20TH ANNIVERSARY

SAFEGUARDS · INMM · RELIABILITY · ASSURANCE

1958-1978

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INMM

NUCLEAR MATERIALS MANAGEMENT

Vol. VII, No. 1
Spring 1978

JOURNAL OF THE INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

EDITORIAL

Reassessment

By W.A. Higinbotham
Brookhaven National Laboratory
Upton, Long Island, N.Y.

In the summer of 1966, President Johnson withdrew the U.S. proposal to develop a multilateral nuclear force with NATO, soon thereafter, the US, UK, and USSR reached agreement on the terms of the nuclear non-proliferation treaty. The September 18 issue of **The New York Times** carried an article headed: Uranium Losses Spur Drive for Tighter U.S. Control of Fissionable Material: the NUMEC MUF had spurred the ABC to initiate a study of safeguards:

The introduction and the recommendations of the Advisory Panel on Safeguarding Special Nuclear Material are reproduced in this issue. This report set the directions for the development of regulatory safeguards and for improved material control and accounting at AEC licensee facilities. It is a document of considerable interest to those concerned with safeguards. You may judge how well it has stood up.

Appendix 8 of the report is also reproduced here because it is the INMM contribution to the study. It would be interesting to learn how much of the ambitious program, proposed then, was actually carried out.

Of particular interest today is what exactly are the Administration's objectives for the International Nuclear Fuel Cycle Evaluation and related programs? How can we help to achieve these objectives? We were fortunate to obtain the paper by **Lawrence Scheinman,** Professor of International Law, Organization and Politics at Cornell, who is this year on leave, serving as Senior Advisor to the Under Secretary of State for Security Assistance, Science and Technology. Scheinman has written a number of perceptive papers on inter-national safeguards and presently is involved in implementing and interperting nonproliferation policies.

The thoughtful paper by **Jim de Montmollin** is another useful perspective. The risks that proliferation of nuclear weapons pose for U.S. and international security have not been carefully analyzed by anyone. But there certainly are some risks. On the other hand, the world needs nuclear energy. A lot of effort is presently being expended in designing and evaluating the proliferation resistance of alternative nuclear fuel cycles. Surely institutional solutions deserve as much emphasis.

During this period of review and reassessment, it seems appropriate that the Journal contain articles of this nature. Any contributions or suggestions for future articles will be appreciated.

In the last issue we initiated a series of bibliographies from safeguards R&D groups. In this issue there is a list of Mound Laboratory titles with abstracts and a detailed summary of the content of recent Sandia physical protection manuals. We hope that others engaged in R&D will take advantage of this opportunity to acquaint the rest of us with what they have accomplished.

Dr. Higinbotham

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Two Pleasant Years

By Roy G. Cardwell, Chairman
Institute of Nuclear Materials Management, Inc.

As I approach the end of my term in the INMM Chair, I can hardly believe that two years have passed since **Armand Soucy** handed me the gavel in Seattle. But, I can believe without any doubt that this has been two of the most pleasant years I have ever spent. Hectic? Yes. INMM is no longer the fledgling "committee" of dedicated folk in the profession who had to pass the hat to pay the bills at the first annual meeting. It is, to paraphrase Past-Chairman **Jim Lovett,** a well recognized and sought-after organization in the forefront of the safeguards and nonproliferation controversy and as a result is both thriving and growing.

Just how thriving has been brought vividly to my attention this year since my close working relationship with **Tom Gerdis** was established by action of the Executive Committee. Tom, with the help of **Willy Higinbotham** and the editorial staff, has developed and is responsible for publishing an Institute Journal of which we can all be proud. In addition, he was recently given more responsibility in administering a greater portion of the society's business activities. These have been attacked with vigor, which is a characteristic I have observed in this young man since he came on board in November, 1971.

But this vigor does not end with Tom. A dedicated group of officers and standing committee chairmen along with an enthusiastic Executive Committee spend a great deal of time without compensation in making the programs of INMM work. It would be an impossible task to cite every example of contribution these past two years by these folk and the many committee members who work with them, but the great amount of time contributed is evident simply by reading their regular reports in the Journal.

I am extremely pleased that our society has moved its operation well into the black financially during the past two years without a major increase in dues or other member costs. This was a primary goal I sought at the outset of my term so that we could proceed with some worthwhile activities, such as scholarships and awards to encourage interest and accomplishment in the profession and at the same time make us more visible as the vital part of the nuclear industry that we are.

Mr. Cardwell

This healthy situation has occurred mostly because **Bob Keepin** and the Annual Meeting Committee orchestrated such a highly successful Washington meeting last June. The amount of work that goes into this major INMM event is very demanding; yet, this group is now working two years into detailed meeting plans and arrangements, and has selected sites and booked hotels for the next four years. There is also no doubt in my mind that by the time you read this the Executive Committee will have heard and accepted a recommendation from a special ad hoc committee to add a winter topical meeting to our schedule.

The situation has also been enhanced because **Harley Toy's** Education Committee has produced two very successful seminars by **John Jaech,** who presented his course both in Ohio and on the West Coast with a great deal of response.

And, I cannot let this opportunity pass without mentioning that John Jaech's tenaciously oriented N-15 organization continues to grind away at those all-important NMM standards. I have been told that INMM produces more standards per member for ANSI than any other participating organization.

Nor can I pass without lifting my glass to Jim Lee for the super job he has done as Membership Chairman, i.e., just about doubling our membership since he took the assignment.

I am also happy to report that, after a major setback, Fred Forscher and his committee have vigorously pursued an entirely different approach to the problem, and I am very hopeful that an acceptable program is now a possibility.

Finally, the goal which has given me the most concern suddenly came together in late February when I received Safeguards Chairman **Syl Suda's** latest report to the Executive Committee. I have been sincerely searching for INMM's proper place in the area of public information and education (not a duplication of but a parallel to other society programs, such as the fine Nuclear Advisory Service sponsored by ANS). When I appointed Syl, I asked him to give some consideration in his organizational plans to getting our side of the story out to the press as quickly and strongly as possible—*a real time response* to inaccurate and disproportional reporting of nuclear incidents. He has

(Continued on Page 21)

David Hall Retires

David B. Hall, LASL employee since 1945 and former leader of R-Division, retired in January. He now is a consultant to the Laboratory's Q-Division, and is a member of the Atomic Safety and Licensing Board.

Hall started at LASL in November 1945 and was group leader for implosion testing (RaLa) from 1945-1947. From 1947 to 1951 he served as group leader in charge of building and operating the first fast plutonium reactor—Clementine.

He was alternate leader of W-Division from 1956-56, and from 1956 to June, 1970, division leader of K-Division, reactor development. During his service with this division, he supervised construction and operation of LAPRE II, LAMPRE I and the UHTREX.

In 1970 he was named leader of the Assay and Accountability Division, a safeguards research and development program, and in 1975 he was named head of the new Reactor Safety and Technology (R) Division.

Before coming to Los Alamos, Hall was physics instructor at the University of Denver, associate physicist at the University of Chicago Metallurgical Laboratory, and was a physicist at the Hanford Engineer Works, Hanford, Wash.

Hall is a fellow of the American Physical Society and American Nuclear Society.

Regular and Special Features and Articles

Our 20th Anniversary 'Roots' Meeting in Cincinnati

By G. Robert Keepin
INMM Vice Chairman
Los Alamos (N.M.) Scientific Laboratory

The Institute's Nineteenth Annual Meeting will open on Tuesday, June 27, 1978 in Cincinnati, Ohio at Stouffer's Cincinnati Towers/Convention Center. Most significantly, the Cincinnati meeting will mark the Twentieth Anniversary of the Institute, and some very special events are being planned to commemorate this major milestone in the life of our growing Institute. As most of you are already well aware, the INMM has its "roots" in the State of Ohio, where it was incorporated on May 17, 1958 as "a non-profit organization of individuals working in government, industry and academic institutions where nuclear materials are utilized."

Returning to the birthplace of the Institute -- in the "Buckeye state" -- was obviously the "natural" choice for our 1978 annual meeting commemorating the Institute's 20th jubilee. In the same "buckeye" spirit, we are hoping to have the distinguished U.S. Senator from Ohio, **Senator John Glenn,** as our 20th Anniversary keynote speaker. Senator Glenn's leadership role in the development of national nuclear energy policy -- and particularly the key issues of nonproliferation and international nuclear trade -- is well known throughout the United States. Moreover, Senator Glenn is a friend and supporter of the work and goals of the Institute; in a recent letter he stated "I share your profound commitment to finding solutions to nuclear energy issues", and specifically asked to be kept apprised of Institute activities, and to be contacted on issues of mutual interest in the field of safeguards and nuclear materials management.

Our keynoter at Cincinnati will head a roster of distinguished speakers and panelists from government and the industrial nuclear community. Under the general meeting theme, "Safeguards and Nonproliferation", the INMM technical program committee, headed by **Gary Molen**, is assembling an excellent technical program designed to keep attendees abreast of the latest developments in the rapidly evolving field of nuclear materials management, safeguards and security.

All of us in the INMM can be justly proud of our Institute which has been working hard on nuclear safeguards problems for two decades -- certainly long before the subject was "discovered" by **Ralph Nader** and the nuclear critics, and also long before there was any "safeguards bandwagon" to jump on.

As many of you are already well aware, we are essentially assured of a successful and smooth running meeting as all local arrangements are in the expert hands of **Bernie Gessiness** (of National Lead of Ohio), Local Arrangements Chairman for our very special 20th Anniversary "Roots" meeting in Cincinnati -- the home of the Cincinnati Reds and Riverfront Stadium, the famed King's Island amusement park, fabled Seven Hills, Foutain Square, and at least two of the nation's five star restaurants.

All of us who share in the Institute's long-standing commitment to the practical reality that nuclear energy is necessary here and now, and that the goals of effective safeguards and nuclear materials management can and are being achieved, should by all means plan to attend this year's Annual meeting in Cincinnati. We hope to see you there in June.

Dr. Keepin

Tribute to Alto

By John L. Jaech, Chairman
Exxon Nuclear Co., Inc.
Richland, Washington

It is fitting that I pay a tribute in this column to **Dick Alto** who had served the Institute faithfully as N15 Secretary for many years until his recent resignation. It is especially fitting that he be given this recognition, inadequate as it may be, because there has been no one more concerned than he about the lack of recognition generally accorded the hard working members of standards writing work groups. At numerous meetings of the INMM Executive Committee, Dick has brought up this subject and it is largely through his persistence that some means of recognition is being planned for N15 writing groups as new standards are approved by ANSI.

While Dick has been outspokenly appreciative of the efforts of writing groups, he at the same time has been modest about his own contributions to the success of N15. In any organization, there is no one more aware of the important work of the secretary than is the chairman. I say without reservations that Dick has been indispensable in his role as N15 Secretary. When I accepted the chairmanship in the Fall of 1974, I was at a loss as to how to proceed. Dick graciously volunteered to meet me in Washington, D.C. one evening and in those few hours he filled me in on how N15 operates. This meeting set the stage for a fine working relationship that lasted until Dick's resignation. It is with a deep feeling of appreciation that I take this means to express my personal thanks to Dick for his efforts, and I am sure that I speak for the entire INMM membership in wishing him well in the future.

While saying goodbye to Dick Alto, we at the same time welcome **Dave Zeff** as his successor. Dave is also employed by Babcock and Wilcox and was recommended by Dick Alto to be his replacement. The transition is certainly simplified in this instance, and I look forward to working closely with Dave in the future.

Looking ahead to the Cincinnati meetings on June 27-29, present indications are that there will be considerable N15 activity taking place just prior to and just after these meetings. At this writing, one subcommittee plans to meet on Sunday, eleven meetings are scheduled for Monday, and eight for Friday. As products, we expect to have several draft standards in final form and ready for balloting in the Fall. There has been a long dry spell in published standards, and I am hopeful that we can get on track again soon.

If you have an interest in standards, whether or not you are a member of the INMM, feel free to drop in on any of the working sessions and witness the birth of a standard. These are open meetings. Hopefully, attendance at one of these will inspire you to participate in the future. Meeting times and locations will be posted.

See you in Cincinnati!

Mr. Jaech

Mr. Alto

Mr. Zeff

Seeks Input

By Dr. Frederick Forscher, Chairman
Pittsburgh, Pennsylvania

There seems to be a consensus that the INMM will recognize safeguards professionals in three specific areas of competence. These designations are specific but clearly, not distinct. There will be considerable overlap in the expected proficiencies among the three, most certainly between the first two, certifications.

a. Material Measurement Professional;
b. Material Control and Accounting Professional;
c. Security and Reactor Safeguards Professional.

The requirements for professional recognition - and this is true for almost every professional organization - includes a written test to evaluate the candidate's knowledge and understanding of the subject matter. We are now at the point in the development of our Certification Program where we would like to assemble a representative collection of test questions in the various areas of proficiency that our membership represents.

This notice in the Journal serves as an invitation to all members of the INMM, and to all readers of the Journal, to propose to the Certification Committee as many questions as the individual proposer feels competent to submit. The following simple guidelines should be observed.

1. Psychometric specialists agree that the most satisfactory form of objective testing is the multiple-choice form. An item of this type begins with an introductory statement (premise) which presents the problem or asks the question, and is followed by four or five choices, one and only one of which is correct.

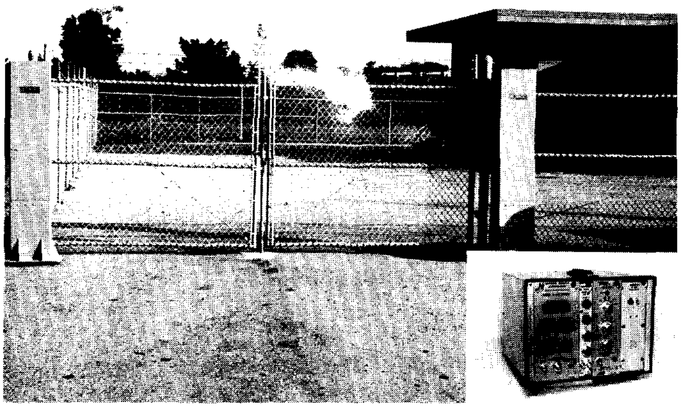
2. The premise should be concise, and stated in such a way, that it is possible to select a single correct answer. Premises should be positive statements (rather then negative statements), should be as short as possible, and unambiguous. If dealing with controversial subjects, the premise should explicitly recognize the existance of the controversy.

3. The correct choice should always be logically and grammatically related to the problem (or question) in the premise. The choice should be clear and unambiguous, and not depend on words which "give away" the answer. The last statement means that the answer should not be determined solely on the bases of "professionally approved" words or phrases (e.g.: as low as practicable, proliferation resistance, etc.)

4. The incorrect choices should be absolutely incorrect, but should sound plausible without being tricky. The incorrect choices should parallel the correct choice in all essential features, such as logic, grammar, and length.

Please mail your contributions to Dr. Frederick Forscher, Chairman, INMM Certification Committee. 6580 Beacon Street, Pittsburgh. PA, 15217.

Dr. James A. Lechner [right], NBS statistician and prominent participant in the NBS Safeguards Measurement Assurance Program, is engrossed in an issue of Energy Commentary and Analysis, a bi-monthly newsletter, issued by Dr. Frederick Forscher, Chairman of the INMM Certification Committee, and consultant to the NBS program. This photo was taken by James W. Lee of Tri-State Motor Transit Company during the 1977 annual meeting of INMM in Washington, D.C.



SNM Vehicle Monitor from NNC

A new Special Nuclear Materials (SNM) Vehicle Monitor for detecting SNM in passenger and truck vehicles is now available from National Nuclear Corporation (NNC), Redwood City, California. This Vehicle Monitor is a continuation of NNC's line of SNM protection monitors which include the HM series Hand-Held Monitors, DM-2 Door Monitors and DM-4 Ultra High Sensitivity Door Monitors.

The NNC Vehicle Monitor features a sturdy, all-weather fiberglass housing, ruggedized and shielded NaI detectors, and the new NNC digital electronics. The NNC Digital Personnel or Vehicle Monitor electronics uses the INTEL 8080A microprocessor to perform the computations to detect SNM alarms. The microprocessor uses a sliding interval counter to distinguish background radiation from SNM material passing through the monitor. The algorithms used for these computations are based on work performed by Los Alamos Scientific Laboratory (LASL) Nuclear Safeguards group. The NNC electronics is all plug-in modular construction, designed for NIM compatibility.

NNC states the Vehicle Monitor is available now with detectors, traffic controller (vehicle sensor) and electronics.

Former INMM Chairman, Bernie Gessiness of National Lead Company of Ohio (shown with his wife Naomi) will be coordinating local arrangements at the next Annual Meeting June 27-29 in Cincinnati. This photo was taken during the reception preceding the annual meeting banquet in Boston in 1972.

Mr. Owings

Owings Succeeds Curl

A Tennessee safeguards man has been designated treasurer of the Institute of Nuclear Materials Management through June 30.

Edward Owings, supervisor of the nuclear materials accountability staff of the Union Carbide Nuclear Division operated Y-12 plant in Oak Ridge, succeeds **Robert U. Curl,** Idaho Falls, Idaho, in the position.

In October, Curl accepted a two-year assignment with the International Atomic Energy Agency, Vienna, Austria.

INMM is an organization of some 560 professionals around the world working in governmental, industrial, and academic institutions where nuclear materials are used.

Owings will be up for election at the 19th INMM annual meeting June 27-29 in Cincinnati, Ohio.

The prominent Rockwood resident holds a B.S. degree in accounting from Tennessee Tech. University. A licensed public accountant in Tennessee, he is a Certified Nuclear Materials Manager.

A CNMM is qualified to develop and establish program standards and requirements for a system of nuclear materials and plant protection.

The nuclear materials manager possesses the proficiency requirement to institute detailed procedures and to take such actions as are necessary to create or implement nuclear materials and plant protection systems.

Owings holds a permanent teaching certificate for secondary education; he has served as an elected member of the Roane County Board of Education for 15 years.

The Nuclear Facility Guard Force: Where Will It End?

By Dr. **Ralph F. Lumb**
President, NUSAC, Inc.
McLean, Virginia

The intent of the next few paragraphs is not to resolve the question posed in the title. Indeed, if that question could be answered with any degree of assurance, Federal policy making would probably be such that there would be no need to ask the question.

Part 73 of Title 10 of the Code of Federal Regulations provides the requisite law making machinery that directs the processors of nuclear fuel and the generators of nuclear power to protect their facilities against radiological sabotage and the theft of special nuclear material. Taken at face value this appears to be a reasonable and proper function for industrial management. Unfortunately, this is not where it ends.

What is seen, instead, is the requirement to establish a series of armed camps, situated at each nuclear reactor site and nuclear processing facility, across the breadth of the United States. These forces are not asked to provide a reasonable measure of physical deterrance to thwart a would be intruder, but rather to become engaged in mortal combat against a highly sophisticated, although as yet unidentified, enemy force.

Weapons ranging from side arms to automatic rifles and special police equipment to include bullet proof vests and gas masks, are suggested for use to meet the onslaught.

Although we now see the development of nuclear power at a virtual standstill, time and need will ultimately cause the rejuvenation of nuclear plant construction. What this means in terms of private, well armed security forces is a dramatic increase in their use at from roughly 70 sites to probably over 200 during the next decade. Over this span of time, we can expect these security forces to gain both in quality and sophistication as the market place demands better results from those engaged in this multimillion dollar business.

From these issues one can draw a host of legitimate questions, the answers to which either have been overlooked by the law makers during the generation of Rule development or were selectively not addressed. It seems both proper and prudent that before the growth of these security forces becomes irreversible, responsible people in Government decision making positions must rationally and intelligently address these concerns. Certainly among the questions to be addressed the following would be included.

- Is the design threat basis that generates the very reason for security forces a rational one? Existing studies, developed through U.S. Government fundings, and intelligence as it is known today, tend to substantiate that the threat level described for nuclear facilities has been generated solely to satisfy several of the objectives of current security rule making. In truth, no known threat currently exists.
- Where in fact does the "high" demand for protection against third parties stem? This issue has been so clouded by computer studies, staff interpretations, and the media, that no clear cut picture is evident. One can, however, hear the same rhetoric over and over again that regulatory action has been demanded by the Congress, the intervenors, and the public-at-large. A far more accurate assertion is that the demands have come from small but vocal groups of intervenors and a few Congressional subcommittees with parallel aims that do not at all necessarily relate to any bonafide interest in security.
- Has the traditional police function been transferred from local and state forces, or a Federal role, to private security forces? Rule making has placed the burden to aggressively intervene on the shoulders of private security forces in any attempted theft of special nuclear material or in other acts that could endanger the health and safety of the public as a result of third party criminal actions. However, these forces have not been provided with any special legal cloak to carry out such actions. Hence, in the long term it can be anticipated that both the members of security forces and their employers will be subjected to frequent litigation and possible civil penalties as a result of their actions. Police functions in the truest sense should be borne by the body of government that is closest and best able to provide such support, not by private industry. This should be true whether that industry is involved in the production of nuclear fuel or nuclear power, or concerned with any other legitimate industrial enterprise. The payment of our taxes is designed to support this form of law enforcment.

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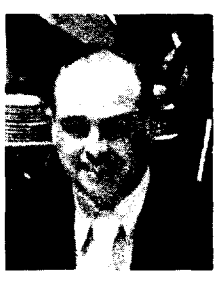

Dr. Lumb

Tests Advanced Concept

Dr. Booman

Dr. **Glenn L. Booman** joined the INMM about six months before the 1976 annual meeting in Seattle. He worked in a program involving the testing and evaluation of an advanced concept for improved materials control in the DOE/Idaho Chemical Reprocessing Plant based on automatic, continuous monitoring of specific plant operations.

Booman has been designated a member of the U.S./Japan technical team for improved safeguards of The Tokai-Maru reprocessing plant (1978). He has been involved in the U.S. Nuclear Regulatory Commission Special Safeguards Study and is currently involved in safeguards evaluations for DOE.

He has been at Idaho Falls in measurement system development, for 23 years at the Idaho National Engineering Laboratory. He served as senior staff scientist assigned to technical guidance efforts for safeguards R&D. He transferred to Brookhaven in international safeguards in April.

Glenn is married. He and his wife Joyce, who reside at Brookhaven National Laboratory, have two children: James, 21, and Jan, 19. James is at the University of Maryland, College Park; Jan, University of Utah, Salt Lake City.

Safeguards Vital in Nuclear Age

SANTA FE, NM. "The United States vitally needs nuclear power today...and will continue to need it well into the next century," Kiwanians from Santa Fe and Los Alamos were told at an interclub luncheon meeting at Santa Fe's La Fonda Hotel recently.

The guest speaker, Dr. G. Robert Keepin, Director of Nuclear Safeguards Programs at the Los Alamos Scientific Laboratory, stressed that future realization of the great potential of nuclear power for supplying expanding worldwide energy demands will require stringent safeguards and control of the special nuclear materials that fuel nuclear reactors.

Dr. Keepin outlined the key role that modern safeguards technology is playing in implementing effective safeguards, surveillance and control of nuclear materials in all types of nuclear facilities.

On the international level, Dr. Keepin noted that as new safeguards instrumentation is developed in the U.S. and other countries, it is made available for evaluation and use by the International Atomic Energy Agency (IAEA) in administering a worldwide system of safeguards inspection and control.

Advertising Index

Committee Seeks Help

By James W. Lee, Chairman
INMM Membership Committee
North Palm Beach, Florida

Despite a noticeable response to the appeal sent to each member with the last edition of the Journal, asking for individual member's assistance in obtaining qualified new members, the end of February finds our new member total trailing this same period last year with nine fewer new members on the books.

While the Institute is not seeking to enlarge for growth's sake alone, it must continue to build a solid base of experienced and qualified persons who are able and willing to help the nuclear industry by their active participation in the work of the Institute. There are many such individuals in the nuclear industry who do not belong to INMM. Members of the Institute have a far better knowledge of these people than the Membership Committee does. That is why your Membership Committee constantly urges you to send it the names of your friends and colleagues who are individuals of the calibre and ability the Institute needs to carry out its important and useful functions.

Where do INMM members come from? Have you ever wondered what mix of the nuclear industry employment makes up our membership? Before you read any further in this column, play a little game with yourself. Write the percentage of each of the following groups which you think comprise the makeup of the new members of the Institute this year. Employees of: Government and Contractors, Industry, Utilities, Foreign.

Then, compare your guess with the actual proportions which follow.

Government and Contractor	22
Industry	16
Utility	1
Foreign	21

Were you surprised? Probably not, for it is logical to assume that a good proportion of our membership comes from the government and related industrial firms. However, in the last few years, we have seen a large upsurge in the proportion of our members who are located in other countries, thanks to the efforts of many members, and especially vice-chairman **Bob Keepin,** past chairman **Jim Lovett, Yoshio Kawashima, Reinosuke Hara, Herman Miller, Ron Tschiegg,** and **Shugo Suenaga.**

Those of you who have been instrumental in obtaining new members may wonder how the Institute processes new applications.

Most applications are received by **Vince DeVito,** our Secretary who approves the application, then forwards it to **Ed Owings,** our Treasurer. After his approval it is sent to **Jim Lee,** Chairman of the Membership Committee who notes his approval, classifies the application and sends a membership card and letter of welcome, which explains ongoing INMM activities and invites the new member to actively participate in the Institute functions by joining one of the committees or volunteering to work with a standards group.

Applications which do not contain references from two INMM members, or at least three other references are given further handling by the Committee.

Journal editor, **Tom Gerdis,** also receives a copy of the application from the Secretary. He, too, writes a letter of welcome and furnishes the new member with a membership directory and a copy of the latest edition of the Journal.

Every effort is made to acquaint a new member with information which will enable him to follow his particular interest in his work with the Institute.

New Members

The following 18 individuals have been accepted for INMM membership as of March 1, 1978. To each, the INMM Executive Committee extends its welcome and congratulations.

New members not mentioned in this issue will be listed in the Summer 1978 (Volume VII, No. 2) to be sent out August 1, 1978.

Minoru Aoki, Accountability, Plutonium Fuel Division, Tokai Works, Power Reactor and Nuclear Fuel Development Corp, Tokai-mura, Ibaraki-ken, Japan 319-11.

Bernard J. Bossick, Manager, Uranium Inventory, Westinghouse Nuclear Fuel Division, Drawer R, Columbia, South Carolina 29250.

Daniel A. Daigler, Senior Engineer (Quality Assurance), United Nuclear Corp., Fuel Recovery Operation, Wood River Junction, Rhode Island 02894.

John B. Estes, Security Training Specialist, Georgia Power Co., No. 6 LaVista, Suite 116, Tucker, Georgia 30084.

Mr. Lee

Where Will It End?

(Continued from Page 10)

• Who is concerned with the growth of relatively uncontrolled military type forces across the U.S.? American tradition has consistently held to severely limiting the influence and power inroads the U.S. military might opt to grab. This is altogether proper and in keeping with tradition. Yet, no one in Government seems at all concerned with the potential proliferation and lack of control over the private guard force armies that are now in the embryonic stage of development at each nuclear site in the U.S. A review should be demanded to indicate what the private security force armies will resemble in the year 2000, given the expected growth of nuclear power and the parallel growth of security forces.

More important is the threat they may pose to the fundamental organs of our national security. Such growth violates American law enforcement tradition and represents the imposition of an unhealthy situation upon an American society that is now struggling to retain its deeply rooted concepts of government.

• Where will the syndrome involving the protection of special nuclear material end? It follows that all hazardous materials manufactured or used by industry may eventually require protection from third parties by use of Federally mandated security forces. The scenario is never ending and can ultimately lead us to a pseudo military based industrial society as is commonly found in many parts of the world.

The questions presented here, and others that could be readily posed, deserve legitimate answers from those who have created the condition. Not answers cloaked in cliches, such as "by public demand," but substantive answers derived from accurate facts and rational thinking. Hand in hand with the development of such answers should be a detailed assessment of whether this is the road America wants one of her principal industries to follow.

James V. Filsinger, Specialist (Nuclear Material Accounting), Battelle, Pacific Northwest Laboratory, P.O. Box 999, Richland, Washington 99352.

Max C. Geisler, Assistant to Manager (Special Materials), Argonne National Laboratory, P.O. Box 2528, Idaho Falls, Idaho 83401.

Samuel R. Greco, Nuclear Material Accountability Representative, Nuclear Fuel Services, Inc., P.O. Box 124, West Valley, New York 14171.

Kazutaka Gotoh, Chief Engineer, Nippon Electric Co., Ltd., 500, Soya, Hadano-shi, Kanagawa-ken, Japan.

Dennis J. Haskins, Physical Security Analyst, Westinghouse Hanford Co., P.O. Box 1970, Richland, Washington 99352.

Betty W. Holz, Systems Analyst, U.S. Nuclear Regulatory Commission, Room 881SS, Washington, D.C. 20555.

William F. Lindsay, Scientist (Safeguards Engineering), Science Applications, Inc., 2201 San Pedro, N.E., Albuquerque, New Mexico 87110.

Toshiyuki Matsuura, Engineering Manager, Nippon Electronics Co., Ltd., 500, Soya, Hatano-shi, Kanagawa-ken, Japan.

Oichi Mizuno, Assistant Senior Engineer, Power Reactor and Nuclear Fuel Development Corp., Tokai-mura, Ibaraki-ken, Japan.

William Powers, Material Control Performance Analyst, Babcock and Wilcox Co., NMD, 609 North Warren Avenue, Apollo, Pennsylvania 15613.

Michael D. Rosenthal, Physical Science Officer, U.S. Arms Control and Disarmament Agency, ACDA/NP/NE, Room 4953, Virginia and 21st, Washington, D.C. 20451.

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Come A Long Way

By Raymond E. Lang
U.S. DOE
Chicago, Illinois

Future meetings: Annual meetings are firm until 1981: Cincinnati, 1978; Albuquerque, 1979; West Palm Beach, 1980; and San Francisco, 1981. The 1981 meeting in San Francisco is not completely firm. Herman Miller and I working on this meeting.

It is still too early to tie the 1982 meeting down, but we should consider the general location that we would like. I suggest that we consider returning to Washington from time to time, and 1982 may be the time.

Proposed Establishment of Meeting Committee

INMM should consider the establishment of a permanent "Meeting Committee" as one of the standing committees of the Institute. Most large organizations have a full-time position of "Meeting Manager." The Vice Chairman of the INMM has served in this capacity for us. Several years ago, the INMM noted the need for more continuity and professionalism in its meetings, and the executive committee assumed the function of long range meeting planning. (Previously, this function had been done by the members at the annual meeting.)

The institute has come a long way in its goal of continuity and professionalism in planning and running its meetings. I suggest that the next step is the establishment of a meeting committee headed by the Meeting Manager.

There are three major advantages to this plan:

1. The Vice Chairman would be free to devote time to overseeing other committees, in addition to the meeting committee. With the growth and diversity of the INMM, it seems that the Vice Chairman's time could be well spent in such broad activities, rather than be tied down to such a major function.

2. The INMM would have a standing organization with the ability to respond on a rapid basis to the need for a special meeting on a timely subject. Such a standing organization could put a topical meeting together in a six to eight week period, as the need rose.

3. Additional members would have the opportunity to become involved with the INMM committee work.

The meeting committee would be composed of several permanent and temporary subcommittees. Permanent subcommittees would include registration, exhibits, meeting treasurer, promotion, and site selection (long range planning). The temporary committees would include the program chairman and local host committees for specific meetings, as well as the general chairman for a meeting. These later committees are rather time consuming, and an individual ought not be expected to serve more than a few years. The former committees are less time consuming and also require some degree of experience; serving for several years would not be a burden on the members.

Raymond E. Lang (r.), LaGrange Park, Ill., Chairman of the Site Selection Committee for INMM annual meetings, visited with Dr. Manuel A. Kanter (l.), director of the safeguards training program at Argonne (Ill.) National Laboratory during one of the breaks at the 1976 meeting in Seattle, Wash.

The Administration's Nuclear Policy: Another Viewpoint

By John Ladesich
Southern California Edison
Rosemead, California

There is a favorite cliche about Government work stating that in the Government one can do nothing, do something, or study the problem, and when in doubt, study the problem again. The Carter Administration's nuclear policies certainly exemplify this mode of operation. The non-proliferation policy which places a moratorium on reprocessing and recycling spent nuclear fuel is a do nothing policy toward the closing and commercialization of the tail end of the fuel cycle. However, to give the appearance of doing something the Administration has initiated the International Fuel Cycle Evaluation study to investigate potential alternative fuel cycles which are more resistant to proliferation. Although many of these alternative fuel cycles have been extensively studied in the past and the present uranimum fuel cycle technology has evolved as the most economical and most practical fuel cycle, continued hope is being expressed that a more secure fuel cycle will be found. Results of this study are not expected for at least a year and the industry must sit on its hands until the Government makes up its mind on what its future policy will be.

Since the oil cisis of 1973-1974 had become a faded memory in the minds of most Americans, the announcement of the President's non-proliferation policy last year has acted as a catalyst to put in the forefront the serious energy problems which face the country in the future. Although there is some debate as to whether the non-proliferation policy is productive or non-productive toward solving the future energy needs of the country, it has brought to the surface a major problem which had to be solved on an international basis, that of safeguarding special nuclear material. If nothing is accomplished other than to achieve some strong international safeguards agreements and mechanisms for inspections of facilities, this will be a significant contribution toward the future development of the nuclear industry.

Utilities are not opposed to the non-proliferation objectives nor to the extensive accountability procedures and physical security which will be needed to insure proper safeguarding of nuclear fuel. They are, however, frustrated at not being able to get on with the job. Their concern is to be able to provide sound and reliable electrical energy to their customers and they are therefore generally supportive of those actions which tend to improve this reliability.

