JNMM
JOURNAL OF
THE INSTITUTE OF
NUCLEAR MATERIALS MANAGEMENT

Protecção física em todo o mundo
BRAZIL

Fyzická ochrana na světě
CZECHOSLOVAKIA

Material-und Objektschutz weltweit
FEDERAL REPUBLIC OF GERMANY

Protection physique dans le monde entier
FRANCE

世界中の物質界保護
JAPAN

Protección física alrededor del mundo
SPAIN

Materialskydd över hela världen
SWEDEN

Physical Protection Around the World
UNITED STATES

Volume XVI, Number 2 ■ January 1988

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On the Cover:
All countries around the world have a mutual interest in developing the peaceful uses of nuclear materials and facilities from acts of theft or sabotage. It is important not only that each nation have confidence in the effectiveness of its own system, but also in the similar systems employed by other nations. This issue of the *Journal* includes papers presenting the physical protection philosophies and practices of eight representative nations.

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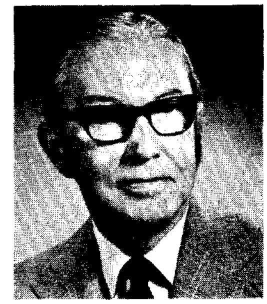


Protection Perspective

All countries around the world have a mutual interest in developing the peaceful uses of nuclear energy and in protecting the nuclear materials and facilities from acts of theft or sabotage which could threaten the public locally or at great distances. It is important not only that each nation have confidence in the effectiveness of its own system of accounting for and control of nuclear materials, but that it also have confidence in the similar systems employed by the other nations with significant nuclear programs.

This issue of the *Journal, Physical Protection Around the World,* presents the philosophical and practical approaches to designing and implementing a physical protection system adopted by a number of different nations. These and other nations cooperated with the International Atomic Energy Agency in drafting recommendations on physical protection from about 1972 through 1977, which are referred to in the papers here as INFCIRC/225.

A fortunate set of circumstances made it possible to present this wide review in this special issue of the *Journal.* For several years the U.S. Department of Energy has supported international training courses in collaboration with the International Atomic Energy Agency (IAEA) on material control and accounting and on physical protection. The Los Alamos National Laboratory has worked with the IAEA on the former and Sandia National Laboratories on the latter. While the approaches to the two related subjects have been based primarily on the U.S. experience in these fields, it has become evident that the approaches adopted by other representative nations should make these courses more valuable to students coming from nations which are now in the process of developing safeguards and physical protection systems.

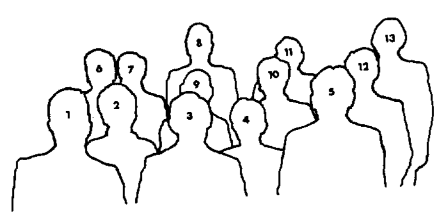
The papers in this issue were presented at the International Training Course on the Physical Protection of Nuclear Facilities and Materials, conducted by Sandia National Laboratories in Albuquerque, N.M., U.S.A., from April 21 to May 15, 1987. The purpose of the guest lecturers was to highlight the fact that physical protection philosophies and techniques must be country-specific, reflecting the social constraints and opportunities which exist in each nation.

We express our deep appreciation to the authors for their cooperation and permission to publish their papers in the *Journal.* A number of others who have assisted in this effort also deserve thanks, notably Cecil S. Sonnier and M. Teresa Olascoaga of Sandia National Laboratories, and Paul E. Ebel of BE, Inc.

Dennis Mangan
Sandia National Laboratories
Albuquerque, New Mexico

William A. Higinbotham
Brookhaven National Laboratory
Upton, New York

Participants in the International Training Course on the Physical Protection of Nuclear Facilities and Materials, conducted by Sandia National Laboratories, Albuquerque, N.M., U.S.A., April 21 - May 15, 1987.



1. J.B. Fechner, FRG; 2. Patricia Newman, Sandia National Laboratories; 3. Jan Lukavsky, Czechoslovakia; 4. Huguette Escure, France; 5. Hideo Kuroi, Japan; 6. Harold Collins, IAEA; 7. Agustin Alonso, Spain; 8. Björn Dufva, Sweden; 9. J.J. Rozental, Brazil; 10. Liz Quinn Ten Eyck, NRC/NMSS; 12. David A. Meyers, DOE/OSS; 13. Dennis L. Mangan, Sandia National Laboratories.

Helping the INMM Grow

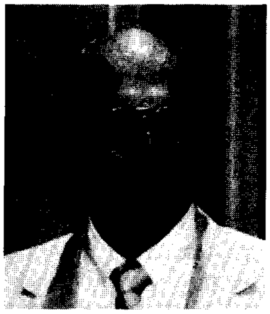
Warmest greetings and best wishes for 1988 to all members and supporters of INMM. I know that at this time of year we all share hope for good things to come, and of course, it is only normal to harbor some fear of the unknowns in the future. It seems that it is at this time of year that the INMM means so much to all of us since the organization represents a strong cadre of safeguards and supporting technology professionals.

The INMM Executive Committee is just back from meeting at Bally's in Las Vegas, site of the 1988 INMM Annual Meeting. The committee met with the hotel staff and toured the facility. The hotel is a terrific facility and the staff will do an excellent job hosting our meeting, which will be held June 26-29. And I hope that all of you are making your plans now to attend. The Program Committee is hard at work and early reports indicate another superior program is in the making. We have a lot of room for exhibitors too, and it looks like we will once again have a good group of representatives from leaders in the field.

Physical protection in safeguards has generally been reserved as an American activity, so this issue of the *Journal* represents a breath of fresh air; taking a look at physical protection around the world. I believe that all of you will find this issue interesting and thought provoking. Clearly, physical protection of sensitive material is the primary means of protection . . . and protection means safeguards.

As we look ahead at 1988, the *Journal*, training, and membership continue to be key issues for the Institute in their own right. The *Journal* is a high quality professional publication and is keenly supported with technical articles. Reader recognition is excellent, but we are still falling short in advertising support.

Training is in a period of transition. Source programs are moving well but some seem unnecessary.



INMM *does* have a role in training, we simply need to pinpoint that role and move ahead.

Membership demands attention since all INMM programs — except membership — have been growing. The challenge is to bring membership up to speed with the overall programs of the organization.

Thank you all for your continued support. I hope to see all of you in Las Vegas this summer at the Annual Meeting.

Charles M. Vaughan
GE Nuclear Energy
Wilmington, North Carolina

IAEA in Perspective: Credibility vs. Perfection

The International Atomic Energy Agency and World Nuclear Order
Lawrance Scheinman,
Resources for the Future,
Washington, D.C.
Distributed by Johns Hopkins University Press
$16.95

". . . Pandora's box is open. The technology cannot be disinvented. The challenge now is to keep it under political, social, and technical controls so that it serves the interest of mankind and does not destroy it. That is a challenge that requires the collective effort of mankind working together in common ways and institutions.

"One such institution already has been fashioned, the International Atomic Energy Agency. Among international organizations, it has an enviable record of achievement. It has been vested with responsibilities and authority that, however constrained they may be, reach beyond that with which any other contemporary global international institution has been endowed. . ."

So concludes Professor Lawrence Scheinman of Cornell University in his political and historical study of the International Atomic Energy Agency (IAEA), primarily known to the readers of the *JNMM* as the organization responsible for implementing international safeguards on the nuclear fuel cycle.

The author, a professor of government at Cornell University, has long studied international nuclear affairs. At the time of this writing, he is serving as a special consultant to the Director General of the IAEA, a position he assumed after completing the manuscript for the book under review.

Writing under the sponsorship of Resources for the Future, Professor Scheinman seeks to increase understanding of the role played by the IAEA in international nuclear affairs following a period when its role was called into question.

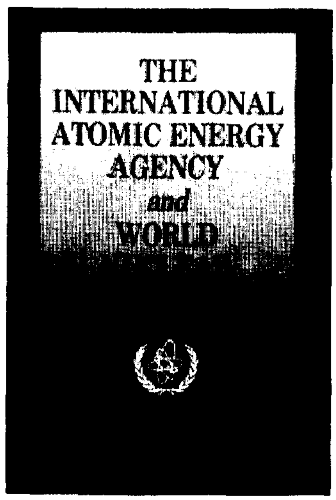
The book begins with a discourse on nuclear nonproliferation policies and institutions as they currently exist. Then comes historical review of the origins of the IAEA, followed by a description of its overall structure and activities. The heart of the book consists of analyses of the IAEA's systems for carrying out its nuclear safeguards verifications on nuclear materials and facilities worldwide. Following this are discourses on important international events relevant to nonproliferation policy that largely transcend the IAEA safeguards system and on problems facing the IAEA itself. The book concludes with an important chapter that offers a series of possible solutions for these problems.

Historically, the author divides the post-World War II nuclear era into three periods. The first encompassed the unsuccessful Baruch plan for international control of nuclear energy and the subsequent years of secrecy. The second began with the Atoms for Peace speech of President Dwight Eisenhower in 1953 and included the establishment of the IAEA, the extensive publication of research results related to peaceful uses of nuclear energy, and the negotiation and coming into force of agreements for nuclear cooperation and most significantly, the NPT (Treaty on the Non-Proliferation of Nuclear Weapons).

The third period, in a way, represents the maturity of the IAEA. Events beyond its purview have forced the world to establish other policies that go beyond the safeguards functions of the IAEA to further impede proliferation of nuclear weapons. It has also been necessary in this recent period to critically analyze and improve the technical efficiency of safeguards procedures themselves.

The transcendent events include the detonation by India in 1974 of a nuclear explosive; the export of sensitive nuclear technologies such as reprocessing or enrichment to (or development by) states with no evident commercial need for them; and the attack by Israel on a research reactor in Iraq. Notwithstanding these events, Professor Scheinman notes, successive U.S. Government administrations have found the IAEA safeguards system to be an indispensable facet of U.S. foreign policy.

The Statute of the IAEA, which was ratified in 1957, anticipated that the advanced nuclear powers would channel their material and technical assistance to other nations through the IAEA, which was to "... ensure, so far as it is able, that assistance provided by or at its request or under its supervision and control is not used in such a way as to further any military purpose," (IAEA Statute).



Although the transfers of research and power reactors and their fuels have not passed through the IAEA as anticipated, the IAEA's technical assistance program to assist developing nations continues to be a major activity and one which is more important than the safeguards program to many of the member states.

The IAEA has its own policy-making board of governors, a general conference of all member states, and a permanently functioning secretariat. In 1986 its budget was $98.7 million, and it employed 1,994 people, of whom 746 were in professional and higher positions. The IAEA is divided into five departments: Technical Cooperation, Nuclear Energy and Safety, Administration, Research and Isotopes, and Safeguards. The Department of Nuclear Energy and Safety is assuming increased importance as a consequence of the reactor accident at Chernobyl in the Soviet Union. The Departments of Technical Cooperation and Safeguards operate programs that benefit or most directly affect relatively underdeveloped states on the one hand and relatively developed states on the other.

Consider now the safeguards systems, of which there are two. Having devolved primarily from the authority given to the Agency in its statute, the older IAEA safeguards system applies to specific nuclear facilities in states not party to the NPT. These facilities require a small percentage of the IAEA's inspection resources, yet the states in which these facilities are located are generally those of most concern about proliferation. This older system is codified in a document (known to the cognoscenti as INFCIRC/66/Rev.2) that includes the purpose and principles of the safeguards, circumstances requiring safeguards, procedures, and definitions. Two annexes covering reprocessing plants and fabrication and conversion plants, respectively, are especially important because they contain the statement that continuous inspection is appropriate for facilities possessing large amounts of sensitive nuclear material.

The newer safeguards system dates from 1972, devolves both from the IAEA statute and the NPT as well as from the IAEA's experience, and is codified in the document INFCIRC/153 (Corrected), which also includes sections on general principles, procedures, and definitions. This newer safeguards system differs from the older one in several ways. The newer one encompasses the entire nuclear fuel cycle in states involved; makes explicit provision for detailed "subsidiary arrangements" to be worked out about safeguards implementation at facilities; relies on the notion of "strategic points" in facilities for making safeguards verifications; requires the state to establish a system of accounting and control of its nuclear material; gives explicit criteria for regulating inspection intensity; enshrines containment and surveillance as complementary measures to material accounting; and includes as the technical objective of safeguards ". . . the timely detection of significant quantities of diversion of nuclear material from peaceful nuclear activities . . . and deterrence of such diversion by risk of early detection." As a practical matter, the routine objective is the verification that declared nuclear materials remain in peaceful use.

Despite the differences in codification between the two safeguards systems, actual verification procedures of nuclear facilities under each tend to be similar.

Problems facing the IAEA concern safeguards and other subjects. Consider first Professor Scheinman's discussion of the former.

IAEA safeguards have often been misunderstood as both necessary and sufficient to prevent nuclear proliferation. Consensus exists as to necessity, but careful students of this subject understand that safeguards are by no means sufficient. (Indeed, one of the reasons for writing the book was to place IAEA safeguards appropriately in their context and to clarify the misunderstanding that safeguards verifications can prevent proliferation.) Safeguards verifications are only one of a number of elements known as the "non-proliferation regime" whose components include ". . . a general world consensus and predisposition against the further spread of nuclear weapons; peaceful use undertakings for nuclear cooperation and trade . . .; voluntary constraints by nuclear suppliers; two treaties — Tlatelolco and NPT; . . . and an international agency, the IAEA, to do the verification by safeguards and to facilitate access to peaceful uses of nuclear energy." I would add other defense alliances, intelligence information, multinational facility operation, and various sanctions to the author's list.

Particular criticisms in the safeguards area relate to limitations on inspector designation, access, and activity; limitations on publicity of the results of verifications; an unwillingness to report safeguards anomalies promptly; quality of inspectors and instruments; and ability to meet the technical objectives relating to timeliness and precision of material accounting verification measures and quality control of the entire safeguards operation. Professor Scheinman answers these criticisms at length: For example, the IAEA has been willing to report anomalous situations. Inspector training and instrumentation have been improving significantly over the last ten years (supported significantly by the U.S. Program of Technical Assistance to IAEA Safeguards and other analogous national and multinational voluntary programs). Let me say that the question of technical objectives depends on achievable measurement accuracies, access to dangerous material, and subtle questions regarding needed detection probabilities in a situation — designed on an adversary basis — that requires and receives facility operator and state authority cooperation for the IAEA to do the verifications. Nevertheless, "an imperfect system that enjoys high political credibility would be preferable to a perfect system that does not."

Other problems facing the IAEA include the view by states not party to the NPT that the IAEA appears to be acting increasingly as an agent of the NPT, the introduction of political issues extraneous to its role in nuclear energy affairs, and the balance between safeguards and technical assistance. With regard to the last point, the IAEA's safeguards function is of most relevance to underdeveloped states. The safeguards function itself will require a reasonable relationship between expectations and capabilities as large, new, sensitive facilities become subject to verification in the not-too-distant future.

Professor Scheinman closes his book with a list of propositions, with explanations, for dealing with these issues. Much depends on renewed strong support by the United States, unhindered by other political matters, and continued ". . . fortunate convergence of Soviet-American nonproliferation goals and newly stated Soviet interest in actively augmenting the general role of the IAEA in the peaceful nuclear arena as well as on the continued support of traditional U.S. allies . . ." Sustained nuclear arms control progress would improve the atmosphere for these solutions.

I found two lapses (and a colleague, one more) in what is generally a well-written, well-organized, and meticulously documented book.

The first concerns the author's discussion of research on safeguards inspection approaches that are aimed at introducing further efficiencies in multiple-facility fuel cycles — so-called fuel-cycle approaches (pp. 280-282). He omitted any discussion of the IAEA's actual experience in testing such an approach in Canada. This increasingly successful experience with a "zone" approach, treating several facilities as a single material balance area, dates back to 1982.

The second point, relatively trivial, is that an organizational chart of the IAEA incorrectly labels the Department of Nuclear Energy and Safety with the name "Standardization Training, and Administrative Support (pp. 94-95)." Since the source document is correct, the confusion with a unit of the Department of Safeguards evidently occurred in redrawing the chart for the book. The third point is that footnote 37 on page 119 should cite INFCIRC/274 (Rev.1), "The Convention on the Physical Protection of Nuclear Material," not the related but different INFCIRC/225 (Rev.1), "The Physical Protection of Nuclear Material."

