguards Project, a joint study by Japan, the United States, Australia, the TROIKA (the United Kingdom, West Germany and the Netherlands), IAEA and the European Atomic Energy Community (Euratom) for developing a safeguards regime suitable for enrichment facilities. As a follow-up to the above meetings, JASPAS (Japan Support Program for Agency Safeguards) and PNC/DOE (a joint program with the U.S. Department of Energy) are currently proceeding with international cooperative activities for the development of more effective and efficient safeguards technology

The results of these joint projects are currently being applied to existing PNC facilities. Some examples include the development of the microwave method for plutonium/uranium mixed conversion, which has an advantage in nonproliferation capabilities; development of non-destructive assay technologies for timely determination of the quantity of nuclear material; and development of advanced containment and surveillance systems applying the latest electronic technology.

PNC's shining example of superior safeguards technology is the advanced safeguards system at Tokai Plutonium Fuel Production Facility (PFPF), which began operations in 1988. PFPF is a showcase facility featuring the latest remote-controlled and automated safeguards technology such as on-line and real-time systems.

Japan must rely on overseas resources for virtually all energy supplies and therefore is committed to reprocessing and plutonium recycling with a long-range view, to encourage more effective use of uranium resources and to stabilize the nuclear power supply.

"Nuclear energy for peaceful use only, and securing nuclear safety," as provided for in the "Atomic Energy Basic Law," is the fundamental nuclear policy of Japan. Based on this, PNC is concerned with reprocessing, enrichment, and plutonium fuel production and with the development of new types of reactors, such as the ATR and FBR. In fact, most of the plutonium utilization facilities in Japan are concentrated in PNC.

Morse Security Group honored by U.S. Department of Commerce

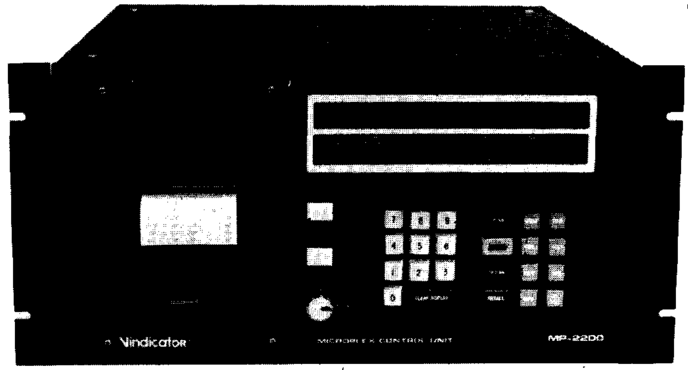
The Morse Security Group has been noted by the National Institute of Standards and Technology, a division of the U.S. Dept. of Commerce, for its achievement in developing the encrypted alarm signalling system used in the T.R.A.P. 5200 Touch Response Alarm Processor manufactured by the Morse Security Group.

The Morse T.R.A.P. system has been placed on the NIST Validated Data Encryption Devices list.

Hy-Security introduces new Gate Operator

Hy-Security Gate Operators, celebrating its tenth year in the gate operator market, has just introduced a new slide gate operator, the 111 LS. The 111 LS is a hydraulic-powered slide gate operator that will operate most commercial slide gates easily. The technology that went into the new operator has been in the developement stage for ten years and was combined with the field experience gained from ten years of pioneering the hydraulic gate operator market to produce this machine.

The new 111 LS will develop over 100 pounds of draw bar pull, and it will cost a third less than other hydraulic models, according to the manufacturer. Like the other machines in the product line, it is rated for continuous duty, accepts all access and safety devices and performs well in all climates. The operating speed of this new machine is 1.3 feet per second, the fastest in its field. For information and details about this new operator, call (800) 321-9947. For a free planning guide for automating a gate, write to Hy-Security Gate Operators, P.O. Box 31532, Seattle, WA 98103.



New monitor and control system from Vindicator

Vindicator Corp. announces the availability of a new Monitor and Control System—the MP-2200. Based upon the MicroplexTM series of monitor and control units, the new MP-2200 offers expanded zone capacity (up to 4080 zones), encrypted data transmission (either DES or proprietary), high speed annunciation, automatic sensor self test and more. The new MP-2200 has internal 6-hour battery backup and has been designed to fully comply with U.S. government standards such as DIAM 50-3.

The unit comes complete with a built-in two-color printer and supports other Vindicator peripherals such as the CM-5510 color graphics system, the PVS-648 video switching system and Vindicator's MD/RD-3300 map displays. The MP-2200 is available either rack mountable or as a desk mount unit and is fully compatible with Vindicator's UHS-Net® Network transponder and gateway products.

Vindicator Corp. develops, manufactures and markets proprietary electronic products and services for the protection and management of critical resources. Headquartered in San Jose, Calif., Vindicator specializes in the design and manufacture of alarm processing systems, multiplexing equipment, entry control systems and both fiber optic and wire data communications networks.

Helium-3 Proportional Counters for Neutron Measurements

TGM Detectors Inc., a major manufacturer and supplier of gas-filled radiation detectors, is now producing Helium-3 (He-3) Proportional Counters, according to Vice President David J. Allard.

The technology for He-3 detector production was obtained by technology transfer from TGM's affiliate Centronic Ltd. in the UK and via aquisition of Harshaw's gas tube division last spring. TGM also provides other styles of radiation detectors, such as Geiger-Mueller (GM) tubes. This new production equipment will provide TGM with the capability to build other styles of radiation detectors such as boron trifluoride neutron detectors, x-ray proportional counters and ion chambers, according to Allard.

TGM Detectors Inc. is a spinoff from the 1960s Tracerlab and began independent production of GM tubes in 1972. The company has attained broad recognition in domestic and international markets for the supply or detectors for health physics and industrial nucleonics applications. It has relocated several times to increasingly larger facilities in Waltham, Mass.

The company was aquired in 1985 by the Morgan Crucible Co.'s Electronic Division when TGM's founders retired.

Canberra offers free spectroscopy guide

Canberra offers a technical applications note entitled "A Practical Guide to High Count Rate Germanium Gamma Spectroscopy." This applications note discusses the basic system components and their impact on the overall system performance, specifically throughput and resolution.

Regardless of your experience in gamma spectroscopy, this guide provides valuable information for configuring a new system or upgrading an existing system. Contact the Canberra Nuclear Products Group at (800) 243-3955 for more information.