Utilities have a minimal requirement for safeguards as compared to other fuel manufacturing facilities, but they do have a great concern over the overall impact because the ultimate costs will be borne by their customers. The fuel at a nuclear generating station is handled as a fuel assembly and safeguards are simplified to piece-count accountability and physical security of the facility. There has been a noticeable increase in improving physical security over the past several years and a much greater emphasis will be needed in the future.

The Administration's nuclear policy has had a significant impact on the utilities planning for future energy resources by placing a very large uncertainty on the future commercialization of the nuclear fuel cycle. Conservation and conventional fossil-fueled units are being selected for new generation in preference over nuclear generation which is being delayed or abandoned. In spite of this uncertainty, the utility industry as a whole will continue to support all efforts to safeguard special nuclear material and will become increasingly more involved in all aspects of nuclear material safeguards.

The INMM can expect greater participation by utilities in the Institute's activities in the future and INMM members must continue their excellent work to provide the incentive. Future energy needs of the United States and the World are so great that the nuclear option with reprocessing and recycle cannot be abandoned. When the dam of opposition is overcome, there will be a flood of new orders and we must be ready to accept the challenge.

Mr. Ladesich

BOOK REVIEW

"Report to the American Physical Society by the Study Group on Nuclear Fuel Cycles and Waste Management (to be published in The Review of Modern Physics)"

By William A. Higinbotham
Brookhaven National Laboratory

It should be obvious that the days of cheap and abundant energy are past and that the US and the rest of the world are confronted with difficult decisions for the future welfare of society. Although nuclear energy should play an important role in the future, the discussions of what that role should be has been more didactic or emotional than socially constructive. There are the pro-nukes on one side, the anti-nukes on the other and the befuddled public and its government somewhere in between. In an effort to initiate a more productive dialogue, various official and unofficial groups have supported studies which, hopefully, would be more objective than those conducted by partisans and more credible to the public than those conducted by government agencies, business or the AF of L.

An early influential study was that sponsored by the Ford Foundation in 1971-4, which produced the Taylor-Willrich volume on nuclear safeguards and suggested that conservation could substantially reduce the requirements for nuclear energy. The recent Ford-MITRE study explained the rational behind the present national effort to find technico-political solutions to proliferation. The National Academy of Sciences-National Research Council has been working on a big study of nuclear and alternative energy sources, which seems to have become so complicated that the report will never be finished.

Perhaps the most useful of these studies, for those involved, one way or another, with nuclear policy, are the two studies conducted by the American Physical Society: The first, a technical review of the Rasmussen report on reactor safety, and the second which deals with radiation hazards, waste disposal, safeguards, and proliferation. Both of these studies focussed on the scientific and technical factors, attempting to provide the basis for decision making. The reactor safety study found some short comings in the Rasmussen report, but generally supported the conclusion that reactor risks are small compared to the benefits that nuclear power offers. The more recent study should clarify a number of issues presently being debated and contribute substantially to a more rational discussion of the proper future role of nuclear power. This paper is not exactly **Reader's Digest** style. It is intended for technical people, in government, in industry, in the news media, and the intervenor groups. It is to be hoped that all of these influential and concerned groups will take the time to study this report.

Dr. Higinbotham

Although the title might give the impression that the APS invented this project, the fact is that it was suggested and paid for by the National Science Foundation. The study group consisted of 12 busy and respected physicists. The report was reviewed by a committee appointed by the APS Council which monitored the study and endorsed the conclusions and recommendations.

Like all recent reports of this nature, it starts with a summary and an introduction. For example: "for normal operation of all fuel cycles studied, potential radiation exposures from either wastes or effluents do not appear to limit deployment of nuclear power." "Recycle would provide significant reduction in ore requirements, but recycle considerations alone for LWR refueling provide little urgency to begin industrial-scale reprocessing within the next decade". "Nuclear power leaves a legacy of radio-active waste, yet delays the exhaustion of fossil fuels. Fossil fuels have great social value—and their depletion will have dramatic consequences for future generations."

The 3rd chapter is a primer on fuel cycles, which I liked, being a physicist. Chapter 4 is the "LWR Fuel Cycle-Technology and Economics of Reprocessing and Recycle." Since many others are studying uranium resources, this group merely notes that the supply picture is very uncertain. In this and subsequent chapters, the physical factors affecting efficient utilization and economics are carefully assessed. In the not too distant future, breeding and recycle appear to become necessary. The safeguards and proliferation factors must be taken into account. The economics of recycle, described in GESMO are reviewed, with some interesting added perspectives. The moratorium on reprocessing is questioned, not for its short term impact on U.S. nuclear power, but rather because the information that this could provide should be useful for policy decisions and will be needed for future fuel cycles. The LWR fuel cycle, including reprocessing and MOX fuel fabrication is well established, while that for many alternative nuclear fuel cycles is not.

Chapter 5 on radiation exposure is a very useful contribution on this much debated subject. The problem is not so much the data, though they are not too solid, as it is of how to express these risks in a meaningful way. Back in the 1950's the AEC said fallout would only hurt you one chance in 10 million or so. The adversaries expressed this as 10,000 women and children dying each year. The physicists in the report looked at three methods to state the risks that are currently in vogue and conclude that the one that appears to be most reasonable is to compare the risk of nuclear generated radioactivity to the natural radioact-

Hosts R. G. Cardwell

The Executive Committee of the Japan Chapter of the Institute of Nuclear Materials Management met on Thursday, January 19 to discuss several pertinent items.

The key items of discussion:

1. Application procedures to the INMM Japan Chapter and the annual membership fee.
2. Current membership situation of the Japan Chapter.
3. Contribution of articles to *Nuclear Materials Management*, journal of INMM.
4. The visit of Roy G. Cardwell, Chairman of INMM, to the Chapter this spring.
5. Future activities of the Japan Chapter.

Extensive discussions were centered on how to increase members and the amount of the membership fee. Currently the Japan Chapter lists 31 members.

Concerning the visit of Mr. Cardwell of ORNL, it was agreed that the Executive Committee will extend a hearty welcome.

It was also agreed that the annual meeting of the Japan Chapter will take place in May at the Nuclear Material Control Center.

The following four individuals were added to the Executive Committee of the Chapter: H. Kurihara, Dr. R. Imai, Dr. K. Nakajima and Dr. H. Natsume.

As to future activities of the Japan Chapter, lecture meetings, seminars, and contribution of articles to the journal of INMM were suggested. A lecture by Mr. Cardwell will be the first step in such activities.

This report was prepared by Yoshio Kawashima, Chairman, and R. Hara, Treasurer.

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ive background and its natural variations in time and by location. They accept the linear extrapolation theory as an upper limit, but expect that it falls off at low rates of exposure when natural processes generally lead to repair. They reject the "hot particle" hypothesis. The general conclusion is that, with any reasonable controls, radiation hazards to the public should not be of concern. US uranium miners were unreasonably exposed in the past and present occupational exposures at reactors should be reduced. The radium in mill tailings is not a serious threat to society, but it could and should be better secured. GESMO estimates of uranium mine releases are probably too high, but overall, the matter of controlled releases should not present significant risks, here or elsewhere.

Chapter 6 is entitled "Safeguards." I cannot argue with the conclusions or recommendations, but the chapter and the references do not show much understanding of the history, practice, or current status of domestic safeguards. The subject is presented in a curious way. There is no description of the safeguards programs of DOE or NRC. The whole chapter speaks of what safeguards could be and how they might work. This chapter also discusses international safeguards briefly, a subject which is treated more thoroughly, from a technical standpoint in Chapter 8. I do not understand how safeguards got such an uninformed treatment in this otherwise excellent report.

Chapter 8 discusses the high level radioactive waste disposal problem. The physics is well described: the short-lived fission products, the longer-lived transuranic isotopes, the relative advantages of calcining or forming into glasses, attractive long-term burial sites (the ocean is still worth considering, but not the ice-caps), possible releases by water, humans, meteorites, etc. The conclusion is that disposal of wastes in a manner that would protect future generations is technically feasible and that the government should get on with it.

Chapter 9 addresses "Advanced Fuel Cycle Alternatives." The motivation for considering them is, of course, the Administration's desire to avoid or at least to hold back incipient proliferation. Although this chapter does not analyze all of the issues being laboriously researched in the DOE-NASAP and INFCE programs, anyone associated with these acronyms should read this chapter carefully. "Plutonium is the most efficient choice for breeder start-up and provides the best performance of any fissile material." "Improved light water reactors can provide significant benefits but would result in less resource extension than would heavy-water and HTGR Thorium reactors," "several fuel cycles, proposed for international safeguards control, have been considered—however plutonium is inevitably present in the spent fuel—". "There is no resource, economic, or safeguards benefit in the suggested Tandern LWR-HWR cycle which cannot be obtained more easily, reliably, and economically with alternative technology."

The appendices are informative except for appendix VI: "The Possibility of Nuclear Proliferation with ^{231}Pa." The text notes that one could, at great expense, extract ¼ kg of this from 1,000 tons of ^{238}u. From proven US reserves, this would be 250 kg. Compare this to 300 kg of Pu/year from a 1,000 Mwe reactor.

NFC & WM is a classic reference for everyone on any side of the nuclear controversy.

INMM STATISTICS COURSE

SAFEGUARDS
INMM
RELIABILITY ASSURANCE

Columbus, Ohio

May 22-26, 1978

The INMM, in cooperation with the Battelle Columbus Laboratories at Columbus, Ohio, is planning a presentation of the course, "Selected Topics in Statistical Methods for SNM Control," in May. Course dates are May 22-26, 1978, at Columbus, Ohio. The course instructor is John L. Jaech of Exxon Nuclear Co. The course was last given in Columbus in November 1977. For further information on future courses, contact Harley Toy at Battelle, Columbus. AC 614-424-7791. Fee: $350. Enrollment limited to 20.

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Past and Future Importance of 'Standing' for Safeguards

By Jerry Cadwell
Technical Support Organization
Brookhaven National Laboratory

Those in the Safeguards community who are normally concerned with technical matters should be aware of certain legal trends that may have an important effect on the private sector and government safeguard policy.

One of these issues in the rather abstruse concept of legal "standing". Standing is the right of an individual or corporation to be recognized by a court as the proper person to bring a law suit.[1] If a court, in its discretion, refuses to grant standing to a claimant before it, no further legal action is possible.

This concept of standing, along with some other related issues, is the key to predicting future legal challenges by individuals or corporations of rulemaking by the Nuclear Regulatory Commission.

Standing involves the rather circular consideration wherein the court must consider the injury complainted of to determine if the claimant should be allowed standing (allowed in court) to complain of the injury.

This means that if a person complains that a safeguard measure violates a fundamental constitutional right, he is more likely to get into court (granted standing) than if he complained of a violation of a lesser right.

Historically, when a person challenged a federal rule making body, such as the Nuclear Regulatory Commission, the courts would be very restrictive about who was granted standing. This restrictive view of standing came about as a result of the federal constitutional requirement of a "case or controversy" and the courts' requirement that the claimant have an "injury" recognizable at law.

However, in the last several years standing has been granted in an increasing number of cases with a few very recent cases showing a possible trend back towards limiting the right to standing.

In addition, it is important to note that exhaustion of administrative appeals is not now necessary to gain standing to sue an agency when it is alleged that the agency action has contravened some fundamental constitutional right [particularly when there is a chilling effect on First Amendment rights: National Student Association vs. Heresy (D.C. Cir. 1969)]. This means that an individual who believes he has been denied a constitutional right could go directly to Federal Court and immediately be granted standing instead of using up the administrative appeals process. The argument can be made that administrative agency (e.g., NRC) rules infringing on constitutional rights represent a question of law, not fact. Questions of law are determined by a reviewing Judge rather than a jury with the court being free to substitute its own judgements for those of the administrators.

Because the concept of standing requires the Court to consider the right infringed, it is important to know which infringed rights can serve as a basis for standing and be vindicated in court. A court would review a particular case on the basis of the Administrative Procedures Act (APA 706) which provides the reviewing court in such a case should:

> "Hold unlawful and set aside agency action findings, and conclusions found to be arbitrary, capricious, an abuse of discretion or otherwise not in accordance with the law...contrary to constitutional right, power, privilege, or immunity, ...(or) unsupported by substantial evidence...In making the foregoing determinations, the court shall review the whole record..."

One court has recently (Strumski vs. Employees Retirement Assn-Cal. Supreme Court-1974) held that "if the order or decision of the agency affects a fundamental vested right, the trial court...must exercise its independent judgement on the evidence and find an abuse of discretion if the findings are not supported by weight of the evidence." APA Sec. 706 has been increasingly used in recent cases because of the easing of standing requirements in challenging agency action.

A trend of the nineteen seventies has been an increasing judicial review of matters concerning invasions of fundamental constitutional rights in the name of security. However, it is interesting to note that the current Federal clearance program (10CFR10) used by NRC has, itself, never been challenged in Federal Court.

Recent court decisions demonstrate a strong trend indicating that the courts are not reluctant to rule on constitutional and statutory issues in rulemaking. Professor **Kenneth Davis,** a renowned authority on administrative law and author of the most noted Administrative Law Treatise, argued in 1958 that the

1. For the sake of clarity, legal citations have intentionally been omitted along with many legal terms of art. Many of the concepts have been freely and generously exerpted from Dr. John O'Brien's PhD Dissertation to Syracuse University 1977 entitled *The Conflict Between Civil Liberties and Nuclear Energy Safeguards: An Analysis of Current and Prospective Federal Regulation.*
2. In an appeal which may be possible, the appellant court will reverse the lower court only if the discretionary refusal of standing is clearly erroneous.

trends of the courts interpreting the Administrative Procedures Act passed in 1946 states that, "a person suffering a legal wrong because of agency action, or adversely affected by an agency action is entitled to judicial review" (Sec. 702). In 1970 the Supreme Court announced the culmination of the trend in stating that **any** "injury in fact" was sufficient for standing and entitled an individual to judicial review (Data Processing Service Organizations vs. Camp). Previous to 1970, a stronger injury test was required by the courts before standing would be granted, therefore limiting the ability of intervenors to bring suit against agency action. Interestingly, even those Justices who dissented on other grounds in the Data Processing case (establishing the easier standing) supported the new, easier standard for granting standing to citizens to challenge Governmental agency actions.

A similar trend occurred when suits were brought against agency action under the National Environmental Policy Act (NEPA). Standing under NEPA slowly broadened and with it so has the number of suits brought under NEPA. Before standing was broadened, environmental organizations, for instance, were denied standing to bring suit because the court held that the organization did not receive an injury which could be recognized as sufficient for standing. With broader standing, environmentalists were able to force the AEC to write Environmental Impact Statements (Calvert Cliffs) as well as to challenge a broad range of Government agency actions affecting the environment.

Alleged wrongs far less onerous than invasions of constitutional rights were considered by the courts in the recent trend toward granting broader standing. For instance, suits have been brought up repeatedly questioning the basis for agency actions such as removing lead from gasoline (EPA vs. Ethyl Corp. (D.C. District 1976)) or suppression of competition (Date Processing).

In addition to standing, the increasing judicial and legislative awareness of privacy as a fundamental

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Mr. Cadwell

constitutional right is a very recent trend which parallels the history of other activist litigation. In essence, it has become easier to gain standing to sue for relief against a government action, particularly in the past five years. Once in court, the burden is on the rulemaking agency to show substantial evidence for its determination to proceed with its rule in spite of instrusions of fundamental constitutional rights.

Where standing has been granted, the success of the activist lawsuit can be attributed to a recent and increasing tendency for judicial review to go beyond the review of the administrative action and to include scrutiny of the evidence upon which the administration determination was based, often holding that the actions were lacking in substantial supportive evidence or clearly erroneous. **Cases decided recently show that the issues of safeguards concern such as government** secrecy, intelligence, and security have been decided with substantial deference to fundamental constitutional rights, requiring the agency involved to show clear proof that the measure is necessary and that it is the best possible alternative. Only after the rule meets these two tests will it be analyzed to determine if its use justifies any infringement on a constitutional right.

Any suit, contending that a violation of a constitutional right has occurred throws upon the governmental agency the burden of proof in substantiating governmental action. A recent line of Supreme Court cases shows an increasing willingness on the part of the Court to review matters such as those involved in safeguards and may be a predictor of an increase in activitist litigation in the safeguard area.

In summary, it has become easier to acquire standing. Further, once the courts have granted standing they seem to be more receptive to arguments that fundamental constitutional rights are involved in areas not previously considered fundamental rights. Finally, the courts seem to be requiring the governmental agencies to provide more justification and proof of the necessity of the measure and the unavailability of a less onerous alternative.

Two Pleasant Years

(Continued from Page 2)

proposed a good, workable approach; and I believe if we pursue it with the support and action of the membership it will go a long way toward promoting public acceptance of nuclear power as their most desirable choice.

Having been an active participant in the Institute's activities since 1969, it would be very disappointing to step out of the picture while it is blossoming at such an accelerated rate. I am therefore looking forward to moving to the Executive Committee where I can still be a part of the action for at least two more years. Unlike old soldiers, I do not plan to fade away.

Nuclear Power and the Proliferation Problem

By James M. de Montmollin
Sandia Laboratories
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Nuclear-weapon proliferation is a complex, many-faceted problem involving questions of international relations, national security, energy resources, and technical aspects of nuclear operations. There is no simple solution, and proposals that address one aspect of the problem arouse opposition because of the impacts in other areas of concern. The problem spans such a range of disciplines and conflicting interests that, as awareness grows, public opinion moves further away from consensus toward fragmented, conflicting views.

One consequence of the controversy over proliferation controls is the impact on the development of nuclear power. The connection between nuclear power and proliferation risk is seen by some of the public as necessitating a clear choice between proliferation and abandoning the full potential of nuclear power as an energy resource. Some proponents of nuclear power have reacted by pointing out other avenues to proliferation which have been used and which pose the greater danger for the future. The effect has been to increase concern over all things nuclear, and nuclear power, the principal peaceful nuclear activity, has borne the greatest share of the burden.

Like total disarmament, nuclear proliferation is a problem that will continue to elude a complete and wholly-satisfactory solution. Proponents of nuclear power, including all those who believe that nuclear energy resources must be utilized by at least some countries in the world, should concentrate their efforts on insuring that nuclear power does not contribute materially to the proliferation problem, whatever progress may be toward the ultimate goal. Proliferation risks arising in the fuel cycle should be isolated as a subset of the larger problem, and those risks should be controlled by aggressive measures that are adequate to gain a consensus of public confidence. That limited objective is an essential step toward the full utilization of nuclear power. If nuclear power continues to be embroiled in the larger problem of complete control of proliferation, its development will continue to lag. As concerned citizens, nuclear power people should continue with others to seek means to control proliferation. However, nuclear power development need not necessarily be limited by the slow progress toward the effective control of nuclear weapons.

The barrier that must be erected between nuclear power and proliferation risk contains essential elements that are institutional. Equally important, however, are the technical elements: first, the selection and operation of suitable fuel cycles, and second, the safeguards that are necessary to close whatever paths that could potentially lead from the fuel cycles to weapon production. It is the task of the nuclear power community to select fuel cycles with minimum potential for diversion and to operate and safeguard them so that the risks of diversion can be contained with feasible institutional arrangements. If that limited goal could be attained, nuclear power would be freed from the burden of the proliferation problem. If, on the other hand, nuclear power continues to be closely associated in public opinion with proliferation risk, it will never develop its full potential as an energy resource.

Figure 1 shows a nuclear fuel cycle such as the LWR cycle, and paths by which materials might conceivably be diverted to weapon production. The barrier that must be erected to isolate nuclear power is shown. Some of the paths lead directly to materials that are isotopically suitable for weapons, requiring only the chemical and physical processing operations involved in weapon fabrication. Materials diverted through other paths require additional nuclear processing, either in clandestine facilities or by unauthorized operations in legitimate facilities, before they are suitable for weapons.

The paths currently receiving the most attention are the righthand ones (H,I,J), originating with materials that are free of fission products and isotopically suitable for explosives. That is the area of greatest concern to the US administration: if such material were diverted, it could be installed in previously-fabricated weapons in a matter of days or a few weeks after the diversion took place. One reaction of the nuclear power industry has been to contend that other paths, for example E4, are also very short and therefore operation of the recycle portion of the fuel cycle, beyond spent-fuel storage, makes the situation little worse than it would be with a once-through fuel cycle.[1,2]

Pointing out that other paths are as bad as the ones that are considered unacceptable does little to gain public support. The debate then spreads to the alleged undesirability of reactor plutonium for weapons use, and to non-power facilities which might incidentally be supplied with feed materials diverted from the power cycle. The latter includes clandestine facilities and research reactors which must be safeguarded against unauthorized operations. The effect is to further entangle nuclear power in the more difficult problems of international safeguards.

The nuclear power community should concentrate on blocking each path at the barrier, so that nuclear power will not continue to be associated with the entire proliferation problem. If a diversion occurs, a principal share of the blame will be centered on the point where materials passed from control and authorized use. For example, in Figure 1 paths A, B, C, and D involve materials that require additional nuclear processing before they can be used in explosives. It would be prudent to insure that the barrier is effective, and not to depend on controls beyond the barrier that are difficult and that may be ineffective. It has been alleged that Israel obtained materials illicitly through just such paths: 200 tons of natural uranium oxide,[3,4] and 93 kilograms of enriched uranium, [5] because of failures in safeguarding operations similar to the fuel-cycle operations shown in the figure. It is beyond the scope of legitimate fuel-cycle operations to control what may have happened to the material after it was diverted, but nuclear power suffers from criticism citing such incidents as evidence of the ineffectiveness of fuel-cycle safeguards. Such loss of public confidence can only be avoided by insuring that safeguards are effective at all points along the barrier. If that is done, nuclear power should not be held accountable for the remaining parts of paths lying outside the fuel-cycle.

Spent fuel requires only reprocessing to make plutonium available for weapons, and nuclear-power proponents have made a point of emphasizing that reprocessing may not provide much of an obstacle.[2] If that is true, it is incumbent upon the nuclear-power community to insure that the barrier is effective along paths E, F, and G. If spent fuel is recycled, it must be accounted for as it moves past E, F, and G; if it is not recycled it must continue to be safeguarded for the indefinite future. The vigilance with which it is safeguarded should not be tempered by debates over the possibilities of illicit reprocessing; it would be self-defeating for the nuclear power community to attempt to rationalize any shortcomings of spent-fuel safeguards by depending on other safeguards over which they have no control.

It is in the recycle portion of the fuel cycle that the impacts of effective proliferation controls are likely to weigh most heavily on the nuclear power community. The concern over the availability of weapons materials not requiring further nuclear processing, which could be diverted along paths H, I, J, has led to consideration of alternatives that would severely impact nuclear-power operations. Among them are the following;

1. Restrict the fuel-cycle to once-through operations, modifying the cycle as necessary to optimize once-through fissile utilization.

2. Contain the entire recycle portion of the fuel cycle, beginning with away-from-reactor spent-fuel storage, in central facilities under multinational control. The barrier is then the physical boundary of the facility, secured by joint interests of more than one state.

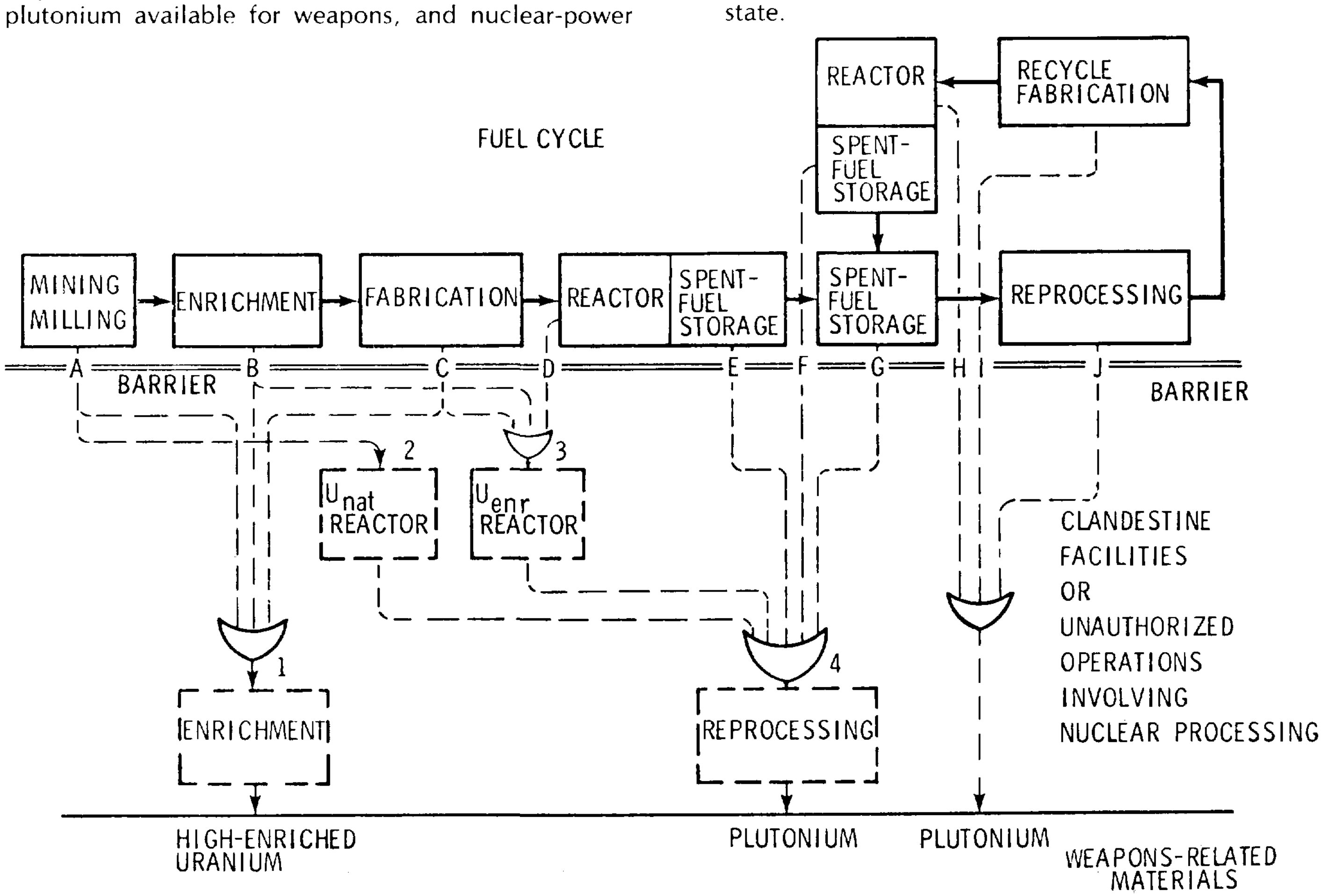

Figure 1 DIVERSION PATHS ORIGINATING IN THE NUCLEAR POWER CYCLE

3. Recycle fuel in selected reactors outside the center, but conduct all reprocessing and recycle-fuel fabrication operations within the center. Protect recycle fuel outside the center by measures such as the following:
   a. Make the recycle fuel more difficult to divert by limited separation of fission products, coprocessing, spiking, or preirradiation.
   b. Limit recycle fueling to a few reactors near the center but outside the physical boundaries, with continuous inspection or other appropriate special safeguards.

Each of these alternatives would have a heavy impact on nuclear power operations, and it is indicative of the seriousness of the problem that less restrictive alternatives receive little consideration. The structure of the fuel cycle itself is likely to be affected, and the external measures that can be applied to the unrestricted commercial operations envisioned a few years ago will not be accepted. The question that the nuclear power community must address is the balance between the benefits of recycling and the burdens of the proposed measures. The stakes involved in recycling, in terms of economics and resource utilization, are very high, and national policies are likely to have a profound impact on the structure of that part of the fuel cycle. It appears that if recycling is to proceed, it will be prudent for nuclear power interests to give their whole-hearted support to an unbiased examination of the alternatives, rather than resorting to diversionary tactics such as emphasizing inadequate control of proliferation risks outside the fuel cycle.

The foregoing suggests that the part of the proliferation problem directly involving nuclear power should be split off and addressed as a subset with a limited goal: to break the connection between nuclear power and the remaining body of proliferation risks. That is now being done jointly by many countries in the International Fuel Cycle Evaluation. Other aspects of the proliferation problem will remain, but nuclear power should not continue to be limited by slow progress toward ultimate control of weapon proliferation, nor should it continue to be jeopardized by the threat of drastic public reaction to the further spread of nuclear weapons.

Current safeguards research and developments programs generally cover all areas of proliferation risks. Reemphasis of the objectives of fuel-cycle safeguards R&D along the lines suggested would lead to some shifting in balance and priorities, with closer collaboration with industry in all parts of the fuel cycle. Nuclear industry and utilities should be motivated primarily by the limited objective of freeing nuclear power from proliferation risks. At the same time, their contributions to the solution of the larger problem of proliferation, as well-informed technical people and as concerned citizens, will always be welcome.

References

1. **Carl Walske,** President, Atomic Industrial Forum, "Nuclear Power and Nuclear Proliferation," paper delivered at the International Conference: Nuclear Power and the Public: A European-American Dialogue, at Geneva, September 27, 1977.

(Continued on Page 29)

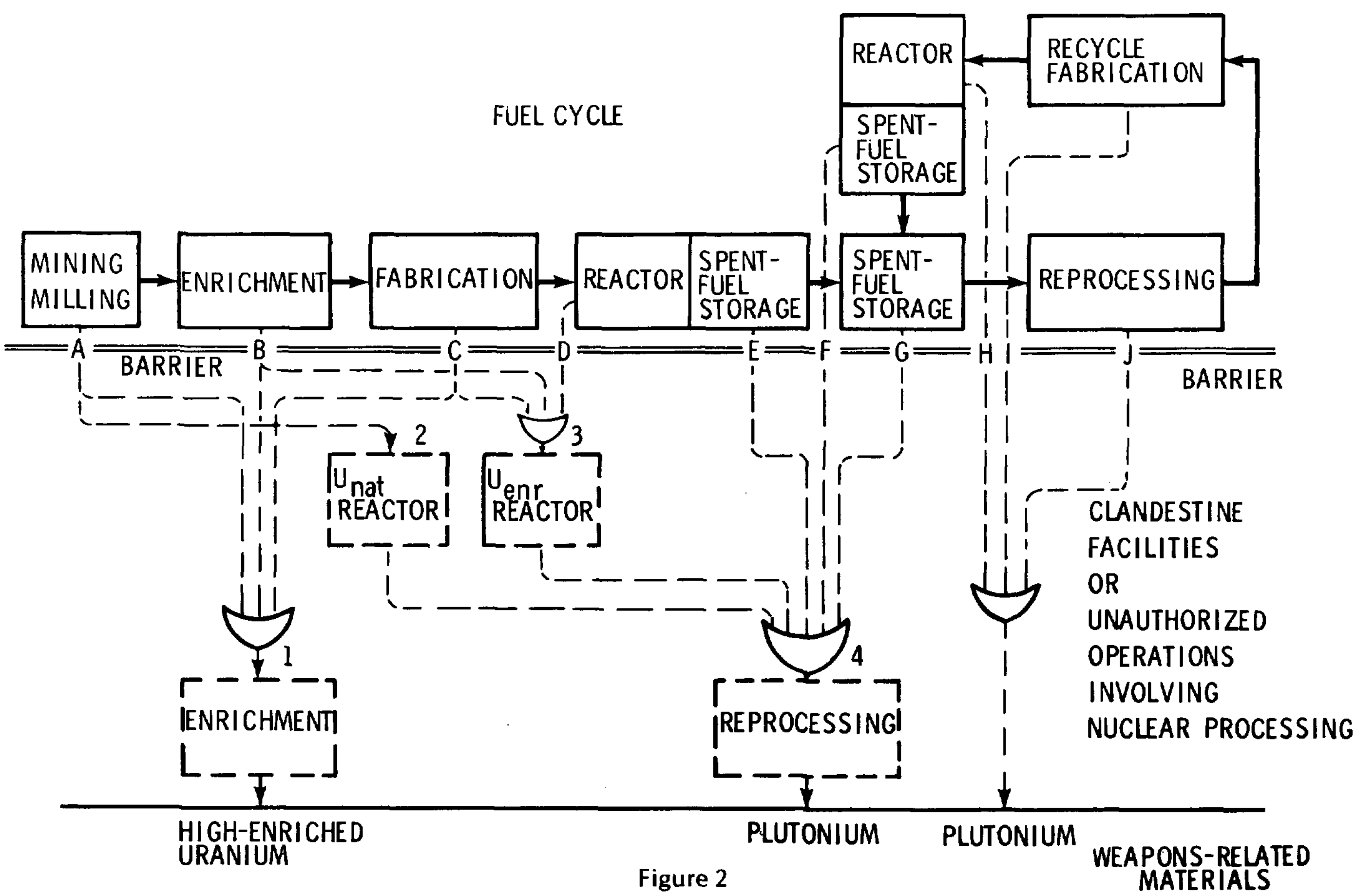

Figure 2

Towards a New Non-Proliferation Regime

By Lawrence Scheinman
U.S. Department of State

I appreciate the opportunity to be here today and to be able to enter into a dialogue on a subject of great importance with such a highly professional audience. Talking with Mr. **Richard Fuller** and Mr. **Gene Weinstock,** I learned that what might be most useful would be for me to set forth the philosophical basis and the more significant characteristics and main themes of the nuclear non-proliferation policy we have developed in President Carter's Administration, and to clarify our objectives, our view of the role and future of nuclear energy, and our appreciation of the opportunities and limitations that we face in striving toward fulfillment of our goals. A number of excellent questions were posed by the Brookhaven Laboratory in recent days and I will, in the context of the discussion this afternoon, endeavor to be as responsive as possible to as many of the concerns and questions as I am able.