On another matter, which may be partly semantic, I disagree with the author. He asserts that states not party to the NPT or comparable treaties have not pledged not to acquire nuclear explosives and are therefore ". . . legally and politically free to develop nuclear weapons or nuclear explosive devices from material, technology, and equipment that is not subject to international safeguards . . ." I questioned the notion of political freedom. While such a state may have that freedom with respect to its domestic politics, it would not necessarily have that freedom (in the sense of absence of immediate negative consequences) with respect to international politics. Such a state would very likely suffer a loss of foreign assistance and would risk greatly heightened tensions with its neighbors were it to openly detonate a nuclear explosive. This to me is hardly a situation of political freedom.

These points aside, the book is an important contribution to the literature of international safeguards and nuclear nonproliferation policy that should be read by anyone studying or participating in these fields. It is the key review of these fields — with policy suggestions — that can put into context more detailed treatments of more specialized areas, such as countries which are of particular proliferation concern and technical safeguards practices.

To conclude, without glossing over the Agency's faults, Professor Scheinman has written a strong defense of the IAEA and its past, present, and future role in facilitating a peaceful order for civilian uses of nuclear energy. All rational beings must hope that it can continue to play this role in the future.

Reviewed by
Les Fishbone
Brookhaven National Laboratory
Upton, New York U.S.A.

Pacific Northwest

The winter meeting of the Pacific Northwest Chapter of INMM was held November 4, 1987. Ken Byers of Battelle, Pacific Northwest Laboratories, presented a paper entitled, "The MBA Custodian — Has This Safeguards Program Element Been Neglected?" During the business portion of the meeting, the officers elected for 1987-88 were introduced and the gavel was passed to Chairman Dean Engel. The following officers were elected for the 1987-88 year:

Chairman
Dean W. Engel
Vice-Chairman
Obie P. Amacker, Jr.
Secretary/Treasurer
Debbie A. Dickman
Executive Committee
Ken R. Byers
F. Gary Fetterolf
Vicki K. Locati
Dean D. Scott, Past Chairman

Debbie A. Dickman
Secretary/Treasurer
INMM Pacific Northwest Chapter
Battelle, Pacific Northwest Laboratories
Richland, Washington

Waste Management

The following summarizes the activities of the TWG on Waste Management:

- A preliminary agenda was prepared for the Spent Fuel Storage Seminar to be held in Washington, D.C., Jan. 20-22, 1988 at the Loews L'Enfant Plaza Hotel. This agenda is published in the *Journal*.
- An article was prepared for the *Journal* describing some of the new legislation that has been introduced in Congress and which impacts waste management programs.
- A proposed budget for the 1987-1988 year was prepared and submitted to the INMM Treasurer.

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

N14 Standards Committee

N14 standards highlights from the past quarter:

N14.1 — 1987 Packaging of Uranium Hexafluoride for Transport was approved Oct. 30, 1987. It is currently in the publication process.

N14.3 — Fritz Seiler, Toxicology Inhalation Institute, has agreed to survey potential users of this standard to determine interest in developing a new standard. The old standard will be withdrawn by ANSI at the end of this year.

N14.20 — Jim Lee discussed the background of this standard and recommended that the standard be withdrawn by N14. A letter ballot for withdrawal will be sent to N14 members.

N14.25 — Bob Glass, Sandia National Laboratories, has accepted the chairmanship of the writing group and Bob Towell, E.I. duPont de Nemours, will serve as co-chairman.

N14.26 — A chairman for this writing group has not been selected. Dick Haelsig agreed to review questions relating to this standard and report to the Management Committee.

N14.28 — J. Arendt is reviewing the status of this standard and present a recommendation on continuing this work.

N14.30 — A draft of this standard will be prepared by January, 1988. The new writing group will then review and comment so the standard can go to N14 for ballot.

New Standards

Marilyn Warrant, Sandia National Laboratories, presented a draft study prepared by Sandia for the Office of Civilian Radioactive Waste Management (OCRWM) on new standards applicable to the OCRWM activities. A list of 16 potential new standards was presented. Preliminary evaluation of these potential standards has resulted in two possibilities for near term development: 1) Qualification of Instrumentation and Facilities for Impact, Puncture, Thermal or Immersion Design Verification Tests, and 2) Qualification of Computer Codes and Users of Codes for Analyses of Type B Packages.

Also, a manual of ANSI and N14 procedures is in preparation. The N14 Committee will meet June 30, 1988 at the INMM Annual Meeting in Las Vegas, Nev.

John W. Arendt, Chairman
INMM/ANSI N14 Committee
Consultant
Oak Ridge, Tennessee

N15 Standards Committee

Activities of the N15 Working Groups have continued to progress in a positive manner. Ron Harlan is the new Chairman of INMM-9, Nondestructive Assay, and the Working Group has been busy. N15.20, "Guide to Calibrating Nondestructive Assay Systems," was transferred from INMM-8, Calibrations, to INMM-9 and subsequently submitted for reaffirmation balloting. The revising of a couple of standards under INMM-9 has also been initiated.

The current status of each of the N15 standards is provided in the list below. Attention should be given to each of the proposed (P) standards with an "inactive" status. For one reason or another there is no interest in and effort toward the completion of the project. Anyone interested in pursuing the completion of a proposed standard should contact N15 Vice Chairman Ken Byers (509-376-0311). Proposed standards which fail to generate any interest will be dropped.

Working Groups are always in need of additional support. If you are interested, please contact Ken Byers for more details.

INMM-1, ACCOUNTABILITY
Gary Kodman

N15.8, Nuclear Material Control Systems for Nuclear Power Plants. *Status:* Revision Ballot Resolution Pending.

N15.9, Nuclear Material Control Systems for Fuel Fabrication Facilities. *Status:* Withdrawal Anticipated.

N15.13, Nuclear Material Control Systems for Fuel Reprocessing Facilities. *Status:* Withdrawal Anticipated.

P/N.15.25, Standards for Measuring Material in Process. *Status:* Inactive.

INMM-2, MATERIAL CLASSIFICATION
Nick Roberts

N15.10, Classification of Unirradiated Plutonium Scrap. *Status:* RRW* 1992.

P/N15.1, Classification of Unirradiated Uranium Scrap. *Status:* Draft in Process.

INMM-3, STATISTICS
Dick Mensing

N15.5, Statistical Terminology and Notation for Nuclear Materials Management. *Status:* RRW in Process.

N15.15, Assessment of the Assumption of Normality (Employing Individual Observed Values). *Status:* RRW in Process.

N15.16, Limit of Error Concepts and Principles of Calculations in Nuclear Material Control. *Status:* RRW in Process.

N15.17, Statistical Evaluation of Shipper/Receiver Differences in the Transfer of Special Nuclear Material. *Status:* RRW in Process.

P/N15.29, Procedures for Correcting Measurement Data for Bias. *Status:* Inactive.

P/N15.30, Sample Size Considerations in the Estimation of Variance. *Status:* Inactive.

P/N15.32, Procedures for Resolving Shipper/Receiver Differences. *Status:* Inactive.

INMM-5, MEASUREMENT CONTROL
Yvonne Ferris

N15.41, Guide to Nuclear Facility Measurement Control. *Status:* RRW due 1989.

P/N15.51, Guide to Measurement Control in an Analytical Laboratory. *Status:* Draft in Process.

P/N15.52, Guide to Measurement Control of Mass Measurement Devices. *Status:* Draft in Process.

P/N15.53, Guide to Mass Spectrometry Measurement Control. *Status:* Draft in Process.

P/N15.54, Guide to Measurement Control of Radioactive Calorimetry. *Status:* Approval Ballot Resolution Pending.

INMM-6, INVENTORY TECHNIQUES
Frank Roberts

N15.3, Physical Inventories of Nuclear Materials. *Status:* Withdrawal in Process.

INMM-7, AUDITS, RECORDS, AND REPORTING TECHNIQUES
Sheldon Kops

N15.11, Audit Opinions on Nuclear Material Balance Reports. *Status:* RRW due 1988.

N15.38, General Requirements for Auditing Nuclear Material Safeguards Systems. *Status:* RRW in Process.

INMM-8, CALIBRATIONS
Bill Rodenburg

N15.18, Mass Calibration Techniques for Nuclear Material Control. *Status:* Revision Ballot Resolution Pending.

N15.19, Volume Calibration Techniques for Nuclear Material Control. *Status:* Revision Balloting Underway.

N15.22, Calibration Techniques for Calorimetric Assay of Plutonium Bearing Solids Applied to Nuclear Materials Control. *Status:* RRW due 1992.

INMM-9, NONDESTRUCTIVE ASSAY
Ron Harlan

N15.20, Guide to Calibrating Nondestructive Assay Systems. *Status:* Reaffirmation Balloting in Process.

N15.23, Guide to Nondestructive Assay of the 235U Content of Unpoisoned Low Enriched Uranium Fuel Rods. *Status:* RRW in Process.

N15.35, Guide to Preparing Calibration Material for Nondestructive Assay by Counting Passive Gamma Rays. *Status:* RRW in Process.

N15.36, Nondestructive Assay Measurement Control and Assurance. *Status:* RRW in Process.

N15.37, Guide to the Automation of Nondestructive Assay Systems for Nuclear Material Control. *Status:* RRW in Process.

P/N15.33, Categorization of Special Nuclear Material for Nondestructive Assay. *Status:* Draft in Process.

P/N15.34, Standardized Containers for Nondestructive Assay. *Status:* Inactive.

P/N15.39, Nondestructive Assay of Low Enriched Uranium Fuel Material. *Status:* Inactive.

P/N15.45, Guide to Preparing Calibration Material for Assay by Counting Induced or Spontaneous Fission Neutrons. *Status:* Inactive.

INMM-10, PHYSICAL SECURITY
John Hockert

N15.40, Definitions of Terms Associated with the Physical Protection of Nuclear Material and Facilities. *Status:* RRW in Process.

P/N15.43, Design Guidelines for Closed Circuit Television for Physical Security at Nuclear Facilities. *Status:* Inactive.

P/N15.44, Guide to Selection and Use of Exterior Sensors for Nuclear Facility Safeguards. *Status:* Inactive.

P/N15.48, Guide to the Identification of Vital Areas at Nuclear Facilities. *Status:* Inactive.

INMM-11, TRAINING AND CERTIFICATION
Barbara Wilt

P/N15.28, Criteria and Standards for the Certification of Nuclear Material Professionals. *Status:* Draft in Process.

INMM-14, INTERNATIONAL SAFEGUARDS
Tom Shea

P/N15.46, Guide to Physical Inventory Taking for International Safeguards. *Status:* Inactive.

P/N15.47, Guide to Reviewing and Verifying Facility Design Information Related to International Safeguards. *Status:* Inactive.

Obie P. Amacker, Jr., Chairman
INMM/ANSI N15 Committee
Pacific Northwest Laboratory
Richland, Washington

**Revision, Reaffirmation or Withdrawal process which is due to be completed five years from approval.*

Membership

I would like to take this opportunity to thank the Executive Committee for inviting me to serve as your membership chairman. I have accepted the position with the goal of continuing the fine efforts expended by the last chairman of this Committee, Roy Cardwell, Martin Marietta Energy Systems, who held the position since 1983. Roy has done an outstanding job of promoting membership in the Institute. Over the years, he has been assisted by many of you, and especially by Institute Secretary Vince DeVito, Martin Marietta Energy Systems, and Treasurer Bob Curl, EG&G Idaho, Inc.

There are no current plans to make any major changes in the Membership Committee's activities. However, any suggestions you may have pertaining to increasing the quality and quantity of our membership will be greatly appreciated. Please send your comments and suggestions to me at Los Alamos National Laboratory, P.O. Box 1663 (MS-G731), Los Alamos, N.M. 87545. I believe that one of the major goals of the INMM is to involve all of its members in the activities of the Institute.

I am looking forward to serving you in this new capacity.

N.J. "Nick" Roberts, Chairman
INMM Membership Committee
Los Alamos National Laboratory
Los Alamos, New Mexico

Constitution and Bylaws

The Central Region Chapter, INMM, approved revisions to its chapter Constitution and Bylaws at the 1987 chapter meeting in Lexington, Ky. on Oct. 23. These were submitted to the INMM Executive Committee in November and have been accepted and entered into the record.

Each chapter should periodically

review its Constitution and Bylaws and bring them up to date. After approval by the membership, the revised documents should be sent to the INMM Constitution and Bylaws Chairman so that the Executive Committee records can be updated.

Fellows

By the time you receive this *Journal*, Chapter Chairmen should have received a letter from the Fellows Committee Chairman inviting nominations for the grade of Fellow of the INMM in 1988. If you are not affiliated with a chapter because of your location and want to sponsor a member, you may do so by writing a letter of nomination to the Fellows Committee Chairman. Such letters must fully describe the qualifications of the nominee and be signed by five INMM members in good standing.

Nominees must be Senior Members of INMM actively engaged in the profession of safeguards. They must have distinguished records of sustained contributions to their profession in the development or exposition of the theory, principles, and/or techniques of nuclear materials management, and must have a minimum of fifteen years experience in the field. The number of Fellows in the INMM is limited by the Bylaws to five percent of the total membership.

A single nomination letter should be signed by all recommenders if possible. If this is difficult because of the location of some, short letters endorsing the original letter signed by one or more additional members and sent directly to the Fellows Chairman will be honored and made a part of the main nominating letter.

Roy A. Cardwell, Chairman
INMM Bylaws & Constitution Committee
Martin Marietta Energy Systems
Oak Ridge, Tennessee

Annual Meeting

The 29th Annual Meeting of the Institute of Nuclear Materials Management will be held June 26-29, 1988 at Bally's Hotel (formerly the MGM Grand Hotel) in Las Vegas, Nev., U.S.A. The committee chairmen for the meeting are:

Technical Program
C.E. Pietri, U.S. Department of Energy
Local Arrangements
B.E. Meurrens, EG&G Energy Measurements
Exhibits
J.C. Hamilton, Martin Marietta Energy Systems
Registration
G.J. Carnival, Rockwell International

The Technical Program Committee will meet during the latter part of February to review abstracts and summaries of papers proposed for presentation at the annual meeting and to develop a preliminary program for the meeting.

M. Teresa Olascoaga
Chairman
INMM Annual Meeting Arrangements Committee
Sandia National Laboratories
Albuquerque, New Mexico

Physical Protection Philosophy and Techniques in Brazil

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Comissao Nacional de Energia Nuclear
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INTRODUCTION

There have been many discussions about the use of accountability measures to detect diversions of nuclear material. A number of states have established their own Safeguard Systems based on this concept.

In recent years, a great deal of effort has been devoted to the development of a Security System to complement the Safeguard System based on accountability. This results from concerns arising out of the increasing frequency and severity of international terrorist activities and the growth of the nuclear industry around the world. The protective measures derived from this Security System would provide greater assurance against diversion. They would also protect the facilities and their components against illegal acts.

Presently, a reliable Domestic Safeguards System is one that strikes a balance between the appropriate accountability and protective measures.

INITIAL REMARKS - SAFEGUARDS PHILOSOPHY

Before concentrating on the real objectives of this paper, let us first discuss three fundamental features of nuclear activities that users of nuclear energy and materials must take into account when considering the welfare of the population: Safeguards, Security, and Safety. These features define three different systems devised to assure that nuclear facilities and materials are properly, securely, and safely handled and that no radioactive material will ever be removed or dispersed. This paper describes briefly the Safeguards System as it is understood in Brazil, introduces the Physical Protection System, and shows their common features which might be integrated to form a broader system.

Safeguards are defined as an array of measures and procedures designed to detect the diversion of nuclear material. The Safeguard System consists of three basic measures, accountability, containment, and surveillance.

- Accountability measures encompass the use of records and reports to provide information on the characteristics, quantity, and location of nuclear materials. They also include the use of methods and techniques for qualitative and quantitative determination of this material.
- Containment measures consist of confining the nuclear material within specific boundaries by use of container storage areas and seals or tamper indicators. They show that the material has remained inviolate for a certain period of time.
- Surveillance measures involve observation of operations carried out with nuclear material to verify that they are in accordance with legitimate purposes. Such observation may be made directly by an inspector or indirectly through use of cameras or any other device for detection of unauthorized movement of material.

Up until now, the greatest effort in the detection of unlawful use of nuclear material has been concentrated on the development and application of these means.

Although accountability, containment, and surveillance measures establish a boundary immediately adjacent to the nuclear material, with respect to detection, they portray an event which took place sometime in the past. In other words, time may elapse between the occurrence of an event (for instance acquisition or removal) and its detection. The safeguards measures described above make little, if any, contribution to the prevention of theft or any malevolent act to a facility which might endanger or harm society. There are compelling reasons why major efforts should be devoted to the development of a protective system which would enhance the effectiveness of the Safeguards program based on accountability.

This new system should be conceived to achieve the following objectives:

- To detect theft of nuclear material or intrusion into a facility;
- To deter or impede theft of nuclear material and adverse actions against the facility or transportation system;
- To respond to threats or sabotage acts; and
- To recover the stolen material.

Both systems have their own specific functions, yet a strong interface can exist between them. This refers primarily to the detection capability of the Safeguards System to provide real-time detection as input data to the Physical Protection System. At this point, one does not refer to two systems that work independently, but to one integrated system that is under research today and already in use in developed countries.

RESPONSIBILITY OF STATE AUTHORITIES

In Brazil, the National Council of Security (NCS) direct branch of the President of the Republic and the Ministry of Mines and Energy (MME) has the overall responsibility for the planning, execution, and control of the nuclear energy policy. These Institutions oversee the activities of the three different corporations engaged in the establishment of a Brazilian nuclear program, namely:

- Comissao Nacional de Energia Nuclear - CNEN/NCS (National Commission of Nuclear Energy)
- Empresas Nucleares Brasileiras S.A. - NUCLEBRAS/MME (Brazilian Nuclear Enterprises)
- Centrais Eletricas Brasileiras S.A. - ELETROBRAS/MME (Brazilian Electric Utilities).

The CNEN is a governmental organization under NCS, acting as an advisor to the NCS. The CNEN is devoted to promoting the use of nuclear energy as well as standardization, regulation, licensing, and inspection of all nuclear activities in the country. NUCLEBRAS is a state-owned company which is responsible for the establishment of a Brazilian nuclear industry comprised of all facilities of the nuclear fuel cycle. ELECTROBRAS, also a state-owned company, plans and coordinates the Brazilian power system. One of its subsidiaries, Centrais Eletricas de FURNAS S.A., is charged with operation of the first Brazilian nuclear power plant.

HISTORY

In Brazil, the responsibility for the establishment, implementation, and maintenance of a physical protection system rests entirely with the concessionary. The role of CNEN is to promulgate and review regulations for physical protection. The CNEN's role also includes providing criteria and standards and periodically verifying compliance with the requirements stated in the rules. At CNEN, the Safeguards and Security Systems are administered by the Safeguards Division. This responsibility was acquired only a few years ago. To cope with these obligations, establishing a functional structure which could support both activities without duplicating the work was necessary. This structure is being gradually implemented.

Brazilian nuclear activities started relatively early. The first nuclear facilities were built during the 50's and 60's in university areas. Their main objectives were research, development of nuclear capability, and training of personnel starting in this new field of science. Although special nuclear material was used as fuel elements, very simple precautions were taken to protect them and the facilities against malevolent acts. The security measures consisted of fences and control of access. There was no standardization among the different facilities in accordance with material characteristic like isotopic composition, physical and chemical form, radiation level, and quantity.

Around the mid-70's, the initial draft of a rule for physical protection was outlined. Its contents were based on the recommendations issued by the IAEA on the subject under document INFCIRC/225. This preliminary draft was submitted to facility operators for comment. After some months, a final document was approved and issued by CNEN under the title, Protecao Fisica de Instalacoes e Materiais Nucleares (Physical Protection of Facilities and Nuclear Materials).

The physical protection rule defines a set of criteria to be used in the formulation and implementation of a Physical Protection Plan. The rule contemplates criteria for:

- Design of facility security zones (Vital Area, Protected Area, Surveyed Area);
- Establishment of administrative control;
- Categorization of nuclear material;
- Establishment of protective measures for nuclear material at fixed sites and in transit according to material category and means of transportation.

Its design, control of access, surveillance, and coercive measures for each security zone are described as having an increasing degree of restriction and prohibition as each penetrates the facility area.

- *Surveyed Area* - This area must have its perimeter delineated by a fence and marked by signs or other means to show that access is controlled. Surveillance must be carried out by guards. Around this zone, an owner's private property must be defined and marked.
- *Protected Area* - This area must be enclosed by a physical barrier. It must be constructed so that no structure or natural bodies obstruct the view. Access must be restricted to authorized persons only. Surveillance must be exercised by the plant security force, according to a predetermined program, and by the operating personnel in the performance of their primary duties. When appropriate, these measures can be supplemented by the use of electronic devices. Parking facilities must be located outside this area. The protected area does not necessarily need to encompass all facility buildings.
- *Vital Area* - This area must enclose the facility buildings where vital equipment is located. Its perimeter can be defined as the facility walls when they provide reasonable resistance to penetration. Access must be restricted to a limited number of authorized personnel. Surveillance is exercised in the same manner as for the Protected Area.

The aim of the group who worked out the physical protection rule was to base the licensing of nuclear activities on the existence of Physical Protection Plans at fixed sites. The same should apply in the case of transportation of nuclear material. Article 2.3.1 of the rule specifies that a Physical Protection Plan should be implemented at each facility. In the same manner, Article 9.2.1.3 stipulates that the CNEN will issue an approval for transfer of nuclear material. This will only occur when the Physical Protection Plan of Transfer has been approved by CNEN.

The group also recognized the role which various systems, equipment, devices, and materials play with regard to the health and safety of the public. Should deliberate acts of failure or destruction of these items occur, which could lead to a significant radiological accident, cause material damage, or the loss of time, then their approval might have to be negotiated. This has led the group to define the items as vital equipment and require that protective measures be extended to them under the condition that the license for nuclear activities will be issued only if protective measures are complied with.

As a result of this rationale, the physical protection rule specified that the concessionary must take into consideration protective criteria and standards. This is done at the design or planning stage of a facility. The concessionary should also define and exercise the protective measures described in a Preliminary Physical Protection Plan to protect vital equipment during the construction stage of the facility.

Contrary to what might have been expected, the first experience gained soon after issuance of the physical protection rule was not related to the protection of the already-existing facilities, but to a power station under construction. Its core was being transported to, and stored at, the construction site. In this operation, detailed administrative and protective measures beyond those contained in the rule had to be defined and implemented.

- Skilled people were gathered and trained, transportation firms were selected, contacts with local law enforcement agencies were made, and coordination with the CNEN and governmental authorities was maintained for the transportation operation.

- Civil work at the fuel building was expedited and finished before the arrival of the fuel elements. The elements were to be stored in the spent and fresh-fuel pits to await the commencement of fuel loading.
- The storage area was defined as a vital area and specific protective measures were established and incorporated into the Preliminary Physical Protection Plan.
- Access control to the construction site was reinforced to minimize the risk of threats or sabotage.
- Temporary physical barriers were erected, so as to isolate this power station from an adjacent one also under construction. This reduced by thousands the number of people allowed into the construction site.

This experience was one of utmost importance. It demonstrated that the governmental organizations and the concessionary are fully aware of and motivated by the importance of physical protection measures. It demonstrated that with effort and cooperation, all adverse conditions can be overcome. Furthermore, as a result of these actions, a psychologically positive atmosphere was generated within society, protecting it from those who protest against nuclear energy.

CONCLUSION

The objective of the Safeguards System is to detect diversion of nuclear material. The objective of the Security System is to prevent theft, dispersal of nuclear material, and sabotage of nuclear facilities. The former system provides means to confirm that the latter system has, or has not, been successful. Early detection of a Safeguards anomaly is extremely important because it can trigger the protective mechanisms providing defense-in-depth of the facility.

The use of an increased level of physical restraints, control of access, intrusion detection capability, and communication and response should be analyzed for the nuclear facilities on a case-by-case basis. It needs to take into consideration the site and environmental conditions, cost effectiveness of the Security System, and above all, the profile of the adversary and types of action which might be of two kinds.

- Overt action, characterized by the use of force tactics.
- Covert action, characterized by stealth and deceit tactics.

In planning the Security System of a facility, one must envision the possibility of an adversary to act, either overtly or covertly, with the help of an insider. Actions of this kind can defeat the defense system of a facility - even the integrated ones which combine elements of the Safeguards and Security Systems. The CNEN is aware of the advantages that these integrated systems can bring to the overall effectiveness of safeguards against clandestine actions.

The CNEN is also aware that no system can function without manpower. For this reason, it believes that real security can be achieved only through the understanding, cooperation, dedication, and motivation of all operating and security personnel within the facility.

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Physical Protection Philosophy and Techniques in Czechoslovakia

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Jan Lukavsky
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The physical protection in Czechoslovakia/CSSR is understood as one of the basic conditions for the safe utilization of nuclear energy. From this point of view, the physical protection measures are part of the nuclear safety requirements. The Nuclear Safety Law is the basic legal document for the physical protection area. In CSSR a very tight connection between the physical protection system and the State System of Accountancy for and Control of Nuclear Material/SSAC is also established. Combining regulatory activities in the field of nuclear safety, accountancy for and control of nuclear materials and physical protection into one complex system enables the minimization of unauthorized removal of nuclear material. This minimizes the possibility of sabotage and also implements effective protection against both inside and external threats. The physical protection is a very important complementary measure to the other ones which assure low risks from the technical and human failures.

The IAEA's document INFCIRC/225 (Rev. 1), "The Physical Protection of Nuclear Material", is applied as a basis for the physical protection measures and requirements concerning nuclear material storage and utilization. The categorization of the nuclear material based on INFCIRC/225 (Rev. 1), as well as the other requirements relevant to individual categories, is valid in CSSR. In 1981 CSSR signed and in 1982 ratified the Convention of the Physical Protection of Nuclear Material. Without waiting for the validation of this document, the convention's requirements become obligatory immediately, and they are applied to both the domestic and the international transportation.

Both documents mentioned above focus on nuclear material, and they do not consider the risks which can arise from the malevolent act against the nuclear facility. However, considering the measures for the physical protection of the nuclear facility, not only must the characteristic of the nuclear material itself be taken into account, but also, the characteristic of the nuclear facility must be considered.

In CSSR each enterprise is obliged to ask the CsAEC for a license before receipt of the nuclear material and it is obliged to seek an extra license for siting, construction and operation. The application for the license has to be supported by the safety reports confirming that all nuclear safety, accountancy, and physical protection requirements are fulfilled. The content of the safety report chapters concerning the physical protection is as follows:

- Evaluation of the geographical location;
- Evaluation of the facility design;
- Description of the physical protection system;
- Evaluation of the relation between the facility operational conditions and the effectiveness of the physical protection system;
- Evaluation of the physical protection system reliability;
- Description of the quality assurance programs for the component fabrication and for the system construction; and
- Description and evaluation of the response activities plans.

The license issued by CsAEC can be controlled using additional conditions. In order to control how the information given in the safety report reflects reality and how the license conditions are fulfilled, the CsAEC has a right to carry out inspections. If anomalies are found, the CsAEC's inspector is authorized to ask the operator to introduce complementary measures, to check the system performance, and in serious cases, to ask the facility to shut down. Of course, this is valid for the anomalies in the field of the physical protection, as well as in the field of nuclear safety. The evaluation of the facility geographical location, the facility design, and the risks resulting from the malevolent acts against the facility represent the basis for the physical protection system design. For each facility, determining which event represents the greatest potential harm to the public, for example the radiation release from the reactor fuel due to core meltdown, is necessary. The physical protection system then is built with the aim to minimize the possibility of such an event. The sensitivity of each facility component to the malevolent acts is determined by the following factors:

- Significance for plant safety;
- Radioactive material inventory;
- Complexity of the intruder's access; and
- Design resistance against the sabotage.

Based on this approach, the optimization of the physical protection measures is carried out with respect to the individual facility components. This means that more complex physical protection requirements are applied to more sensitive parts of the facility, and simple requirements are applied to less sensitive parts. The categorization of the nuclear facility components is based on this principle. The nuclear facility components are categorized, as well as the nuclear material in the INFCIRC/225 (Rev. 1), into three categories. The INFCIRC/225 (Rev. 1) requirements can be used as guidelines for the physical protection of the nuclear facilities such as nuclear power plants, research reactors, laboratories etc.

The conditions for the safe operation of the nuclear facility are created during its construction. From this point of view, the quality assurance programs are part of the physical protection system. Malevolent acts during the facility construction, mainly ones which are not detected, can have negative influence on the facility's safety in the future. Here, special measures are taken to minimize the possibility of sabotage carried out by insiders.

Basic elements in CSSR's nuclear program are the nuclear power plants/LWR type. The predominant concern for the LWRs from the physical protection point of view is a sabotage incident with the release of the radioactive materials which exceed the accepted limits due to the core meltdown. In creating physical protection systems, we prefer highly sophisticated ones rather than those based on numerous guards. We do not underestimate the role of the human factor, however; therefore, a big effort is focused on the protective force's education and exercise. Only a well trained, qualified, and adequately armed staff can neutralize the intruders without affecting plant operation.

From the physical protection point of view, the transportation of nuclear material is considered the most vulnerable part of the nuclear fuel cycle. Therefore, special attention is paid to the fuel shipment. This consists mainly of highly enriched uranium and the irradiated fuel transportation. We fully adhere to the Convention of the Physical Protection of Nuclear Material, and the physical protection measures in CSSR reflect the categorization of the material transported.

Based on experience, the following aspects are very important for an effective physical protection system performance:

- Knowledge of the physical protection goals;
- Complex legal and technical requirements and regulations;
- Well functioning license procedures;
- Sophisticated technical systems;
- Research and development;
- Staff education and training; and
- Regulatory body inspection activities.

Further development of peaceful nuclear energy utilization needs more extensive international cooperation. The physical protection cannot be separated from such cooperation, especially in the field of nuclear material shipments. Also, bilateral and multilateral cooperation is necessary in order to prevent nuclear material diversions.

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Physical Protection Philosophy and Techniques in the Federal Republic of Germany

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INTRODUCTION

Adequate physical protection measures are required by law as a licensing prerequisite for all transporters of nuclear materials and for all nuclear installations such as nuclear power plants, enrichment, fuel fabrication, storage, and reprocessing facilities in the Federal Republic of Germany (FRG). The objective of these measures is to prevent the following:

- Any risk to the health and safety of the public that might be caused by direct radiation exposure or by significant release of radioactive substances through sabotage or other criminal acts, and
- Any single or repeated theft or robbery of nuclear materials in quantities sufficient for the construction of a critical assembly.

For nuclear power plants, the requirement to avoid any significant release of radioactive substances means, even in cases of sabotage or other criminal acts, essential safety functions like shut-down of the reactor and maintenance of it in the shut-down state, adequate heat-removal from the core and the spent-fuel storage pool, and the integrity of certain barriers around radioactive substances must be maintained. However, the primary objective of physical protection measures in the FRG is not to keep the respective plant operational in cases of sabotage. For instance, sabotage was committed to power line masts in about 90 cases in 1986. As long as such events do not impair the emergency power supply of nuclear installations in an unacceptable way, no physical protection measures will be initiated by the regulatory authorities.

The type and extent of physical protection measures are determined by the category of material in the facility or transport vehicle. The national security categorization scheme (category I, II, and III) is nearly identical to the IAEA scheme published in INFCIRC/274. The potential levels of radiation exposure which could be caused by sabotage or assaults to facilities or transport vehicles are also taken into account during the assignment of physical protection categories.

The applicant for a construction or operating license of a nuclear facility or for a handling, storage, or transportation license for nuclear materials is responsible for submitting a detailed physical protection concept to the FRG national authorities. The state nuclear regulatory authority and the state ministry for internal affairs will then together review and assess this information in order to determine whether the necessary level of physical protection can be ensured, before granting the license. The regulatory authority also works with an independent expert organization for the assessment of the various documents. If the applicant's concept shows any significant deficiency when compared to relevant international or national codes, guidelines or standards on physical protection, the competent authorities will require that this concept be upgraded accordingly. The detailed technical, organizational, and personnel measures must then be developed and implemented by the applicant.

This paper will describe the *integrated physical protection concept*, which is the basis for the measures to be implemented by the applicant and the state authorities. A general overview of the *vulnerability analysis* and examples of various *physical protection measures for nuclear facilities and for transportation of nuclear material* will follow.

INTEGRATED PHYSICAL PROTECTION CONCEPT

The integrated physical protection concept of the FRG constitutes the basis for all physical protection measures for nuclear facilities and for transporters of nuclear materials. This concept was agreed upon in 1977 by all state ministries for internal affairs and encompasses two cornerstones:

- Preventative basic protection by the applicant/licensee,
- Measures by the local law enforcement agencies (police forces).