Let me begin by sketching for you the milieu that informed our policy thinking and helped to establish our objectives and priorities. In running over this ground I will be covering familiar territory for some of you and for this I apologize, but unless we understand that we are talking about the same animal we run the risk of talking past one another or misinterpreting each other's perceptions and views.

Non-Proliferation Policy (1)

Nuclear proliferation is widely regarded as one of the most challenging and significant problems of our time. It is so because unfettered proliferation, that is to say the emergence of a multi-proliferated world with many nuclear weapons powers, would lead to a far less stable world than the one in which we live today. Given the uncertainties that attend the social and political order of modern civilization and the nation-state system that is its organizing principle, the probability of nuclear conflict in a multi-proliferation world borders on virtual certainty. The proliferation of nuclear explosive capabilities to increasing numbers of countries or accessibility to explosive devices by sub-national groups would reduce our ability to control international crises, have a serious detrimental effect on our alliances, and expose our nation to grave risks.

These considerations call forth the objectives of our non-proliferation policy—to slow, if not stop, the spread of nuclear weapons capabilities; to ensure that we can effectively manage any destabilizing effects that may result from the diffusion of nuclear technology as efforts to meet legitimate energy concerns through nuclear means go forward; and to foster the development of a widely supported international regime of norms and institutions that can accommodate and regulate nuclear development, use and commerce in the face of technical and political change.

These objectives are predicated on the belief that technological development has not definitively advanced beyond the reach of social controls. But their very statement implies the risk of that eventuality if conventional assumptions are not evaluated against a changing environment. This manner of conceptualizing the problem has not gone unchallenged. Some would argue that we already have passed the point of no return with the growth of the nuclear club and the spread of nuclear technology, and the continued proliferation is inevitable. Others, like the *French strategist, Gallois,* argue that nuclear spread is not inherently destabilizing and that even modest nuclear capability can have deterrent effect. In our view proliferation is not a question of absolutes, and it is an arena in which the opportunity to affect outcomes has not been lost. While there is no assurance that further proliferation will not occur, it does matter who, and how many, proliferate, when, and under what conditions.

To extrapolate from Soviet-American deterrence experience the proposition that stabilization of other dyadic relationships would result from the spread of nuclear weapons, entails sweeping assumptions about the stability of governments and regimes, the degree of responsibility that nuclear capability breeds, the absence of redemptive missions, and the inconsequential effects that proliferation would have on the central strategic balance. All of these assumptions seem doubtful and short-sighted at best. The notion that only big country proliferation poses any direct threat to US security, for example, and that concern with small country proliferation is somewhat misplaced, overlooks the potential for small state proliferation triggering further proliferation in states whose possession of nuclear weapons could directly threaten the central strategic balance—Japan, for example, in the context of Korean and Taiwanese proliferation, not to speak of the implications of Middle East nuclear proliferation for the stability and security of the international system. Hence, proliferation at any level is potentially very serious either for its direct effect or for its triggering effect on neighbors and potential protagonists.

On balance, then, we believe that proliferation is more likely to be destabilizing than stabilizing, and that the acquisition of nuclear weapons is of dubious value either in enhancing national security or political status. Broad acceptance of these conclusions would provide a firm foundation on which to rest a non-proliferation strategy and regime and it is toward that goal that our efforts are directed.

The sources of, and "solutions" to, the proliferation problem are complex and interdependent. They are further complicated by the fact that the technology and infrastructure that undergird the peaceful uses of the atom also are the essential ingredients of a nuclear explosives capability. Consequently, efforts to preserve for society the benefits of the peaceful uses of atomic energy are always **potentially** in conflict with efforts to minimize the social risk of the development and use of nuclear power. There are no magic formulas that can be applied to resolving this problem; only the certainty that a judicious blend of political, institutional, technical and legal elements can and must be brought together to ensure that the continued use of nuclear energy remains consistent with maintaining international security.

"Efforts to preserve for society the benefits of the peaceful uses of atomic energy"—these words bear repeating because of the view some have taken that the United States Government believes that we should renounce nuclear energy in order to preserve national security. Quite the contrary, the Carter Administration has made clear that nuclear energy is an essential ingredient in meeting our energy needs in the balance of this century, and that renouncing nuclear energy at this stage of history would reduce rather than enhance national security.

If this is so for the United States, with its relatively strong energy resource position, it is even more so for countries less fortunate than we in the endowment of natural resources. We both recognize and are sensitive to this fact. Our policy is not to set a choice between energy security and the risk of proliferation, but to seek out and choose among alternative nuclear-based technologies and institutional contexts those that are the most proliferation resistant. In this way, and in this way alone, will we be able to "preserve...the benefits of peaceful atomic energy." Anything less could lead to the withdrawal of public support for nuclear power with the potential result of **reduced** energy security, heightened social and economic pressures and increased international tension.

To place matters in their proper perspective it would be useful to recall the preambular language of the final communique of the INFCE organizing conference issued in Washington on October 21, 1977—"conscious of the urgent need to meet the world's energy requirements and that nuclear energy should be made widely available to that end." No less important in view of what I said earlier about the need for a broad consensus on a viable nonproliferation regime is the affirmation that "effective measures can and should be taken at the national level and through international agreements to minimize the danger of the proliferation of nuclear weapons."

Motivation

At a minimum, proliferation has two dimensions: the **motivation** to acquire nuclear weapons and the **technical ability** to bring that objective to fruition. Motivation is unquestionably the more difficult and longer-term problem for it involves perceptions of national security which at times may be at odds with objective reality; intuitive predictions of the ebb and flow of international political developments; and the intangible element of status and prestige that states sometimes believe are the reward for achieving the ability to acquire nuclear explosives. These considerations impose on us the need to reduce incentives to acquire nuclear weapons capabilities by: increasing the credibility of our security guarantees; helping to create an atmosphere in which states agree that their interests are better served by avoiding the further spread of nuclear weapons; making progress in achieving meaningful and verifiable arms control agreements; limiting or prohibiting nuclear testing; and generally behaving in a way that devalues the prestige identified with nuclear weapons.

Insofar as super power behavior serves as a touchstone for national perceptions, it is of some value to note continued effort to control vertical proliferation through such instrumentalities as SALT and the negotiations for a comprehensive test ban. These efforts can contribute toward reducing the perceived importance of the role of nuclear weapons in international politics. Along with other measures such as nuclear weapons free zones, the constructive atmosphere mentioned a moment ago can be generated.

An extremely important element in motivation is the Non-Proliferation Treaty which has helped to establish a presumption against the legitimacy of proliferation, and to foster the creation of a regime in which states perceive their security interests better served by avoiding the spread of nuclear weapons. The Treaty provides reassurance that potential adversaries are confining their nuclear activities to peaceful purposes and that, in the event of diversion, the safeguard system provided for by the Treaty would give timely warning of that diversion. Because it is an indispensable framework for effective non-proliferation efforts, the US continues to seek universal adherence to the Treaty. We also seek to avoid placing undue stress on the delicate fabric of the Treaty reflected in its distinction between nuclear weapon and non-nuclear weapon states. Contrary to some claims, the United States has gone to great lengths to avoid discriminatory policies in the civil nuclear sphere. The efforts of this Administration to achieve a deferral of the international spread of reprocessing plants cannot be characterized as a discriminatory tolerance of sensitive technologies in some non-nuclear weapon states but not in others. Rather, in the context of seeking more proliferation-resistant fuel cycles we started with the **existing** situation recognizing that a confrontational or coercive approach very likely would have elicited nationalistic resistance and a non-cooperative mood. What we asked others to consider we imposed on ourselves with the decision to endorse and extend the Ford Administration decision to impose a moratorium on commercial reprocessing in the United States. Nor have we encouraged others already involved in reprocessing to contemplate extension of their capabilities. Thus, we have expressed a negative view on the expansion of the Windscale facility in Great Britain and elicited from the Japanese a commitment to make no major moves toward building a second reprocessing plant beyond Tokai at least for the duration of INFCE and to fully take into account the findings and conclusions of that fuel cycle evaluation in any subsequent decisions. Our policy is consistent in its opposition to the start-up of any **new** reprocessing plants abroad.

Capability

Capability presents an equally important but different set of challenges: if no less difficult, these challenges are at least somewhat more identifiable and tangible. Over the course of the past thirty years our efforts to reconcile the spread of commercial nuclear capabilities with the possibility of their military misuse have gone through four phases: The proposal for international control of nuclear energy under the Baruch Plan; the policy of secrecy and export restriction; the era of Atoms for Peace; and the post-Atoms for Peace phase that we now are in.

The Atoms for Peace era, which dominated our policy between 1954 and 1974 had two major accomplishments: it isolated the commercial fuel cycle from weapons use, and it established a general climate of opinion against the spread of nuclear weapons capabilities as I mentioned a moment ago in discussing the NPT. The basic approach of Atoms for Peace was to assist countries in development of civilian nuclear energy in return for their guarantees to use such assistance only for peaceful purposes. The guarantees were and are today verified by the development and implementation of a system of international safeguards administered by the International Atomic Energy Agency—a system which remains the **sine qua non** for development of peaceful atomic energy and fundamental to a policy of international nuclear cooperation—a system concerning which this audience needs no elucidation.

New Challenges and New Responses

During the past several years, particularly since the energy crisis dating from 1973—(which led to projected increased nuclear demand, a belief in an eventual uranium shortage, and the conclusion that early movement from a uranium to a plutonium-based economy was in order, with consequent emphasis on reprocessing of spent fuel to derive from it the fuel value of plutonium and unused uranium), and the detonation of a "peaceful" nuclear device by India using plutonium derived from a Canadian supplied research reactor—we have begun to question whether the safeguards policy that has worked so well in the past would continue to work as well in the future. The source of this concern is the potential spread of facilities such as reprocessing and enrichment plants, and materials such as plutonium and highly enriched uranium, that could be used for military nuclear purposes.

The technical definition of the international safeguards system applied by the IAEA is the **timely detection of diversion** of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and **deterrence of such diversion by the risk of early detection.**

The essence of the safeguards system in **political** terms is that it provide sufficient warning time of a diversion of nuclear materials for diplomatic action to be undertaken in response to the threatened proliferation—that is to say sufficient time for international diplomatic action in terms of consultation and determination of the strategy to follow to be initiated with a view to deflecting the diverting country from its chosen course of action. With the current generation of reactors and the low enriched fuel that they use, and without reprocessing of spent fuel to extract plutonium, and a limited number of enrichment facilities, our current international safeguards system works well enough to meet the criterion of "timely detection of diversion"—the criterion inscribed in the **basic IAEA safeguards document. In this event we would be able to continue to keep commercial and** military uses of nuclear energy isolated from one another.

However, with the spread of sensitive facilities and technologies such as chemical reprocessing and enrichment, and the consequent ready access to, or stockpiling of, plutonium or highly enriched uranium, the credibility of a safeguards system might no longer exist. If a country with full fuel cycle capabilities were to perceive its security to be threatened and to conclude that the best way to enhance security would be to arm itself with nuclear weapons it might take weeks or even only days to proliferate. In such an environment, and under such circumstances, it is seriously questionable whether the public would willingly endure continued development and commerce in nuclear energy.

I should add that while "timely warning" is a very visible and widely discussed criterion regarding the evaluation of fuel cycles from a proliferation perspective, it is **not** the only one. For example on reprocessing arrangements, the legislation as amended to reflect Administration thinking, asserts that account should be taken of the size and scope of the activities involved, the non-proliferation policies of the country concerned and the probabilities that the arrangements will provide timely warning to the U.S. of diversions well in advance of the time at which the NNWS could transform the diverted material into a nuclear explosive device.

This Administration has been faulted by some of its critics on grounds of allegedly having taken a narrow and unidimensional approach to the proliferation problem. The emphasis on reprocessing, particularly of power reactor fuel and the commercial nuclear fuel cycle is seen as the sum and substance of its understanding and conceptualization of the proliferation issue. Nothing could be further from the truth. Plutonium and reprocessing were the most visible and highlighted part of our non-proliferation concerns because they were the most immediate and potentially unmanageable problems facing us. The emphasis on the commercial fuel cycle did **not** reflect a belief that this, rather than research reactors, dedicated facilities, or enrichment techniques was a more attractive pathway to acquiring weapons-usable material for a country so determined. What it did reflect was a conviction that (1) we were now on the threshold of **premature** introduction of the plutonium fuel cycle, (2) steps were necessary now to avert irrevocable commitments to a fuel cycle strategy whose technology could, indeed probably would, outstrip our capacity to meaningfully control it, and (3) appreciation of the political fact that with commercial reprocessing plants under national control many states could come very close indeed to a weapons option without political leadership having to directly face the **unambiguous** decision to develop a weapons program—a decision that they would have to face if they had to decide to build a dedicated or a covert facility. We felt that by seeking deferral of commercial reprocessing, we would avoid the progressive approximation to weapons capability, that we and others could afford this deferral in the context of the present generation of nuclear reactors, and that there was time to explore breeder alternatives in terms of technical, economic and security considerations before commercializing any one particular fuel cycle.

To return to the point on public opinion, we believe that we cannot afford to risk losing the benefits of peaceful nuclear energy and that every effort should be made to avert the further spread of national facilities and stockpiles of materials capable of quick or direct conversion to weapons purposes while at the same time meeting our obligations under the NPT and striving to preserve for all the benefits of peaceful nuclear energy. To attain this goal requires promoting **nuclear fuel cycle development** and **institutional arrangements** that tend to **maximize** the margin for diplomacy to work effectively if the IAEA safeguards alarm should sound; and it is toward this goal that current U.S. policy is directed. In short, our emphasis is on maintaining the same distance between commercial nuclear fuel cycles and military uses of atomic energy in the next generation of nuclear technology as exists today. This means knowing more than we do now; being more confident in the effectiveness of international safeguards; and not commercializing technologies unless and until they are safeguardable in the broader political sense of the term as I used it moments ago.

These considerations have led to the crafting of a strategy for the future development and use of nuclear technology. That strategy has essentially four components:

(A) A continuing emphasis on international safeguards including the improvement of safeguards techniques, strengthening of the IAEA and promulgating global acceptance of comprehensive safeguards on all civil nuclear activities. As you know, about $10 million is being contributed by the U.S. to the IAEA in support of improved safeguards. Furthermore, the non-proliferation legislation that has now passed both Houses of Congress requires full-scope safeguards as an export licensing criterion after 24 months (subject to a Presidential waiver that the Congress could override). Our long-term goal is universal adherence to NPT, but in recognition of the reluctance of some states to become parties to the Treaty we have decided to continue supply as long as all facilities in a country are internationally safeguarded;

(B) restraint in the transfer of sensitive facilities and technologies, particularly enrichment and reprocessing, so as to delay the spread of weapons-usable material and the facilities that produce them. Toward this objective we have sought the support and cooperation of other supplier nations. Our objective is **not** to indefinitely prevent further development of these technologies but to avert their spread until they are as safeguardable as the current reactor generation. We also believe that in any event the number of such facilities should be limited internationally, and where established, managed under multinational arrangements. The policy of not exporting enrichment or reprocessing plants was confirmed by President Carter on April 27, (1977). The supplier nations in general have agreed to exercise maximum restraint in the transfer of sensitive technology and both the German and French Governments have announced indefinite moratoria on the transfer of reprocessing technology. Our policy on sensitive transfers extends to HEU for research reactors. Many of these reactors can be converted to LEU and U.S. policy now requires justification for use of HEU and makes exports of weapons quantities subject to Presidential approval. While conditions are stringent, exports are **not** prohibited;

(C) development of incentives for other nations to forego sensitive facility development including assured supplies of non-sensitive nuclear fuels on a timely, adequate, reliable and economic basis at the front end of the fuel cycle, and ensuring that there is sufficient spent fuel storage capacity at the back end. To these ends the President has taken several key decisions which, when implemented, will go far toward meeting some of the principal concerns of nuclear consumers with regard to the viability of the nuclear fuel cycle. These include more flexible terms and conditions for contracting enrichment services with the U.S. as well as development of multi-national and international assurance measures.

It is in the context of our restraint and incentives effort that some of the harshest criticism of our policy has arisen. The restraints are predicated on the belief that past assumptions—held by nuclear industry in this and other countries for more than two decades—about the necessity to reprocess spent fuel to recover plutonium for purposes of recycling in light water reactors need to be revisited and that the economic and resource claims that served as a basis for justifying reprocessing are not well founded.

The proliferation implications of separated plutonium and the risk that terrorists might steal plutonium for weapons purposes are one basis for this belief. But they are not the only ones. There are substantial grounds for challenging the previous assumption that recycling plutonium in light water reactors is **economically** advantageous. Current estimates show that any such economic advantage would be marginal at best. Furthermore, such recycle does **not** provide independence in nuclear fuel **resources** and there are other potential ways of stretching uranium resources (e.g., special shift...). Finally, it is not at all certain that reprocessing would alleviate **waste disposal** problems; indeed there is evidence that disposal problems could be exacerbated. Thus, economic, resource and waste disposal considerations add to safeguards and physical security factors in support of reevaluating earlier assumptions about reprocessing at this time.

The question is whether we have come too far down the plutonium road or whether there is still time to re-examine our course of action. We believe that we do have time to examine fuel cycle alternatives that minimize proliferation and physical security risks. This is what led **President Carter** on April 7, 1977 to defer indefinitely commercial reprocessing in the U.S. and to restructure our breeder program -- **NOT** to foreclose the breeder, but to ensure that whatever breeder is brought to commercialization does not pose undue threats to the social order. We do **not** pretend that we can predict the future path of nuclear development but we **do** believe that we have time to explore alternative nuclear technology pathways in a search for systems that are technically feasible, economically attractive, and more proliferation-resistant than some of the current technological choices. Nuclear power growth rates have dropped precipitiously in recent years (in the U.S. from 1200 G to approximately 350 G by the turn of the century; in Japan from 49 G to about 30 G by the mid-1980's; and in FRG from 50 G to 25 G by 1985*, to give a few examples) and resource estimates have come under new scrutiny in an effort to provide a firmer base for predicting reserves. Pessimistic estimates of proven plus probable reserves of U in the U.S. of 1.8 million tons are sufficient to provide 30 year lifetime fuel loads for 350 G and DOE uses a figure **twice** as high. If this is true for the U.S., it is more than plausible to hypothesize a similar situation in other resource bearing countries. The downward revision of estimated demand for U by a factor of 3 (over the next 20 years) strengthens our view that we have time to examine alternatives to the plutonium breeder. Clearly, however, the long-term success of a strategy based on assured supplies of finite resources depends on strong and reliable international cooperative enterprises;

(D) international cooperation in the study of how to avoid premature commitment to new technologies until they can be adequately safeguarded and in the identification of acceptable, viable and safe nuclear fuel cycles. This effort is summarized in the INFCE launched on October 19 in Washington with the participation of over 40 countries and International Organizations. The projected two-year evaluation will explore the entire range of fuel cycle activity from resource evaluation to the identification of potentially attractive advanced reactor and fuel cycle concepts.

We suffer no illusions. We are fully cognizant of the resource differences between cooperating nations and the importance to resource-dependent countries to enhance their energy base, reduce their external dependencies, and to alleviate the pressures of large-scale imports of basic resources on their balance of payments. We are no less aware of the need to reduce the gap between industrial and developing states, between North and South, between technological haves and have-nots. Recognition of these factors goes far toward explaining our emphasis on incentives, assurances and assistance which, by the way, extends beyond the purely nuclear realm to other energy sectors, both the conventional and the exotic. It also explains why we solicited the participation of developing countries such as Iran, India, Pakistan, Nigeria, and the Philippines in the International Nuclear Fuel Cycle Evaluation undertaking.

Finally, it bears emphasis that we do not expect simple technical fixes to emerge and resolve our problems. We assume, as a matter of course, that the search for technical routes that reduce the inimical characteristics of particular technologies is likely to yield only partially satisfactory results and must be accompanied by ancillary measures of an institutional or political nature. But we are equally persuaded that while institutional arrangements can reinforce technical approaches and/or compensate for deficiencies of technical measures there also are real limits as to what can be achieved through the institutional approach. Just as it is inappropriate to rely on the technical community to achieve "breakthroughs" that resolve proliferation concerns, it is inadvisable to rely on the political/institutional approach to fully meet those concerns. There is a real risk that in reacting to the perceived oversimplification by the political community of the reach of technological problem-solving, the technical community will place too great a burden of expectation on the ability of the political community to provide answers. Each of these approaches has limitations; this must be recognized at the outset and not lost sight of over time.

I hope that this necessarily brief but nevertheless "tous azimuts" approach has been of some help in clarifying our perceptions, objectives, strategies and expectations. At the very least I am sure it has provided a sufficient base from which to launch a dialogue. Thank you.

* The estimates for the EC as a whole have been dropped from between 160 and 200 G by 1985 to less than 100 G.

(1) For a comprehensive review of what we have sought to achieve, see Joseph S. Nye, "Non-Proliferation: The Long-Term Strategy," Foreign Affairs, April, 1978.

Nuclear Power and the Proliferation Problem

(Continued from Page 24)

2. **Nucleonics Week,** Vol. 18, No. 43, p. 1, October 27, 1977.

3. **Washington Post,** May 3, 1977.

4. **New York Times,** April 29, 1977, p.1.

5. **Nucleonics Week,** Vol. 18, No. 41, p. 7, October 13, 1977.

Second of a Series

Titles and Abstracts of Recent Safeguards R&D Publications and Reports

Editor's Note—As you may recall, the summer issue of the Journal contained a plea that agencies and R&D laboratories regularly send in titles and abstracts of articles and reports of interest to others working in the field of safeguards. Los Alamos Scientific Laboratory presented its titles and abstracts in the winter issue. Now Mound Laboratory operated by the Monsanto Research Corp., Miamisburg, Ohio, has furnished similar information.

We hope to publish another listing in the summer issue. The deadline is June 1, 1978. Please call or write to Dr. William A. Higinbotham (516-345-2908 or FTS 664-2908) at Brookhaven National Laboratory, Upton NY 11973 U.S. America—**Thomas A. Gerdis.**

1) W. W. Rodenburg, "Calorimetric Assay of Plutonium," Mound Laboratory Report MLM-NUREG-2704; NRC Report NUREG-0228 (May, 1977).
   ABSTRACT: This report describes procedures for applying calorimetry for the control and accounting of plutonium. These procedures will be useful in establishing a measurement program to fulfill the regulatory requirements.
2) W. W. Rodenburg, "Some Examples of the Estimation of Error for Calorimetric Assay of Plutonium-Bearing Solids," Mound Laboratory Report MLM-NUREG-2407; NRC Report NUREG-0229 (June, 1977).
   ABSTRACT: This report provides numerical examples of error estimation and related measurement assurance programs for the calorimetric assay of plutonium. It is primarily intended for users who do not consider themselves experts in the field of calorimetry. These examples will provide practical and useful information in establishing a calorimetric assay capability which fulfills regulatory requirements.
3) D. R. Rogers and W. W. Rodenberg, "Evaluation of Calibration Alternatives for Calorimetric Assay of Reactor Grade PuO_2," Mound Laboratory Interim Report MLM-MU-77-68-0002, August 31, 1977.
   ABSTRACT: Progress on an experimental evaluation of five methods for determining the effective specific power of reactor grade plutonium dioxide is described. The experimental work is at least 50% completed and is proceeding without major difficulties. Analysis of the data collected to date indicates that the precision and accuracy of the better methods are comparable to standard plutonium assay methods such as coulometry. The biases between methods appear to be small and may result from the inaccuracy of the plutonium half-lives reported in ANSI N15.22-1975.
4) W. W. Rodenburg and D. R. Rogers, "Calorimetric Assay of Reactor Grade PuO_2," Proceedings of the 21st Conference of Analytical Chemistry in Energy Technology, Gatlinburg, Tennessee, 4-6 October 1977; *Analytical Chemistry in Nuclear Fuel Reprocessing*, Science Press (1978).
   ABSTRACT: This paper describes an experiment to estimate the random and systematic errors in determining the effective specific power of plutonium. Precisions and accuracies comparable to coulometric assay were demonstrated for a wide range of plutonium isotopic compositions. Thus, calorimetric assay can provide an effective method for plutonium assay of materials in the nuclear fuel cycle.
5) P. W. Seabaugh, D. R. Rogers, H. A. Wolterman, F. C. Fushimi, and A. F. Ciramella, "Application of Controllable Unit Methodology to a Realistic Model of a High-Throughput, Mixed-Oxide Fabrication Process," Mound Laboratory draft report MLM-MU-77-68-0001 (August 17, 1977).
   ABSTRACT: A controllable unit method of material control identifies errors for corrective action, locates areas and time frames of suspected diversions, defines time and sensitivity limits of diversion flags, defines the time frame in which passthrough quantities of special nuclear materials remain controllable, and provides a basis for identification of incremental cost associated with purely safeguards considerations. The concept provides a rationale from which measurement variability and specific safeguards criteria can be evaluated according to the degrees of control or improvement attainable. Currently the methodology is being applied to a computer simulated model of a 200 metric ton, high-throughput, mixed-oxide fuel fabrication process.
6) P. W. Seabaugh, D. R. Rogers, F. C. Fushimi, H. A. Woltermann and A. F. Ciramella, "Controllable Unit Approach to Material Control," in *Trans-*

actions of the American Nuclear Society Winter Meeting, Washington, D.C. November 27 - December 2, 1977, 27, 185 (November 1977), MLM-2434 (OP).

ABSTRACT: In this study, the Controllable Unit Approach (CUA), was applied to a 200 metric ton mixed-oxide (4% PuO_2 in UO_2) process. The performance criterion used was "Detect a loss (single or accumulative) of 2 kg of PuO_2 from the mixed-oxide process over a two-month inventory period with a 97.5% probability of success. The loss should be detected within one day of reaching the 2 kg magnitude". The results of this study using the systemmatic approach of the CUA methodology show that the mixed-oxide process can meet the stated performance criterion without substantial modifications of the process or material control system.

7) P. W. Seabaugh, D. R. Rogers, H. A. Woltermann, F. C. Fushimi and A. F. Ciramella, "Application of Controllable Unit Methodology to a Realistic Model of a High-Throughput, Mixed-Oxide Fabrication Process," *J. Inst. Nucl. Mater. Manage. Vol. VI*, No. III (Fall 1977)

H.A. Woltermann, P.W. Seabaugh, D.R. Rogers, F.C. Fushimi and A.F. Cireamella, "Nuclear Power: New Technique for Safeguarding Special Nuclear Material," *Proceedings of the Third International Conference of Environmental Problems of the Extractive Industries-Materials, Energy and Environment, Dayton, Ohio, 29 November - 1 December 1977*, p. 3.6.1, MLM-2474 (OP).

ABSTRACT: A controllable unit method of material control identifies errors for corrective action, locates areas and time frames of suspected diversions, defines time and sensitivity limits of diversion flags, defines the time frame in which pass-through quantities of special nuclear materials remain controllable, and provides a basis for identification of incremental cost associated with purely safeguards considerations. The concept provides a rationale from which measurement variability and specific safeguards criteria can be evaluated according to the degrees of control or improvement attainable. Currently the methodology is being applied to a computer simulated model of a 200 metric ton fabrication process. Results to date indicate that the controllable unit approach can detect the loss of 2 kg of PuO_2 with a probability of 97.5% with the measurement system proposed by Westinghouse.

8) C. R. Hudgens, "X-Ray Fluorescent Emission Analysis of Slurried Samples of Particulate Solids: Application to Uranium and Thorium" X-Ray Fluorenscence Workshop sponsored by the Virginia Section of the American Nuclear Society, Lunchburg, Va., October 4-5, 1976, MLM-2364(OP).

ABSTRACT: Chemical treatment of difficultly soluble particulate materials for x-ray fluorescence (XRF) analysis can be avoided by analyzing the solids as slurries. Turbulent stirring assures sample homogeneity and exposes all the sample to analysis. Particulate size effects are minimal: in the illustrated analysis of ThO_2 and U_3O_8, reduction to 80-mesh was found adequate. The slurry cell is usable, without modification, for liquids. The slurried sample (and liquid) analysis is easily adaptable to on-line, automated analyses. Indeed, an on-line flow-through system should yield superior results owing to the continuous removal of interfering x-ray-induced photochemical products.

9) W. W. Strohm, J. F. Lemming and W. W. Rodenburg, "Traceability of the Nondestructive Assay of Plutonium Using Calorimetry for Measurement Control," *J. Inst. Nucl. Mater. Manage., Vol. VI*, No. III (Fall 1977).

ABSTRACT: Calorimetry provides a method to establish the traceability of the nondestructive assay (NDA) of plutonium utilizing the traceability of calorimetric assay and its relative insensitivity to sample matrix. Efforts at Mound Laboratory to establish the traceability of the calorimetric assay of plutonium are described. Results from the Plutonium Metal Exchange Program and a calibration alternatives experiment are the basis for determining the bias between calorimetric assay and chemical assay. The probable cause of the bias is identified. Current uses of calorimetric assay for NDA measurement control and extension of calorimetry to dynamic calibration of NDA are discussed.

10) C. R. Rudy and K. C. Jordan, "Tritium Half-Life," Mound Laboratory Report MLM-2458, 22 Dec., 1977.

ABSTRACT: Least squares analyses of calorimetric measurements made at Mound Laboratory on two tritide compounds over a period of 18 yr were performed to determine the half-life of tritium. A half-life of 12.3232 plus or minus 0.0043 mean solar years was obtained.

11) "Nuclear Safeguards Progress Report: January-June 1976," MLM-2380, 14 January 1977, 25 pp.

12) "Progress Report for the Division of Safeguards and Security: July-December 1976," MLM-2429, 29 June 1977, 16 pp.

13) "Progress Report for the Division of Safeguards and Security: January-June 1977," MLM-2485, 23 December 1977, 16 pp.

Nuclear Inventory and Management System (NIMS)
A Program for Nuclear Fuels Accounting

By O.P. Pitts, Jr., and J.D. Gilbreath
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In the early 1970's as TVA expanded its nuclear power program, the need for an integrated system to account for fuel cycle materials was recognized. Prior to the development of this system it was agreed among those organizations concerned with planning and procurement, production, financial accounting, cycle cost warranty, and material accountability to the Nuclear Regulatory Commission that an integrated effort would be made to ensure that the nuclear fuel data used for these purposes would be consistent and that duplication of effort would be avoided. System development would be done in-house, with no more sophistication than necessary, using the computer to the fullest extent.

TVA currently has 17 nuclear reactors representing a generating capacity of over 20,000 MWE either operating, under construction, or planned. In addition, TVA has an agressive program for the development of uranium resources to meet the anticipated fuel requirements for these plants. The need for rapid updating and transmittal of accurate information regarding material quantities, status, location, and costs is obvious from a business management standpoint alone. The requirements imposed by the NRC for material safeguards and by the Federal Energy Regulatory Commission for fuel accounting provide additional incentives and a few special constraints.

An integrated accounting system had been implemented for nuclear fuel assemblies at our first operating nuclear plant, Browns Ferry, and had demonstrated the feasibility and advantages of this approach. A joint effort involving TVA's Divisions of Finance and Power Resource Planning was initiated in January 1976 to develop and automate an integrated fuel cycle accounting system, the Nuclear Inventory and Management System or NIMS. NIMS should be fully operational by the time this article is published.

We recognize that since the initial development of NIMS, there are questions as to whether fuel reprocessing and plutonium recycle will become future options. The elements of NIMS concerned with these aspects of the nuclear fuel cycle are shown here only to illustrate the approach taken in the development of NIMS and its potential capability for handling a variety of possible nuclear materials transactions.

Material Accounting

Exhibit I shows the basic material flow logic incorporated in NIMS. Each facility is assigned a unique alpha-numeric code which identifies the facility type (i.e., mine, mill, etc.) and the specific facility of a given type (i.e., Browns Ferry Nuclear Plant unit 1). These numbers can be directly correlated to the Reporting Identification Symbol (RIS) for those facilities licensed to handle nuclear materials. Accounts for each facility further subdivide material at that facility into either feed material, in-process material, or finished material and identify its physical/chemical form in conventional units (i.e., kilograms uranium as Uf_6). Where required, further breakdowns are provided to account for enriched uranium by nominal enrichment.

Exhibit II shows the headings for the detailed facility accounts and units corresponding to the facilities from Exhibit I. The "Primary Quantity Units" are those listed in the lefthand column. Secondary quantity units are provided to allow more definitive description of a specific material transaction.

Exhibit III shows a sample account listing for one type of facility. Using this format, a balance on raw material, material in process, and finished material is possible. Also, historical and current information on material quantities and movements is readily provided. As noted here and throughout NIMS, capability is provided for reprocessing and recycle.

Our present plan is to have these accounts updated and balanced monthly based on the best evaluated information, including input data such as NRC Material Transaction Reports, shipping and receiving documents, facility operating reports, and independent analyses.

Exhibit IV is a sample input coding form for NIMS to record the movement of material. Within TVA, this form will be filled in and checked by our Nuclear Materials Coordinating Group and forwarded to our Power Accounting Branch for entry into the process cost system.

Financial Accounting

Nuclear Fuel Assembly Accounting

In its accounting for nuclear fuel TVA follows the well-known Uniform System of Accounts prescribed by the Federal Energy Regulatory Commission. Initially a system was developed to account only for the finished nuclear fuel assemblies supplied under comprehensive contracts which extended for several years with the same vendors which furnished the BWR and PWR nuclear steam supply systems. In support of general ledger accounts computer programs were developed to document the allocation of original cost, reprocessing, and salvage estimates to individual assemblies, and to calculate amortization of the amounts to fuel expense based directly on production computer reports. Details of this system are described in Exhibit V.