Preventative Basic Protection

Preventative Basic Protection means all technical, personnel and administrative measures which the applicant/licensee has to provide in order to ensure an adequate level of physical protection. "Adequate level" means that these preventative basic protection measures alone shall prevent the potential aggressors from gaining access to relevant buildings, systems, components, or transportation vehicles until police forces can arrive on site. In addition it prevents adversaries from initiating plant states or transportation situations leading to significant radiological consequences for the public, and from committing theft or robbery of nuclear material.

The requirement that the respective barriers shall prevent aggressors from entering vital areas for at least the delay time is also designed to create favorable conditions for the counterattack by the police forces. Appropriate security measures shall be provided for the early detection and localization of the aggressors outside the buildings. Other important elements of the preventative basic protection are reliable alarm communication lines to the police forces, dependable resistance by the licensee's guard services, effective access control systems, and an on-going program of personnel security screening.

Local Law Enforcement

The measures by the local law enforcement agencies (police forces) comprise all police activities which are necessary to terminate the assault as quickly and as effectively as possible, and to prevent the adversary from entering protected areas or from destroying important systems and components. Elements of these police activities are general surveillance measures outside the plant and adequate response forces and sufficient equipment reserves (including transportation and communication capacity) for every site and for the different transportation routes. In addition, police activities include detailed response procedures for every facility and transport, centralized alerting systems for announcing certain security risk levels for nuclear installations, mutual drills by police forces and operator's guard services, coordination centers for police actions, transport-escorts for weapon-grade category I - nuclear material, and counterattacks in case of an actual assault. The centralized alerting system is kept operational day and night. All state ministries for internal affairs, all nuclear licensing and surveillance authorities, and all nuclear facilities are linked to this system. The announcement of a specific security risk level will initiate situation-dependent additional security measures by the police and by the operating organization of the nuclear facilities.

There is a strong interdependence between the preventative basic protection measures by the licensee and the measures by the local police. Therefore, close coordination and "tuning" of the activities of both sides are a must. This close coordination is achieved through mutual participation of nuclear licensing authorities and law enforcement authorities in several working groups, which specify general physical protection requirements. On site, the coordination is ensured by a local security and protection commission for each facility. The local police authority, the nuclear licensing authority, the emergency management authority, and the licensee are members of this commission. Their responsibility is to tailor the measures mentioned above to the characteristics of the site and of the plant, and to ensure that they are operable.

VULNERABILITY ANALYSIS

As a starting point for the specification of the necessary physical protection measures, the respective plant design or transportation concept and packing design must be analyzed with respect to their vulnerability to external or internal adversaries. For this vulnerability analysis, assumptions have to be made concerning the external and internal threat level. In the FRG, the reference threat level has been specified by criminal investigation authorities, by intelligence agencies, and by police authorities together with other regulatory authorities.

Threat Level

The present threat level has three elements:

- A violent crowd of people with an integrated group of adversaries outside the plant or transportation vehicle;
- A small group of adversaries outside the plant or transportation vehicle; or
- A single adversary inside the plant or transportation vehicle.

The group of adversaries is assumed to be knowledgeable of the facility operation, of the characteristic safety features of the plant or transportation vehicle, and of the location of important systems and components. The group of adversaries is taken to be armed and to bring along with them as many tools and as much equipment for surmounting fences and penetrating technical barriers as they are able to carry.

The single adversary is assumed to have access to every tool or other equipment that is located inside the plant or transportation vehicle and to have normal access to protected areas and may cooperate with the external group of adversaries.

Vulnerability Analysis

As a next step of the vulnerability analysis, representative actions of the threat elements are analyzed with respect to their consequences in order to identify where and what type of security measures are necessary. For nuclear power plants, for instance, plant states like the following must not be initiated by adversary actions and, therefore, they require appropriate security measures:

- Complete interruption of steam generator cooling while reactor-pressure-vessel is closed (PWR);
- Complete interruption of residual heat-removal while reactor pressure-vessel is open (PWR);
- Complete interruption of electric power supply (PWR, BWR);
- Loss of primary coolant while ECCS is inoperable (PWR); or
- Destruction of irradiated fuel elements.

The vulnerability analysis will thus help to identify which of the buildings, systems, and components need to be physically protected. For nuclear power plants, examples for such buildings are the reactor building, the emergency feedwater building and interconnecting cable and piping ducts.

Vulnerability analyses for transportation vehicles follow the same scheme, taking into account the specific characteristics of the different transportation routes (by air, waterway, railway, or road) and of the transported goods (type of material, physico-chemical state, and packing).

Once the buildings, systems, and components which have to be protected are clearly identified, the following physical protection requirements have to be fulfilled by appropriate security measures:

- Detect and verify an assault or insider action as early as possible;
- Call out local police forces at once and ensure uninterruptable communication;
- Prevent penetration of adversaries into protected buildings during delay time of police forces;
- Prevent destruction of protected systems and components by explosive charges;
- Impede the movement of big quantities of explosive charges or other offensive equipment on-site to protected buildings by truck;
- Impede cooperation between external group of adversaries and insider adversary;
- Impede intrusion of violent crowd onto the site;
- Supervise plant and personnel, and control the access and flow of material in order to:
  - grant access to protected areas (external and internal) or systems only to authorized personnel and only when necessary;
  - keep records on activities in protected areas for identification of insider actions;
  - impede undetected insider actions;
  - limit and control the introduction of explosive charges or other offensive equipment; and

- detect unnoticed tampering of systems and components by insider adversaries as early as possible.
- Ensure trustworthiness of all personnel through a screening process;
- Enable effective police actions and (for transport of nuclear material);
- Maintain permanent contact to transportation vehicles and keep reliable track of vehicle location.

PHYSICAL PROTECTION MEASURES FOR NUCLEAR FACILITIES

When physical protection measures are being specified for a nuclear facility on the basis of the vulnerability analysis, certain credit can be given to existing technical and administrative safety provisions of the facility. Safety features like redundancy and physical separation of safety systems, design of certain buildings against aircraft crash and pressure waves from chemical explosions, operational and accident instrumentation, design for accident prevention and mitigation of consequences, structural and technical measures for radiation protection and for fire protection purposes, routine inspections of components, radiation protection access control procedures, key systems, and work permit procedures contribute significantly to the physical protection of the plant. Several of these also protect against the insider threat.

The following is a description of structural and other technical, personnel, and organizational physical protection measures for category I-nuclear facilities. Examples for this type of facility are nuclear power plants, reprocessing plants, and some fuel fabrication plants. For nuclear power plants, the predominant objective is the prevention of unacceptable releases of radioactive substances, whereas for the latter installations, the prevention of any diversion of nuclear material prevails.

Structural

In the FRG, priority is given to structural and other technical security measures. This principal leads to the establishment of external, internal, and special protected areas, which have to be surrounded and protected by appropriate structural or technical barriers.

External Protected Area

The external protected area is established around the buildings that need physical protection. It should have a width of at least 35 m. The purpose of this area and the barriers around it is to prevent aggressors from reaching the enclosed buildings undetected. Also, it is to limit the offensive equipment that can be carried by the adversaries and to create favorable conditions for the early alerting of the police forces and for counteractions of guard services and the police.

The barriers around external protected areas consist of the following elements:

- A security fence to impede the intrusion of a violent crowd of people sufficiently and to facilitate police countermeasures in case of demonstrations;
- A wire-mesh double-fence with Y-shaped barbed-wire diverters on top and with a protection against undermining;
- Vehicle barriers to withstand the heaviest commercially available truck consisting of ditches, reinforced concrete walls, concrete elements, horizontal steel bars, or natural obstacles; and
- A bullet resistant barrier around the guards and entrance building at the passage, where personnel and supplies normally enter or leave the external protected area.

Outside the barriers there should be an open zone to facilitate early detection of assault preparations.

Exterior Intrusion Sensor System

An exterior intrusion sensor system for early and reliable detection that will locate any attempt to penetrate or otherwise overcome the outer enclosure is necessary. This intrusion sensor system may be buried in the ground or freestanding inside the double-fence. The systems in use are pressure sensors, magnetic field sensors, ported coaxial cable sensors, fence disturbance sensors, and bistatic microwave systems. Infrared systems tend to produce high alarm rates under unfavorable weather conditions like dense fog or snowfall (visibility less than 30 m), which are rather frequent in northern Europe. Therefore, these systems are only applied for protecting limited perimeter sections. In general, an appropriate combination of two systems which apply different physical principles of operation will reduce the nuisance alarm rates and the possibility of defeating each of the single systems.

Alarm Verification System

The alarm-verification system shall enable the security personnel to distinguish nuisance alarms from real ones. This consists of surveillance CCTV-cameras being activated by the exterior intrusion sensor system and appropriate lighting installations for night and unfavorable weather conditions. In addition to the CCTV, the outer enclosure is supervised by guards on patrol. At night and during unfavorable weather conditions the external protected area is illuminated.

Guards and Entrance Building

The guards and entrance building at the operational entrance to the site have the responsibility to control and document the flow of personnel, with respect to identity and right of access, and to supervise the flow of equipment and supplies. The passage applies locks for vehicles and turnstiles for personnel in order to ensure that only one vehicle can be searched and only one pass can be issued at a time. Authorized personnel will also only be allowed to enter one by one. All technical surveillance and alarm systems of the external protected area are operated from this building. There are reliable communication systems to the local police forces and to the security control center.

Internal Protected Area

The internal protected area encompasses all structures that need physical protection against external or insider threat. These structures have to be surrounded by barriers. Any attempt by aggressors to penetrate through these barriers into the building should be sufficiently impeded to provide time for the police forces to arrive. The barriers have to be even stronger when penetration by special explosive charges can lead to an unacceptable destruction of safety features. Not only surrounding walls have to be designed accordingly, but also every relevant opening in the walls like doors, windows, ventilation channels, duct work, and shafts of similar safety significance.

Barriers

Many field tests using different explosive charges have been conducted on concrete walls of various thickness and reinforcement in order to determine the effect these charges have on standard barriers.

The test results served as valuable information for the development of a computer code which made possible the prediction of the effect an explosive charge will have on a specific structural barrier.

Personnel Entries

The entries to the internal protected area are supervised by technical provisions (like CCTV systems). The respective doors can be blocked and unblocked from the security control center. They are supervised for attempts to destroy or otherwise manipulate these doors. For emergency situations inside the respective building, all security doors along escape routes are equipped with crash bars for unimpeded egress. However, in order to minimize any risk from an insider adversary cooperating with an external group, these crash bar functions may be blocked from the security control center for a certain amount of time to accommodate a case of a real alarm situation.

Access to the internal protected area via these security doors for authorized personnel is granted through card-based access control systems. They identify and register the bearer of the admission card. Positive identification of the bearer is achieved either by technical means or by administrative procedures. Turnstile systems allow only one person to enter at a time. The number of entries to the internal protected area is kept as small as possible.

Special Protected Areas

Special protected areas are located within the internal protected areas. They are established around systems or installations which need special physical protection against insider threats. Only a limited number of authorized personnel will have access to special protected areas. Keys to special protected areas are only given to a small number of identified personnel and for limited amounts of time during their work shift. The activities of personnel inside this area often are subject to surveillance by CCTV or by a second person accompanying him. As an alternative, the special protected area and the systems therein are checked for their orderly state afterwards.

Security Control Center

An example of a special protected area, the security control center, is located in the vicinity of the reactor main control room inside an internal protected area. The main purpose of this control center is to detect and verify assaults by adversaries, to call out the police forces when necessary, and to block relevant doors. All technical security systems of the internal and of the special protected areas are operated and controlled from the security control center.

The security systems that are normally operated by the guards at the entrance building can be operated with priority from the security control center. All entries through outer or internal enclosures can be blocked or unblocked from this position. The security status of the whole facility, including the guards and entrance building, can be supervised. The security control center has reliable, redundant, and diverse communication channels to the police forces.

The design of all technical security systems will include a provision for an alarm indicator in the security control center at any attempt to manipulate the system or upon malfunction. The security systems are connected to the emergency power supply which is also physically protected.

Inspections

All barriers around the different protected areas, all communication systems, and all other technical security systems, including the physical protection center, have to be inspected or retested at regular intervals by the operating organization and by independent experts on behalf of the competent state authority. The objective of these inspections and tests is to make sure that the availability and performance criteria which had been applied during the licensing process are met throughout the operating life of the plant. Test or inspection methods and intervals, test procedures and conditions, target values, acceptable deviations, and remedial actions in cases of unacceptable deviations have all been specified by authorities. The test and inspection results have to be documented. Test or inspection intervals for the operating organization may vary between days to six months depending on the respective system or component. Additional tests or inspections by independent experts are requested on an annual basis. The system hardware, the power and emergency power supply, alarm level settings, and displays are subject to functional tests and visual inspections, as well.

Personnel Security Measures

Personnel security measures pertain to the physical protection commissioner, the guard services, and the security screening for trustworthiness.

Physical Protection Commissioner

The physical protection commissioner is responsible for specifying all security measures and for maintaining them in the state required by the respective situation. Therefore, he represents the operating organization when items relevant to the physical protection of the plant are discussed with the regulatory authorities. He is the chief of the security guard services. Deputy physical protection commissioners have to be nominated in order to ensure a round-the-clock representation of this function on site. Many decisions on security matters may have safety implications or may even lead to conflicts with safety needs. The organizational structure shall be such that in case of inevitable conflicts the final decision, after consultation with the physical protection commissioner, is the responsibility of the shift supervisor.

Guard Service

The tasks of the guard services are as follows:

- Surveillance of the outer enclosure and the area within and outside the external protected area, reporting of security-relevant observations;
- Control of flow of personnel, vehicles and material, and preventative search for offensive or dangerous items at the various entries to protected areas;
- Escort of visitors or unscreened personnel;
- Patrols inside internal protected areas in case of certain security risk levels;
- Alarming of police forces; and
- Defense with adequate means in case of adversary assaults.

The guard services maintain the security control center, the guards and entrance building, and do the patrolling. They are fully equipped and carry walkie-talkies and a pistol or revolver. The requirements for their training and retraining (every three months) have been specified in cooperation with the police authorities. Subjects included in the retraining program are shooting exercises, knowledge of relevant safety and security features of the respective plant, operation of security systems, cooperation with police forces, and appropriate actions to be taken in case of actual assaults.

Security Screening

Members of the guard services and any other personnel on site, including external construction, maintenance, and repair personnel, must have a security clearance for trustworthiness. This reduces the risk of sabotage with nuclear or radiological consequences by insider actions. There are three different levels of security screening, depending on the responsibilities and tasks of the respective person. This depends on the hierarchical position in the operating organization, on the areas to which he has the right of access, and on the operational state of the plant. Personnel are only admitted to take over the respective assignment when the security screening does not disclose any facts which can be interpreted as an indication of sabotage risks. The screening process has to be repeated every five years and is conducted by the responsible regulatory authority together with security authorities.

Visitors and unscreened personnel may enter the plant area only when escorted by a guard or by screened personnel.

Organizational Security Measures

Most of the organizational security measures have already been mentioned. These include graded access-admission levels, close cooperation between guard services and local police forces, and confidential treatment of information relevant to security. The control and documentation of flow of personnel and materials are executed at the passage through the outer enclosure at every entrance to the internal protected area and to special protected areas. At the main entrance, the operational personnel have to exchange their utility identity card for a special admission card. It will at least enable them to pass the turnstile system at the main entrance to enter the external protected area. For entry to the internal protected area, positive identification of the bearer of the respective admission card is necessary. Credit can be given to equivalent operational identification procedures.

Insider Threat

At the end of this part of the paper, I will briefly address the matter of insider threat. The vulnerability analyses show that the potential threat by a well-informed member of the operating personnel, who has the right of access to the internal protected area or to special protected areas, is serious. The possibilities for an insider to initiate unacceptable plant states in a short period of time undetected are numerous. Appropriate countermeasures normally lead to serious conflicts with operational safety requirements, with work safety rules, and with personal rights of the employees. Informing the employees of the philosophy behind these countermeasures and participation while specifying the measures, is very important for the acceptance and afterwards for the efficiency of these countermeasures.

Countermeasures applied in the FRG are designed to prevent or impede insider actions and to detect such actions timely should they occur. Examples for the respective measures are as follows:

- Security screening of all personnel and permanent escorting of unscreened personnel;
- Graded access-authorization system;
- Identification and documentation of personnel and of operational activities inside internal and special protected areas;
- Compartmentalization of redundant trains of vital equipment;
- Key or locking-systems which admit access to only one secured area at a time, and which cannot be falsified easily;
- Locks on vital components or controls;
- Monitoring of critical components;
- Two-men rule;
- Operational testing of systems and components after repair or maintenance by independent operating personnel.

These measures have been fully implemented at most plants. Compartmentalization and technical measures against cooperation of insiders and external adversaries can be retrofitted to older plants to a limited extent.

PHYSICAL PROTECTION OF RESEARCH REACTORS

There are five research reactors in the FRG which are of some interest with respect to physical protection. Four of them are open swimming-pool-type MTR-reactors. The fifth one is D_2O-moderated in a closed tank with irradiation tubes. The MTR-fuel elements consist of a U-Al-alloy with Al-cladding.

Due to the high enrichment and quantity of the nuclear fuel of these research reactors, they are Category I-installations. Physical protection of the unirradiated fuel elements is the main objective. The research reactors were constructed and commissioned in the early sixties. Their buildings, in general, do not have walls which meet present day requirements for barriers of Category I internal enclosures. Compensation for this weakness has been adjusted in two ways: by a decrease of the enrichment factor to < 20% and by an installation that sufficiently protects the fuel storage facilities.

An unacceptable release of radioactive substances from the research reactors mentioned above could only be caused by a core melt down. Analyses have shown that because of the inherent safety features, like natural convection, such an event cannot be initiated by direct destruction or manipulation of safety systems in a short time interval. There will be sufficient time for back-up measures. The concrete shielding of the reactor core offers good protection against effects from explosive charges.

Physical protection of a research reactor concentrates on the following items:

- External protected area and exterior intrusion sensor system, as well as alarm verification;
- Access control at the entrance to the reactor building;
- Inspection of material transports into the reactor building;
- Supervision of all entries and escape routes from the reactor building;
- Locking and surveillance of rooms containing cross-connection field and reactor coolant circuitry components;
- Application of the two-men rule; and
- Installation of additional emergency power generator.

PHYSICAL PROTECTION OF SHIPMENT OF NUCLEAR MATERIAL

In recent years about 1600 shipments of nuclear material per year were carried out within the nuclear fuel cycle. Only 55 shipments were in Category I and II, including a total of about 1600 kg of Pu. These numbers are, however, increasing. German nuclear power plants, up to now, have made use of reprocessing services in France and the United Kingdom. The waste plus plutonium has to be taken back; therefore, the emphasis, with respect to physical protection, will be on transportation of nuclear material in the near future. Practically all Category I-transportation was carried out on the road. Railroad-transports were of category II (spent fuel casks) or III only.

Air-transports of Category I material that took place between the Federal Republic of Germany and foreign countries were executed by airplanes of the German Air force or of NATO-allies' air forces. The Category I-material was handed over directly to the armored ground transportation vehicle from the respective airplane and under the protection of the armed escorts of the vehicle and the police.

The objectives of physical protection measures for transportation are identical to those already mentioned. They are to prevent unacceptable radiation exposure through sabotage or other criminal acts and to prevent diversion of nuclear material. The integrated physical protection concept as described also applies to transportation, as do the measures executed by the local police forces. In addition, there are permanent police escorts for weapon-grade Category I-material.

The licensee/carrier has to provide for technical security measures like the design of the transportation vehicle, escort vehicle, enclosures of nuclear material, control and surveillance systems, and communication systems. Also, he provides for personnel security measures like authorized transportation agents, escort personnel, and a transportation control center, and for organizational security measures such as optimized routing, advance notification of shipment, and contingency planning. The technical and the personnel measures are such that a successful execution of an assault by adversaries can be prevented for the delay time of the police forces.

Below, several examples of technical, personnel, and organizational security measures for Category I-transportation on the road will be given. The respective requirements for railroad transportation are practically the same; however, items like minimization of transportation time, safe routing, sealing of packing and immediate transfer of materials to succeeding carriers, as mentioned in INFCIRC/225, will not be discussed. Transportation routes and times are normally agreed upon by the carrier, the sender, the addressee, the supervising authority and the coordination center of the police forces. They may be subject to short-term changes because of changing conditions of the threat situation.

Technical Physical Protection Measures (Category I-Transports)

There are several important requirements concerning the design of the transportation vehicle. The first is that the driver's cabin and the compartment for the authorized transportation agent must be burglary retardant, bullet resistant, fire retardant, and gastight. The transportation agent's compartment shall be detached from the driver's cabin as a measure against the insider threat. The design shall be such that the transportation and escort personnel will have sufficient time to transmit a detailed report on the situation, including the exact position of the vehicle to the transport control center, should an assault actually occur. The vehicle has to be equipped with an immobilization system that will prevent its theft. This system has two diverse modes of operation for the German security transportation vehicle.

Two independent communication systems are required to ensure reliable communication between each of the two partners of the transporting vehicle, the escort vehicle on one side and the transport control center on the other side. In addition, there is a communication system between the two vehicles and to the police forces.

The exact position of the transportation vehicle is determined by the transport personnel transmission to the transportation control center up to now. The authorities are investigating the applicability and the limitations of automatic position finding systems, which make use of modern navigation techniques and automatic transmission of the respective position to the control center.

Technical detection and surveillance systems have to be installed on the transportation vehicle against secret theft of the cargo. These systems can also supervise the vehicle and the state of the barriers. Manipulation or malfunction of these systems will initiate an alarm automatically.

The cargo has to be stored inside a locked and sealed cargo compartment and tied to this compartment. A mechanical barrier is provided around the nuclear material composed of the packing of the respective material, and the barriers of the cargo compartment. These barriers shall withstand all chemical, thermal and mechanical offensive equipment, and explosive charges as anticipated for the vulnerability analysis for at least the delay time of the police forces.

In addition to the transport vehicle, an armored escort vehicle is required. This escort vehicle facilitates supervising the transportation vehicle while it is en route and improves the reliability of communication to the transportation control center.

Transport Personnel Physical Protection

The personnel physical protection measures encompass the authorized transportation agent, the escort personnel, and the transportation control center. The authorized transportation agent is responsible for all physical protection measures when the vehicle is under way. The agent is especially responsible for controlling locks and seals, for alarming the transportation control center in case of an assault, for initiating countermeasures on the spot, and for transferring the cargo to the addressee. He travels in a detached compartment. In addition, there are armed escorting guards in the transportation vehicle and in the armored escort vehicle. These personnel have to be appropriately trained and have to undergo a security screening.

The transportation control center has the following tasks:

- To track the position of the transport;
- To pick up all messages on assaults;
- To alarm the police forces via their coordination center; and
- To coordinate all security activities.

The licensee has to install this control center. It shall be equipped with all communication systems that are necessary to fulfill the tasks mentioned above. The transportation control center shall be located in a controlled area and be protected by mechanical barriers. The transportation control center has to be adequately staffed at all times while a shipment is under way. All personnel of this center must have a security clearance.

Organizational Transport Security Measures

One example of organizational security measures is the advance notification of shipment. For instance, every shipment of Category I has to be announced to the supervising authority and to the coordination center of the police authorities. This is done well in advance of its departure and is transmitted by coded telex or other protected communication channels. It will enable the above mentioned authorities to take all security measures within their responsibility in due time.

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Physical Protection Philosophy and Techniques in France

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INTRODUCTION

Acts of malevolence have always been a major concern in the nuclear industry. Potential threats and their consequences include:

- Sabotage of nuclear facilities can cause severe:
  - economic damage: Nuclear facilities are costly and repairs would be time consuming, difficult, and in the worst cases, even impossible.
  - radiological damage: If barriers are broken, radioactive contamination can occur both on the site and in the environment.
- Sabotage of highly radioactive materials during transportation may have a more direct impact on the environment and the population.
- Theft or diversion of nuclear materials may have even greater significance if strategic materials are involved since blackmail against the government or the population of a country is at stake.

In any case, the psychological impact through the media would be huge.

For forty years, France has been developing nuclear energy applications to the highest degree. The share of nuclear-generated electricity in the national production reached 70% in 1986. The industry has utilized all steps of the fuel cycle. France is fully aware of the risks in using nuclear energy and has taken technical and regulatory precautions to prevent malevolent acts, yet is prepared to deal with them should they occur.

Physical protection measures in France to prevent sabotage and theft of nuclear material are reviewed briefly on the following pages.

INTERNATIONAL COMMITMENTS

Definition and implementation of physical protection measures of nuclear materials are the responsibility of each individual state. However, each is subject to international agreements. France sent a letter to the IAEA on January 11, 1978, pledging to act in accordance with the principles contained in attached documents when considering the export of nuclear material, equipment, or technology. Annex B (Criteria for Levels of Physical Protection) of INFCIRC/254 sets forth the minimum requirements applying to all states, suppliers, or recipients.

Later, France signed the Convention on the Physical Protection of Nuclear Materials (INFCIRC/274, Rev. 1, May 1980) which recently came into effect. Ratification by France should come with the ratification by other states of the European Community, along with the community itself which has also signed the agreement.

On November 20, 1984, the text of a statement on Common Policy was adopted by the Ministers of Foreign Affairs of Belgium, Denmark, West Germany, France, Greece, Ireland, Luxembourg, the Netherlands, and the United Kingdom. This statement deals with storage and transfer of plutonium or uranium enriched to more than 20% in ^{235}U in and between the EEC member states.

FRENCH REGULATION

Confidentiality

With the French regulation, confidentiality of measures taken is a major condition of success. Detailed information on physical protection systems is strictly limited to cleared individuals who need it for professional reasons. This principle applies to the most sensitive security features and specifically to:

- Threat spectrum is to be considered and the accepted consequences;
- Equipment implemented such as intrusion detection systems and means for delaying the progression of the aggressors;
- Detailed procedures for gaining access to nuclear materials;
- Importance of the response force and minimum time necessary for response;

Further instructions exist, but are confidential and will not be quoted in this paper.

Protection of Nuclear Sites

A law dated December 29, 1958, applies to so called "facilities of vital importance." These facilities, whether nuclear or non-nuclear, are those which if made unavailable or destroyed would seriously decrease the economic potential or security of the country. Companies operating such facilities are required to cooperate, at their own expense, in the implementation of protection measures against any sabotage or theft attempts. They must also adopt a physical protection plan (PPP) as specified by law.

This plan is drawn up according to a generic model imposed by interministerial instructions. The PPP is a descriptive summary of security measures taken by the operator. This must be submitted to the Minister of Industry and approved by the Prefect of the department where the facility is located. The Prefect is the representative of the government.

The protection system has several goals:

- To cause potential malevolents to break the law if they forcibly enter a secure facility;
- To detect and locate intruders and initiate an alarm;
- To determine the cause of the alarm; decide whether an emergency situation exists; transmit the alarm to facility management and to external authorities designated by the Prefect; and take necessary actions. All stages of alarm reporting must be ensured by having several alternate means;
- To observe and delay the progression of intruders. In nuclear power plants, rules specify in-depth protection installed in three concentric levels:
  - A controlled area which includes the whole facility,
  - A protected area which includes the sectors needed for the plant operation,
  - A vital area with reinforced protection which includes the zones where sabotage could seriously endanger nuclear safety.

Protection of Facilities

Expert groups have been recently established to investigate and assess threats of sabotage of nuclear facilities and their potential radiological consequences. These experts first identify the sensitive parts of the facilities (areas, equipment, etc.) which, if ever damaged or destroyed, could bring about a major accident.

These analyses are completed on facilities under construction, as well as on existing facilities.

Recommendations by the expert groups attach the greatest importance to the fact that security measures do not hamper the safe operation of nuclear facilities in all circumstances.

This process is being completed on facilities under construction as well as on existing facilities.

Protection of Nuclear Materials

The cornerstone of the French regulation is the law of July 25, 1980, on protection and control of nuclear materials and the subsequent decree of May 12, 1981.

The main articles of the law state the following:

- Fusible, fissile, or fertile nuclear materials with the exception of ores are subject to the provisions of the law.
- Import, export, preparation, possession, transfer, or use and transportation of nuclear materials are subject to license authorization and to control as stipulated in the decree.
- Agents performing inspection procedures are holders of an authorization granted by the State authorities, are under oath, and are sworn to professional secrecy.
- Four levels of penalties are provided. The first three pertain to criminal offense and the last one pertains to misdemeanors. Punishable violations are undue appropriation, false information given in order to obtain a license, deliberate violation of regulations, opposition to inspection, and failure to report a loss or theft.

The decree of May 12, 1981, specifies the following:

- The list of nuclear materials: uranium, plutonium, thorium, deuterium, tritium, lithium 6. The last three are not mentioned in international agreements.
- The authority, which grants the license, is the Minister of Industry. The Minister of the Interior and (with respect to import and export licenses) the Minister of Foreign Affairs are consulted by the Minister of Industry on license applications.
- The content of the license applications.
- The minimum thresholds which are considered for authorization. Below these thresholds and above other defined thresholds, the amount of nuclear materials and the activities carried out must be declared annually.
- The obligations of a licensee:
  - follow-up and accounting measures;
  - containment, surveillance, and physical protection measures for these materials and for the premises and facilities in which they are located;
  - protection measures during transport and;
  - the minimum physical protection measures to be taken.

Minimum physical protection measures to be taken in the facilities depend on the category of the nuclear materials. Three categories are described below. The thresholds of the categories used in France are less than the values given in INFCIRC/254. For instance, the threshold for category II plutonium is 400 g, instead of 500 g, as specified in INFCIRC/254.

A description of the minimum physical protection measures in these three categories is as follows:

- Category III – Use and storage of materials within a zone of restricted access.
- Category II – Use and storage of materials within a protected zone of restricted access, placed under the constant supervision of guards or security systems and surrounded by a physical barrier with a limited number of entrance points subject to adequate surveillance.
- Category I – Use and storage of materials within a highly protected zone. In addition, access is restricted to persons who are known to present full guarantee in security matters and which is placed under the constant surveillance of guards who remain in close contact with armed forces. Specific measures are designed for the detection and prevention of any attack, any unauthorized penetration, and any unauthorized removal of materials.

Measures applied within the facility must be known only by persons who are regularly authorized for this purpose by the Minister of Industry or by the license holder.

Protection measures during transportation is the subject of several articles of the decree which are as follows:

- A joint commission to the Ministry of Industry has been formed for the Protection of Transport of Nuclear Materials. It is required to rule on license applications concerning transport activity, on the general routes to be followed, on the means of transport, and, more generally, on the rules applicable to the protection and control of nuclear materials during transportation.
- Prior notification is sent to the Minister of Industry and Minister of Interior before transportation is carried out. (These provisions do not apply to natural or depleted uranium and thorium.) Any incident affecting the transportation has to be promptly brought to the attention of the nearest law force, to the Ministry of Industry, and (if applicable) to the nearest Customs authorities. In case of transportation to or from abroad, a special authorization has to be requested from the Minister of Industry stipulating the time, place, and conditions of transfer of the materials.
- The transportation means and routes must be approved, and the transports must be checked periodically at a fixed and protected installation for any transportation of category I and II. This can

be done directly by the carrier or by securing the services of an organization authorized by the Minister of Industry.

- Special protection must be provided by an escort at the cost of the carrier for any transportation of materials in category I. If necessary, the Minister of the Interior decides on the participation of armed forces.
- The authorization of agents performing inspections of the license holder is granted by the Minister of Industry.

Other decisions or orders have followed these two basic regulations. Some deal with provisions to be taken for the physical protection of category I nuclear materials in the facilities.

An order of March 26, 1982, amplified rules for ensuring protection and control of nuclear materials during transportation. These are for the surveillance of conditions in which the transportation is carried out for the alerting of authorities in case of incident endangering the execution of the transportation of nuclear materials and for delaying an adversary from accomplishing his objective. The order specifies the following:

- Procedures of prenotification and agreement for execution are described for transport of categories I, II, and III.
- An appropriate communication system is prescribed for the two first categories.
- Other rules deal with particular points related to transportation by road, railway, sea, or air.
- The "Institut de Protection et de Sûreté Nucléaire" of the Commissariat á l'Energie Atomique (CEA) is entrusted, under the authority of the Ministry of Industry, with managing the transportation of nuclear materials. It may give the carriers all technical instructions in compliance with general rules which are detailed in the order. It ensures the permanent follow up from a control center by different means of communication.