Process Cost System

More recently TVA has expanded its nuclear fuel program to include the acquisition and exploration of uranium ore reserves, the development and mining of these reserves, and their processing to finished fuel assemblies through conversion, enrichment, and fabrication. Process and inventory cost accounting systems described in Exhibit VI are in the final stages of development to account for the cost of assemblies through the steps of the nuclear fuel cycle.

Integration of Material and Financial Accounting

Documentation, such as mine and mill operating reports and purchase invoices for yellow cake showing quantities of nuclear material moving in the nuclear fuel cycle, is routed through the Nuclear Materials Coordinator (NMC) on its way to the accounting office where it forms the basis of an accounting transaction in the process cost system. The NMC coordinates TVA's compliance with its regulatory obligations under Titles 10 and 18 CFR.

The NMC's staff reviews the documentation and prepares the standardized computer input form showing the exact quantity, units, and classification of the material for entry into the process cost system. Debit and credit cost accounts appropriate for the movement are also shown on the input form, thus providing a tie-in to the dollar amounts applicable to the transaction.

Computer programs have been developed to make the accounting entries for the process cost transactions and to generate reports showing the location, quantity, and cost of nuclear materials in the various steps of the fuel cycle. Examples of process and inventory cost system reports are shown in Exhibit VII.

Summary

We have presented an outline and some details of an integrated system of accounting for nuclear fuel designed to serve the needs of financial accounting, fuel planning and procurement, and material accountability according to NRC requirements.

The system has resulted from a joint effort by nuclear engineers and accountants working together, learning to understand and communicate with each other, with the result that common interests are served without duplication. Input of quantities and costs to the system is controlled by knowledgeable people. The resultant detailed cost statements provide dependable support for TVA financial statements.

"FLOW CHART OF NIMS TRANSFERS" EXHIBIT I

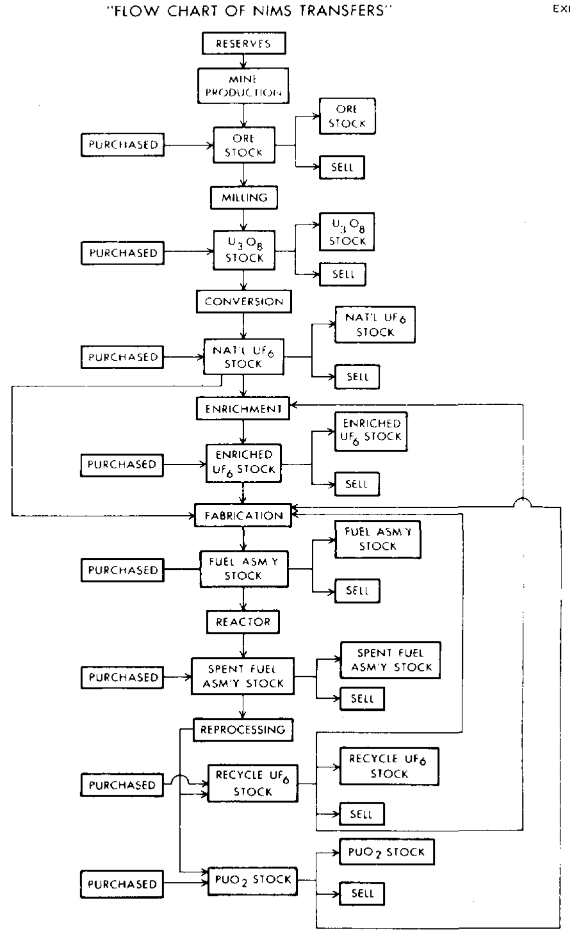

EXHIBIT II

Facilities	Primary Quantity Units	Secondary Quantity Units								
Mines	Tons Ore	Grade	lbs U_3O_8							
Mills	Tons Ore	Grade	lbs U_3O_8							
Converters	lbs U_3O_8	KgU as UF6								
Enrichers	KgU as UF6	Grams U-235	Grams U-236							
Fabricators	Number of Fuel Assemblies	Grams U	Grams U-235	Grams U-236	Grams Pu	Grams Fissile Pu				
Reactors	Number of Fuel Assemblies	Grams U	Grams U-235	Grams U-236	Grams Pu	Grams Fissile Pu				
Reprocessors	Grams U	Grams U-235	Grams U-236	Grams Pu	Grams Fissile Pu					

NUCLEAR INVENTORY AND MANAGEMENT SYSTEM
ENRICHMENT ACCOUNTS

EXHIBIT III

ACCOUNT NUMBER	ACCOUNT TITLE	PRIMARY QUANTITY UNITS MONTH	FY	TO DATE	SECONDARY QUANTITY UNITS MONTH	FY	TO DATE
	UF_6 IN STORAGE, BEGINNING OF PERIOD						
L5XX-080-90-050.30	RAW UF_6 RECEIPTS FROM CONVERSION						
L5XX-080-90-050.31	RAW UF_6 PURCHASED						
L5XX-080-90-050.37	RAW UF_6 ADJUSTMENTS						
L5XX-080-90-050.39	RAW UF_6 TRANSFERS						
L5XX-080-90-	RECYCLE UF_6 RECEIPTS						
L5XX-080-90-	RECYCLE UF_6 PURCHASED						
L5XX-080-90-	RECYCLE UF_6 ADJUSTMENTS (WGT & ENRCH)						
	RECYCLE UF_6 ADJUSTMENTS (U-236)						
L5XX-080-90-	RECYCLE UF_6 TRANSFERS						
	RECYCLE UF_6 NET RECEIPTS AS EQUIV NAT'L FEED						
	UF_6 IN STORAGE, END OF PERIOD						
	UF_6 IN PROCESS, BEGINNING OF PERIOD						
L5XX-080-90-052.40	UF_6 RECEIPTS INTO PROCESSING						
L5XX-080-90-052.461	ENRICHED UF_6 ADJUSTMENTS (WGT & ENRCH)						
L5XX-080-90-052.462	ENRICHED UF_6 ADJUSTMENTS (U-236)						
L5XX-080-90-052.49	ENRICHED UF_6 TRANSFERRED						
	ENRICHED UF_6 NET TRANSFERS AS EQUIV NAT'L FEED						
	UF_6 IN PROCESS, END OF PERIOD						
	TOTAL SWU PERFORMED						
	ENRICHED UF_6 IN STORAGE, BEGIN OF PERIOD						
L5XX-080-90-050.40	ENRICHED UF_6 RECEIPTS FROM PROCESSING						
L5XX-080-90-050.41	ENRICHED UF_6 PURCHASED						
L5XX-080-90-050.47	ENRICHED UF_6 ADJUSTMENTS						
L5XX-080-90-050.49	ENRICHED UF_6 TRANSFERS						
	ENRICHED UF_6 IN STORAGE, END OF PERIOD						

EXHIBIT IV

NIMS QUANTITY
INPUT CODING FORM

FROM:		ACCOUNT				
PREFIX	—	SUB PROJ	—	ORG	—	ACTIVITY
01 02 03 04	05	06 07 08	09	10 11	12	13 14 15 16 17 18 19 20 21 22 23 24

TO:		ACCOUNT				
PREFIX	—	SUB PROJ	—	ORG	—	ACTIVITY
25 26 27 28	29	30 31 32	33	34 35	36	37 38 39 40 41 42 43 44 45 46 47 48

1 QUANTITY		FUEL ASSEMBLIES	3 EST. LBS. U_3O_8		4 KG U AS U_3O_8/UF_6	
49 50 51 52 53 54 55 56	57 58 59	60 61 62 63 64	65 66 67 68 69 70 71 72	73 74 75	76 77 78 79 80 81 82 83	84 85 86

5 GRAMS U-235		6 GRAMS U		7 GRAMS U-236	
87 88 89 90 91 92 93 94	95 96 97	98 99 100 101 102 103 104 105	106 107 108	109 110 111 112 113 114 115 116	117 118 119

8 GRAMS PU		9 GRAMS FISSILE PU	
120 121 122 123 124 125 126 127	128 129 130	131 132 133 134 135 136 137 138	139 140 141

CONTRACT NUMBER	JOURNAL VOUCHER OR PAY VOUCHER NUMBER	MONTH	RECORD CODE
142 143 144 145 146 147 148 149 150 151	152 153 154 155 156 157 158 159	160 161	162 163

ACCOUNT STRUCTURE
NUCLEAR FUEL IN PROCESS--COMPREHENSIVE
CONTRACTS WITH NSSS VENDORS

The following account series are used to accumulate the original cost of nuclear fuel assemblies and to record its amortization to fuel expense in proportion to the thermal energy (million Btu's) expected to be produced:

Original Cost

N**-xxx-xx-051.1-B***	Inspection of nuclear fuel in process of assembly
-051.2-B***	Payments to vendors for nuclear fuel assemblies
-051.3-B***	Allowance for funds capitalized--comprehensive contracts
-051.4-B***	Storage and other miscellaneous direct costs--comprehensive contracts
-051.9-B***	Costs transferred to stock or reactor--credit

***-3-digit number to identify initial core or reload batch--1st digit to show reactor unit number; 2nd & 3rd digits to show the initial core or reload batch number

xx-2-digit number to identify power division responsible for budgeting and control of costs

xxx-3-digit number to identify balance sheet category

**-2-digit number to identify nuclear plant

Amortization

N**-xxx-xx-059.1	Write-off of original cost
-059.2	Write-off of estimated reprocessing and transportation
-059.3	Write-off of estimated salvage credit--U&Pu
-059.4	Original cost transferred from spent nuclear fuel
-059.5	Actual reprocessing and transportation cost
-059.6	Actual salvage credit--U&Pu
-059.7	Final adjustment to expense

DETAILS OF A TYPICAL ASSEMBLY

QUANTITY RECORD
NUCLEAR FUEL ASSEMBLIES
(MONTH, DATE, & YEAR)

EXHIBIT V
PAGE 2 OF 3

PAGE 1

ASSBLY NO	JV REF	INITIAL WGT GRAMS URAN	INITIAL WGT GRAMS U235	% U235	DEPLETION MONTH GR URAN	DEPLETION MONTH GR U235	DEPLETION TO DATE GR URAN	DEPLETION TO DATE GR U235	% INIT	PRESENT WGT GRAMS URAN	PRESENT WGT GRAMS U235	% U235
YZ 100	74P4053	187220.0	4150.000	2.22	119.1	60.597	221.9	198.573	4.78	186998.1	3951.427	2.11

(NOTE) TO CONVERT TO MWD/MTU MULTIPLY BY 1.102315

PAGE 2

ASSBLY NO	JV REF	RATED BURNUP MWD/STU (NOTE)	TOTAL EXPOSURE MWD/STU (NOTE) MONTH	TOTAL EXPOSURE MWD/STU (NOTE) TO DATE	HEAT OUTPUT MBTU MONTH	HEAT OUTPUT MBTU TO DATE	PU YIELD MONTH TOTAL-GR	PU YIELD MONTH 239 & 241	% 240	PU YIELD TO DATE TOTAL-GR	PU YIELD TO DATE 239 & 241	% 240
YZ 100	74P4053	17920	272.527	663.273	4607	11212	26.3280	25.261000	4.01	86.5240	84.36000	2.48

PAGE 3

ASSBLY NO	JV REF	ACTUAL SALVAGE GRAMS URAN	ACTUAL SALVAGE GRAMS U235	ACTUAL SALVAGE GRAMS PU	FINAL ADJUSTMENTS GRAMS URAN	FINAL ADJUSTMENTS GRAMS U235	FINAL ADJUSTMENTS GRAMS PU
YZ 100	74P4053						

NOTE:
DETAILS ARE SHOWN FOR INDIVIDUAL ASSEMBLIES UNDER HEADINGS FOR PLANT, REACTOR NO., CORE OR RELOAD BATCH NO., TYPE NO., STORAGE AREA; IN STOCK, REACTOR, SPENT FUEL POOL, OR AT REPROCESSOR, WITH SUBTOTALS AND TOTALS AS APPROPRIATE.

DETAILS OF A TYPICAL ASSEMBLY

COST RECORD
NUCLEAR FUEL ASSEMBLIES
(MONTH, DATE, & YEAR)

EXHIBIT V
PAGE 3 OF 3

PAGE 1

ASSBLY NO	JV REF	ORIGINAL COST	EST REPROC & TRANSP	EST SALVAGE CR URAN	EST SALVAGE CR PU239&241	UNIT COSTS IN CENTS/MBTU OF RATED OUTPUT ORIG COST	EST RPR&TR	EST SALV-U	ES SALV-PU
YZ 100	74P4053	71588	1432	1561-	2995-	23.6317963	.4727152	.5152991	.9886745

PAGE 2

ASSBLY NO	JV REF	ACCUM WRITEOFF ORIG COST MONTH	TO DATE	ACCUM WRITEOFF EST REP & TRNSP MONTH	TO DATE	ACCUM WRITEOFF EST SALV CR-U MONTH	TO DATE	ACCUM WRITEOFF EST SALV CR-PU MONTH	TO DATE	ACCUM WRITEOFF NET ORIG COST TO DATE	UNAMORTIZED NET ORIG COST TO DATE
YZ 100	74P4053	1089	2650	22	52	24-	57-	45-	111-	2534	65930

PAGE 3

ASSBLY NO	JV REF	ACTUAL REPROC & TRANSP COST MONTH	TO DATE	ACTUAL SALV CR URAN MONTH	TO DATE	ACTUAL SALV CR PU MONTH	TO DATE	FINAL ADJMENT TO EXPENSE MONTH	TO DATE
YZ 100	74P4053								

NOTE:
DETAILS ARE SHOWN FOR INDIVIDUAL ASSEMBLIES UNDER HEADINGS FOR PLANT, REACTOR NO., CORE OR RELOAD BATCH NO., TYPE NO., STORAGE AREA; IN STOCK, REACTOR, SPENT FUEL POOL, OR AT REPROCESSOR, WITH SUBTOTALS AND TOTALS AS APPROPRIATE.

Mineable Reserves (note)

L***-xxx-xx-040.10 #   Mineable reserves--additions
-040.11 #   Mineable reserves--adjustments
-040.19 #   Mineable reserves--mined--credit

Note: Memo accounts for quantities only. Actual accounting entries for reserve transactions are made to plant work orders.

Uranium Mine Development and Preoperation

L***-xxx-xx-100   Mine development and preoperation costs
-101   Environmental impact statement (EIS) costs
-107   Indirect costs allocated to mine development
-109   Mine development and preoperation costs transferred--credit

Uranium Mill Development and Preoperation

L***-xxx-xx-200   Mill development and preoperation costs
-201   Environmental impact statement (EIS) costs
-207   Indirect costs allocated to mill development
-209   Mill development and preoperation costs transferred--credit

Mine Production

L***-xxx-xx-052.110 #   Depletion of uranium reserves
-052.111   Amortization of mine development and preoperation costs
-052.120   Mine production costs
-052.121   Royalties based on mine production
-052.122   Mine monitoring and inspection by TVA
-052.14   Loading and shipping costs--uranium ore
-052.16   Land restoration costs
-052.17   Indirect costs allocated to mine production
-052.19 #   Uranium ore costs transferred--credit

***-3-digit number to identify location

xxx-3-digit number to identify balance sheet category

xx-2-digit number to identify power division responsible for budgeting and control of costs

#-physical quantities are associated only with these accounts

Mill Production

L***-xxx-xx-052.210	#	Uranium ore to mill
-052.211		Transportation of uranium ore to mill
-052.22		Amortization of mill development and pre-operation costs
-052.230		Mill production costs
-052.231		Mill monitoring and inspection by TVA
-052.232		Depreciation of mill facilities
-052.233		Mill by-products disposed of--credit
-052.234		Royalties based on mill production
-052.25		Loading and shipping costs--U_3O_8
-052.26	#	Milling weight adjustments
-052.27		Indirect costs allocated to mill production
-052.28		Allowance for funds capitalized--mill production
-052.29	#	U_3O_8 transferred--credit

Conversion of U_3O_8 to Raw UF_6

L***-xxx-xx-052.30	#	Uranium conc. (U_3O_8) to conversion plant
-052.31		Transportation of U_3O_8 to conversion plant
-052.32		Contract payments for conversion
-052.33		Conversion plant monitoring and inspection by TVA
-052.34		Weighing and sampling costs
-052.35		Loading and shipping costs--raw UF_6
-052.36	#	Conversion weight adjustments
-052.37		Indirect costs allocated to conversion
-052.38		Allowance for funds capitalized--conversion
-052.39	#	Raw UF_6 transferred--credit

Enrichment of UF_6

L***-xxx-xx-052.40	#	Raw UF_6 (feed material) to enrichment plant
-052.41		Transportation of raw UF_6 to enrichment plant
-052.42		Advanced payments for enrichment
-052.43		Contract payments for enrichment
-052.45		Loading and shipping costs--enriched UF_6
-052.46	#	Enrichment weight adjustments
-052.47		Indirect costs allocated to enrichment
-052.48		Allowance for funds capitalized--enriched UF_6
-052.49	#	Enriched UF_6 transferred--credit

Fabrication of Nuclear Fuel Assemblies

L***-xxx-xx-052.50 #	Enriched UF_6 to fabrication plant
-052.51	Transportation of enriched UF_6 to fabrication plant
-052.52	Contract payments for fuel assembly fabrication
-052.53	Fabrication plant monitoring and inspections by TVA
-052.55	Loading and shipping costs--nuclear fuel assemblies
-052.56 #	Fabrication weight adjustments
-052.57	Indirect costs allocated to fuel assemblies
-052.58	Allowance for funds capitalized--fabrication
-052.59 #	Nuclear fuel assemblies transferred--credit

Nuclear Fuel Reprocessing

Accounts in this series will be provided later as the need arises.

ACCOUNT STRUCTURE NUCLEAR FUEL MATERIALS AND ASSEMBLIES IN STOCK

Uranium Ore in Stock

L***-xxx-xx-050.10	#	Uranium ore mined
-050.11	#	Uranium ore purchased
-050.12		Transportation cost--ore to stock
-050.13		Uranium ore weighing, sampling, storage physical inventory, and other miscellaneous direct costs
-050.15	#	Uranium ore stock transfers
-050.16		Indirect costs allocated to uranium ore purchases
-050.17	#	Uranium ore stock weight and grade adjustments
-050.18		Allowance for funds capitalized--uranium ore
-050.19	#	Uranium ore transferred from stock--credit

U_3O_8 in Stock

L***-xxx-xx-050.20	#	U_3O_8 milled
-050.21	#	U_3O_8 purchased
-050.22		Advanced payments for U_3O_8
-050.23		Transportation cost--U_3O_8 to stock
-050.24		U_3O_8 weighing, sampling, storage, physical inventory, and other miscellaneous direct costs
-050.25	#	U_3O_8 stock transfers
-050.26		Indirect costs allocated to U_3O_8 purchases
-050.27	#	U_3O_8 stock weight and grade adjustments
-050.28		Allowance for funds capitalized--U_3O_8 stock
-050.29	#	U_3O_8 transferred from stock--cred.

UF_6 in Stock

L***-xxx-xx-050.30	#	Raw UF_6 converted under TVA contract
-050.31	#	Raw UF_6 purchased
-050.32		Transportation cost--UF_6 stock
-050.33		Raw UF_6 storage, physical inventory, and other miscellaneous direct costs
-050.35	#	Raw UF_6 stock transfers
-050.36		Indirect costs allocated to UF_6 purchases
-050.37	#	Raw UF_6 stock weight adjustments
-050.38		Allowance for funds capitalized--UF_6 stock
-050.39	#	Raw UF_6 transferred from stock--credit

***-3-digit number to identify location

xxx-3-digit number to identify balance sheet category

xx-2-digit number to identify power division responsible for budgeting and control of costs

#-physical quantities are associated only with these accounts

Enriched UF_6 in Stock

L***-xxx-xx-050.40	#	UF_6 enriched under TVA contract
-050.41	#	Enriched UF_6 purchased
-050.42		Transportation cost--enriched UF_6
-050.43		Enriched UF_6 storage, physical inventory, and other miscellaneous direct costs
-050.45	#	Enriched UF_6 stock transfers
-050.47	#	Enriched UF_6 stock weight adjustments
-050.48		Allowance for funds capitalized--enriched UF_6 stock
-050.49	#	Enriched UF_6 transferred from stock--credit

Nuclear Fuel Assemblies in Stock

L***-xxx-xx-050.50	#	Nuclear fuel assemblies furnished under TVA fabrication contracts
-050.51	#	Nuclear fuel assemblies furnished under comprehensive contracts
-050.52		Transportation cost--fuel assemblies in stock
-050.53		Nuclear fuel assembly storage, physical inventory, and other miscellaneous direct costs
-050.55	#	Fuel assembly stock transfers
-050.58		Allowance for funds capitalized--fuel assemblies in stock
-050.59	#	Nuclear fuel assemblies transferred--credit

Recycled UF_6 in Stock

Accounts in this series will be provided later as the need arises.

Plutonium in Stock

Accounts in this series will be provided later as the need arises.

TYPICAL PROCESS COST REPORT

U3O8 MILLING IN PROCESS
MARCH 31, 1977

EXHIBIT VII
PAGE 1 OF 5

L300 RICHLAND MILL	ACCT	UNITS	QUANTITY MONTH	QUANTITY FY	QUANTITY TO DATE	TOTAL COST-$ MONTH	TOTAL COST-$ FY	TOTAL COST-$ TO DATE	UNIT COST-$ MONTH	UNIT COST-$ FY	UNIT COST-$ TO DATE
IN PROCESS-BEGIN OF PERIOD		LB-U308			7367			38095			5.171
ADDED TO PRODUCTION-											
URANIUM ORE	052.210	TON-ORE	24251	171702							
		LB-U308	60193	482646		51646	509674		.858	1.056	
TRANSPORTATION	052.211										
AMORT OF MILL DEV	052.22					8264	105358				
MILL PRODUCTION	052.230					195994	1925672				
MILL MONITOR BY TVA	052.231					1523	15260				
DEPR OF MILL	052.232										
BY-PRODUCTS--CREDIT	052.233										
ROYALTIES	052.234										
LOAD & SHIP	052.25										
WEIGHT ADJ	052.26	LB-U308	7767-	49759-							
INDIRECT COSTS	052.27										
FUNDS CAPITALIZED	052.28					1350	22311				
SUBTOTAL		LB-U308	52426	432887		258777	2578275		4.936	5.956	
SUBTOTAL-IN PROCESS		LB-U308	59793	733544		296872	3756596		4.965	4.490	
TRANSFERRED TO STOCK	052.29	LB-U308	51246-	724997-		254436-	3714160-		4.965	5.123	
		KG-U	19711-	278869-							
IN PROCESS-END OF PERIOD		LB-U308			8547			42436			4.965
L301 EDGEMONT MILL											
IN PROCESS-BEGIN OF PERIOD		LB-U308			7406			37489			5.062
ADDED TO PRODUCTION-											
URANIUM ORE	052.210	TON-ORE	26275	82138							
		LB-U308	65660	205260		69074	204849		1.052	.998	
TRANSPORTATION	052.211										
AMORT OF MILL DEV	052.22					7265	24260				
MILL PRODUCTION	052.230					201936	461888				
MILL MONITOR BY TVA	052.231					1026	2566				
DEPR OF MILL	052.232										
BY-PRODUCTS--CREDIT	052.233										
ROYALTIES	052.234					16415	51315				
LOAD & SHIP	052.25										
WEIGHT ADJ	052.26	LB-U308	9518-	29562-							
INDIRECT COSTS	052.27										
FUNDS CAPITALIZED	052.28					2011	6725				
SUBTOTAL		LB-U308	56142	175698		297727	751603		5.303	4.278	
SUBTOTAL-IN PROCESS		LB-U308	63548	198875		335216	842434		5.275	4.236	
TRANSFERRED TO STOCK	052.29	LB-U308	56044-	191371-		295631-	802849-		5.275	4.195	
		KG-U	21557-	73610-							
IN PROCESS-END OF PERIOD		LB-U308			7504			39585			5.275

U308 MILLING IN PROCESS
MARCH 31, 1977

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TOTAL ALL MILLS	ACCT	UNITS	QUANTITY MONTH	QUANTITY FY	QUANTITY TO DATE	TOTAL COST-$ MONTH	TOTAL COST-$ FY	TOTAL COST-$ TO DATE	UNIT COST-$ MONTH	UNIT COST-$ FY	UNIT COST-$ TO DATE
IN PROCESS-BEGIN OF PERIOD		LB-U308			14773			75584			5.116
ADDED TO PRODUCTION		TON-ORE	50576	253840							
		LB-U308	108568	608585		556504	3329878		5.126	5.472	
TRANSFERRED TO STOCK		LB-U308	107290-	916368-		550067-	4517009-		5.127	4.984	
		KG-U	41268-	352476-							
IN PROCESS-END OF PERIOD		LB-U308			16051			82021			5.110

U308 IN STOCK
MARCH 31, 1977

	ACCT	UNITS	QUANTITY MONTH	QUANTITY FY	QUANTITY TO DATE	TOTAL COST -$ MONTH	TOTAL COST -$ FY	TOTAL COST -$ TO DATE	UNIT COST -$ MONTH	UNIT COST -$ FY	UNIT COST -$ TO DATE
U308 IN STOCK -BEGIN OF PERIOD											
L300 RICHLAND MILL		LB -U308			1218725			8981426			7.370
		KG -U			468781						
L399 ADV PAYT -TV 32843A								11736096			
L400 RIVERTON CONV		LB -U308			452021			3331180			7.370
		KG -U			173869						
TOTAL -BEGIN OF PERIOD											
ADV PAYT								11736096			
U308 ON HAND		LB -U308			1670746			12312606			7.370
		KG -U			642650						
TOTAL								24048702			
U308 ADDED TO STOCK -CURRENT PERIOD											
L300 RICHLAND MILL											
U308 MILLED	050.20	LB -U308	51246	724997		254436	3714160		4.965	5.123	
		KG -U	19711	278869							
U308 PURCHASED	050.21	LB -U308	40351	115016		355894	1121406		8.820	9.750	
		KG -U	15521	44241							
TRANSPORTATION	050.23										
WEIGH, SAMPLE, ETC.	050.24					4234	27602				
STOCK TRANSFERS	050.25	LB -U308									
		KG -U									
INDIRECT COSTS	050.26					792	7625				
WEIGHT ADJ	050.27	LB -U308									
		KG -U									
FUNDS CAPITALIZED	050.28					49410	1185829				
SUBTOTAL		LB -U308	91597	840013		664766	6056622		7.258	7.210	
		KG -U	35232	323110							
L398 NO LOCATION											
WEIGH, SAMPLE, ETC.	050.24					10024	61064				
INDIRECT COSTS	050.26					4967	28723				
FUNDS CAPITALIZED	050.28					157	1350				
SUBTOTAL						15148	91137				
L399 ADV PAYT -TV 32843A											
ADVANCE PAYTS											
FUNDS CAPITALIZED						70417	636566				
SUBTOTAL						70417	636566				

U3O8 IN STOCK
MARCH 31, 1977

EXHIBIT VII
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	ACCT	UNITS	QUANTITY MONTH	QUANTITY FY	QUANTITY TO DATE	TOTAL COST-$ MONTH	TOTAL COST-$ FY	TOTAL COST-$ TO DATE	UNIT COST-$ MONTH	UNIT COST-$ FY	UNIT COST-$ TO DATE
L400 RIVERTON CONV											
U3O8 MILLED	050.20	LB-U3O8	56044	191371		295631	802849		5.275	4.195	
		KG-U	21557	73610							
U3O8 PURCHASED	050.21	LB-U3O8	39536	628732		344991	5669276		8.726	9.017	
		KG-U	15208	241841							
TRANSPORTATION	050.23										
WEIGH, SAMPLE, ETC.	050.24										
STOCK TRANSFERS	050.25	LB-U3O8									
		KG-U									
INDIRECT COSTS	050.26					3125	28295				
WEIGHT ADJ	050.27	LB-U3O8									
		KG-U									
FUNDS CAPITALIZED	050.28					24466	293593				
SUBTOTAL		LB-U3O8	95580	820103		668213	6794013		6.991	8.284	
		KG-U	36765	315448							
TOTAL-ADDED TO STOCK											
ADV PAYT						70417	636566				
U3O8 ON HAND		LB-U3O8	187177	1660116		1348127	12941772		7.202	7.795	
		KG-U	71997	638555							
TOTAL						1418544	13578338				
SUBTOTAL-PRIOR TO TRANSFER (NOTE)											
ADV PAYT						70417	636566				
U3O8 ON HAND		LB-U3O8	1857923	3105296		13660733	22513707		7.353	7.250	
		KG-U	714647	1194436							
TOTAL						25467246	23150273				
U3O8 TRANSFERRED FROM STOCK											
L300 RICHLAND MILL											
TRANSFERRED	050.29	LB-U3O8	89564-	728453-		658536-	5209896-		7.353	7.152	
		KG-U	34450-	280199-							
L400 RIVERTON CONV											
TRANSFERRED	050.29	LB-U3O8	45238-	653722-		332621-	4634235-		7.353	7.089	
		KG-U	17401-	251453-							
TOTAL-TRANSFERRED		LB-U3O8	134802-	1382175-		991157-	9844131-		7.353	7.122	
		KG-U	51851-	531652-							

U3O8 IN STOCK
MARCH 31, 1977

	ACCT	UNITS	QUANTITY MONTH	QUANTITY FY	QUANTITY TO DATE	TOTAL COST-$ MONTH	TOTAL COST-$ FY	TOTAL COST-$ TO DATE	UNIT COST-$ MONTH	UNIT COST-$ FY	UNIT COST-$ TO DATE
U3O8 IN STOCK-END OF PERIOD											
L300 RICHLAND MILL		LB-U3O8			1220758			8975856			7.353
		KG-U			469563						
L399 ADV PAYT-TV 32843A								11806513			
L400 RIVERTON CONV		LB-U3O8			502363			3693720			7.353
		KG-U			193233						
TOTAL-END OF PERIOD											
ADV PAYT								11806513			
U3O8 ON HAND		LB-U3O8			1723121			12669576			7.353
		KG-U			662796						
TOTAL								24476089			

THE PROPOSED NRC MATERIAL ACCESS SCREENING PROGRAM

By John N. O'Brien
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The need for a personnel screening system for access to special nuclear material (SNM) and, in more recent years, to vital areas at power reactors, has long been recognized. It seems to be the diversity and complexity of the issues involved which have forestalled development of a working system. The debate over what type of system should be used and what investigative techniques may be employed cuts across the lines of energy demand, security needs, health and safety concerns, management policies, and individual rights. The task of balancing these factors against each other to arrive at an optimal system is indeed formidable.

The history of efforts to control what has become known as "material access" is confusing and somewhat haphazard. In the early years of the AEC, SNM was classified; therefore, access was only granted to those with the appropriate security clearance. The objective of classification was to keep secret information about the physics of fission bombs. Without the material to test, estimates of critical mass, for example, could not be verified.

After 1955 the Atoms For Peace program began a general trend toward declassifying materials and information concerning production of energy from nuclear fission. Along with declassification came commercial development of nuclear power. Industry has been instructed since then to screen its own employees to prevent theft or sabotage.

On March 17, 1977 NRC issued proposed rules for comment which would require the equivalent of a security clearance for:

(1) all individuals who require unescorted access to special nuclear material or vital areas,
(2) personnel in positions which would enable them, acting alone or with others, to divert special nuclear material or to commit sabotage, and
(3) drivers of motor vehicles and pilots of aircraft transporting certain quantities of special nuclear material and personnel who escort road, rail, air, or sea shipment of special nuclear material.[1]

The scope of personnel who are affected is clearly a matter of interpretation. NRC has defined the scope to include:

(a). (1) All jobs in which an individual could steal or divert special nuclear material, or commit sabotage which would endanger the public by exposure to radiation, by working alone or in cooperation with an individual who does not possess an NRC-U special nuclear material access authorization, or by directing or coercing any individual to assist in the theft, diversion, or sabotage. Such jobs include but are not limited to:
(i) all positions in the licensees security force
(ii) management positions with authority to:
(A) Direct the actions of members of the security force or alter security procedures, or
(B) Direct routine movements of special nuclear material, or
(C) Direct the routine status of vital equipment
(ii) All jobs which require unescorted access within on-site alarm stations
(iv) All jobs which require unescorted access to special nuclear material or within vital areas
(2) All jobs which require unescorted access within protected areas and which do not fall within the criterion of paragraph
(a) (1) of this section[2]

The licensees have been asked to enumerate positions which fit these criteria in their physical protection plan.

The proposed rules specify that the two clearances involved are NRC-U and NRC-R which are similar to DOE-Q and DOE-L, respectively. The higher clearance, NRC-U, would be required for all positions which require unescorted access to SNM or vital areas and those positions where an individual alone, or in conspiracy with another individual not possessing an NRC-U clearance, could steal or divert SNM or commit sabotage. In addition, drivers of motor vehicles and pilots of aircraft, as well as escorts, who transport SNM by road, rail, air, or sea must have NRC-U clearance.

The NRC-R clearance would be required of individuals who have unescorted access to protected areas and are not otherwise required to possess the NRC-U clearance.

The NRC-R clearance is based on a National Agency Check (NAC) which involves a check of FBI fingerprint, criminal, and subversive files; of the Civil Service Commission security investigation index; of the investigative files of the appropriate branch of the armed services if the individual has had civilian employment or military service in any branch; and of the files of the Immigration and Naturalization Service and passport records of the Department of State, if considered necessary.