PHYSICAL PROTECTION RESEARCH AND DEVELOPMENT (R & D)

The CEA has undertaken a broad program of research and development in order to improve protection of nuclear materials in facilities and in transit, at the best cost/benefit ratio. Appropriate integration in the design of physical protection requirements leads to the best overall efficiency. However, upgrading the protection of existing facilities or vehicles is sometimes necessary.

Tests of various fences, intrusion detection systems, and access control systems are performed on an experimentation-ground in actual conditions. A technical evaluation is set up for every piece of equipment, and the subsequent date file is distributed to every person in charge of physical protection in the CEA-Group (which includes COGEMA). The choice is made at the nuclear establishment level and takes into account the requested protection level, the topography of the area to be protected, and the local conditions.

Other work is being conducted in explosives detection, nuclear materials detection, static and activated barriers, and resistance of different structures to various types of aggressions.

An important experimental program was also conducted recently on transportation vehicles to upgrade the quality of the associated communication system and the resistance to aggressions. New techniques have been implemented on existing tractors and trailers, as well as on new vehicles.

An agreement was signed in 1983 between the DOE and the CEA on exchange of information in the field of physical protection R&D. This exchange of results and viewpoints has proven fruitful for both parties.

Huguette Escure joined Commissariat a l'Energie Atomique (CEA) in 1982 as a member of the technical staff working in the reprocessing design program. She is currently involved in nuclear facilities physical protection and performs inspections for the Ministry of Industry. Dr. Escure spent nine years at Technicatome Engineering where she specialized in process design and safety analyses dealing with nuclear reactor and other nuclear plants' design and construction. She earned her Ph.D. in Physical Chemistry from the University of Rennes and is graduated from the Higher National Chemical College of Rennes and the Institute of Nuclear Sciences and Techniques.

Physical Protection Philosophy and Techniques in Japan

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UNDERLYING FACTORS IN THE UTILIZATION OF NUCLEAR ENERGY IN JAPAN

Japan is composed of four major islands isolated from the Eurasian Continent by the Japan Sea. The total area is small, approximately 143,000 square miles which is almost the same size as the British Isles. The highly mountainous nature of these islands leaves only 16 percent open field, which accommodates almost the total population of 120 million people, of a single race, all sharing similar culture backgrounds.

Natural resources in Japan, except water, are too scarce to maintain 120 million people. Therefore, industrial activities have to be maintained at a high level in order to sustain a reasonable living standard. As a result, Japan ranks high in energy consumption among the countries of the world. Since the oil crisis in 1972, the Japanese Government has implemented an intensive "Energy Saving Policy", which has accomplished a 15% reduction of the total energy consumption. Nevertheless, the overall dependence on imported energy resources still stands at a level higher than 80%.

With these ominous circumstances, Japan's expectations in utilizing nuclear energy remain very high, even though utilization of nuclear energy needs new technologies with some potential risk in new dimensions. Although sophisticated efforts would be needed to cope with legends of the so-called "Faustian Bargain" relating to nuclear issues, we are convinced that the associated risks could be manageable. Under these circumstances, neither anti-nuclear extremists nor influential political parties insisting on an anti-nuclear policy have ever emerged, although some anti-nuclear movements have been observed.

In 1955, Japan enacted "The Atomic Energy Basic Law" which prescribes that the research, development, and utilization of atomic energy must be carried out only for peaceful purposes. In the same year, the Atomic Energy Commission, chaired by the State Minister for Science and Technology, was established to recommend to the Prime Minister policy issues relating to nuclear energy. In 1956, the Science and Technology Agency was established as the government body responsible for science and technology issues, and the nuclear issue played a major role at that time. When the "Law for Regulation of Nuclear Source Materials, Nuclear Fuel Materials, and Nuclear Reactors" was enacted in 1958, Japanese legislation and administration for the utilization of nuclear energy was completed.

Since then, Japan has been making efforts to promote the peaceful use of atomic energy. In 1966, the first commercial nuclear plant went into operation. Today, 32 nuclear power plants are in operation providing 24.5 million KWe. This corresponds to 23% of the total power generating capacity in Japan. Eleven more plants are under construction, and five are in the planning stage. In addition, there are in operation, five commercial LEU fuel fabrication plants, one pilot plant for fuel reprocessing, and one pilot plant for enrichment.

Japan is importing low enriched uranium for power reactors from the US and France due to the shortage of enrichment capacity at this time. All power plants in Japan are distributed around the coastal area, and most of the spent fuel is shipped from the nearest port to France or to the UK for reprocessing services.

In addition, considerable efforts have been devoted to programs to develop technologies in a wide range of areas relating to the establishment of a complete fuel cycle. Such programs include fast breeder reactors, fuel enrichment, fuel reprocessing, and waste disposal. However, some of these programs are a little bit further behind schedule than we expected. They are suffering from the impact of escalating costs and tighter budgets. Nevertheless, bearing in mind the long lead time necessary to establish safe and secure technologies, we should continue steady efforts toward sound nuclear fuel cycles.

RELEVANT LEGISLATION AND ADMINISTRATIVE STRUCTURE

Legal Norms

Legal norms for the peaceful use of nuclear energy in Japan consist of the "Atomic Energy Basic Law", enacted in 1955, and the "Law for Regulation of Nuclear Source Materials, Nuclear Fuel Materials, and Nuclear Reactors", enacted in 1957. In these two laws, there is no specific article dedicated only to physical protection, but it is the official interpretation that these two laws and associated licensing regulations and procedures can well accommodate the requirements of physical protection.

To acquire a license for construction and operation of nuclear facilities, it is necessary to assure that the proposed operation complies with the following four conditions: (1) the proposed facility shall not be used for non-peaceful purposes, (2) the proposed operator shall have the ability to construct and operate the facility well, both technically and financially, (3) the construction and operation of the proposed facility shall not disturb the programmatic approaches of research, development and utilization activities in

Japan, and (4) the location and design of the proposed facility shall not cause a calamity.

After acquiring the license, the operator of the facility must comply with two further regulations: to protect the nuclear facility strictly and to account for and control the nuclear material by the appropriate execution of safeguards.

Administrative Bodies

The Atomic Energy Commission (AEC) and the Safeguards Division of the Science and Technology Agency (STA) play key roles in physical protection, from policy making to implementation of nuclear non-proliferation issues. The Safeguards Division of the STA is responsible for the implementation of safeguards, as well as for other non-proliferation measures including physical protection.

Licensing Procedures

The Nuclear Regulatory Authority provides facility operators with appropriate instruction on physical protection as one of the requirements for protecting nuclear materials in facilities or in transit. The Authority verifies that all nuclear facilities are designed and operated in conformance with the guidelines of physical protection.

Physical Protection Guidelines

The AEC has established a special committee on physical protection to investigate an appropriate physical protection system in Japan. This takes into account the increased amount of nuclear material in Japan and the recommendation on physical protection of nuclear material by the IAEA in 1975 (INFCIRC225).

In 1977 the special committee provided an interim report, followed by government instructions, on the physical protection of all nuclear facilities in Japan. In 1980, the committee provided the final report, which included the guidelines on physical protection and an outline which is attached in the Appendix to this paper. These guidelines are basically comparable to INFCIRC255/Rev. 1 and clarify the responsibilities of facility operators, the regulatory authority, and the law enforcement authority.

UNDERLYING PHILOSOPHY ON IMPLEMENTATION OF PHYSICAL PROTECTION

The physical protection guidelines recommended by the IAEA in INFCIRC255/Rev. 1 provide a valuable concept for constructing a physical protection system. However, as is natural for this type of recommendation, it does not specifically spell out the depth of protection, allowing a certain flexibility in order to cover all member states with different sociological and political circumstances. The depth of protection should be determined and modified according to the social circumstances in various countries.

Nuclear incidents relating to the security of nuclear materials and facilities could be caused by a number of illegal actions like theft, robbery of nuclear material, attack on a nuclear facility, or sabotage resulting in radioactive contamination. These actions may be committed by criminals, lunatics, anti-nuclear extremists, or authentic political terrorists.

Note that all incidents relating to physical protection are caused by intentional human actions. The motivations to take such illegal actions are not technical ones. Consequently, the countermeasures against such actions must be political ones. In other words, political measures to alleviate such motivations are the primary measures. Technical measures should be considered to be very important, but complementary to the political measures.

In fact, political and technical measures are interrelated in terms of the concept of "deterrence". Naturally, political measures depend so much on historical, sociological, and cultural backgrounds specific to each nation that obtaining meaningful accomplishments takes time. In contrast to political measures, technical measures may provide us with a quick fix. Therefore, taken together, technical and political measures provide us with the most efficient system against the risk of such incidents. That the physical protection system in a given country should be built in full utilization of the social features of that county is of vital importance. In this context, this paper explains the underlying philosophies on implementation of physical protection which focus on the sociological features specific to Japan.

Possible Threat

Nuclear threats may take different forms - theft, robbery or forcible attack, or sabotage.

- *Theft* - Theft of nuclear material is a realistic threat as the total amount and variety of nuclear material in the commercial sector increases. Therefore, facility operators must provide countermeasures against the theft of nuclear material, thus reducing the risk factor close to zero.
- *Robbery Or Forcible Attack* - Physical protection measures taken by operators in Japan are premised upon an assumption of general civil order. Foreseeable levels of violence may range from just hoaxes to terrorist-like violence. Physical protection is certainly related to the social circumstances of other countries. Looking at the domestic front, violence with heavy weapons or high explosives is unlikely because of the following features of society in Japan:
  - the homogenous racial composition and weak religious influence on human life significantly diminish incentives to use severe violence; and
  - legal prohibition of all civilian guns and ammunition, with a violation penalty of 10 years maximum imprisonment has helped to maintain the social milieu almost free from severe violence.

Looking at the international front, the ease of immigration/customs control resulting from the geographical features of isolated islands has traditionally contributed to weaken international ties of violence. However, as statistics point out, detecting the smuggling of small firearms such as handguns or handgrenades is difficult. Therefore, facility operators are requested to take appropriate countermeasures against forcible entry made by a group with small firearms or explosives.

Social circumstances change from time to time. We are seriously concerned about current trends of violence with strengthened international connections and tendencies to attack soft targets, i.e. those with relatively little apparent security.

- *Sabotage* - Countermeasures against sabotage shall be taken by facility operators, but protection against sabotage is a physical protection function unrelated to the design of the plant itself.

Characteristics Of Offenders

Offenders may be categorized as authentic political terrorists, anti-nuclear extremists, criminals, or lunatics in one dimension, and insiders or outsiders in the other dimension.

As mentioned previously, an attack on nuclear facilities by a group of political terrorists or anti-nuclear extremists seems to be very unlikely in Japan because of certain political calculations and moral constraints. Therefore, criminals or lunatics might be possible offenders in Japan.

Insider problems have traditionally been very rare in Japan. This is mainly due to a strong "group consciousness" which has long been one of the most prominent characteristics of Japanese society. Rather than ideological or professional common attributes, loyalty to the group and the practical benefit of belonging to the group are key virtues in Japanese society. At every level of society the Japanese have a strong sense of who is on the inside and who is not. Inside the group they are very closely involved in each other's personal lives. Consequently, serious personal matters are sometime the affair of the entire group.

These social features have developed an employment system specific to Japan. Newcomers are not accepted into the group (company) until they have been carefully screened, tested, and trained in its ethics and morality. But once employed, they are usually not dismissed for any functional failures. They may be dismissed if they break the group standards and tarnish the image of the group.

These specific features of Japanese society do not always provide us with an advantage in dealing with insider problems. Under certain circumstances, the strong group consciousness could develop a curious atmosphere to cover up any possible misbehavior of a person in the group. A typical example can be seen in the case of the tragedy of Japan Airlines that happened in 1982. The DC-8 passenger flight bound for Tokyo from Fukuoka was crashed into the sea intentionally by the lunatic captain in command. The co-pilot tried to block his captain, but could not succeed because it happened during the final landing approach. As a consequence, 24 passengers were killed and 150 were injured. Many of the captain's colleagues had reportedly observed his curious behavior and perceived something different, but did not take any action. As this experience indicated, lunatic insiders in relatively high positions may be a realistic threat of sabotage and must be examined more closely.

Countermeasures

In this section some specific considerations on countermeasures employed in Japan will be discussed.

• *Facility Guards*

As mentioned previously, in Japan all civilians have been prohibited by law for more than 100 years from having firearms and ammunition. Persons permitted to have firearms are limited to policemen and government investigators for narcotics, etc. Therefore, facility guards cannot have any firearms and are prohibited from responding directly against offenders. Their duties are to detect any threats as early as possible, to communicate with relevant security authorities, and to harden respective targets by hardware devices. Entry and exit control are also the duty of guards. Without armed guards, expecting significant retardation effects by the fence is hard but a fence is mainly for early detection of intruders.

Unarmed guards at nuclear facilities might be one unique feature specific to Japan. In order to compensate for the weakness of unarmed guards, at least one squad branch office of local police is situated close to nuclear facilities. The network of national and local police is closely coordinated, and security measures are well maintained. Thus, police can get to any nuclear facility in Japan within a very short time.

• *Protecting Against Insider Threat*

Precaution seems to be more effective than prevention to cope with insider problems. In this context, education, training, and screening of facility employees might be principal measures, and entry control and two-men criteria might be complementary measures.

Entry control is used mainly for preventing the carrying-in of explosives and firearms. Exit control is mainly for preventing the carrying-out of nuclear materials. All nuclear power plants in Japan request a complete clothes change to company-supplied clothes at the plant entry point under surveillance of facility guards. This procedure, which was originally introduced for preventing any possibility of radioactive contamination of the uncontrolled area outside the plant, has helped entry control for physical protection.

For screening purposes, the personal origin records and the personal certificate issued by the local governor are very helpful.

If someone decides to commit an illegal action and he is not a lunatic or deranged there is always a certain reason behind it due to moral or personal objection. The most dangerous thing is a person taking action imprudently, without knowing how serious the consequences might be. Of great concern is a case in which, if the saboteur had been well-informed of the consequences, he would not have taken action. Education and training about physical protection issues are of vital importance to preclude insider problems.

Nuclear Material In Transit

In Japan there are about 200 instances of transportation of nuclear materials to and from facilities every year. These transportations are categorized into two different modes. One mode is domestic, and the other is international. Due to Japan's geographical situation, the international transportation consists of long-distances and intercontinental movement of nuclear material.

• *Domestic Transportation*

Conforming to physical protection guidelines, the transportation plan must be examined in detail in advance by the transporter, regulatory authority, and law enforcement authority. The detailed information on transportation must be kept confidential, but local authorities on the route of the transportation must be well informed. When special nuclear material is transported over the road, the regulatory authority and the law enforcement authority require the licensee to implement a number of security measures. Such safety measures include law enforcement response arrangements, licensee's escort vehicles backed by radio communication, and armed national police vehicles accompanying the shipment to guard the nuclear material.

• *International Transportation*

Insofar as international transportation is concerned, Japanese traditional circumstances, explained earlier, do not exist. International transportation may be the "Achilles Heel" of the Japanese nuclear industry. This difficult situation is dramatically reported in the story of "The Curious Voyage of the Seishin Maru"[1], which cost 5 million dollars in order to improve security for one shipment of plutonium. Certainly, international shipment of special nuclear material is a controversial issue involving not only technical issues, but also political issues. Therefore, tackling these issues now is of vital importance. Japan is seriously committed to take all possible measures to improve the security of nuclear materials under international transportation.

TECHNOLOGY FOR PHYSICAL PROTECTION

Behind the concept of physical protection, there is always the ethical view that man's inborn nature is not always good or trustworthy. This can be seen in implementation procedures of the "Two-men criteria" and "Screening". In general, this ethical view is difficult for the Japanese mind to accept because of the traditional Japanese ethical view that man's inborn nature is good.

One important consideration in building a physical protection system is to rely upon hardware devices to the maximum extent. Important devices necessary for the physical protection system are represented by barriers, entry/exit control devices, surveillance devices, intrusion detection devices, tamper indication devices, and monitoring/communication systems. Although the depth of defense is different, most devices are not specific to physical protection but common in all security businesses for banks, airports, computers, communication systems, etc.

"Cry Wolf" Syndrome

When we rely heavily upon hardware in constructing a physical protection system, the reliability of the devices must be very high, and the false alarm rate of the sensors should be very low. Frequent false alarms may result in by-passing the respective alarm circuit or lowering the sensitivity of sensors to the degree that they are incapable of detecting any anomaly. There still remains a certain tendency to rely upon the system, even though the system does not work all the time.