The NRC-U clearance will involve all of the elements of the NAC and, in addition, require a full-field investigation. This includes the use of investigators interviewing neighbors, friends and other associates, asking detailed questions regarding the applicant's background and lifestyle.

LEGAL AUTHORITY

Congress in 1974 amended the Atomic Energy Act to authorize the NRC to establish employee screening programs for private companies having access to special nuclear materials. The legislation provides that the NRC may:

> Prescribe such regulations or orders as it deems necessary to guard against the loss or diversion of any special nuclear material including regulations or orders designating activities involving quantities of special nuclear materials which in the opinion of the Commission are important to the common defense and security; that may be conducted only by persons whose character associations and loyalty shall have been investigated under standards and specifications established by the Commission and as to whom the Commission shall have determined that permitting each such individual to conduct the activity will not be inimical to common defense and security.(3)

Until the recently proposed rules, no regulations have been promulgated. Clearance procedures have been used by NRC as promulgated, for the most part in 1960, but these procedures are expressly for the protection of restricted data and national security information and are embodied in 10 CFR 10. No mention is made in current regulations of protection "against the loss or diversion of any special nuclear material ..."

The sketchy legislative history of the 1974 amendment to the Atomic Energy Act makes it doubtful that Congress believed it was authorizing a security program so broad that it would raise major issues. The legislation was passed as part of a package of amendments which was described as "an AEC housekeeping bill."(4) There was no discussion in the House of the section in question here beyond Congressman **Hosmer**'s remark that it is a "clarification and expansion of the (Nuclear Regulatory) Commission's authority with respect to licensing people who handle nuclear fuels."(5) There is no record of any Senate debate on the provision.(6)

In the absence of Congressional guidance it appears that Congress had no intention of creating a wholly new set of criteria for employment in the nuclear power industry. It has been argued that the magnitude of any new screening program designed to protect SNM or prevent sabotage would be minor, relative to the total federal personnel screening program.

The significance of a nuclear safeguards screening program may not stem from magnitude, however. The type of activity that safeguards screening addresses is that of theft of SNM or sabotage of a nuclear facility. Clearance practices are now aimed solely at protection of information. Current federal regulations state that:

> This part establishes the criteria, procedures and methods for resolving questions concerning the eligibility of individuals who are employed by or applicants for employment with NRC contractors, agents, and licensees of the NRC, individuals who are NRC employees or applicants for NRC employment, and other persons designated by the Executive Director for Operations of the NRC, for *access to Restricted Data* pursuant to the Atomic Energy Act of 1954, as amended and the Energy Reorganization Act of 1974, or for *access to national security information*...(emphasis added)(7)

Current programs are designed to deny access to those individuals who may place foreign interests over those of the United States. Safeguards screening activities must also deny access to those who would act in violent antisocial ways or opposition to domestic policies. In other worlds, nuclear theft and sabotage are different violations of trust than revealing classified information. **Willrich** and **Taylor**, in their book, *Nuclear Theft: Risks and Safeguards,* enumerate three major reasons for a safeguards related employee screening program:

- to guard against internal sabotage
- to reduce the risk of employee theft of small quantities of SNM
- to reduce the threat that a group planning forcible theft could establish a link on the inside of a facility containing SNM(8)

Currently used clearance procedures are stringent, but have failed in the past to fully protect classified information. Because of the perceived consequences of a successful diversion of SNM, it is quite possible that screening for purposes of material access would be more stringent and therefore, could generate law suits challenging these procedures on substantial grounds.

CURRENT ISSUES

NRC has grappled with the problem of material access clearance since 1974 with little success. In 1976 NRC staffers conceded that nuclear critics would see such personnel screening "as the sure road to '1984' with its 'Big Brother' and other societal horrors that **George Orwell** wrote about 30-odd years ago."(9)

The problems raised by the proposed rules are abundant. The licensee will be required to pay $950 for each NRC-U clearance and $30 each for NRC-R clearances. That represents a significant expenditure at an average facility. In several types of positions the attrition rates are very high. For example, the average turn over per year in plant security guard forces is over 50%. The holding time for an applicant for a position requring NRC-U clearance will be routinely 60 to 90 days. This clearly presents personnel management problems.

At the heart of the issue is what the screening process is supposed to do. The objective of the material access screening program, whatever it is determined to be, must be embodied in the criteria by which determinations of eligibility are made. The proposed rules adopt those same criteria as used for access to restricted data and national security information. NRC has considered the question of the validity of the criteria for material access:

The present NRC security clearance criteria (10 CFR Part 10) were developed for access to information and, as such, not all criteria may be equally significant for questions of access to special nuclear material and some may not be perceived as relevant in specific cases. Also, there may be cases in which additional criteria, not now included in 10 CFR Part 10, would be more to the point. However, these criteria do correspond to the Federal Government's general approach to personnel security, and specifically, ERDA had adopted them for use in its own materials access program (42 FR 7946). Furthermore, the criteria are in the nature of guidelines to be used in a decision process characterized by common sense judgments, rather than quantitative criteria. Moreover, the Commission is reluctant to devise a new set of criteria without evidence that any new criteria would significantly improve upon those which presently exist. Hence, the Commission's proposal is to rely on the government-wide criteria as guidelines in deciding questions of access to or control over special nuclear material.[10]

The General Accounting Office (GAO) disagrees. In a report issued recently the GAO, which serves as the auditing and review agency of Congress, stated that the Government's procedures for screening employees have been jumbled by changing attitudes and laws. The report concludes that the entire system needs a thorough overhaul. GAO cited several reasons for this. For example, there is no clear definition of disloyal acts and there is a lack of clear guidelines for making screening determinations.

The major problem seems to be that recent legal developments set up conflicting goals between the original authority, which emphasized the protection of national security, and more recent legislation and court decisions which protect individual rights.

INDIVIDUAL RIGHTS

The conflict between individual rights and the need for a personnel screening system may be substantial. While the proposed rules may relieve the licensee of the burden of directly overseeing its screening procedures, they may also bring about a major confrontation which will be an unfortunate addition to the ongoing debate over nuclear energy production, providing grist for extended litigation and general "bad press" for the industry.

The major conflict occurs because of several particular court cases and statutes addressing the right of privacy. The gist of these legal developments is that privacy, as an individual right, is fundamentally linked to the expression of First Amendment rights. It has been recognized over the last several years that erroding the right to privacy seriously eviscerates rights granted under the Bill of Rights generally.

As an example of this developing legal environment, in 1974 Congress passed into law the Privacy Act[11] which, among other things, prohibits the retention of federal records concerning the exercise of First Amendment rights except in cases involving national security. In two recent cases the federal courts severely narrowed the scope of legitimate national security concerns to a very limited set of occurrences.[12] These laws will tend to inhibit screening determinations unless NRC bases material access clearance on national security.

There are compelling reasons for keeping commercial nuclear safeguards outside of the national security debate. One reason is that the protection of health, safety and welfare is more the function of private industry. In addition, the Atomic Energy Act delegates power to NRC to impose regulation for the protection of health, safety, and welfare as well as the protection of common defense and security. Aside from the fact that the protection of a power reactor from sabotage is more a matter of health and safety than of national security as defined by legislation and case law, regulation for the purpose of protecting health and safety has less general opposition than regulation protecting national security for this application. The distinction may appear shallow, but it is, in fact, very subtle. It would be wrong to assert that the nuclear energy industry presents no national security issues, but the entire spectrum of nuclear safeguards is aimed at protecting against the loss of lives and property -- not protecting the existence of the Federal Government. If NRC argues that the threat of theft and sabotage in the commercial nuclear energy industry presents a threat of enough magnitude to warrant the imposition of national security powers, it is contrary to its contention that commercial nuclear energy production presents only minor threats when compared to other common societal activities. In addition, it is generally accepted that United States industry must protect health and safety, while it has generally not been given responsibility for national security.

There are substantial problems in the screening process as proposed by NRC. In order to mitigate these problems, NRC may have to develop an innovative approach to screening which takes into account recent changes in the legal climate. In addition, the different type of positions NRC's program will affect as opposed to other occupations requiring clearance must be considered. The guard at a nuclear power reactor is far different in most respects from the scientist at a research facility. These factors tend to support the argument that the screening process used to restrict access to SNM and vital areas at power reactors must be different from those presently used by NRC for information access. Transplanting procedures and criteria from information access to material access may very well create more serious and complex problems than they solve.

In order to devise a proper screening system, a thorough examination of the objectives of the system must be made. The objectives which are similar to those of information access will reveal what parts of current screening practices should be used. Material access will most definitely contain objectives which are different from those of information access. These objectives will require social scientific, psychiatric, and legal analysis. If NRC is to avoid making a major issue of the material access screening system, it must openly and honestly apply diverse expertise and novel thinking. A partial fix in the form of standard security clearance will open another route for intervenor litigation and further slow

(Continued on Page 56)

REPORT OF THE ADVISORY PANEL ON SAFEGUARDING SPECIAL NUCLEAR MATERIAL

Editor's Note—As is mentioned in the editorial, it seemed to be most appropriate to republish the Introduction and Recommendations of the "Lumb Panel Report," upon which much of the present structure and content of safeguards is based. The members of this panel were: Ralph F. Lumb, (chairman), Francis P. Cotter, Gerald Charnoff, Paul Grady, Ashton J. O'Donnell, Louis H. Roddis, Jr., *Fred H. Tingey, Vincent C. Bespe* (executive secretary), and Ralph G. Page (secretary).

I. Introduction and Abstract of Recommendations

With the inception of the nuclear age, the foreign policy of the United States crystalized on the objective of limiting the number of nuclear powers. The Baruch Plan to control nuclear weapons and to assure that special nuclear materials would be used principally for the peaceful purposes was submitted to the United Nations in 1946, though it was never adopted. The Atoms for Peace Program was conditioned on, and recognized the need for, assurances that the materials transferred under the program would not be diverted to military pursuits. The incorporation of safeguards requirements in bilateral agreements for cooperation, and the systematic transfer by the United States of its bilateral safeguards responsibilities to the International Atomic Energy Agency is consistent with this objective. The United States ratification of the Moscow Treaty of 1963, the so-called "Limited Nuclear Test Ban Treaty," was the lineal descendant of this policy objective. Thus it has been, and continues to be, a basic foreign policy objective of the United States to strictly limit the proliferation of nations with nuclear weapons capability.

The accelerating introduction of nuclear power on an economically competitive basis in this country and abroad during the last two years has resulted in dramatic forecasts of nuclear power growth during the next decade or two. While the benefits of abundant and economic nuclear power are many and generally well-known, this development will inevitably result in the availability of large quantities of special nuclear materials. If uncontrolled, nuclear weapons development and production programs could be initiated in many countries. By 1980, it has been forceast,[9] plutonium will be produced throughout the world at a rate of more than 100 kilograms per day. Such quantities of material contain the potential for production of a substantial amount of the world's electric power. Alternatively, however, they are sufficient for the daily production of many nuclear weapons.

While it is unreasonable and unrealistic to terminate the nuclear power program because of its potential for contributing to the spread of nuclear weapons, the forecast by-product production of plutonium makes it essential that an effective world-wide international safeguards system be established quickly.

There are obviously a number of ways for non-nuclear nations to obtain a nuclear weapons capability, e.g.,

- the indigenous development of a technology capability;
- the acquisition of materials or finished weapons supplied for such purpose by a nuclear power;
- the theft of finished weapons components or assembled weapons; and
- the diversion of materials developed in, or supplied for, peaceful application of nuclear energy.

Attainment of the objective of the non-proliferation policy accordingly involves a multifaceted program of formal and informal understanding, including:

- restricting the transfer of nuclear weapons and nuclear weapons technology to non-nuclear nations;
- inducements to such nations to refrain from independently developing nuclear weapons; and
- a safeguards program to protect against the diversion of materials to unauthorized purposes.

The safeguards program is designed to detect promptly, and thereby deter, diversions of special nuclear materials from peaceful programs to weapons applications. In the United States, the "safeguards" program is also expected to detect any diversion to unauthorized purposes of military materials, weapons, and weapons components, at least until they are transferred by the AEC to the Department of Defense.

The objectives of the safeguards program, properly implemented, can compel nations seeking nuclear arsenals to follow more expensive, and therefore less attractive, routes to nuclear weapons than would be the case if plutonium, for example, were acquired for military purposes as a by-product of a civilian nuclear power program.

Safeguards programs should also be designed in recognition of the problem of terrorist or criminal groups clandestinely acquiring nuclear weapons or materials useful therein. Although such illegal groups are more likely to steal finished components or weapons than divert materials from peaceful programs, criminal organizations may be attracted to divert such materials if a black market develops, as it is likely to. It should be recognized that political and social restraints would not influence terrorist, insurrectionist or criminal groups. Therefore, criminal sanctions, e.g., fines and prison terms, are essential elements of an effective safeguards program.

An international safeguards program can help reduce tensions and perhaps contribute useful precedents for effective disarmament and other peace keeping arrangements.

The Panel recognizes that even if successfully put into practice on a world-wide basis, the safeguards program by itself cannot effectively assure that this country's non-proliferation objectives will be attained. Nonetheless, for the reasons discussed above, the safeguards program is worthy of the active support of all interested governmental agencies.

The Panel believes that the AEC generally has been responsive to its obligations, under the Atomic Energy Act, for safeguarding special nuclear materials. Over the past twenty years there has evolved a safeguards system applicable to AEC cost-type contractors which incorporates most of the essential elements for safeguarding special nuclear materials. The Panel notes that the AEC has recognized the need for modification of its safeguards program in the light of changing activities. The Panel generally concurs with the actions taken and contemplated.

The Panel has noted and recommends steps which the AEC can take to improve its programs. These recommendations are intended to promote a well coordinated, comprehensive safeguard system capable of coping with the rapid escalation in the distribution of nuclear technology and special nuclear materials.

Recommendations

1. The Atomic Energy Act of 1954 and the Atomic Weapons Rewards Act of 1955 should be modified to provide severe criminal penalties for unauthorized diversions of special nuclear materials and to provide rewards for information about such diversions. AEC regulations should require that these provisions be publicized and prominently posted at all installations handling significant* quantities of special nuclear materials.

2. a. Responsibility for policy making and overseeing the safeguards program should be vested in a single AEC office at a level sufficiently high that it can efficiently and economically coordinate this nation's domestic and international safeguards program.
   b. An Interagency Committee composed of representatives of sufficiently high stature from the AEC and such agencies as the Departments of Justice, State, Defense, Commerce, Treasury - as well as the Central Intelligence Agency and Arms Control and Disarmament Agency - should be established to formally involve these agencies in the safeguards program.

(At the Commission's request, the Panel transmitted on January 20, 1967, its specific and detailed suggestions for an organizational structure designed to achieve these objectives.)

3. All persons having access to significant quantities of unclassified* special nuclear materials should have a clearance equivalent to "L" clearances which are used in the AEC Classified Information Access Program.

4. The AEC, in cooperation with its licensees, should develop minimum physical protection standards applicable to licensees for the safeguarding of special nuclear materials. These standards should take into consideration the strategic importance of special nuclear materials as well as their high dollar value.

5. There should be provisions made for a review by the AEC of the design and construction of facilities that handle significant quantities of special nuclear materials to determine their adequacy for safeguards purposes.

6. Criteria should be established for acceptable limits for shipper receiver differences, materials unaccounted for, quantities discarded or lost, and maximum quantities of special nuclear materials permitted on inventory in forms unmeasurable or which can be measured only with a very large error, with due regard for the quantities, form and accessibility of the materials involved. In the event these limits are exceeded, the AEC should require an investigation and report.

7. The questions and forms of special nuclear materials handled should be principal determinants in establishing the safeguards program. There should be established minimum quantities below which no special safeguards provisions are made.

8. Increased emphasis should be given to systems of internal management control within all organizations handling special nuclear materials in order to minimize the risk of diversions to unauthorized purposes.

9. The United States should intensify its efforts to establish an effective universal safeguards system under the International Atomic Energy Agency. Toward this end the U.S. should encourage:
   a. Euratom and IAEA to arrange for appropriate surveillance by IAEA of the Euratom safeguards program, including active participation as appropriate in inspection of facilities;
   b. Voluntary acceptance by other nations, especially the major powers, of the IAEA safeguards inspections;

* As used herein, significant quantities of special nuclear materials refer to quantities in excess of 5000 grams of contained uranium 235, uranium 233, plutonium, or any combination thereof.

* For classified materials, special clearances are required by AEC.

c. The assignment by member nations of qualified personnel to the IAEA safeguards program for terms of at least five to seven years;

d. International pooling through the IAEA of information regarding diversions (actual, attempted, or potential) of special nuclear materials to unauthorized purposes.

10. a. The AEC should continue the present safeguards policy as provided for in the US-Euratom agreement for cooperation until Euratom and IAEA agree to surveillance by IAEA of the Euratom safeguards system.

b. The AEC should improve its evaluation of the effectiveness of the Euratom safeguards program.

11. The AEC should increase its research and development effort on safeguards techniques and should encourage and support other national and international efforts to improve safeguards.

12. The United States should encourage the International Atomic Energy Agency and other interested nations to establish an International School of Safeguards to train inspectors, develop research programs, and accumulate and distribute information relating to safeguards.

13. There should be an independent review of the safeguards currently applicable to materials and weapons transferred to the Department of Defense under Section 91b. of the Atomic Energy Act of 1954.

APPENDIX 8

February 10, 1967

INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT PROGRAM FOR THE SAFEGUARDING OF SPECIAL NUCLEAR MATERIALS

The prevention of proliferation of special nuclear materials for unauthorized uses may be broadly divided into two general problem areas: (1) prevention against diversion, and (2) detection of diversion.

Prevention is concerned primarily with physical security of special nuclear materials, while detection concerns accounting systems for special nuclear material, technical measurement systems for such material, inspection and audit systems, as well as intelligence activities.

The Institute has surveyed both the areas of prevention and detection of diversion of special nuclear materials for unauthorized uses with the objective of arriving at a safeguards program for the Institute, the results of which would contribute to the overall safeguards program of the United States.

The Institute believes that physical security, while important, will not deter the well trained agent. While some improvements in physical security protection are possible and desirable, the Institute believes that the more dependable means of detecting (and, by threat of detection, deterring) the diversion of special nuclear materials is through accurate material balances. The Institute will direct a major portion of its activities toward improving material balance techniques.

The Institute has concluded that its major contributions can be made in the area of subjects for detection of diversion as opposed to the general subject of prevention of diversion. To this end, the Institute contemplates the following program.

(1) *The Institute will prepare a series of standard (or recommended) systems for accounting for strategic special nuclear materials.* It is recognized that details of systems of accounting for nuclear materials will vary with the type of operation and therefore it is proposed to prepare a separate standard system of accounting for:

(a) Enrichment plants
(b) Conversion plants
(c) Fuel Fabrication plants
(d) Reactors
(e) Reprocessing plants
(f) Shipments

(2) *The Institute will develop a series of standard measurement systems* for use in the activities listed in (1) above to establish the quantities of special nuclear materials involved, such that complete and accurate material balances around each of these activities can be accomplished. These measurement systems will involve both weight/volume determinations as well as sampling and analysis.

(3) *The Institute will prepare standard systems for the inventorying of special nuclear materials* in the various types of activities outlined in (1).

(4) *The Institute will establish standard inspection and audit systems* for policing the above described accounting, measurement and inventory systems.

(5) *The Institute will revise its procedures for the certification of nuclear materials managers* to incorporate a comprehensive written test concerning special nuclear material measurements, inventory techniques, accounting techniques, inspection and audit techniques, the economic significance of loss of special nuclear material, and the national security significance of the loss of special nuclear material.

(6) *The Institute will undertake to establish what constitutes a reasonable loss of special nuclear material* in the various operations set forth in (1). This reasonable loss should be established in the light of what is economically practical for a given production operation and an estimate should be made of the expense involved in reducing such loss.

The Institute does not envision the above standards preparation effort as being purely original work at the outset. The establishment of the standards as described in (1)-(4), above, will be directed towards getting down on paper, techniques which are being used presently which reflect the best practice of the industry, suitably modified to take into consideration the safeguards objectives. The Standards Committee of the Institute will establish the format for these standards and assign each of the tasks to individuals for prompt development of an initial draft.

COMMENTS

In addition to the safeguards program recommended, the Institute recommends that the government consider establishing the following requirements as deterrents against proliferation of special nuclear materials:

(1) All persons handling or processing significant quantities of special nuclear materials, or having access to accountability records or reports, or having any

responsibility in connection therewith should possess AEC "L" Clearances as a minimum.

(2) All plants and facilities in which significant quantities of special nuclear material are handled or processed should have posted at all accesses to such facilities the legal penalties for diversion of special nuclear material for unauthorized uses. All employees of such facilities should be required to read and have explained to them these penalties and should sign an acknowledgement of their understanding of such penalties.

(3) All unattended storage facilities of significant quantities of special nuclear material should be kept locked and should be equipped with a suitable alarm system. A record should be kept of all persons entering and leaving these facilities.

(4) All facilities in which significant quantities of special nuclear material are stored, handled, or processed should have 24-hour armed guard surveillance or suitable alarm system.

Proposed NRC Material Access Screening Program

(Continued from Page 52)

the development of a reliable nuclear safeguards strategy.

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Recent Developments and Accomplishments in Safeguards Education and Standards for the Control of Nuclear Materials

By Roy G. Cardwell*
Chairman
Institute of Nuclear Materials Management

EDITOR'S NOTE: The following presentation was made at the Winter Meeting of the American Nuclear Society on November 30, 1977, in San Francisco, California. The author has edited his manuscript slightly for journal publication.

It is my privilege to present to you a brief discussion of the contributions of the Institute of Nuclear Materials Management in two important areas on which our profession is very dependent: (1) standards for the control of nuclear materials, and (2) the continuing nuclear management education process. But, before I do, please permit me a moment to acquaint you a bit with the Institute and its work.

Created on May 17, 1958, INMM is a nonprofit organization of individuals working in government, industry, and academic institutions wherever nuclear materials are utilized. Its basic objectives are to further the advancement of nuclear materials management in (a) the application of principles of accounting, auditing, engineering, mathematics, physics, statistics, and physical security for the safeguarding of nuclear facilities and nuclear materials in facilities and transportation, (b) the promotion of research in the field of nuclear materials management, (c) the encouragement, development, and preparation of American National Standards Institute standards consistent with existing professional and regulatory requirements, (d) the promotion of international cooperation in nuclear materials management, and (e) the continued development of the qualifications and usefulness of those individuals engaged in nuclear materials management as a profession. We are bending our efforts toward total management and control of our valuable nuclear materials by safeguarding them as they move through the fuel cycle, by the selection of reliable control methods, and by the assurance of both quantity and quality of our product.

INMM was created to fill a common need among all nuclear materials managers ....that of bringing together an uncommon group of people in a common effort. For, unlike the usual professional society, our educational and work backgrounds would sometimes seem to be as varied as our individual members themselves. I believe that the interaction brought about through the two activities that I will briefly discuss this morning, STANDARDS and EDUCATION, have been by far the major factors in helping us to mutually understand our interdiscipline problems and have emerged as the supporting pillars of our society.

ANSI STANDARDS

INMM has been the society designate for N-15 standards by the American National Standards Institute since 1968, publishing our first standard in 1970. *Figure 1* shows the way our N-15 effort is organized.

For those of you who are not familiar with how a standard gets to be a standard, the process in outlined in *Fig. 2*. The result of this effort for the past eight years has been the development and publication of 20 very useful standards as shown in *Fig. 3*.

But, as the constituent said to his Congressman, "What have you done for me lately?" What are the recent developments in our standards effort?....which is, of course, what this paper is supposed to be about. *Figure 4* lists our current standards in process and summarizes their status.

One comment on INMM-11. The Institute has as one of its major goals an ongoing certification program for people in the nuclear management field. For several years certification was offered through a committee created by the society who devised and administered the qualification and testing procedures they deemed necessary for awarding the certificate. It was thought that a better way to set up qualifications was through an ANSI Standard; hence, INMM-11. After several months and considerable effort, it now appears this was not the way to go; and this committee has been removed from the N-15 organization and asked to devise another system.

EDUCATIONAL OPPORTUNITIES

The second part of this paper concerns the continuing education program of INMM. Because of the wide variety of expertise within our membership ranks, the Education Committee has been able to organize and offer some exceptional opportunities. I have selected two to discuss here. The first is currently ongoing and the second is just now being organized.

Our N-15 Chairman, John Jaech, is also involved with our Education Program, having organized and written, and is now teaching an advanced statistics course oriented particularly to nuclear materials control. John is a very well-known nuclear statistician with the Exxon people in Richland and is the author of a book, *Statistical Methods in Nuclear Materials Control*, on which the course is based. He has given it on three occasions at Argonne National Laboratory and more recently at Richland and Battelle-Columbus. He tells me that he "found a home" in Columbus and plans to offer the course there on a more-or-less regular basis. Incidentally, INMM courses are open to nonmembers as well as members, and we invite your inquiries in this regard. There are three general topics in this course that are fully outlined in *Fig. 5*.

I must confess that I have not taken John's course, so I do not completely understand some of the terms, but this will give you an idea of the content and applicability of this particular course to materials control. I will rather proudly admit that we do survey each student on completion of the course — and thus far have received a high degree of complimentary comment, particularly as to its usefulness to them.

The other current education project that I will discuss briefly was inspired by the current emphasis on security. We believe that the prevention of theft or unauthorized diversion of nuclear materials and the physical security of a nuclear facility are best accomplished by a qualified guard force; but, because of the complexities of both nuclear materials and the present society in which the nuclear industry operates, such a force must be specially organized, trained, and oriented above the normal plant protection standard. Our purpose is to consolidate the efforts of highly qualified, experienced security personnel selected from all over the United States in the writing and presentation of an extensive, continuing seminar in the organization, operation, and supervision of a nuclear facility guard force.

A standing committee is now being established to detail and finalize the curriculum, select and engage faculty, and determine general policy of the school. We plan that this committee will consist of appropriate representatives from DOE, NRC, contractors, licensees, and the Institute. Both DOE and NRC have indicated a high interest in the school, and we are currently negotiating with these agencies.

The proposed training outline is shown in Fig. 6 only in very general detail. In regard to the last two items, we propose that the field work include range firing of standard weapons, and that the panel discussion will give the faculty an opportunity to repeat or expand on the more questionable or complex subject matter.

Thank you very much for this opportunity to talk to you about some of our programs.

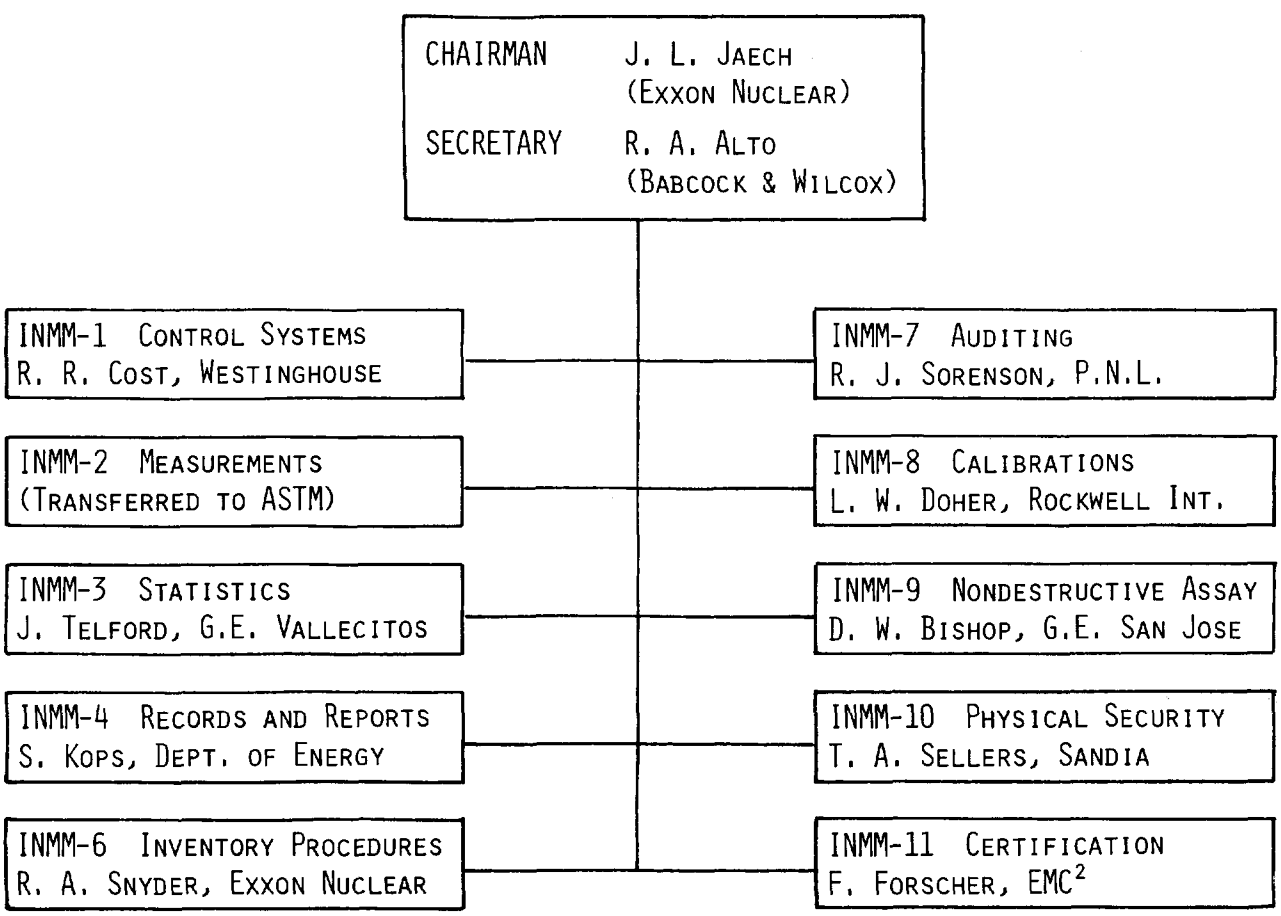

Fig. 1. The N-15 Organization.

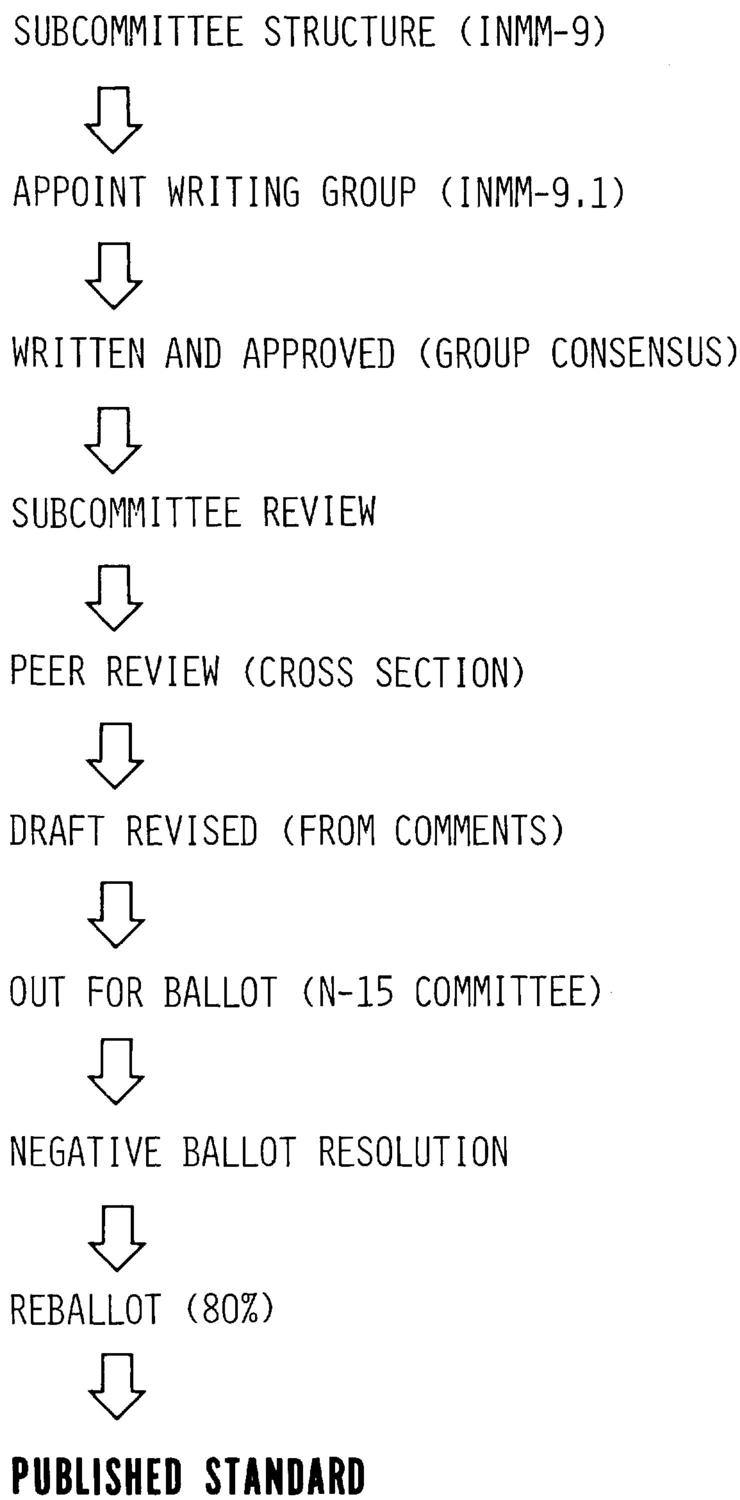

Fig. 2. Processing an N-15 Standard.

INMM-1 PUBLISHED STANDARDS

ANSI NUMBER	TITLE
N15.1 -1970	Unirradiated Uranium Scrap, Classification of
N15.4 -1971	Nuclear Material Control Systems for Conversion Facilities, Guide to Practice
N15.8 -1974	Nuclear Material Control Systems for Nuclear Power Reactors
N15.9 -1975	Nuclear Material Control Systems for Fuel Fabrication Facilities
N15.10-1972	Unirradiated Plutonium Scrap, Classification of
N15.13-1974	Nuclear Material Control Systems for Irradiated Fuel Processing Facilities, A Guide to Practice

INMM-3 PUBLISHED STANDARDS

ANSI NUMBER	TITLE
N15.5 -1972	Statistical Terminology and Notation for Nuclear Materials Management
N15.15-1974	Assessment of the Assumption of Normality in Small Samples
N15.16-1974	Limit of Error Concepts and Principles of Calculation in Nuclear Material Control
N15.17-1975	Concepts and Principles for the Statistical Evaluation of Shipper-Receiver Differences in the Transfer of Special Nuclear Materials

INMM-8 PUBLISHED STANDARDS

ANSI NUMBER	TITLE
N15.18-1975	Mass Calibration Techniques for Nuclear Materials Control
N15.19-1975	Volume Calibration Techniques for Nuclear Materials Control
N15.20-1975	Guide to Calibrating Nondestructive Assay Systems
N15.22-1975	Calibration Techniques for the Calorimetric Assay of Plutonium-Bearing Solids Applied To Nuclear Materials Control

OTHER N-15 PUBLISHED STANDARDS

ANSI NUMBER	
N15.2 -1971 INMM- 4	Record and Reporting Units for Nuclear Materials Control
N15.3 -1972 INMM- 6	Physical Inventories of Nuclear Materials
N15.6 -1972* INMM- 2	Accountability of Uranium Tetrafluoride, Analytical Procedures for
N15.7 -1972* INMM- 2	Accountability of Uranium Hexafluoride, Analytical Procedures for
N15.11-1973 INMM- 7	Auditing Nuclear Materials Statements
N15.26-1976 INMM- 10	Physical Protection of Special Nuclear Material Within a Facility

*Transferred to N-11

Fig. 3. ANSI Standards Published by INMM.

	TITLE	COMMENTS
N15.5 INMM-3	"Statistical Terminology and Notation for Nuclear Materials Management- "Revision	Ready for balloting by about September 1.
N15.29 INMM-3	"Procedures for Correcting Measurement Data for Bias,"	Detailed Proposed outline developed with writing of first draft to follow.
N15.24 INMM-4	"Standard for the Recordkeeping and Reporting of License Inventory Data,"	Draft of standard suitable for review outside of INMM-4 to be completed.
N15.25 INMM-6	"Standard for Measuring Material in Process Equipment,"	Draft for outside review by September 1. Ready for balloting by December 1.
N15.38 INMM-7	"A Generic Guide for Auditing Nuclear Materials Safeguards Systems,"	Draft for outside review by September 1. Ready for balloting by December 1.

Fig. 4. Standards in Process.

Calculating Uncertainties of Safeguard Indices

- Error Models
  - Random Errors, Systematic Errors, Biases
  - Additive and Multiplicative Models
- Error Propagation
  - Taylor's Series
- Calculating the Variance of MUF
  - Random
  - Systematic
  - Total
- Calculating the Variance of Difference Statistics
  - Shipper-Receiver Data
  - Inspection Data
- Alternative Indices of Control Performance
  - Cumulative MUF
  - Conditional MUF

Estimating Measurement Variances

- Systematic Errors
  - Comparisons and Standard
  - Bias Corrections
  - Fluctuating Biases
- Random Errors
  - Replicate Measurements
  - Analysis of Variance
  - Rounding Errors
  - Paired Data
  - Several Measurement Methods
  - Combining Estimates

Quantitative Aspects of Auditing/Inspection

- Statement of Problem
  - Auditing for Clerical Errors, Procedural Violations
  - Independent Verification of Materials Balance
  - Inspection Planning
    - Attributes Inspection
    - Variables Inspection
  - Evaluation of Sample Plan
  - Analysis of Inspection Data

Fig. 5. Selected Topics in Statistical Methods for Special Nuclear Material Control.

I. GENERAL ORIENTATION
II. GUARD FORCE ORGANIZATION
III. GUARD ORDERS (SOP)
IV. WEAPONS
V. ACCESS CONTROL AND AUTHORIZATION
VI. PHYSICAL PROTECTION
VII. COMMUNICATIONS
VIII. INTRUSION DETECTION SYSTEMS
IX. PLANNING - EMERGENCY
X. HEALTH PHYSICS (ORIENTATION COVERAGE)
XI. ADMINISTRATIVE
XII. FIELD WORK
XIII. PANEL DISCUSSION

Fig. 6. Guard Force Organization and Supervision.

DOE/SS Handbooks—A Means of Disseminating Physical Security Equipment Information

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Abstract

In this article, a series of handbooks which are used to disseminate physical security equipment information is described. These handbooks have been prepared by Sandia Laboratories, Albuquerque, New Mexico, under the sponsorship of the U.S. Department of Energy, Safeguards and Security (DOE/SS). They contain data obtained from evaluation programs conducted at various laboratories supported by DOE, the Department of Defense (DOD), other government agencies, and information provided by commercial security equipment suppliers. Handbooks in the areas of intrusion detection systems, entry-control systems, and barrier technology presently exist and an overview of their contents is given. These handbooks were written to fulfill immediate DOE needs but were planned so they would also be useful to other organizations, both national and international, who are responsible for protecting items of value or strategic importance, especially those charged with protecting Special Nuclear Materials (SNM). Handbooks in the areas of locks, seals, and safeguards central control systems are presently being prepared and outlines of their anticipated contents are also given.

Distribution of the handbooks is controlled by DOE/SS. The handbooks have been requested by virtually every U.S. Government agency which uses physical security equipment, by various commercial power companies, by various architectural and engineering firms, and by agencies from several foreign countries.

Introduction

The DOE-Sponsored Fixed Facilities Physical Protection Research and Development Program.

The protection of strategic quantities of Special Nuclear Materials (SNM)** against theft or diversion has become of growing concern due to (1) the increasing incidence of organized, overt terrorism during recent years, (2) the publicity concerning the fabrication of crude nuclear bombs and the hazards of malevolent dispersal of radioactive material, particularly plutonium, and (3) the increasing quantities of plutonium and highly enriched uranium associated with the nuclear fuel cycle. This concern has emphasized the need for improved physical protection of SNM against not only well-organized, armed terrorist attacks but also diversion through employee collusion.

In order to meet the need for improved protection of nuclear material and facilities, the Department of Energy, Safeguards and Security (DOE/SS)† is developing a

* This work was supported by the U.S. Department of Energy under DOE contract AT(26-1)-789.

**Strategic quantities of SNM are presently defined as follows:

1. Uranium 235 (contained in uranium enriched to 20 percent or more in the U-235 isotope) alone, or in combination with plutonium and/or U-233 when (multiplying the plutonium and/or U-233 content by 2-1/2) the total is 5000 grams or more.
2. Plutonium and/or uranium 233 where the plutonium and/or U-233 content is 2000 grams or more.

† DOE/SS was formerly ERDA/DSS, the Energy Research and Development Administration, Division of Safeguards and Security.

nuclear safeguards technology which can be used by both the government and the nuclear industry. The scope of the technology development programs has been previously reported.[1-8] The dissemination of safeguards information beyond the scope of physical security equipment is occurring, but it will not be discussed in this paper.[8-10]

The Fixed Facilities Physical Protection Research and Development Program, which was initiated at Sandia Laboratories in late 1974, is a part of the DOE-sponsored nuclear safeguards technology development effort. The Sandia Laboratories program is directed toward (1) system analysis and assessment, (2) physical security equipment evaluation and development, and (3) system design and operational testing and evaluation. The handbooks described in this report are the result of the equipment evaluation and development portion of the Sandia program. These handbooks are used to disseminate information concerning physical security equipment and techniques throughout DOE, other government agencies, and the nuclear industry, both domestic and foreign. Distribution of the handbooks is controlled by DOE/SS.

Equipment handbooks which presently exist are (1) the Intrusion Detection Systems Handbook, SAND76-0554, November 1976 (Revised October 1977), (2) the Entry-Control Systems Handbook, SAND77-1033, September 1977, and (3) the Barrier Technology Handbook, SAND77-0777, which, it is anticipated, will be available in mid-1978. A photograph of these handbooks is shown in Figure 1. Additional handbooks in the areas of locks, seals, and safeguards central control systems are presently being prepared. Because of the dynamic nature of the material being covered, the handbooks are published in looseleaf form so that page revisions can be made as significant additional information becomes available. Major subdivisions of each chapter are numbered so that inserting or deleting pages can be accomplished without significantly altering the table of contents or other subdivisions in the chapter. Additionally, each page is dated and a current status listing of all pages accompanies each package of replacement pages. All of these provisions allow for timely and orderly updating of the handbooks.

The next section describes the three currently existing handbooks. Then, the three envisioned handbooks are briefly discussed. Finally, a brief summary of what has been accomplished to date and suggested future plans are presented.

Existing Handbooks

Intrusion Detection Systems Handbook

The purpose of the Intrusion Detection Systems Handbook is to provide information

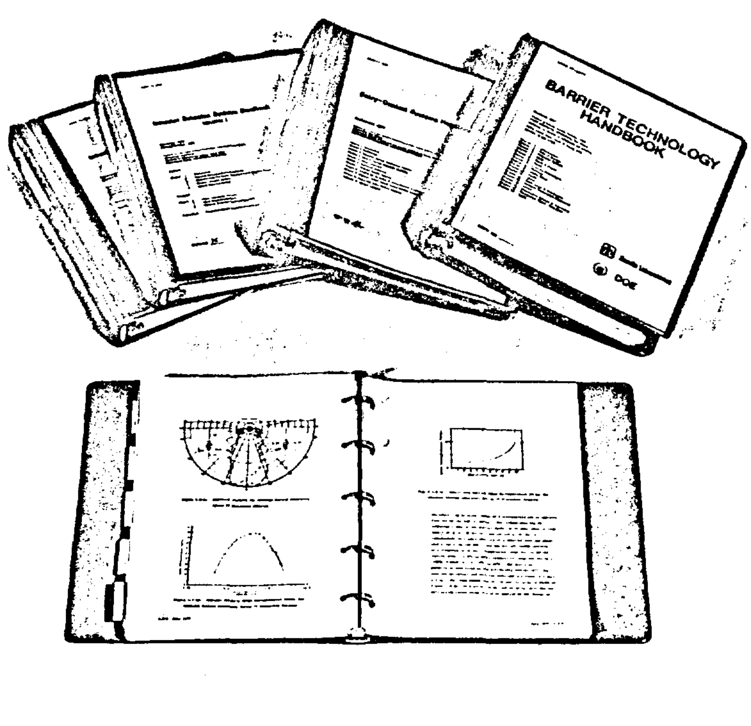


Figure 1. Existing Physical Protection Systems Handbooks

on the selection, procurement, installation, testing, and maintenance of elements of an intrusion detection system. These elements include: (1) sensors, both for exterior and interior use, (2) equipment used to assess alarms generated by the sensors, and (3) equipment used to report sensor status to the system's operating personnel. Also included in this handbook is a discussion on integrating these elements into an operationally-effective intrusion detection system. The handbook was initially published in November 1976; it was extensively revised in October 1977.

Handbook Contents -- The handbook presently contains eight chapters and one appendix. Chapter 1 is an introductory chapter which identifies the purpose and the use of the handbook and lists information sources. Chapter 2 ("Intrustion Detection System Concepts") provides an overview of the key concepts which must be considered in planning an operationally-effective intrusion detection system. After reading this general information, the user can determine, with the aid of Chapter 3 ("Considerations for Sensor Selection and Subsystem Design") the initial choice of the technological type of sensor(s) and sensor configuration best suited for a particular site. Site and environmental characteristics which affect both exterior and interior sensor performance are discussed. Chapter 4 ("Exterior Intrusion Sensors") and Chapter 5 ("Interior Intrusion Sensors") provide guidance for selecting, procuring, installing, testing, and maintaining specific kinds of sensors. Chapter 6 ("Alarm Assessment Systems") is primarily concerned with the vital role of video assessment in an operationally-effective intrusion detection system and places particular emphasis on closed-circuit television (CCTV). Chapter 7 ("Alarm Reporting Systems") describes the wide variety of equipment which can be used to report sensor status to system operating personnel. In addition to alarm reporting (information display), alarm communication systems are also covered. Chapter 8 ("Intrusion Detection System Integration") identifies additional information which must be considered and/or obtained before the intrusion detection system elements can be integrated into an operationally-effective intrusion detection system. Finally, the appendix discusses methods of protecting electronic equipment from electrical disturbances.

Handbook Preview -- The Intrusion Detection Systems Handbook is organized to acquaint the reader with intrusion detection system concepts (Chapter 2) and the attributes of a site which affect sensor performance (Chapter 3) before presenting the details of system hardware (Chapters 4 through 7). Chapter 8 brings the previously presented information into focus by describing the process of integrating and interfacing the various individual elements, procedures, and personnel into one system for providing intrusion detection at a facility. The expression "operationally-effective" is used to describe systems which have achieved a reasonable balance between (1) optimization of system hardware, (2) comprehension, acceptance, and efficient utilization of the system by security personnel, and (3) a sufficient degree of detection capability at the facility.

It is essential that any new intrusion detection system, or one that is to be improved, be carefully planned and analyzed to ensure that it will perform its function reliably and that its strengths and weaknesses are identified and understood. Included in the planning and analysis is the development of (1) a system philosophy, (2) a preliminary system design, (3) on-site experiments and evaluation, (4) final system design, (5) construction and installation considerations, (6) a program schedule, (7) cost considerations, and (8) procurement.

Intrusion detection systems hardware is comprised of sensors, alarm assessment systems, and alarm reporting systems (including alarm communications and information display equipment). The performance of the sensing and assessment equipment is heavily influenced by the physical environment in which it must operate, as well as by installation and maintenance. Since present-day knowledge of the correlation between sensor operation and the physical environment is limited, some on-site evaluation will be required before, during, and after installation. An operationally-effective intrusion detection system is also influenced by facility regulations, procedures, and personnel. All of these items, coupled with the type of facility or material to be protected and the most likely threat (including some intruder attributes), influence the final system selection. The influential factors which must be considered along with the hardware to produce an operationally-effective intrusion detection system are shown in Figure 2.

Intrusion detection systems are generally used in association with a barrier system so that attempts to penetrate the barrier will result in an alarm. Intrusion detection systems interface with entry-control systems to allow authorized activity at a facility. Exterior detection systems are used to detect entry into clear areas or isolation zones that constitute the perimeter of a protected area, a protected building, or a fixed-site facility. Interior detection systems can be used to detect penetration into a structure, to detect movement within a structure, or to provide knowledge of contact with a critical or sensitive item.

A sensing device in combination with a processor forms the basic detection element; this combination is commonly called a

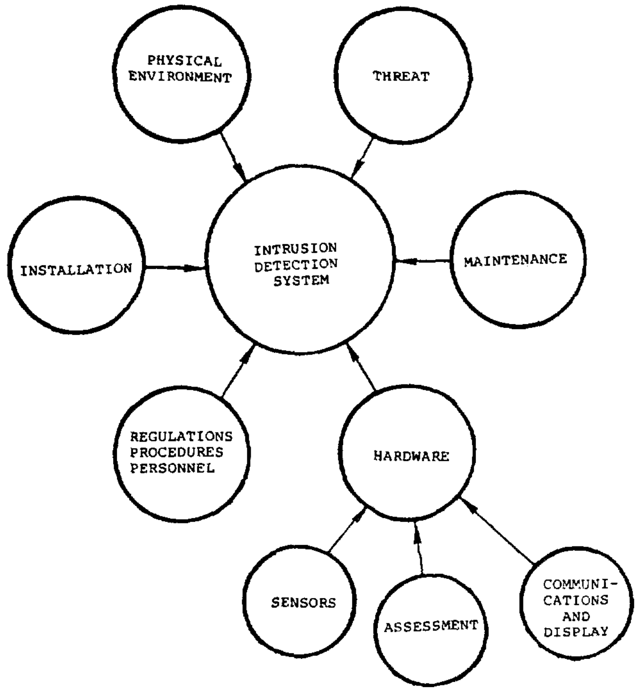


Figure 2. Factors Which Influence Intrusion Detection System Selection

"sensor." Three performance characteristics associated with sensors are listed below:

1. Probability of Detection (P_d) provides an indication of sensor performance in detecting an adversary within the zone covered by the sensor. Probability of detection involves not only the characteristics of the sensor, but also the characteristics and environment of the site, the method of installation and adjustment, and the assumed behavior of an intruder. For example, in addition to simply walking through an area, an intruder may attempt an intrusion by various methods such as running, crawling, jumping, or moving very slowly. Depending upon the particular sensor characteristics, the probability of detection may be considerably different for the different types of intrusions. The prevalent use of a single number to represent P_d of an individual sensor or of an entire sensor system can produce both misleading and erroneous results. If P_d is described by a single number, the conditions under which this number applies should be described also.

2. False Alarm Rate (FAR) signifies the expected rate of occurrence of alarms which are not attributable to adversary activity. For the purpose of sensor evaluation per se, it is often useful to categorize nonadversary-related alarms as false alarms (reason unknown) and nuisance alarms (reason known). However, in this handbook, both categories are included in the term "false alarm," i.e., false alarms are considered to be any alarms which are not caused by adversary activity. The FAR (given as alarms per unit time) affects assessment activity since each time an alarm occurs, the assessment system must be employed. If there were no false alarms, the assessment system would only be used to determine adversary characteristics and to direct response force actions. An acceptable FAR depends heavily on the ability to identify the source of each alarm. A high FAR will tend to undermine confidence in the system. For this reason, the system design goal should be to eliminate as many causes of false alarms as possible.

3. Vulnerability to Defeat is another measure of sensor quality. Obviously a sensor which is very good with respect to FAR and P_d, would still not necessarily be a desirable choice if it is trivially easy to defeat. Sensors can be made less vulnerable to defeat if they are equipped with tamper alarms, anticapture circuitry, line supervision capability, and full end-to-end self-test capability. Installation practices such as overlapping the sensor fields to provide mutual protection for each sensor or the addition of special sensors (point sensors) to protect weak points in the sensor system are also essential considerations in the design of a sensor system.

Typically, an intrusion detection system employs perimeter sensors, building penetration sensors, and interior sensors. Additionally, proximity sensors or movement sensors are often installed on critical or sensitive material. The sensors should not be considered as separate entities since together they can provide a high P_d for the items being protected. This combination demonstrates a safeguards concept known as "protection-in-depth," which is simply a number of protective measures in series, i.e., an intruder must successfully circumvent or defeat each of the protective measures in sequence before access to the protected material or facility is achieved.

A major design goal is to obtain an intrusion detection system which exhibits a low FAR and an acceptable P_d and is not susceptible to defeat. The stated goal can be achieved by logically or hierarchically combining the outputs of different types of sensors. No single sensor that will reliably detect all intruders and still have an acceptably low FAR for all expected natural and manmade environments presently exists. However, the number of sensor types in a system should not be increased and/or logically combined or implemented to change any of the performance characteristics mentioned above without considering how these changes affect the other performance characteristics. A common assumption is that the system should be adjusted to achieve a value of P_d which is very close to 1, and that any resultant increase in FAR will be tolerated. This assumption is acceptable only if the system FAR is equal to or less than that FAR which each security force will tolerate while at the same time still treating each alarm as a credible alarm. When this FAR is exceeded and the system is turned off or ignored, the actual system P_d goes to zero.

When using exterior sensors on the perimeter of an area or building, a well-defined clear zone or isolation zone is highly desirable. Such a zone results in a reduction of the FAR inadvertently caused by innocent people, large animals, blowing debris, etc. In addition, the perimeter should be divided into independently alarmed segments in order to localize the area of an alarm. This provides the capability to rapidly assess an alarm; it likewise can assist response force operations. Fences can move in the wind and cause false alarms; therefore, if fences are used to delineate the clear zone or isolation zone, they must be carefully located and constructed.

Figure 3 (reproduced from Chapter 4 of the Intrusion Detection Systems Handbook) shows the effective detection zone width and height of a particular exterior microwave system. As can be noted, the effective detection zone dimensions depend largely upon the mounting height of the sensor for units operating over the same type of surface.

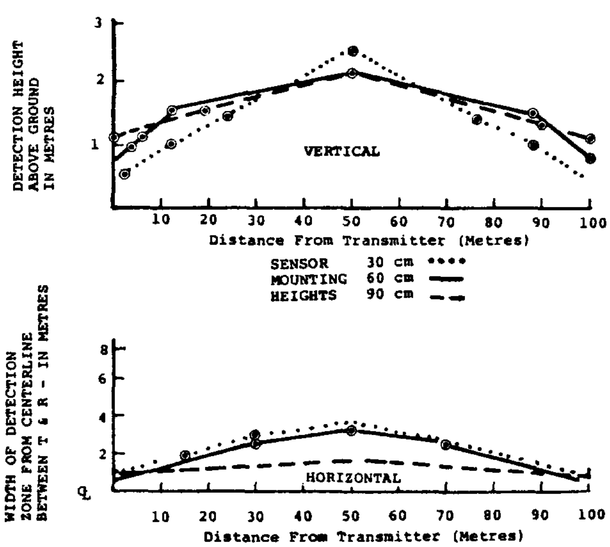


Figure 3. Vertical and Horizontal Detection Envelopes for a Particular Exterior Microwave System

Figures 4, 5, and 6 present the detection patterns, intruder velocity range multiplication factor, and sensitivity setting range multiplication factor for a particular interior ultrasonic detector. The detection pattern is shown for two orthogonal orientations. The range multiplication factors provide an indication of the effects of intruder velocity and sensor sensitivity setting on the detection pattern. Information similar to this is presented about a number of different sensors in Chapter 5.

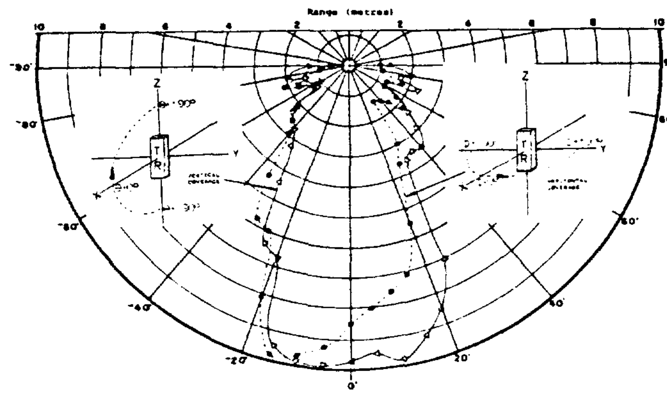


Figure 4. Detection Patterns for a Particular Ultrasonic Sensor

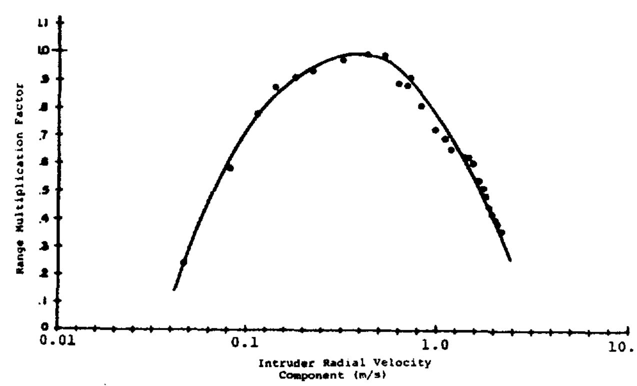


Figure 5. Intruder Velocity Range Multiplication Factor for Sensor Detection Pattern Shown in Figure 4

Alarm assessment is the process of determining the cause of an alarm. Accurate and rapid assessment is essential to prevent the commitment of response forces as a result of false alarms or diversionary action by intruders. Chapter 6 is a miniature textbook on the applications of CCTV to alarm assessment. It begins with a tutorial description of generic video components which emphasizes component function and operation and the individual components relation to the overall video system. This is followed by sections on system and subsystem selection, procurement, installation, performance, and maintenance. The chapter concludes with a "System Design Example" which presents an example of a typical video assessment system. The example provides an overview of the requirements and problems of video alarm assessment system design. A major point made by the example is that even though all of the CCTV components required are commercially available and single camera/single monitor systems are quite simple, an adequate video alarm assessment system is technologically complex and represents an investment in engineering time, hardware and installation costs, and maintenance requirements comparable to each of the other components (exterior sensors, interior sensors, alarm information display) of a total intrusion detection system.

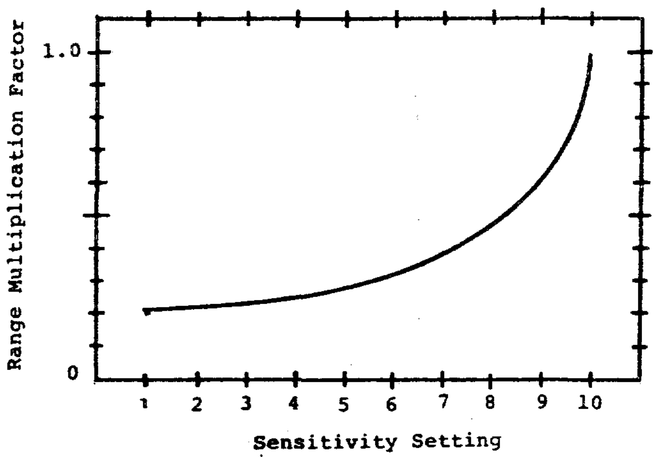


Figure 6. Sensitivity Setting Range Multiplication Factor for Sensor Pattern Shown in Figure 4

Chapter 7 makes it evident that the term "Alarm Reporting System" encompasses a wide variety of equipment which is used for communicating alarm information from intrusion detection sensors to security personnel. There are substantial differences among the various commercially available alarm reporting systems. Notable differences include such characteristics as (1) the geographical distribution of alarm communication hardware, (2) the degree of security (e.g., line supervision) which is provided by the alarm communication system, (3) the system capacity in terms of the number of points or zones which can be monitored, (4) the quantity of information presented to the security personnel (operator or guard), (5) the degree of control which the operator/guard can exercise over the information presented, (6) the clarity of the information presented, (7) ease of operation, and (8) overall system cost.

Appendix A is included at the end of the handbook to acquaint the user with methods of protecting electronic equipment against electrical disturbances such as lightning, ground currents and emissions from nearby electrical equipment, power and communication lines, and radio, television, and radar transmitters.

Entry-Control Systems Handbook

The major purposes of the Entry-Control Systems Handbook are (1) to provide a general entry-control systems philosophy and concepts for various applications, (2) to provide a theoretical discussion of the operating principles of the various elements of an entry-control system, (3) to provide descriptions of entry-control elements that are presently available or under development, including a discussion of operating characteristics and test results, and (4) to provide a discussion of entry-control portal systems. The handbook was initially published in September 1977.

Handbook Contents -- The Entry-Control Systems Handbook is structured as follows: Chapter 1 ("Introduction") contains the general philosophy of entry-control systems, the purpose of the handbook, instructions on how to use the handbook, and information sources. Chapters 2 through 7 ("Credentials," "Personnel Identity Verification Systems," "Special Nuclear Materials Monitors," "Metal Detectors," "Explosive Detectors," and "Package Search Systems") provide guidance for selecting, installing, and maintaining these kinds of entry-control equipment. Descriptions of the various available types of equipment are provided along with discussions about development in areas where adequate equipment is not available. Chapter 8 ("Criteria for Selection of Entry-Control Equipment") discusses the application criteria for selecting entry-control equipment and the site characteristics which affect that choice.

Chapters 9 and 10 ("Machine-Aided Manual Entry-Control Systems" and "Automated Entry-Control Systems") discuss both machine-aided manual and automated portal systems. Descriptions of available systems are provided along with discussions of systems under development.

Appendix A ("System Example") discusses a hypothetical situation in which SNM located in six different areas within a facility is safeguarded in part by the installation of an entry-control system.

Handbook Preview -- The handbook is organized to present the general philosophy of entry-control systems (Chapter 1) before presenting the details of system hardware (Chapters 2 through 7). The remainder of the handbook describes the attributes of a site which affect system performance and the manner in which individual pieces of hardware can be blended into a system. The primary functions of entry-control systems are (1) to control personnel access to and egress from sensitive areas, e.g., areas containing SNM, vital equipment, and/or classified matter, (2) to detect contraband material (such as, explosives for sabotage purposes), and (3) to prevent the unauthorized removal of items of value or strategic importance, especially SNM.

There are three categories of entry-control systems: (1) manual, (2) machine-aided manual, and (3) automated. An equal level of security can perhaps be provided by each of these systems, although there can be a wide variation in technical complexity and cost. The type of system used depends on a number of factors, such as: (1) quantity and distribution of SNM to be protected and detected, (2) number and rate of personnel requiring admittance, (3) type of facility (R&D or production), and (4) types of additional safeguards measures, such as barriers and intrusion detection systems. Since these are site-specific considerations, no single system can be recommended for universal use. A system which is well-suited for one facility may be totally unsuited for use at another and the management at each facility must determine the entry-control system that is best suited for their facility.

A credential is described in Chapter 2 as a badge or other device issued to an employee to certify authority for access to controlled areas. The various types of credentials, their performance features, names, and addresses of credential system manufacturers are given in the chapter.

Chapter 3 discusses general personnel access problems. The identity of persons desiring access must be verified to ensure that they are indeed the ones to whom credentials were issued. Some comparative personnel identification techniques discussed are speech, handwriting, fingerprint, hand geometry, video comparator, and memorized number. These various techniques are evaluated against the following characteristics: (1) verification error rate, (2) resistance to counterfeiting, (3) throughput rate, (4) storage requirements for a reference file, (5) enrollment time, (6) cost, and (7) reliability.

Chapter 4 defines the purpose of SNM monitors used at entry-control terminals as the detection of concealed SNM on persons, in packages, or in vehicles exiting from controlled areas. The various types of entry-control equipment used and their operational strengths and weaknesses are discussed in this chapter.

Metal detectors are discussed in Chapter 5. When they are used as security devices for nuclear facilities, metal detectors must perform three functions: (1) detection of weapons and hand tools intended for sabotage, (2) detection of the presence of metal used to shield SNM, and (3) detection of metallic SNM.

The options available to facility managers for choosing explosive detection systems are outlined in Chapter 6; package search systems are discussed in Chapter 7.

In Chapter 8, the following criteria for selection of entry-control equipment are given: (1) detection capability, (2) security level, (3) throughput rate, (4) reliability, (5) environmental conditions (temperature and humidity, pulsed noise sources, continuous noise sources, and rain, snow, and wind), and (6) cost.

A machine-aided manual entry-control system (Chapter 9) utilizes one or more entry-control elements to assist a guard in making decisions to allow or deny entry to or exit from a controlled area. When this type of entry-control system is used, the final decision to allow or deny entry or exit is made by one or more guards. Machine-aided manual entry-control systems are currently in use at many facilities. Automated systems are still being developed.

A conceptual example of a machine-aided manual entry-control system for a nuclear facility is shown in Figure 7. There are many possible configurations for this system. However, in general, the subsystems shown are necessary for effective entry-control.

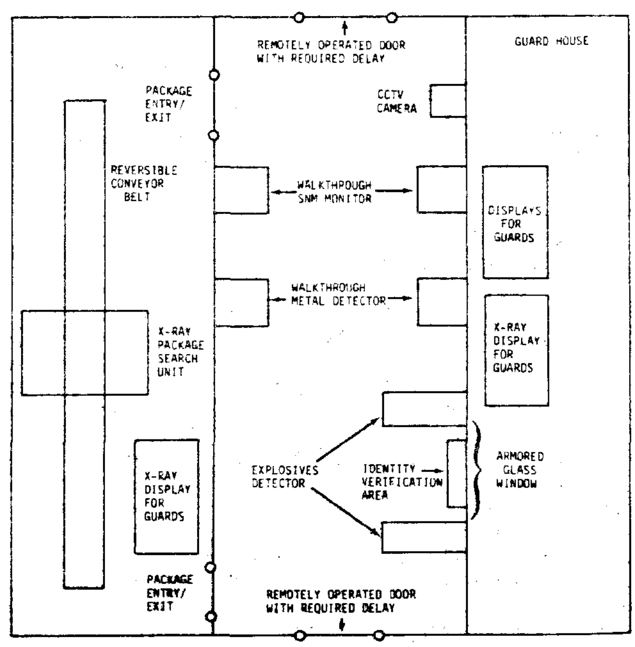


Figure 7. A Conceptual Machine-Aided Manual Entry-Control System

Automated entry-control systems (Chapter 10) are being developed which will handle routine processing automatically and require security force action only when situations arise which cannot be handled in a normal manner. Such situations include alarm activation, user aid requests, and user-initiated duress alarms. These require guard assessment and response.

Automated entry-control systems are composed of a central control, a communication network, a portal system, a bypass system, and an enrollment center.

Figure 8 illustrates an entry-control system containing each of these components. As a system, these components function to restrict access to a facility to authorized personnel and to prevent the exit or entry of contraband material. The actual level of security provided depends heavily on the sophistication of the portal systems, the degree of tamper-proofing afforded by the communication system, and the type of system utilized as a central control.