In addition, rather frequent anomaly signals actuated by the system cause facility guards to impute all alarms to false alarms, thus ignoring them. This is the dangerous syndrome of the legend of "The Boy Who Cried Wolf". Therefore, the designer of the physical protection system should always keep this in mind.

Secured Automatic Remote Continual Monitoring System

In many countries, development efforts are encouraged to improve security systems. Japan has also engaged in such development efforts. Among them is the Secured Automatic Remote Continual Monitoring System developed by Japan-US cooperation.

A typical example is the TRANSEAVER System (TRANsportation by SEA VERification). The system continually monitors any changes in the status of containment and surveillance sensors safeguarding sea-going cargo, and it tracks the position of the cargo during transportation. Communications are timely and encrypted to prevent falsification or tapping by unauthorized persons.

The system is designed to meet the requirements of a very low false alarm rate. Together with this requirement, unattended automatic operations, cost performance, and easy maintenance are also important factors to be accommodated. The system is divided into three sub-systems: the Ship-board system, the INMARSAT Communication System, and the Land-based system.

The Ship-board system consists of containment/surveillance sensors attached to containers known as Physical Protection Containers. These containers carry nuclear material and a communication container in which navigation and communication devices are installed.

The INMARSAT Communication System provides voice and data communication in real-time to the worldwide telecommunication network, through the INMARSAT satellite system. The ship at sea can be linked to any shore point by international telephone.

The Land-based system can be situated at any place where a dial-up international telephone is available in order to monitor the location and status of nuclear materials during sea transportation.

The system was developed as part of a secure global remote monitoring system. The development of a new aircraft monitoring system named "ARTEMIS" is planned for the future under cooperation with the US.

Integrated Concept For Nuclear Safety, Safeguards And Security

Although their objectives are different, safety, safeguards, and security systems need common technical and administrative features. For example, effective physical containments such as a reactor building which has the safety purpose of containing radioactivity in case of an accident, in conjunction with surveillance devices, can provide an effective measure to detect the clandestine removal of nuclear materials for international safeguards. The containment also provides a tough barrier to prevent and to retard forcible entry for physical protection purposes.

Various key surveillance devices such as CCTV, intrusion sensors, tamper sensors, and real-time remote communications devices that can signal alert conditions can be common to international safeguards and domestic physical protection.

The two-men criteria, entry control procedures, and contingency planning are common to security and safety in administrative procedures.

To build an integrated hardware and administrative system for safety, security, and safeguards without duplicating the investment is a challenge. In order to accomplish this, the key is to accommodate safeguards and security measures into plant design in the beginning stage of plant design.

LESSONS LEARNED

Constructing appropriate physical protection systems in order to protect nuclear material from theft, robbery, sabotage, or seizure is imperative for users of nuclear energy. However, construction of the physical protection system will be inexpensive. We are living in a society where there are many competing demands for rather limited resources. In Japan, we have had some specific problems, and this paper will contain some lessons learned from these past experiences.

Cost Of Security

Traditionally, the Japanese have found the idea that security should cost money incomprehensible. To the Japanese, security has been like water, free of charge to all. This attitude might have been developed by the unique geographical nature and historical background of a certain chain of lucky breaks specific to Japan.

A garden-like villa on isolated islands just off the Eurasian Continent, Japan has provided its people with a fortunate environment in which hardships are few. One of the greatest advantages isolation has given the Japanese is the non-invasion of their islands. The Japanese only once faced the possibility of invasion. In the 13th century, mighty Mongolian fleets attacked Japan and attempted to invade. They failed due to lucky divine winds "deus ex machina". At that time, strong typhoons suddenly hit the fleets and almost completely destroyed them.

On the domestic dimension, the Japanese have always lived free from severe religious and racial confrontations owing to a single race, thus having the same Japanese cultural background. Japan has plenty of social pressure, but none like religious persecution. Certainly, war and strife aplenty have plagued the nation, but in comparison to the fate of other parts of the world, the bloodshed and fighting the Japanese have known amount to little more than squabbles between closely related clans. There were castles in Japan, yet these were only to protect the interests of the ruling class and not to repel a foreign invader. In other parts of the world there have been many examples that community security provided by the city walls was imperative and was to be obtained by great labor and expense. No Japanese person anywhere ever entertained the idea of surrounding an entire city with protective walls because he felt no need of them.

This historical and geographical background gave the Japanese the attitude that steps taken for the sake of security ought not to cost anything because any devices or measures of security are not necessary and therefore, are not worth paying for.

However, too much of a good thing is as bad as too little. Excessive security has turned the Japanese into a cloistered people who panic when faced with crises of even minor security. Taking into consideration modern internationalization covering the whole world, in general, Japan cannot continue to stay in a cloistered environment. The real challenge for Japan has been to enlighten the people on the necessity of physical protection, while the national characteristic has always made us more inclined to be domestically oriented and reactive, rather than proactive.

Civil Liberties Concerns

History tells us that every society has had illegitimate violence to some extent. If a society attempts to eliminate illegitimate violence totally, the society would raise the level of legitimate violence to a point that may jeopardize civil liberties, including freedom and privacy. In this context, Louis O. Giuffrida, director of FEMA, proposed putting our combined efforts into trying to define the maximum level of illegitimate violence we can tolerate and still remain a free society. I am convinced that his proposal is of vital importance to maintain a free society. Otherwise, humanity will be jeopardized, and a miserable controlled society is bound to arise.

A range of views has been observed as to whether increased physical protection and surveillance activities to protect nuclear materials would lead to conflicts with basic civil liberties. This is really a difficult problem. All who are involved in the physical protection business should always keep the following points in mind. Because of the extremely high consequences of the physical protection system, it may sometimes consist of procedural and technical measures which have potential conflict with civil liberties. Use of such procedures and devices may be upheld by the public only for strictly limited and proper purposes. This situation occurred when many countries ratified the NPT and voluntarily accepted the IAEA safeguards inspections. There may be a certain conflict with the sovereignty of these countries.

Now consider a bad instance related to this concern which Japan had. Generally speaking, most office rooms are so secure in Japan that a person could leave cash in the unlocked drawer of his desk. It happened in an office that cash in an unlocked drawer had been occasionally stolen. Then the owner imprudently decided to identify the thieves by a CCTV surveillance system used for physical protection. As a result, a thief was clearly identified on the video tape.

What do you think about this case? We considered this case very seriously because this case might invite damage to the public acceptance of physical protection measures. The reasons are as follows:

- Equipment or devices developed for physical protection must not be used for other purposes without public consent. If this is not guaranteed, the public will not accept sophisticated systems that might have potential conflict with civil liberties for physical protection.
- In a bank the money is stored in protected areas which minimize the temptation to steal it. Of course, there are many surveillance devices in banks, but there is also clear notification to inform people that the bank is protected with surveillance systems. These surveillance devices are accepted by the public.

Once damaged by a single bad example, the public acceptance would be extremely hard to re-establish. Therefore, we finally decided not to use this video for any purpose and it was destroyed.

Communication And Mutual Understanding

In democratic countries, implementing any program of great importance without public acceptance is impossible. The public would not agree to construct physical protection systems without being told why. This demands intense dialogue with the involved public on different levels. This is true, especially in dealing with physical protection issues which are primarily related to sociopolitical problems.

Physical protection is doomed to deal with an event of very low probability, but very high consequence. In other words, it has the nature of "no news is good news" that involves things intangible for people not in the field of security. Under these circumstances, differences in viewpoints and approaches to physical protection are frequently observed among different people with different professional backgrounds or positions.

In our experience, due to such diversity of view points and intangibility of problems, obtaining necessary resources and staffing for physical protection is not easy. In order to cope with this difficulty, mutual understanding, developed on the basis of dialogue, seems to be the only sound way to solve problems.

The fundamental way people think in a given community is usually related to the background particular to that community. Therefore, dialogue should be developed case by case, taking into consideration specific features of each community. Preferably, the dialogue should make use of clear examples.

To explain this principle, in Kyoto, Japan there is a rock garden. The designer is unknown, but he must have lived at least 500 years ago. The garden is seemingly very simple. All you can see is a rectangle of white sand, about 50 x 100 ft., with rocks carefully placed within it. The rocks and white sand are the same, but constantly different. In broad daylight, there is one vision and by moonlight, another. To see what there is to see is left to each visitor's insight. The garden used to provide Zen philosophers with a place for meditation. For meditation, what does the white sand mean - ocean, space, or universe? And continent or earth for rocks? It depends on your imagination.

If you place a few people on different sides of this garden and ask them to count the number of rocks in the garden, to your amazement, all the observers will come up with different answers. Some of them will have counted fourteen, some of them thirteen, and some of them even as few as twelve. Now what is right? In fact, none of them, since there are fifteen rocks in the garden. That depending on your relative position around the garden, you will observe a different number of rocks, and no one can observe fifteen rocks from any position is the result of careful arrangement by the designer .

This illustrates that several persons can take a look at the same object at the same time and yet come up with different points of view, depending on their relative position and their perception of the object. If communication is poor among them, such a situation may be serious enough to introduce suspicious consequences among them. Only elaborate communication or dialogue can develop mutual understanding (not necessarily mutual agreement) of their positions and develop further mutual cooperation to find out the right number of rocks.

Discussions of different points of view and different perceptions are very necessary; otherwise, we will miss a chance to know what the truth is. One of the major objectives of this paper is to provide a chance for good communication to develop and to promote an understanding of the Japanese culture and the Japanese approach to physical protection. That with the expression of this different view of physical protection, hopefully a spirit of mutual cooperation among different countries will be enhanced.

APPENDIX

Outline of Recommendations
on Physical Protection by the Japan AEC

I. General Recommendation
   1. Measures which should be taken by concerned persons for physical protection of nuclear material in use, storage, and transit according to the category recommended by IAEA.
   2. Guidelines for emergency actions.
   3. Promotion of research and development activities on physical protection.
   4. Legislative issues.
   5. International cooperation.

II. Physical Protection Requirements in Use, Storage and Transit
   1. Goals
      Taking into account the social circumstances in Japan, the committee recommended that the goals of physical protection measures taken by operators should be to;
      1) Establish and maintain the appropriate communication system with the relevant security authorities in order to inform them of any threat quickly.
      2) Take adequate measures through systems and devices to prevent or retard any offense until the security authorities can respond.
   2. Physical Protection Requirements in Use and Storage should be to:
      1) Define and designate special areas for physical protection.
      2) Provide surveillance and custody of protected areas.
      3) Control entry into protected areas.
      4) Account for and control nuclear material.
      5) Provide intrusion detection system to unauthorized entry to protected areas.
      6) Manage appropriately all detailed information of physical protection.
      7) Structure the responsible organization and system for physical protection.
      8) Maintain physical protection system and devices.
      9) Provide employees with training on physical protection.
   3. Physical Protection Requirements in Transit should be to:
      1) Plan for transit operation.
      2) Provide for escorts charged with responsibility for security.
      3) Arrange communication systems in transit.
      4) Protect transport vessel.
      5) Manage appropriately detailed information on physical protection.

III. Guidelines for Emergency Actions
   1. Emergency Program of Action
      Those who operate nuclear facilities and transport nuclear material should prepare the emergency program of action to counter effectively any possible threats in accordance with the phases cited in the next section after consultation with relevant authorities.
   2. Phase of Emergency
      1) Phase I: A time when those who operate nuclear facilities and transport nuclear material are not yet convinced that a threat exists, but have reason to suspect unauthorized acts may be committed.
      2) Phase II: A time when those who operate nuclear facilities and transport nuclear material are firmly convinced a threat exists, but no nuclear material has yet been illegally removed.
      3) Phase III: The time when any nuclear material is illegally removed.
   3. Major issues incorporated in the Emergency Program of Actions
      1) To provide a quick and effective transition plan for the executive system from the ordinary phase to the emergency phase, e.g., mobilization of responsible person.
      2) To retard or to prevent any illegal act including sabotage by means of physical protection devices; e.g., closing protective doors, locking making transport vehicles immovable.
      3) To grasp the situation and to communicate quickly to relevant authorities.
      4) To protect personnel from radiological contamination.

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Physical Protection Philosophy and Techniques in Spain

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INTRODUCTION

From the physical protection view, the development and use of nuclear energy in Spain is characterized by a predominance of nuclear power stations of the light water reactor variety. The only exception is Vandellos I, which is a gas cooled graphite moderated reactor of French origin. This means that most of the nuclear materials handled in Spain are in Category III in the IAEA classification system. The above does not mean that other types of nuclear materials are not used in the National Research Center and other institutions, but such amounts cannot be considered significant.

The country is also active in fuel cycle activities. Those belonging to the first part of the cycle started through a national company called ENUSA founded in 1972. Apart from the obvious activities relating to uranium exploration, mining and milling, ENUSA now has in operation a fuel manufacturing installation serving the needs of the country. Enriched uranium for such activities comes mainly from France. ENUSA keeps 11.11% of the stock in EURODIF.

The back end of the cycle is being assigned to a recently created state company called ENRESA. Presently, ENRESA has not yet embarked on reprocessing activities. Its primary concern is solving the problems of waste management. Presently, spent fuel elements are stored in Spain in fuel pools. The enlarged capacity will be consumed in approximately ten years. By that time, a solution will have to be found.

The discussion above clearly indicates that physical protection in Spain is mainly concerned with avoiding acts of sabotage aimed at releasing substantial amounts of radioactivity and with preventing damages to owners-operators' installations.

In this paper, we will introduce and discuss the main aspects of physical protection in relation to cases in Spain. There will be an analysis of "the nature of the problem", followed by the solutions given from the legal and technological point of view. Some figures on the cost of physical security will be given, and the problems importing countries will encounter in physical protection will be addressed. This paper will end with some salient conclusions.

THE NATURE OF THE PROBLEM

The establishment of any sound physical protection system requires the detailed analysis of the problem. The two circumstances of great importance to the country are: a) the nature of the threat and b) the characteristics of materials and installations to be protected as measured by the extent and evolution of nuclear technology.

The Nature of the Threat

Spain is located within a politically stable area, but with internal terrorist activities. The nature of the threat is very complex; historical, social, cultural and political motivations are involved. The highly developed nuclear technology and the emerging antinuclear sentiments of society help to justify the violent actions against nuclear installations.
destruction of property and the taking of lives to force extreme actions. One would expect to meet well prepared enemies using limited, but sophisticated equipment, and working within a well organized group. The response will call for equal sophistication in the physical protection system and good training. All of this was experienced in Spain during the construction of its nuclear power stations.

There could be another type of terrorism active during construction. It could be performed by the workers in the plant and it is aimed at: 1) expanding the construction time and, therefore, alleviating any possibility of unemployment; and 2) forcing extreme situations that border on violence with the intention of obtaining larger salaries or better social benefits.

The problem is not directly related to physical protection because these actions do not involve stealing nuclear substances or releasing radioactivity. However, when performed in nuclear power plants, they may indirectly relate to the latter. There could be intentionally produced minor acts of sabotage that could pass inadvertently during the commissioning phase and not become apparent until later on. A few examples to look for are dents or blockages in pipes, untightened nuts, wrong electrical connections and dirtiness of sensitive equipment. Clearly, good quality assurance and quality control are crucial up to this point; however, many acts of sabotage can be performed after test acceptance. Physical protection in this case will prevent the execution of any act within a complex system.

The Extent and Evolution of the Problem

Spain is a qualified importer of nuclear technology, because it participates heavily in the design and construction of its nuclear power plants and related installations. As Spain reaches a high technological stage in development, analyzing the degree of involvement of physical protection activities and the evolution of this involvement is important. Spain has passed through the following steps which are typical of any country introducing nuclear technology.

- *Scientific and Technological Initiation* - Countries generally start building national nuclear research centers with one or more research reactors. Because of the national nature of these centers, they are often put under the protection of a national police body. This was the case in Spain. Access control is established based more on human resources than on instrumental control. This situation, for the most part, is generally satisfactory, as has been proven by the Spanish case.

- *Construction of the First Nuclear Power Plant* - The construction of the first generation of nuclear power plants did not include any elaborate physical protection measures. The only protection established was that by the owner to prevent loss of property or theft of goods and materials. Later on, the antinuclear movement, together with rather violent vindications by workers, forced the Spanish utilities to establish elaborate physical protection methods. This was prevalent in the construction of the second and third generation of plants.