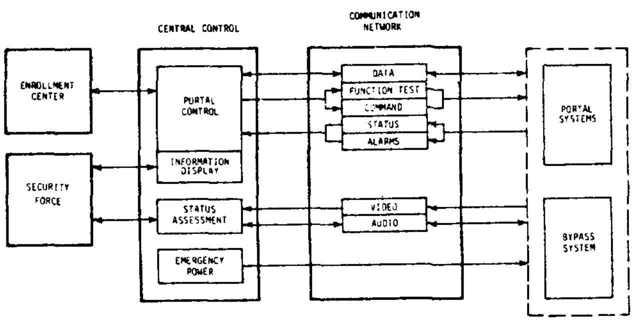


Figure 8. Entry-Control Systems

The system example found in Appendix A, in addition to the constraints mentioned earlier, is also based on the following assumptions. Passage of 1700 personnel into the Protected Area (PA) must be accommodated in 15 minutes by means of perimeter portals at two different points, with approximately 850 persons entering at each point. Once within the PA, personnel disperse, with approximately 1300 entering the six Material Access Areas (MAAs). The remaining 400 consist of administrative and clerical personnel. Due to particularly heavy traffic, two of the six MAAs require two building portals each. Consequently, a total of eight building portals are required for access control. The entry-control system to be implemented must utilize currently available entry-control equipment. This system example addresses personnel access only and does not include material handling facilities or vehicle portals.

Barrier Technology Handbook

The purposes of this handbook are (1) to define the role of barriers in a total physical security system, (2) to provide a central source of barrier penetration time data, and (3) to establish practical limits of present and state-of-the-art barrier technology. It is anticipated that the Barrier Technology Handbook, SAND77-0777, will be available in mid-1978.

Handbook Contents -- The handbook contains 17 chapters. Chapter 1 is an introductory chapter which identifies the purposes of the handbook and lists information sources. Chapter 2 ("Role of Barriers") discusses the scenario for barrier studies, threat attributes, and adversary action sequences. The philosophical aspects of barrier design trade-offs which affect or are affected by intrusion detection systems and/or response forces are also presented, as are considerations concerning delay times, attack tools, and penetration methods. The next 13 chapters discuss the following barrier categories: perimeter barriers, walls, roofs and floors, doors, locking mechanisms, windows, utility ports, vaults, igloos, earth cover and overburden, airborne penetration deterrents, armor, and dispensable barriers and deterrents. Chapters 16 and 17 contain barrier penetration times and penetration rates for specific types of barriers.

Developmental testing to date has concentrated on types and configurations of barriers that represent existing installations with the two-fold objective of establishing a data base of actual penetration times for performing security effectiveness evaluations and developing techniques for upgrading existing barriers. The barrier data base includes information gathered from literature searches, tests, analyses, and estimates extrapolated from existing data. The tests and analyses were performed by Sandia Laboratories and other government and private agencies. The barrier data base is the primary source of information for this handbook. Maintaining the barrier data base is an integral part of the barrier program.

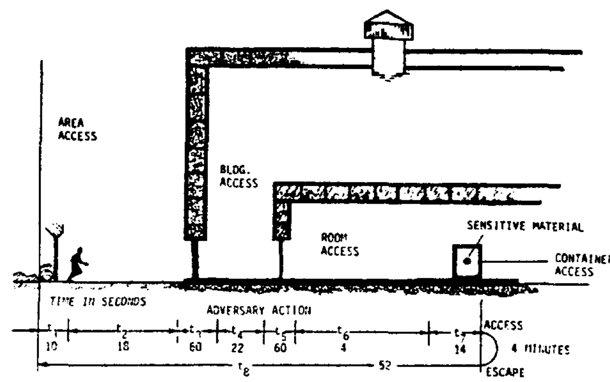
Handbook Preview -- The handbook is structured to first acquaint the reader with the role of barriers (Chapter 2) in a physical protection system. This is followed by detailed discussions about the various types of barriers presently available and a description of a barrier data base which serves as the primary source of information for this handbook. Most security barriers at industrial facilities were designed to deter or defeat sporadic acts of casual thievery. In the escalating environment of terrorist activity, traditional fences, buildings, doors, and locks present little deterrence or delay. The concept of delay is extremely important. Each additional minute required by the adversary action sequence provides additional time for response forces to interrupt the action. A few minutes delay may have a significant effect. Ensuring that barriers are in effect around the clock (gates and doors must periodically be open or unlocked) may be difficult. With the exception of a few barriers provided by natural elements such as rugged coastlines, high cliffs, mountaintops, and vast distances, physical protection and delay must be provided by barriers that are carefully planned and positioned in the path of the adversary. The degree of delay afforded depends on the nature of the physical obstacles deployed. These obstacles for a physical protection system may be conceived of as a series of concentric protective structures, ideally with associated detection systems. The total effectiveness of the protection system is enhanced if the barrier and detection systems are planned and designed at the same time.

A balanced design concept ensures that each aspect of a barrier configuration affords equal access impedance, i.e., no weak links. For example, an adversary action sequence will not require burning a hole in a door if the locks or hinges are clearly more vulnerable.

An example of a simple theft scenario at an industrial-type facility which has conventional barriers is shown in Figure 9. The scenario starts with the adversary just outside the fenced area and ends when the adversary has exited the fenced area with the stolen material. In this example, the adversary can accomplish the theft in about 4 minutes, if not interrupted by guards. Guards, of course, may not be available to interrupt the adversary unless he is detected at some point in the scenario and an alarm is sounded. To illustrate the short guard response times needed for various protection system goals, assume that a perimeter detection system with an immediate alarm capability exists just inside the fence. If the protection system goal is to intercept the adversary before he can penetrate the building, the guards must arrive within 78 seconds of the alarm. If the protection system goal is to intercept an adversary before he can touch the sensitive material, the guards must arrive within 3 minutes of the alarm. If the protection system goal is to prevent removal of sensitive material from the fenced area, the guards must intercept the adversary within 4 minutes of the alarm.

Because of the short penetration times of many conventional barriers and, therefore, short total adversary scenario times, enhanced or new barriers may be needed to increase the delay time and gain adequate time for the guards response.

The forcible entry example (Figure 9) illustrates how individual barrier penetration times (climb fence, drill door, pry door, open container) selected from the data base in Chapter 16 can be combined with rates in Chapter 17 (run, walk) to establish total adversary scenario times.



Task	Mean Time (seconds)	Task Description
1	10	Jump Fence
2	18	Run 250 Feet
3	60	Drill Door
4	22	Walk 150 Feet
5	60	Pry Door
6	4	Walk to Cage
7	14	Cut Grill Cage
8	52	Escape
	240	Total (4 minutes)

Figure 9. Forcible Entry (Example)

Potential adversary threats have the option of using tactics of force, stealth, and deceit, or combinations of these tactics. The barrier evaluation program is primarily directed toward adversary tactics of force or stealth. Entry-control features and procedures address deceit. To provide a basis for barrier studies the potential threat has been assumed to be an outside terrorist-like group capable of assaults at the competence level of a paramilitary group. In addition, the threat could be an insider (authorized personnel) working alone or with an outsider group.

The most common type of perimenter barrier (Chapter 3) is chain-link fencing with gates of compatible materials. Perimeter barriers are usually quite extensive and a cost-per-lineal foot of effectiveness must be considered in the initial installation. An economical but easily penetrated fence is often coupled with the use of a roving personnel patrol. A barrier which provides significant penetration delay time may hold the adversary at the point of intrusion long enough to assess the alarm and to allow a response force to intercept the intruder at the point of alarm.

Walls (Chapter 4) of buildings, vaults, and other structures are usually considered to be more resistant to penetration and less desirable as targets for forcible entry than are doors, windows, vents, and other conventional wall openings. However, most existing walls can be breached in short periods of time if adequate tools are used and may actually be the optimum path of entry for a forcible attack. Upgrading of existing walls or new wall designs can significantly extend the penetration delay times against hand, power, or thermal tools, thus forcing the attacker to selectively increase his tool requirements and to alter his methods of operation.

Combinations of tools, i.e., power and hand tools or explosives and power tools, are often required to accomplish wall penetration. Selection of the best tools or combinations of tools is essential to shortening penetration times. It is assumed that a team of attackers will utilize the optimum tools and will be skilled in their use. The handbook includes a discussion of wall configurations with graphs to illustrate comparative penetration times for various classes of tools, different wall constructions, and the effects of upgrades or modification on penetration times.

Roofs and floors are discussed in Chapter 5. Generally, floors offer more resistance than roofs because they are normally not as exposed and are constructed to accommodate the stress created by the weight of the structure as well as its contents. Penetration resistance is difficult to determine, with the possible exception of vaults, which are normally constructed with a balanced design, i.e., walls, roof, and floor are comparably constructed.

Chapter 6 evaluates the various doors used in typical industrial facilities and applies the criteria of balanced design necessary for effectiveness in a barrier array.

Information similar to that found in Chapters 3, 4, and 5 concerning locking mechanisms, windows, utility ports, vaults, igloos, earth cover and overburden, airborne penetration deterrents and armor is given in Chapters 7 through 14. Windows, for example, constitute a barrier which affords no significant penetration delay time without enhancement, because most windows can be penetrated with hand tools in less than 1 minute. Windows are often the "weak link" in the total building barrier system.

Dispensable barriers and deterrents are discussed in Chapter 15. After the adversary has defeated the perimeter barrier and the outer rings of the protective structure and approaches the inner barriers, the malevolence of the intent becomes apparent. At this point, deterrence can escalate to make removal of the sensitive material as difficult as possible. Physiological design factors can be used to disrupt adversary plans. Deterrents should be designed for direct interference with sensory and motor processes in addition to adding physical encumbrances. This would include visual obscurants and chemical agents which create a hostile environment. Social acceptance may prevent the installation of systems that would automatically inflict permanent serious bodily injury to the adversary. Dispensable barrier technology affords methods of augmenting protective structures to provide higher levels of protection.

The barrier data base (Chapter 16) provides penetration times for specific barriers; Chapter 17 contains supplementary penetration rates. Since rates for each task vary, depending upon the physical fitness, size, skill, and luck of the personnel, different penetration times are obtained. Sometimes adjustments can be made to the task rates to allow for this variation. Judgment must be used in deciding what adverse conditions (time delays) can be expected while penetrating a barrier. For example, burning through a ceiling may take longer than burning through a floor, even though the burning rate and barrier are identical. Other areas of judgment where allowances can be made are (1) rate allowances, e.g., set-up and tear-down, tool maintenance, personnel (rest, delay) breakage, and fatigue (difficulty, unfavorable weather, nonproductive time, and work area congestion), (2) team or group work allowances (training, rehearsals, dedication, and motivation), and (3) human bias allowances (change variation, bad/good luck, unforeseen conditions, skill, effort, and stamina).

All rates are calculated for performance under ideal conditions by a dedicated group and not the general population. Categories of rates are climbing, cutting, crawling, digging, explosives, forcing, running, vehicle, and walking.

A study of the Barrier Technology Handbook leads to the following observations: (1) Fences and padlocks provide minimal delay, (2) conventional construction provides only nominal delay, (3) explosives are effective penetration tools, (4) provision of even a few minutes delay around the clock may be very difficult, (5) earth cover or other overburden materials furnish effective penetration delay, (6) large, closely spaced reinforcing increases concrete penetration delay, (7) multiple barriers compound penetration tasks, and (8) colocating alarms and barriers detains adversaries at predictable locations.

Envisioned Handbooks

Locks

Although some information is available, few comprehensive data sources on locks exist. Documentation is necessary to identify the proper uses and functions of locks in safeguards and security applications (in particular, what locks are suitable for these applications), to set forth regulation guidelines, and to serve as a handbook for safeguards and security personnel.

The purposes of this envisioned handbook are (1) to cover the general types of locks that are available today, (2) to establish a source of current lock information including results of existing lock evaluations, (3) to evaluate and report on those locks and devices for which data are lacking, and (4) to characterize the various lock types for both pick and forced entry resistance.

Tentative chapter headings include (1) Introduction, (2) Philosophy, (3) General Description of Locks and Locking Features, (4) Test Methods, (5) Key Locks, (6) Keyless Locks, (7) Combination Locks, and (8) Specifications and Standards.

The initial version of this handbook is scheduled to be published in September 1978.

Seals

Information concerning seals is also either nonexistent or scattered and needs to be documented for the same reasons offered above for locks.

The major topics to be addressed in this handbook are (1) when and how seals are used, (2) recommended seals for various applications, (3) proper installation of seals, and (4) seal verification procedures.

The initial version of this handbook is scheduled to be published in August 1978.

Safeguards Central Control Systems (SCCS) Handbook

The purposes of the proposed SCCS handbook are (1) to describe a safeguards central control system, (2) to provide information for the selection of a system that will support the safeguards requirements of nuclear facilities, and (3) to elaborate upon the factors which must be considered when designing and implementing a safeguards central control system.

The SCCS handbook is organized into three major parts. Part 1 describes the basic concepts of the SCCS, Part 2 describes the approach to concept application, and Part 3 contains detailed features of each element which must be considered in acquiring and developing the SCCS.

Summary and Conclusions

The Intrusion Detection Systems Handbook, the Entry-Control Systems Handbook, and the Barrier Technology Handbook, which are reviewed in this report, have all been the result of the equipment portion of the DOE-sponsored Fixed Facility Program. They are available from DOE/SS, Century XXI, Building A-2, Washington, D.C. 20545. These handbooks have fulfilled an immediate DOE need and been found useful by virtually every U.S. Government agency which employs physical security equipment, by various commercial power companies, by various architectural and engineering firms, and by agencies from several foreign countries.

Some of the information contained in these handbooks is new; however, much of it has been obtained from previously existing sources. The intent in compiling and organizing this material has been to make it readily available and useful to the safeguards community. New information continues to be obtained from ongoing evaluation programs and operational facilities and will be incorporated into these handbooks for dissemination. It is expected that in the future the basic format of the handbooks will be expanded from "This is how specific models of physical security equipment perform" to also include "These are the performance criteria which must be met by a technological type of physical security equipment."

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Inventory and Verification of Stored Nuclear Materials

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ABSTRACT

We describe prototype equipment and operational procedures which have been developed to manage the storage, inventory, and verification of special nuclear material for a particular vault at the Los Alamos Scientific Laboratory. A brief discussion is given regarding personnel access, veri-ficiation of nuclear materials placed in and removed from storage vaults, and a method of continuous monitoring of the stored material. A detailed description of the statistical comparison of nuclear material signatures is given.

Introduction

Careful management of special nuclear material (SNM) requires that one address the problem of physical identification and inventory of the material in conjunction with personnel access to material storage areas. Consideration of these problems has led to the design and operation of a controlled SNM storage system. This paper discusses various equipment which has been developed for tasks such as portal control, nuclear material verification, and contin-uous monitoring of stored material. Analy-tical treatment of the statistical compar-ison of nuclear material signatures is emphasized.

Real Time Inventory

A scheme of continuously monitoring the presence of SNM while in temporary short term or long term storage, together with portal security and SNM verification, comprises a possible real time inventory system.

Designing a way of maintaining a con-tinuous check on the presence of SNM while in storage, and making this scheme compatible with existing vaults, container geometry, and other plant specific considerations is a complex task. Consequently, the following system is not meant to be a generalized solution to this problem but rather a specific solution to one of LASL's storage vaults, which is not significantly different from many other storage vaults.

Criteria used in designing such a system are strongly influenced by an effort to keep the cost to a minimum and also be conceptually simple.

Figure 1 shows this system in schematic form. Separate portals are designated for personnel and for SNM, so that, hypothetically, SNM should not pass through the material portal and, conversely, personnel cannot pass through the material portal, which is labeled as the verification station in this figure. The vault contains standard flat shelving on which the cans of SNM are stored in an upright orientation. Each can of material sits on a shelf monitor, which is permanently attached to the shelf. This shelf monitor continuously detects the gamma rays emitted from the material, as well as measures the weight of the material. The weight sensor also doubles as a tamper-indicating device in that the weight reading is dependent on a capacitance of which the container is a part. Therefore, the weight indication will change even if the container is only touched. The personnel portal is comprised of a gamma sensitive doorway monitor and a metal detec-tor. Work is being done by several facil-ities and manufacturers to develop a metal detector that can distinguish steel from shielding material such as lead. This would allow personnel to enter and leave the vault wearing normal amounts of steel, but detect someone trying to bring unauthorized lead shielding into the vault.

The verification chamber acts as the portal for the SNM. This chamber is designed so that the material must be placed in the chamber, and cannot be passed through with-out being measured, since only one door can be opened at any given time. A signature is obtained of each container of SNM placed in storage at the time it enters the vault. This signature is comprised of the gross weight of the container, including the SNM, a gross neutron count, a four-channel gamma spectrum, and a gross gamma count. The gross gamma count is used to check the correct operation of the four gamma channels and is also proportional to the count expected from the shelf monitor. This provides a cross check between the verification chamber and the shelf monitor to which this container is assigned.

The verification signature that is taken at the time of entry of the material into the vault is stored in the computer, together with the ID number of the container.

When this material is required at a later time, it is remeasured in the verification chamber and another signature is obtained. The two signatures are then compared to verify that the material is unchanged during the period of storage. The verification therefore acts as a backup to the shelf monitors in determining whether the contents of the container have been altered. The system will also help to reduce or eliminate incorrect withdrawals. Another function of the verification is to keep a record of the material traffic and the individual responsible for each transaction. Each material handler will have a unique access code which will identify him and allow him access to the vault.

Verification Chamber

One of the problems in assaying a wide variety of SNM is that the accuracy of the technique used to assay the material is generally dependent on such material parameters as geometry, chemical composition, mass, isotopic ratio, packaging, and other parameters. Any single assay technique will not yield good accuracy over a wide spectrum of varying parameters. The concept of a verification signature takes advantage of this variety, in that the probability of having two identical signatures from separate containers is much smaller for this type of vault than from a vault containing a uniform material type. Although a verification signature is not unique to each container, experimentally it is found that this signature is sufficiently unique to be useful in this application. The purpose of this verification signature is to ensure that material which has been in storage has not been tampered with during that period. It adds another degree of assurance that the shelf system is doing its job and provides a way of inventory taking that is easier than a detailed assay.

Figure 2 shows a schematic diagram of the verification chamber. A 25-kg capacity Digimetric balance, accurate to 1 gram, is outside and beneath the neutron and gamma shielding. The pan of the balance is 31-cm diameter and is surrounded by four ^{3}He tubes, 2.5-cm diameter by 31-cm long, and moderated by 2.5 cm of polyethylene. A 5-cm x 5-cm NaI(Tℓ) detector is mounted in the top of the chamber looking down at the balance and is centered on the balance pan. This detector has 6 mm of Pb shielding on its side, and has a 13-mm Pb mask in front of the detector with a 19-mm aperture to limit the count rate in the detector. The chamber walls are 10-mm thick steel over which 13 mm of Pb and 100 mm of borated polyethylene are placed to reduce the gamma and neutron background within the cavity of the chamber. The gamma spectrum was divided into five energy windows as follows: 1) 103-167 keV, 2) 167-268 keV, 3) 268-549 keV, 4) > 549 keV, and 5) > 103 keV Window #1 was set to look at x-rays from uranium and plutonium and the lower level discriminator (LLD) was purposely set high to eliminate any effect from the 60-keV line from ^{241}Pu. In some samples, the 60-keV line is intense enough to spill over into the x-ray region. Window #1 will therefore be affected by x-rays from both uranium and plutonium samples. Window #2 is set from 167- to 268-keV and will see the main 185-keV line from ^{235}U, and principally the 208-keV line from ^{241}Pu, which grows in and decays at a rate which is dependent on the age of the material and the amount of ^{241}Pu initially present in the sample. However, the age of an arbitrary sample of plutonium would be difficult to determine. To further complicate matters, any given sample might well be composed of plutonium of different ages. Any appreciable grow-in by the 208-keV line occurs in the first month after it leaves the reactor. Therefore, any special considerations or corrections for this window will be for the decay of ^{241}Pu. Correction for the grow-in of ^{241}Am and its contribution to the 208-keV line is negligible until the sample age approaches 50 years. The third window, from 268- to 549-keV, is intended to encompass the ^{239}Pu line complex in this region. Window #4 looks for gammas greater than 549 keV. Both plutonium and uranium have some lower intensity gamma emissions in this region. Window #5 is not really a separate single channel analyzer, but uses the LLD in Window #1 to count all gammas above this level. This acts as a check on the proper operation of the four single channel analyzers as well as giving a count proportional to that expected from a shelf monitor.

The weight and total gamma count taken of a container in the verification station is compared with the shelf monitor measurements at the time the container is placed on the shelf. This allows for a periodic check of the calibration and operation of that shelf monitor and also that the correct container is placed in its assigned shelf location.

Measurements

A number of plutonium and uranium samples were measured in the verification chamber. The samples were selected to represent the typical types of material stored in this particular vault. The plutonium samples were all PuO_2 but varied in purity and isotopic ratio. The oxide is generally placed in a small sealed metal can, which is then placed within a second sealed metal can. This latter container measures approximately 9-cm diameter by 15-cm height. Anywhere from one to eight of these containers are usually placed in a large unsealed metal "lard can" of 30-cm diameter by 40-cm height. This Hanford Ash is generally shipped and stored within these lard cans, and is the largest container which the verification chamber is designed to accommodate, and is the "worst case" situation from the standpoint of signature repeatability.

In order to get some idea of the possible signature variation to expect as a result of contents shifting, a series of ten measurements was made on each sample.

Some samples, as mentioned before, are comprised of several small cans of material, which are not constrained from moving within a large lard can. For each of the ten measurements, the samples were taken and placed at offcenter positions on the balance pan to show the effects of these perturbations above normal counting statistics. The sample used in the following discussion on the statistical comparison of nuclear material signatures is Hanford Ash sample #ASH-4629, and is contained in a single small container and placed in the lard can.

Statistical Comparison of Signatures

A statistical method based on hypothesis testing is applied to the comparison of multicomponent nuclear signatures. This method is specifically directed to the problem of comparing the two verification signatures obtained when nuclear material is placed in and removed from a storage vault. The basic problem is to determine, within an acceptable confidence limit, whether a sample removed from a particular vault location is the same sample that was previously stored in that location. The method is used to compare experimentally determined signatures of plutonium samples.

The statistical methods discussed here are applicable to the general problem of comparing two multicomponent variables. As such, these methods can be used for related problems such as nuclear identification based on comparison of few-region neutron or gamma-ray spectra. Two advantages of the hypothesis testing method are the quantitative specification of a single confidence level and the inclusion of correlation effects between individual signature components.

The Group Q-2 prototype verification station is used to measure signatures of several typical plutonium samples obtained from a LASL storage vault. The sample signature is described by the vector

$$x = [x_1, \cdots, x_p],$$

where the x_n are signature components. For the prototype verification station measurements, p = 7 with

x_1 = sample mass

x_2 = total neutron counts

x_3, x_4, x_5, and x_6 = gamma ray counts in the energy windows (103-167 keV), (167-268 keV), (268-549 keV), (> 549 keV)

x_7 = total gamma ray counts above 103 keV

The verification procedure consists of measuring a reference signature x_i when the sample goes in the storage vault, and then comparing this with the signature x_0 measured when the sample is taken out of the vault. If the two signatures agree within a specified confidence limit, the sample removed from the vault is verified as being the same sample that was initially stored in the particular vault location.

Statistical Methodology

A brief descritpion of hypothesis testing is given to explain the techniques developed for signature comparison. Consider observations of a single variate X, with N units selected at random. The observed values are $x_1, \cdots, x_N$. The density function of X is described by $f(x_1;\theta_1,\cdots,\theta_k)$, where the θ_i are the function parameters. The likelihood of the observations is defined as the joint density of the variates, as follows:

$$L(\theta_1,\cdots,\theta_k) = \prod_{i=1}^{N} f(x_i;\theta_1,\cdots,\theta_k) \quad (1)$$

The maximum likelihood method of estimation requires that the estimates $\hat{\theta}_i$ be chosen so as to maximize L. For a normally distributed variable with density function

$$f(x) = (2\pi)^{-\frac{1}{2}} \sigma^{-1} \exp[-\tfrac{1}{2}(\tfrac{x-\mu}{\sigma})^2] \quad (2)$$

the parameters are the mean μ and the variance σ^2. If some hypotheses are made about the parameters, then statistical inference can be used to test these hypotheses. Let H_0 represent the original stated hypothesis to be tested and H_1 represent the alternative hypothesis. The decision rule will be to accept H_0 if $(x_1,\cdots,x_p) \in W-w$ and accept H_1 if $(x_1,\cdots,x_p) \in w$, where w is a specified part of the sample space W. w is the critical region or rejection region for H_0. If the true condition is specified by H_0 or H_1, the following two types of errors can occur:

Type I error -- Declare H_1 true when in fact H_0 is true.

Type II error -- Declare H_0 true when in fact H_1 is true.

The correctness of the choice can be given in the usual two-way table:

	Condition	
Action	H_0 True	H_1 True
Accept truth of H_0	Correct	Type II error
Accept truth of H_1	Type I error	Correct

Probabilities of the two types of errors are described by:

α = prob. of Type I error = $P([x_1,\cdots,x_p] \in w \mid H_0 \text{ true})$

β = prob. of Type II error = $P([x_1,\cdots,x_p] \in W\text{-}w \mid H_1 \text{ true})$.

α is called the size of the test and $(1-\beta)$ the power of the test. The usual hypothesis test uses a fixed size α with the critical region chosen so as to minimize β, which results in a maximum power. For a fixed sample size, α and β are inversely related. Changes in the critical region that reduce α will result in an increased β, and a reduction in β can only be accomplished at the expense of a larger α. Therefore, a decision must be made as to the relative importance of Type I and Type II errors.

If both hypotheses are simple, as described by $H_0 : \{\theta_i\} = \{\theta_{i0}\}$ and $H_1 : \{\theta_i\} = \{\theta_{i1}\}$, the Neyman-Pearson lemma states that the most powerful test of size α will have a critical region defined by the following decision rule using the likelihood ratio:

$$\text{Accept } H_0 \text{ if } \lambda = \frac{\prod_{i=1}^{N} f(x_i;\theta_{10},\cdots,\theta_{k0})}{\prod_{i=1}^{N} f(x_i,\theta_{11},\cdots\theta_{k1})} > c$$

and accept H_1 if $\lambda < c$, where λ is the likelihood ratio and c is a constant chosen such that $P(\lambda < c) = \alpha$.

Multivariate Hypothesis Testing

Several basic multivariate statistical concepts will be discussed prior to applying hypothesis testing to the problem of signature comparison.

The expected value of a random vector $\mathbf{x}$ is the vector of expected values $E(\mathbf{x}) = [E(x_1),\cdots,E(x_p)]$. The covariance of elements x_i and x_j of vector $\mathbf{x}$ is the product moment of those variates about their respective means

$$\text{cov}(x_i,x_j) = E\{[x_1-E(x_i)]\ [x_j-E(x_j)]\} = \sigma_{ij}$$

If i=j, then $\text{cov}(x_i,x_j)$ is the variance of x_i denoted by $\sigma_{ij} = \sigma_i^2$. Extending the variance concept to the p-component vector $\mathbf{x}$ gives the matrix of variances and covariances called the covariance matrix of $\mathbf{x}$, denoted by

$$\boldsymbol{\Sigma} = E\{[\mathbf{x}-E(\mathbf{x})]\ [\mathbf{x}-E(\mathbf{x})]'\} = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1p} \\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2p} \\ \cdot & \cdot & \cdot & \cdot \\ \sigma_{p1} & \sigma_{p2} & \cdots & \sigma_{pp} \end{bmatrix}$$

The correlation coefficient of x_i and x_j is defined as $\rho_{ij} = \sigma_{ij}/\sigma_i\sigma_j$. If x_i and x_j are independently distributed, $\sigma_{ij} = 0$ and $\rho_{ij} = 0$.

The joint density function of p independent normal variates is

$$\phi(x) = \prod_{i=1}^{p} f(x_i;\mu_i,\sigma_i) = (2\pi)^{-p/2}\left(\prod_{i=1}^{p}\sigma_i\right)^{-1} \exp\left[-\tfrac{1}{2}\sum_{i=1}^{p}\left(\frac{x_i-\mu_i}{\sigma_i}\right)^2\right] \quad (3)$$

where $f(x_i;\sigma_i,\mu_i)$ is given by (2). Writing $\mathbf{x}' = [x_1,\cdots,x_p]$,

$\boldsymbol{\mu}' = [\mu_1,\cdots,\mu_p]$, and

$$\boldsymbol{\Sigma} = \begin{bmatrix} \sigma_1^2 & \cdots & 0 \\ \cdot & \cdot & \cdot \\ 0 & \cdots & \sigma_p^2 \end{bmatrix}$$

the joint density function (3) becomes

$$\phi(\mathbf{x}) = (2\pi)^{-p/2}|\boldsymbol{\Sigma}|^{-\frac{1}{2}}\exp[-\tfrac{1}{2}(\mathbf{x}-\boldsymbol{\mu})'\boldsymbol{\Sigma}^{-1}(\mathbf{x}-\boldsymbol{\mu})] \quad (4)$$

where $|\boldsymbol{\Sigma}|$ and $\boldsymbol{\Sigma}^{-1}$ are the determinant and inverse, respectively, of the covariance matrix $\boldsymbol{\Sigma}$. Comparing the multivariate normal density function (4) with the single variate density function (2), shows that the vector $\mathbf{x}$ replaces x, the vector $\boldsymbol{\mu}$ replaces μ, and the diagonal matrix $\boldsymbol{\Sigma}$ replaces σ^2. For the general p-dimensional normal density function, the covariance matrix $\boldsymbol{\Sigma}$ can have non-zero off diagonal elements σ_{ij}.

Suppose N observations are recorded on p responses. The data matrix is

$$\mathbf{X} = \begin{bmatrix} x_1 & \cdots & x_{1p} \\ \cdot & \cdot & \cdot \\ x_{N1} & \cdots & x_{1p} \end{bmatrix} = \begin{bmatrix} \mathbf{x}_1' \\ \cdot \\ \cdot \\ \mathbf{x}_N' \end{bmatrix} \quad (5)$$

These data represent a p-dimensional random variable having the multinormal distribution with mean vector $\boldsymbol{\mu}$ and nonsingular covariance matrix $\boldsymbol{\Sigma}$. The observation likelihood is

$$L(\boldsymbol{\mu},\boldsymbol{\Sigma}) = (2\pi)^{-Np/2}|\boldsymbol{\Sigma}|^{-N/2}\exp[-\tfrac{1}{2}\sum_{i=1}^{N}(\mathbf{x}-\boldsymbol{\mu})'\boldsymbol{\Sigma}^{-1}(\ -\boldsymbol{\mu})]. \quad (6)$$

The sample mean vector is defined as

$$\bar{\mathbf{x}} = N^{-1}\sum_{i=1}^{N}\mathbf{x}_i \quad (7)$$

and the matrix of sums of squares and cross products is

$$\mathbf{A} = \sum_{i=1}^{N} (\mathbf{x}_i - \bar{\mathbf{x}})(\mathbf{x}_i - \bar{\mathbf{x}})' \quad . \tag{8}$$

Using (6), it can be shown that the parameter estimates which maximize $L(\boldsymbol{\mu}, \boldsymbol{\Sigma})$ are $\hat{\boldsymbol{\mu}} = \bar{\mathbf{x}}$ and $\hat{\boldsymbol{\Sigma}} = N^{-1}\mathbf{A}$. Since $\hat{\boldsymbol{\Sigma}}$ is biased, an unbiased expression called the sample covariance matrix is used and is given by

$$\mathbf{S} = (N-1)^{-1}\mathbf{A} . \tag{9}$$

The data matrix $\mathbf{X}$ given by (5) involves the mean vector $\boldsymbol{\mu}$ and unknown $\boldsymbol{\Sigma}$ elements σ_{ij}. Let the null hypothesis be

$$H_0 : [\mu_1, \cdots, \mu_p] = [\mu_{10}, \cdots, \mu_{p0}] \tag{10}$$

and the alternative hypothesis be

$$H_1 : [\mu_1, \cdots, \mu_p] \neq [\mu_{10}, \cdots \mu_{p0}] \quad .$$

If N independent observation vectors have been collected on $\mathbf{X}$ [Eq. (5)], then estimates $\bar{\mathbf{x}}$ and $\mathbf{S}$ of $\boldsymbol{\mu}$ and $\boldsymbol{\Sigma}$ can be computed from Eqs. (7) and (9). From the union-intersection test construction principle of S. N. Roy, the hypothesis [Eq. (10)] can be tested using the statistic

$$t(\boldsymbol{\alpha}) = \frac{\boldsymbol{\alpha}'(\bar{\mathbf{X}} - \boldsymbol{\mu}_0)\sqrt{N}}{\sqrt{\boldsymbol{\alpha}'\mathbf{S}\boldsymbol{\alpha}}}$$

with acceptance region $t^2(\boldsymbol{\alpha}) \leq t^2_{\beta/2;N-1}$, where $\boldsymbol{\alpha}$ is an non-null p-component vector of real elements. Using the Lagrangian multiplier technique, it can be shown that the maximum $t^2(\boldsymbol{\alpha})$ statistic is

$$\lambda = \mathrm{tr}[\mathbf{S}^{-1}(\bar{\mathbf{X}} - \boldsymbol{\mu}_0)(\bar{\mathbf{X}} - \boldsymbol{\mu}_0)'N]$$

or

$$\lambda = T^2 = N(\bar{\mathbf{X}} - \boldsymbol{\mu}_0)'\,\mathbf{S}^{-1}(\bar{\mathbf{X}} - \boldsymbol{\mu}_0) \quad .$$

The quadratic form λ is the single sample Hotelling T^2 statistic. When the null hypothesis (10) is true, the quantity

$$F = \frac{N-p}{(N-1)p}\, T^2$$

has the variance ratio F distribution with degress of freedom p and N-p. The decision rule for a test of level α becomes

$$\text{Accept } H_0 \text{ if } T^2 \leq \frac{(N-1)p}{N-p} F_{\alpha;p,N-p} \tag{11}$$

and reject H_0 otherwise.

<u>Verification Signature Comparison</u>

The previously discussed multivariate hypothesis testing methods can be applied directly to the comparison of two verification signatures. If M measurements of the signature are made when the sample goes in the verification station and N measurements are made when the sample comes out, the two resulting data matrices are

$$\mathbf{X}_i = \begin{bmatrix} x_{i11}, \cdots, x_{ip1} \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ x_{i1M}, \cdots, x_{ipM} \end{bmatrix}$$

and (12)

$$\mathbf{X}_o = \begin{bmatrix} x_{o11}, \cdots, x_{op1} \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ x_{o1N}, \cdots, x_{opN} \end{bmatrix}$$

When the covariance matrix is assumed to be common to the two signatures, the unbiased estimate of $\boldsymbol{\Sigma}$ is

$$\mathbf{S} = (N-k)^{-1} \sum_{h=1}^{k} \mathbf{A}_h \tag{13}$$

where $\mathbf{A}_h$ is calculated from (8) and k is the number of data matrices. The signature comparison is expressed by stating as the null hypothesis that the signature mean vectors are equal:

$$H_0 : \boldsymbol{\mu}_i = \boldsymbol{\mu}_o$$

with the alternative hypothesis

$$H_1 : \boldsymbol{\mu}_i \neq \boldsymbol{\mu}_o \quad .$$

From the data matrices (12), the two mean vectors estimates $\bar{\mathbf{X}}_i$ and $\bar{\mathbf{X}}_o$ are computed using (7). The matrices of sums of squares and cross products, $\mathbf{A}_i$ and $\mathbf{A}_o$, are computed and used to determine the estimate $\mathbf{S}$ according to (13), with k=2 in this case. The union-intersection principle results in the Hotelling T^2 statistic

$$T^2 = \frac{MN}{M+N} (\bar{\mathbf{X}}_i - \bar{\mathbf{X}}_o)'\,\mathbf{S}^{-1}(\bar{\mathbf{X}}_i - \bar{\mathbf{X}}_o) \quad . \tag{14}$$

The quantity

$$F = \frac{M+N-p-1}{(M+N-2)p}\, T^2$$

has the variance ratio F distribution with degrees of freedom p and M+N-p-1. The decision rule for a test of level α becomes

$$\text{Accept } H_0 \text{ if } T^2 \leq \frac{(M+N-2)p}{M+N-p-1} F_{\alpha;p,M+N-p-1} \tag{15}$$

and reject H_0 otherwise.

The computational procedure for signature comparison can be summarized as consisting of two calculational steps. First, the T^2 is calculated from (14). Second, $F_{\alpha;p,M+N-p-1}$ is calculated numerically or from tabulated F distribution values and then the test condition (15) is evaluated. If (15) is satisfied, H_0 is accepted and the two signatures $\mathbf{X}_i$ and $\mathbf{X}_o$ are verified as being the same. If (15) is not satisfied, the signature verification fails.

The estimated covariance matrix $\mathbf{S}$ as computed from (13) includes covariance contributions $\mathbf{A}_i$ and $\mathbf{A}_o$ of both the sample-in and sample-out data matrices (12). If the sample is altered after being placed in storage, the covariance $\mathbf{A}_o$ will probably change since the individual signature component correlations are expected to change. For example, a change in sample mass can change neutron and gamma ray activity. This would affect the correlation through $\text{cov}(x_1,x_j)$, where x_1 is the sample mass and the x_j are neutron and gamma ray counts. Since the covariance $\mathbf{A}_i$ and $\mathbf{A}_o$ are not expected to be approximately equal if the sample has been altered, the estimated covariance can be evaluated using only the sample-in data matrix $\mathbf{X}_i$. This provides a more sensitive T^2 test statistic, since $\mathbf{S}$ will now be determined only by the reference (sample-in) data rather than data averaged with a reference sample and altered sample. In this case, T^2 is still calculated from (14), where $\mathbf{S}$ is determined from (9) with $\mathbf{A} = \mathbf{A}_i$. The verification decision is then based on the test condition (11) with N replaced by M (the number of sample-in signature measurements).

To apply these signature comparison techniques, a minimum number of sample-in and sample-out signature measurements are required. The sample-in signature must be measured $M > p$ times, where p is the number of signature components. The sample-out signature must be measured $N \geq 2$ times. The sample-in signature measurements can be made consecutively without moving the sample from its position in the verification station. The same situation exists when the sample-out measurements are made. As the number of signature measurements increases beyond the required minima, the probability of Type I and Type II errors decreases.

Example Signature Comparison Calculations

A computer program TSQTEST has been written to perform signature comparisons using the T^2 statistic hypothesis testing method. This program was used to analyze signature data taken with eight plutonium samples. These measurements were made for the purpose of testing the prototype verification station rather than actually verifying the samples. Thus, it was known that the verifications should be positive since the samples had not been altered between measurements. Eight measurements were made of the sample-in signature and two of the sample-out signature. This corresponds to the required minimum number of measurements for the seven-component signature vector. The signature verification calculation for one of the samples, #ASH-4629, is summarized in Table I. A test size $\alpha = 0.05$ was chosen. As indicated on the last line of Table I, the signature verification was positive with $(1-\alpha)$ confidence of 95%.

To illustrate the sensitivity of the T^2 test, consider the following hypothetical situation. After sample #ASH-4629 has been placed in storage, a portion of the plutonium is removed and replaced with an equal mass of non-radioactive material. The altered sample has a sample-out signature with decreased neutron and gamma ray count rates. For example, suppose that these count rates $[x_2,\cdots,x_7]$ are reduced uniformly by some amount Δ. Values of Δ = -20%, -10%, -5%, were chosen and the T^2 test [Eq. (11)] was evaluated to determine if these signature changes could be detected. The results of these tests are shown in Figure 3. For values of α from 0.01 to 0.25, two distinct regions are defined. For a given α and Δ, a T^2 value which falls below the T^2_{crit} curve results in the decision that the signatures are equal. This causes a Type II error since signature equality is accepted, *when in fact the signatures are not* equal (alternative hypothesis). T^2 values which lie above the T^2_{crit} curve result in the correct decision that the signatures are unequal. To consider a particular example, suppose that one wants to be able to detect a count rate change of Δ = -10% for the #ASH-4629 sample. The sample-in signature data is given in Table I. From Figure 3, the region of correct decision (signature inequality) is defined by $T^2(\Delta = -0.10)$ values that lie above the T^2_{crit} curve. These T^2 correspond to $\alpha = \geq 0.095$. Thus, in order to be able to detect the Δ = -10% change, there will be at least a 9.5% statistical false alarm probability. A false alarm is defined as the acceptance of signature inequality when in fact the sample is unaltered (Type I error).

For verification station signature comparison, it is probably preferable to reduce β at the expense of a larger α. This will increase the probability of detecting small sample changes at the expense of having a higher statistical false alarm rate. Suppose the relatively large value of $\alpha = 0.10$ is chosen. The statistical false alarm rate will then be 10%. If the requirement is made that a second sample-out signature determination is necessary whenever signature inequality is indicated, then the probability of two consecutive false alarms will be $(0.1)^2$ = 1%. This procedure would provide high sensitivity to small sample changes while reducing false alarms to an acceptable level.

The TSQTEST calculations were made using a CDC 7600 computer. These calculations involve several fairly involved procedures such as double precision matrix inversion and numerical evaluation of F distribution parameters. Such procedures require substantial computer capability for efficient execution and probably could not be easily performed with hard wired portable equipment. Signature data acquired by portable detection equipment would probably have to be analyzed later with separate computer facilities.

Acknowledgements

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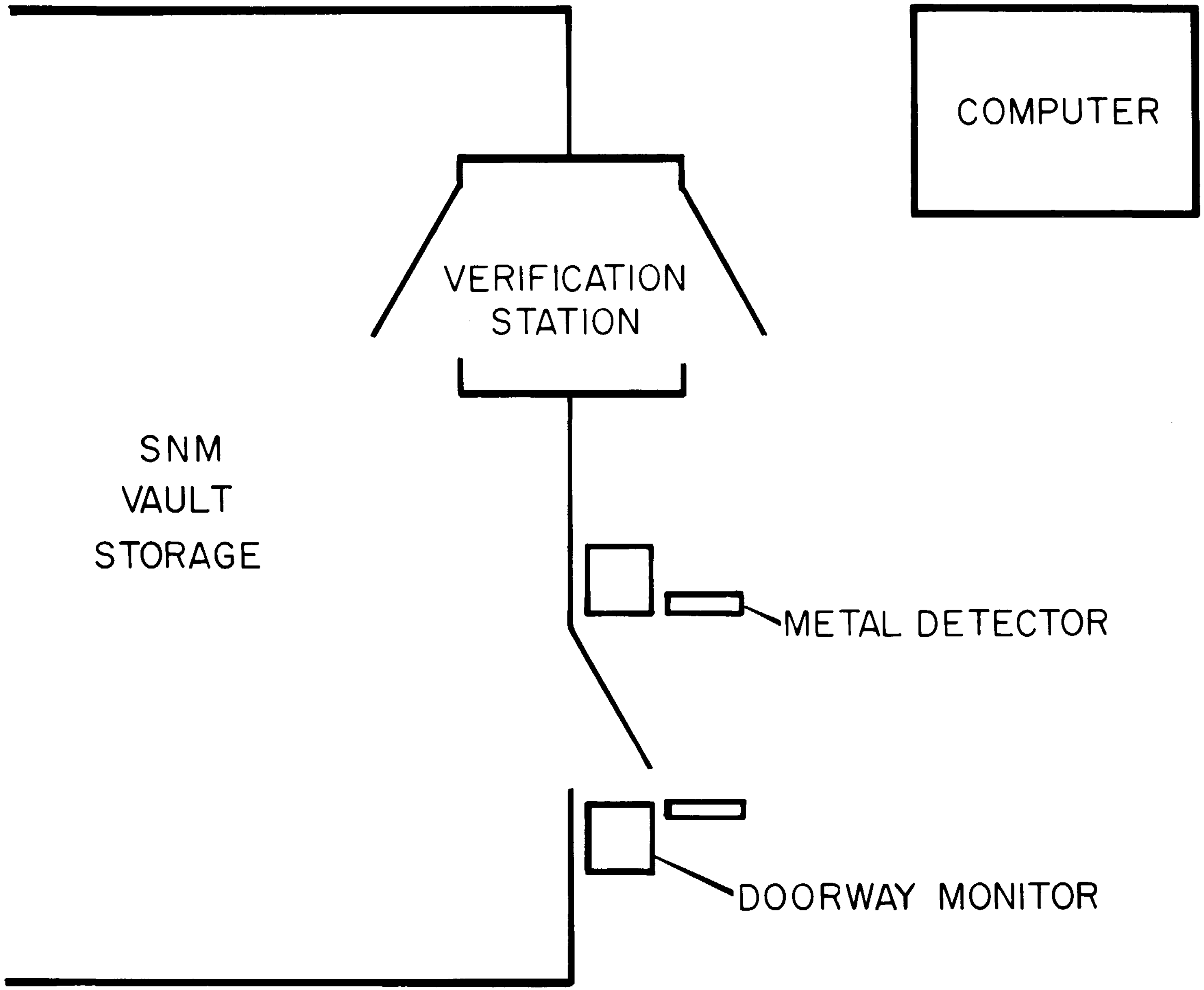

FIG.1, VAULT LAYOUT

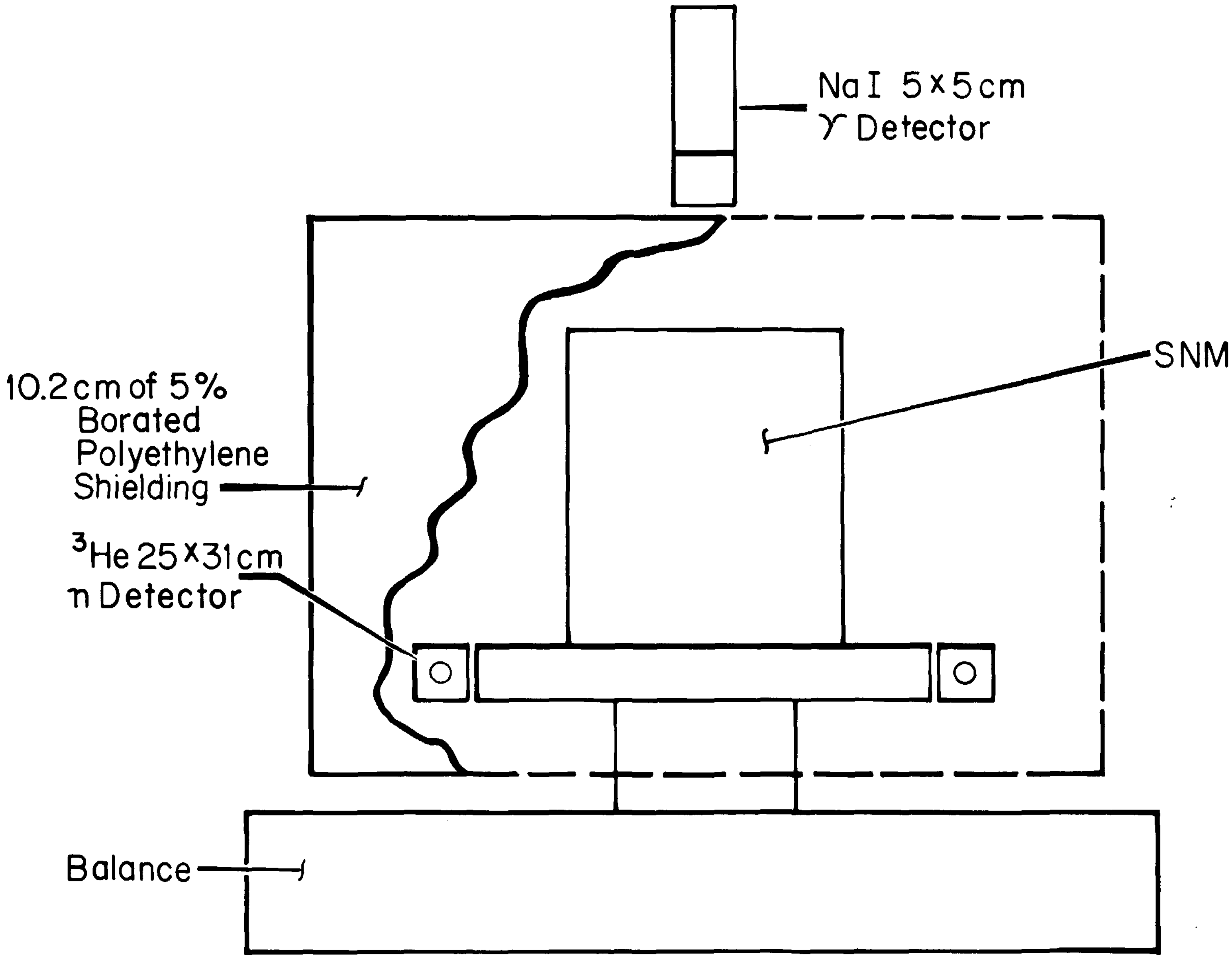

FIG. 2, VERIFICATION CHAMBER

Table I

Sample ID ASH 4629

Signature vector has 7 components
Input signature measured 8 times
Output signature measured 2 times
Size of test is 0.05
Only the input data is used to compute the covariance matrix

Input Data Matrix

2497.00	128821.00	193731.00	127311.00	239167.00	36418.00	580977.00
2493.00	133215.00	185843.00	121136.00	231138.00	33328.00	556681.00
2496.00	134007.00	186783.00	121651.00	231217.00	33844.00	558703.00
2497.00	128635.00	188916.00	122266.00	233070.00	32554.00	561891.00
2494.00	127977.00	185888.00	120074.00	231177.00	33554.00	556007.00
2500.00	129408.00	183562.00	119906.00	230431.00	33389.00	552997.00
2492.00	128764.00	186782.00	121804.00	231306.00	34117.00	559267.00
2493.00	131449.00	187525.00	121737.00	233698.00	33262.00	561462.00

Output Data Matrix

2493.00	128731.00	183196.00	118791.00	229687.00	33095.00	550373.00
2495.00	127553.00	201628.00	128168.00	242738.00	34537.00	591685.00

Input Mean Vector

2495.25	130284.50	187378.75	121985.62	232650.50	33808.25	560998.12

Output Mean Vector

2494.00	128142.00	192412.00	123479.50	236212.50	33816.00	571029.00

Table I (cont.)

Covariance Matrix

0.7357E+01	-0.1172E+04	0.3085E+03	0.7331E+03	0.1111E+04	0.2902E+03	0.2476E+04
-0.1172E+04	0.5295E+07	-0.1527E+07	-0.8244E+06	-0.1627E+07	-0.4537E+06	-0.4315E+07
0.3085E+03	-0.1527E+07	0.8942E+07	0.6660E+07	0.8120E+07	0.2440E+07	0.2505E+08
0.7331E+03	-0.8244E+06	0.6660E+07	0.5335E+07	0.6286E+07	0.2197E+07	0.1964E+08
0.1111E+04	-0.1627E+07	0.8120E+07	0.6286E+07	0.8141E+07	0.2496E+07	0.2404E+08
0.2902E+03	-0.4537E+06	0.2440E+07	0.2197E+07	0.2496E+07	0.1321E+07	0.8121E+07
0.2476E+04	-0.4315E+07	0.2505E+08	0.1964E+08	0.2404E+08	0.8121E+07	0.7371E+08

F(7,1,0.95) = 0.2368E+03

TSQ = 0.22717E+03 is less than critical value 0.16574E+04

Two signatures correspond to sample ASH 4629 with 0.95 confidence

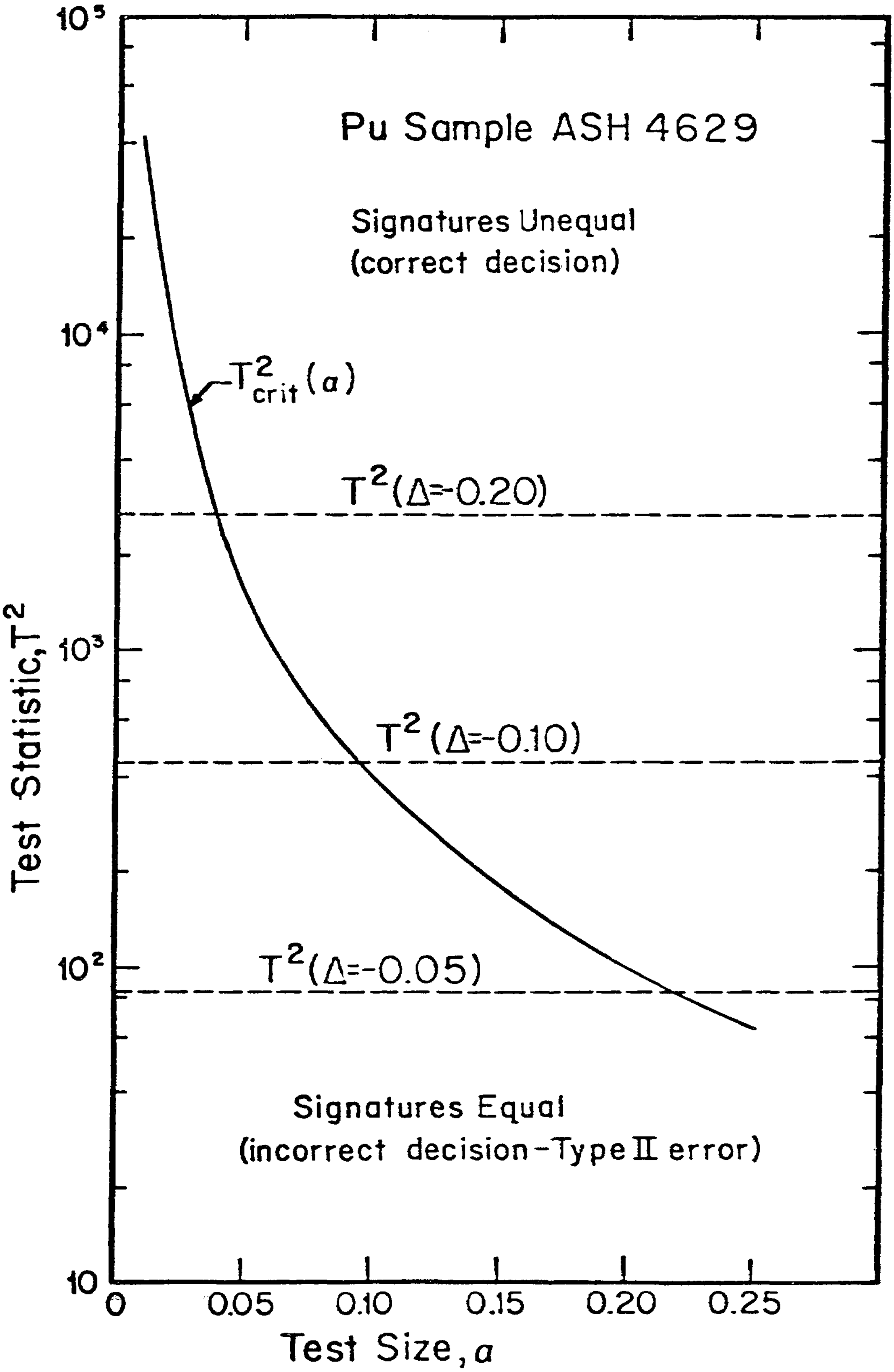

Figure 3 Signature Verification Sensitivity for ASH 4629

LASL—Pioneer of Nuclear Safeguards Research

Acronyms are often like umbrellas — small canopies covering large, and sometimes complex subjects. So it is with "SNM" short for "Strategic Nuclear Materials" — the key ingredient of nuclear power, and at the same time the stuff of controversy in the nuclear age.

SNM is defined by the U.S. government as "amounts greater than 2 kilograms of plutonium and 5 kilograms of uranium enriched to more than 20 percent." Before passage of the Atomic Energy Act of 1954, all of the strategic nuclear materials and facilities in this country were owned and controlled by the government. The 1954 Act permitted commercial organizations to own SNM for peaceful uses of nuclear energy, and all over the world, a vigorous courtship of the powerful atom began.

"In 1954 it was comparatively easy to control nuclear materials," G. Robert Keepin, Associate Q-Division Leader of Nuclear Safeguards and Director of LASL's Nuclear Safeguards Program comments, "because relatively small amounts were in use, and the high monetary value of the materials as well as the severe criminal penalties for their unauthorized use, provided sufficient incentives for strict accountability and control."

By the mid-60's, Keepin says, expansion of the nuclear industry made it apparent that a large number of commercial organizations would be handling SNM, and an expanded program was initiated by the Atomic Energy Commission for safeguarding both nuclear materials and facilities.

Two federal agencies have safeguards responsibilities: the Department of Energy (DOE), which oversees safeguards in government-owned facilities and conducts research and development on domestic and international safeguards technology and applications; and the Nuclear Regulatory Commission (NRC), charged with establishing safeguards regulations for domestic commercial activities and ensuring compliance with these requirements.

Both agencies work closely with LASL, the laboratory that pioneered modern safeguards research as early as 1966, when a small R&D group, headed by Keepin, was formed with LASL's N-Division. Los Alamos safeguards R&D has spearheaded the development of a wide range of new techniques and methods for implementing effective safeguards on both the international and domestic levels.

To transfer newly developed safeguards technology to the nuclear industry, Los Alamos conducts the world's foremost "School for Safeguards." Since its initiation in 1973, the DOE-sponsored safeguards training program at LASL has trained some 400 safeguards inspectors and instrument users from DOE, NRC, and more than 30 foreign countries, in the use of nondestructive assay (NDA) techniques and equipment developed at Los Alamos.

Nondestructive assay permits accurate, rapid measurement of nuclear materials without destroying the sample or item being measured. Such NDA techniques are the cornerstone of LASL's DYMAC (Dynamic Materials Control) system, an SNM measurement and control concept that is currently being implemented in the Laboratory's new plutonium process facility for continuous assay and accountability of materials moving through the plant.

That both industry and government are aware of the need for an aggressive nuclear materials control program is evident from the history of international nuclear safeguards development.

In 1957, the Vienna, Austria-based International Atomic Energy Agency was formed under the auspices of the United Nations. Its charter: To foster peaceful uses of nuclear energy.

In 1961, the IAEA established an overall system for applying nuclear materials safeguards. In 1964, the 88th U.S. Congress passed the Private Ownership of Special Nuclear Materials Act (which went into effect in 1970).

A treaty on Non-Proliferation of Nuclear Weapons was drawn up at the Geneva Disarmament Conference and endorsed, in 1968, by the United Naions. Placed in force in 1970, the Nonproliferation Treaty has now been signed by some 112 countries.

Signatories to this treaty are prohibited from transferring nuclear weapons to any country that does not have a nuclear weapons capability. Such countries are prohibited from manufacturing nuclear weapons or acquiring them, and they are obligated to adopt IAEA safeguards and to accept IAEA inspection of their nuclear facilities to ensure that there is no diversion of nuclear materials to military applications.

For countries without nuclear technology, procedures have been devised for such countries to participate in the development and utilization of the peaceful atom and still assure that the required nuclear materials are properly safeguarded against diversion.

Scientist Exemplifies Japanese Commitment

Japan has a strong, rapidly expanding nuclear industry, a firm commitment to peaceful use of the atom, and an extraordinary dedication to improving its technological nuclear research base.

That dedication is exemplified by a visiting LASL staff member, Keisuke Kaieda, who came to Los Alamos in October, 1977, for 12 months of study with the Laboratory's Nuclear Safeguards Program. Kaieda, a nuclear engineer with the Japan Atomic Energy Research Institute (JAERI), was forced to leave his family in Japan. His daughter, Emi, 9, has a heart ailment, and her physician would not allow her to come to Los Alamos because our high altitude could be harmful to her.

Kaieda will visit Emi, his wife Akemi, and his 7-year-old son, Yoshinori in August in Los Angeles. The reunion will be the family's only opportunity to be together until Kaieda returns to Japan next October.

JAERI is roughly the equivalent of LASL in relation to the government — LASL is operated by the University of California under contract to the Department of Energy, and JAERI is a research and development laboratory funded by the Scientific Technical Agency of the Japanese government.

Kaieda is in Los Alamos because, he says, "We are trying to learn how and to what extent the Non-Proliferation Treaty can be implemented without interference with the peaceful use of atomic energy."

Keisuke Kaieda, a nuclear engineer with the Japan Atomic Energy Research Institute, is at LASL for a year "to learn how and to what extent the Non-Proliferation Treaty can be implemented without interference with the peaceful use of atomic energy."

The visiting staff member believes that modern safeguards technology might be compared with computer technology: "There are 2 basic elements, 'software,' and 'hardware'," he says. "Software is the NPT, an instrument of fundamental importance.

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Paul Elkins, left, and Robert Ford, both E-5, are among many persons involved in setting up the central computer facility for the plutonium handling plant. The computers will allow an operator to know instantly the location and status of nuclear materials being used in the plant.

The United States has played a leading role in developing the technology required for effective international safeguards, and LASL's Bob Keepin believes U.S. technology has, by and large, kept pace with the increasingly strict safeguards requirements being placed on this country's domestic nuclear fuel cycle.

However, he notes that "Safeguards plays an even more important role in the international arena, where the threat of nuclear material diversion and malevolent use can come not only from subnational groups, but from a concealed effort by an entire nation."

As amounts of nuclear materials and the number of nuclear facilities increase with the worldwide growth of nuclear power, safeguards will be continuously improved and expanded.

"Whatever overall safeguards and security measures are taken, stringent in-plant materials control seems destined to play a major role in safeguarding SNM in sensitive fuel-cycle facilities — both national and international," Keepin emphasizes.

To meet the demanding safeguards needs of the future, more than 100 LASL employees are now engaged in nuclear safeguards R&D at Los Alamos.

Technical Assistance Stressed

"Japan has 7 nuclear power plants now operating and is planning to construct 5 more," Kaieda explains. "In addition, we have a nuclear fuel reprocessing plant purchased from France, and will have another, larger reprocessing plant in operation by 1980. We will also have a nuclear fuel fabrication plant in operation soon. With this investment, Japan must stay on top of advanced technology in all aspects of the nuclear fuel cycle, including safeguards."

Kaieda, whose specialty is nondestructive assay of spent nuclear reactor fuel, will return to Japan to take part in that country's NDA safeguards program. Specifically, he will be using NDA techniques, including LASL's concepts and technology, to determine the amount of plutonium in spent fuel using gamma spectroscopy techniques such as are taught at the LASL's safeguards school.

An impressive number of nations have signed the Non-Proliferation Treaty, which is designed to halt the spread of nuclear arms. However, the Treaty would serve little purpose if compliance with the terms of the treaty cannot be effectively implemented and independently verified by the International Atomic Energy Agency. This worldwide responsibility is an awesome mandate for the IAEA, and the Agency is indeed hard pressed to keep up with the spread of nuclear technology.

To enhance IAEA safeguards capabilities, the U.S. Congress has authorized a program of special technical assistance to the Agency. Funding for the new program is from the U.S. State Department, with Brookhaven National Laboratory playing a coordinating role and LASL providing a major source of manpower, equipment, and the wealth of the Laboratory's safeguards experience.

Charles Hatcher, Q-1 is program manager for the technical assistance plan that was implemented early in 1977. He stresses that the program is designed to complement the methods and techniques that IAEA normally uses to implement international safeguards funded from its regular budget.

In addition to money for equipment and manpower, the United States is strongly supporting IAEA on a policy level by helping extend the application of the agency's safeguards through the worldwide Nuclear Users Group, and by fostering development and promotion of multi-national, regional fuel cycle centers, including international centers for storage of spent fuel and plutonium. The U.S. has agreed to have IAEA safeguards applied to all of this country's nuclear facilities except those of direct national security significance, and the United States is strongly committed to supporting and strengthening the effectiveness of international safeguards.

Hatcher says three major changes will take place in the worldwide safeguards program in the next few years.

"The first change will be an enormous increase in the information that must be gathered and analyzed as more nuclear facilities come under IAEA safeguards," he explains. "The second change will be the new types and sizes of nuclear facilities in various countries that will become central to the questions of proliferation. These facilities include isotope separation plants, large spent fuel reprocessing plants, and plants for fabricated mixed uranium-platonium oxide fuel for power reactors or highly enriched uranium fuel for research reactors."

The third major change will be the requirement that IAEA deal with complete nuclear fuel cycles within a single state or within close international groupings. Hatcher believes "These changes will mean IAEA safeguards must be adapted to the particular (national or international) facility in order to achieve the required level of effectiveness."

Hatcher points out that IAEA's safeguards staff is heavily burdened by present obligations, and "When the changes I have outlined occur, that load will become essentially impossible."

To alleviate the problem, the new American assistance plan provides for skilled technical experts to aid the IAEA. These experts (including a LASL safeguards staffer presently on one-year assignment to the IAEA) are introducing new and improved techniques for measurement, accountability, containment and surveillance of strategic nuclear materials.

"The major goals of the new plan are to improve the agency's effectiveness and timeliness in detecting missing nuclear material," Hatcher says. "New methods of measuring will be made available to IAEA, and together with improved surveillance and containment capability, these techniques will allow substantial improvements to be made in every area of IAEA safeguards responsibility."

The dynamic growth of the nuclear industry around the world may require new agreements in the future, with consequent evolution and changes in IAEA safeguards functions, but Hatcher is confident that cooperative effort can keep pace with the expansion.

"We have the technology and the commitment," he says, "and I believe the benefits of nuclear energy are worth the effort we must expend in achieving effective international safeguards."

Exemplifies Japanese Commitment

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Hardware is the broad spectrum of non-destructive assay (NDA) techniques that are necessary to make the Treaty work. Used together, these elements can solve the problem of safeguarding nuclear materials."

Kaieda believes that the United States leads the world in development of advanced NDA techniques for safeguarding and controlling nuclear material, and he is in Los Alamos to study the DYMAC (Dynamic Material Control) system and LASL' basic safeguards concepts.

"I believe we can exchange ideas and this will prove of mutual benefit," he says. Kaieda describes the Japanese government's budget for basic scientific research as "Small — perhaps $4 million, compared with as much as $150 million in America."

Nevertheless, he says, Japan has a vital interest in safeguards, and has probably sent more scientists and industry representatives to Los Alamos and other U.S. research institutions than has any other nation.

Bob Marshall, Q-3, *focuses attention to a thermal neutron coincidence counter* on a glovebox in an area of the facility where fuel pellets are made. Any container of nuclear material that is to be transferred out of this work area must be subjected to monitoring of the neutron counter.

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IRT Offers NDA Course

Instruction in Neutron Radiography for industrial, nondestructive inspection will be available June 5-9, 1978 at IRT Corporation's San Diego laboratories.

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The course is intended for those managers, scientists and engineers with responsibility for nondestructive testing and inspection, quality control or quality assurance. Prior familiarity with nuclear technology or other specialized fields is not essential.

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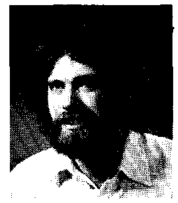
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