- *Operation of the First Nuclear Power Plant* - With the operation of any nuclear power plant, the situation changes with respect to physical protection. There are nuclear substances to steal and radioactive materials to be released, but to engage in other actions is highly impractical. Generally, only class III materials are involved in most cases and the radioactivity (98%) inventory is within the poorly accessible irradiated fuel. At a later time, the remaining 2% is much more accessible and even the release of a small fraction of it could be very damaging.

The lineal elements which may be present during the construction phase introduce vulnerability elements which must be addressed. The following are worth mentioning: a) electrical energy transmission lines; b) incoming and outgoing nuclear substances and radioactive materials; c) ultimate heat sink; and d) plant personnel.

While the protection of the plant may be accomplished within a high degree of confidence, the same cannot be said about external elements. This has been the case in Spain with power transmission lines and plant personnel.

- *Operation of a Nuclear Power System* - After countries develop a few nuclear facilities, introducing elements of rationality and uniformity in the approach to physical protection will be convenient. The most important steps are: a) the clear definition of responsibilities; b) the establishment of basic regulations and detailed codes and standards; c) the creation of an appropriate technology, and d) the involvement of state bodies for controlling and monitoring such activities. Spain is far from having achieved a complete regulatory pyramid, as with most advanced countries. These aspects have not passed without notice as they are demonstrated in other parts of this paper.

- *Operation of a Nuclear Fuel Cycle* - A substantial nuclear power program makes consideration of fuel cycle activities necessary. Spain was prompt in reacting to these needs. In 1972 ENUSA was created and in 1984 ENRESA was created to cover respectively both halves of the nuclear fuel cycle. The first one already has a fuel manufacturing plant under production. The latter has just started its operation.

The two most sensitive parts of the nuclear fuel cycle are the enrichment and reprocessing. Neither of these two processes is performed in Spain. Nevertheless, the fuel manufacturing plant is being subjected to safeguards. Its external parts and transportation of nuclear substances in and out the plant are physically protected.

REGULATORY PYRAMIDS FOR PHYSICAL PROTECTION

As a general principle, any hazardous industry must be regulated; so must nuclear energy. Every country, even with very limited nuclear activities, has promulgated a basic nuclear law that is clearly established. In Spain, such a law was promulgated in 1964. In that law there is a recognition of the strategic nature of nuclear materials and the toxicity of ionizing radiation. In most of these documents, especially those promulgated early, there are not explicit requirements on physical protection. However, principles are mentioned which could be used for subsequent development, to the point of having a complete regulatory pyramid covering this important aspect of nuclear technology.

Only the most advanced countries have developed a complete regulatory pyramid covering physical protection. The USA and France are two good examples. Importing countries, even qualified importers, do not need to develop a complete regulatory pyramid on physical protection before reaching a significant level of nuclear development. In Spain, developing regulations in accordance with the arising of problems has been more advisable, at least when considering details. In this way, a more realistic set of regulations could be accomplished. This does not include the early establishment of basic criteria and principles which should be promulgated as early as practical.

In Spain, regulations have been established on a case by case basis since the establishment of our basic 1964 law. Now the nuclear program is developed to the point that we can promulgate and create a more substantial code of regulations.

The construction permits for nuclear power plants of the first (those starting operation between 1968 and 1972) and second generations (those with construction authorization granted between 1974 and 1976) did not include any specific consideration of physical protection. The first reference to this appears in the Trillo construction authorization granted in 1979. The transcription into English of the text reads as follows:

> *A 10. Physical Protection* - The plant project shall incorporate the appropriate means to guarantee physical protection of the installation. The minimum level shall be the one reached in the country of origin of the project. Implementation shall take place during the construction, and the requirements shall be fully in place before fuel loading.

Clearly, the intention of the regulator was to make sure that physical protection methods and systems were implemented and incorporated before fuel loading. The text does not give the applicant any hint as to the methods acceptable, apart from stating that the minimum level to be reached would be comparable to the one in the country of origin. In this case, it would be the Federal Republic of Germany.

The construction permit for Trillo II was granted a year later. The text is a little more explicit and can be transcribed as follows:

> *A 11. Physical Protection* - The project shall incorporate means required to protect the installation physically. The implementation of such shall follow the requisites given in Regulatory Guide DSN-07-80, published by the Spanish Nuclear Energy Board, and Guide INFCIR/22/Rev. 1 by the IAEA. Regulations in the country of origin must be followed. Any deviation from the referred guides should be favorably appreciated by the Directorate General for Energy.

The same text is included in the construction authorization for Vandellos II, granted in 1981, the last to date. In these later cases, the legislator is much more explicit in signaling available detailed documents. Also established is that the system incorporated into the station should be acceptable by the authority.

Interestingly, in 1980 the construction authorization for the first fuel manufacturing plant at Juzbado was granted. The plant is now in production. In this case, physical protection and safeguards did not pass without attention. The transcription of the corresponding text in the authorization is as follows:

> "The general plant for safeguards and control of nuclear substances within the installation shall follow IAEA document INFCIR/66/Rev. 2. Due attention must also be paid to Regulatory Guide 5.45 from the US NRC or equivalent document".

Again, the legislator has made reference to internationally accepted standards and to the regulatory documents of the most technically advanced countries.

The owner-operators have responded by requesting help from national and international designers and suppliers in Spain. The development of hardware and software for physical protection has been done in such a way that technology transfer has been maximized. This was accomplished as requested because of the nature and sensitivity of the problem involved.

THE RESPONSE OF SPANISH UTILITIES TO PHYSICAL PROTECTION REQUIREMENTS

Presently, Spain has fourteen nuclear power plants of which eight are in operation, two are under construction and four are on standby. The country has already accumulated over 70 reactor-years of operating experience and close to 100 reactor-years of construction experience. Two of the four units on standby are under the threat of terrorism and therefore the completion of construction and commissioning has been made impossible. The other two units have been temporarily stopped following a governmental decision based on the lower than expected increase in electrical demand.

The 14 units mentioned above can be distributed into three generations based on the time construction started. The first generation (3 units) started commercial operation between 1968 and 1972. The second generation includes 5 units with construction authorizations granted between 1973 and 1975; all are already operating commercially. The third generation includes the two plants under commissioning and the four on standby.

No specific physical protection requirements were available at the time the first generation of plants was being designed, constructed and operated. In the USA, the country of origin for all of these units but one, 10CFR Part 70 was not published until 1977. The design and construction of the second generation of plants were well advanced in process. Furthermore, the necessity for physical protection was not clearly seen at this time in Spain. The first regulatory activity came with the third generation of plants in 1979.

The antinuclear movement in Spain reached a high peak between 1973 and 1977. That movement led to the terrorist attacks on one of the units under construction. This movement also led to demonstrations and worker strikes on the others. The operating plants were not at all affected by this situation. This change in attitude prompted the Spanish utilities and the licensing authorities to establish well developed physical protection techniques. These techniques were back-fitted into the operating plants and the ones under construction. New plants were also to follow that trend under the strict requirements of the regulatory agency.

Despite the differences in plants and utilities, a high degree of physical protection uniformity had been reached on the approach of the design. Such has also led to the formation of experts, consultants, manufacturers and engineering companies competent in this field.

To analyze the approach to physical protection taken by the Spanish utilities with nuclear power plants is of interest. In all cases, the responsibility for the project has been retained by the utility concerned. Engineering and consulting companies have been involved as appropriate. For plants under construction, the main reactor supplier and architect-engineer have also been involved to avoid interferences. In the latter case, the design, fabrication, construction, installation and commissioning of the physical protection system have followed closely those of the plant itself. For plants in operation, the back-fitting of the physical protection system has been the responsibility of the owner-operator with the help of specialized consultants.

The hardware and software installed in the different plants are also similar. The following paragraphs summarize the situation.

The perimeter fences include two barriers which have an average separation of six meters and an average length of 2,500 meters. In all cases, the administrative buildings are enclosed within the fences. The space in between fences is lighted with a minimum level of two LUX at soil level needing a power supply no less than 150 KVA.

The average number of TV cameras per unit is about 50. Most of them include motorized units and are associated with perimeter detectors through the computer.

Perimeter detectors are mainly based on microwaves, two detectors every 90 m., and electric field detectors every 100 m.

The central control generally includes two computers interconnected to cope with a dual failure of crossed components. Peripherals may vary, but printers and viewers are always included.

Three basic structures are generally used: a Central Alarm Station (CAS), a Secondary Alarm Station (SAS), and an Access Control Building (ACB). There is a repair and maintenance shop, independent from those of the plant. The surface area of each structure is different from plant to plant, and may vary anywhere from tens to hundreds of square meters.

Electricity supply to the physical protection system has been a major consideration in all cases. It includes a normal power supply from the main station plus an emergency diesel generator with power varying from 80 to 150 KVA. An Uninterrupted Power Supply (UPS) to guarantee the operation of central and access controls also exists.

Vital areas have about an average of 80, with up to 115 reading posts. Codified cards which are mainly magnetic and read by the computer are used. The main access screening includes checks for explosives and metal. Using x-rays to inspect personal belongings is also common.

Organizational aspects of physical protection include having a separate organization that is different from the plant manager. The organization includes the guards, maintenance personnel, and necessary staff, with a total varying between 30 and 70. The guards belong to specialized companies and are well trained. In all cases, relations with national external forces have been secured by appropriate and prompt attention.

THE COST OF A PHYSICAL PROTECTION SYSTEM

A recent study [1] shows that the capital cost of a Physical Protection System for a two-unit station in Spain may reach about 2,400 million Spanish pesetas (equivalent to some 15 million US dollars). The structure of these costs could be as given in Table I.

Table I

Structure of Capital Cost Expenditures (%) of a Physical Protection System for a Two Unit Station

A. Services	
Engineering	3.0
Installation, Testing and Commissioning	20.7
Subtotal	23.7%
B. Equipment	
Central Control	2.8
Fence Detection System	1.7
Access Control	1.3
TV System	1.7
Cables and Conduits	17.7
Inspection Equipment	0.8
Lighting	0.9
Communications	0.2
Electricity Supply Systems	2.4
Miscellaneous	0.3
Subtotal	29.8%
C. Civil Works	
Civil Works	46.5%
Grand Total	100.0%

Of note is that a high percentage is incorporated into civil structures, cables, and conduits. Civil works include the physical protection buildings, air conditioning, and vital area separation structures. For projects of that size, more than 400,000 meters of cables, 50,000 meters of conduits, and 10,000 electrical connectors are installed.

That the reported cost structure is only an example and may vary widely from case to case must be stressed. The scope of the physical protection system is the most important consideration, together with the quality and degree of redundancy of the installed equipment and the topography of the site. The power of the station is much less important. From other countries, the cost of imported equipment and engineering is higher than in the country of origin. The cost of the item is generally lower when the importing country has developed its own engineering skills.

The publication quoted earlier has also estimated that operating costs would be about 324 million Spanish pesetas yearly (equivalent to some two million US dollars). Most of that cost goes to the police forces, as indicated in Table II.

Table II

Structure (%) of Variable Yearly Costs of a Physical Protection System for a Two-Unit Station

Police Forces	89%
Maintenance	9%
Spare Parts	2%
Total	100%

The police forces include 16 persons fully equipped and well trained. Maintenance is performed by national contractors, and some spare parts may be imported. Under normal conditions, those expenses contribute less than one per cent to the cost of the KWh.

Comparing the figures above with those published some years back [2] on the situation in the USA is of interest. The study (1983) shows that the "... average plant has about $8 millions invested...". However, from the 25 plants investigated "... the maximum capital investment per unit was about $25 million, and the minimum about $0.7 million...". It goes on to say "... Major factors that separate the more expensive from the less expensive systems are the size of the facility and selection of the computer-based access control system...".

Also of interest from the above source is that "... the annual operating budget for security is about $1.4 million per reactor unit. Approximately 85% of the security operating budget goes to security force expenses...". These two numbers are in agreement with Spanish figures.

When all these figures are added together, including related fuel cycle, transport activities, and the cost of depreciation, the conclusion is clear: the total cost of physical security is high.

THE PROBLEMS IN DEVELOPING COUNTRIES

The countries can be divided into three groups, according to the level reached in their nuclear development.

The EXPORTERS are those countries who have been able to develop nuclear technology, or parts thereof, up to the commercial status, through their efforts in research and development. These have also developed the corresponding technology for physical protection and possess complete regulatory pyramids satisfactorily covering this aspect.

QUALIFIED IMPORTERS are those countries who have performed a considerable effort in research and development, but have not been able to reach the commercial level. They have to import their nuclear power plants from the EXPORTERS, but contribute considerably to their design and construction. They are also responsible for their implementation. Spain is clearly within this group. Most of the countries in this group already possess a sizeable nuclear energy program and have accumulated some experience in operating nuclear power plants. Generally, they do not possess the technology to implement all aspects of physical protection, and they lack complete regulatory pyramids. Nevertheless, from the technical as well as regulatory sides, they have the basic and fundamental aspects.

IMPORTERS are those countries initiating the installations of their first nuclear power projects, generally under "turn key" type of contracts. A common practice is that they do not participate much in the design, construction, and physical protection systems of their first nuclear power plants. They are normally responsible for the operation of their plants and the physical protection systems. In this context, their taking care of this problem is highly advisable.

Despite the differences above, the three groups of countries must have a common level of physical protection. These levels must be commensurable with the corresponding level of threat to which they are subjected. Three common elements that equally come into play are regulations, technology, and implementation. The problem includes a new element of difficulty when compared with other aspects of nuclear technology. This is due to the confidentiality and sensitivity of physical protection.

Clearly, most countries will not be able to apply and develop a complete and satisfactory regulatory pyramid like the EXPORTERS. In the USA, apart from the different parts to 10CFR, there are more than fifteen Regulatory Guides, reports in the NUREG and SANDIA series, and detailed codes and standards, apart from the research and development program, going on at different institutions.

IMPORTERS will have to import at least part of the physical protection principles applied in the country of origin of the project. They will also need substantial parts of the corresponding regulatory pyramid. This may create problems of interpretation and adjustment to the administrative set up for the IMPORTER.

The general recommendations developed and published by the IAEA, supplemented with details from the country of origin, could serve as a solution to the problem. Even in this case, the countries will have to create a body of expertise to know and to interpret correctly the scientific and technological aspects behind such regulations. Because of the sensitivity and confidentiality of the problem, that such knowledge is not always easy to acquire is also a consideration.

The problem has two faces from the technology side. First, the owner-operator will try to include in his station the most advanced technology. On the other side, technological aspects must remain confidential. On their own, QUALIFIED IMPORTERS will try to participate in the transfer of technology. This would include the design, development, installation, and maintenance of the physical protection systems. To solve this problem, Spanish enterprises have established agreements with foreign counterparts. Efforts should be put into these cases to secure the transfer of technology.

Implementation of a physical protection system includes equipment and personnel. Both must be integrated for the system to be meaningful. Human resources include technicians to install and repair the equipment, and guards. Technicians have to be properly trained. Guards should not be a problem in any country. The only problem in this respect will be to establish and to maintain the appropriate contacts with the national police or military forces. This is a problem well above the possibilities and responsibilities of the owner-operator.

Another important problem for developing countries will be how to avoid falling behind in technology, which is rapidly evolving. The problem may become acute in those organizations short of qualified personnel. This could happen within the staff of the different parties involved, including regulatory authorities, owner-operators of nuclear installation, and engineering firms and constructors. Apart from that, the nature of the problem requires the different organizations to assign the responsibility of such systems to the most senior personnel.

SUMMARY AND CONCLUSIONS

The presentation above could be summarized into the following conclusions:

- *On the Extent of Physical Protection in Spain* - Nuclear activities in the country are mainly concerned with nuclear power plants of the light water reactor type. This would include related fuel cycle activities, but exclude enrichment and reprocessing. Only nuclear materials belonging to category III are considered. Apart from that, substantial amounts of radioactive materials are found at nuclear power plants. Therefore, physical protection is mainly concerned with avoiding sabotage which could result in radioactivity releases against nuclear installations.
- *On the Nature of the Threat* - As a country in Western Europe, Spain is situated within a politically stable region, but is threatened by serious terrorist activities, including historical, social and cultural motivations. Terrorist actions are expected to be performed by small, well organized and armed groups, with a capacity to identify weak points in the physical protection system and with some social support. Apart from these, small acts of industrial sabotage are also probable on the part of construction workers and are designed to enlarge construction times and to avoid unemployment.
- *On the Evolution of the Problem* - Spain is a country with a substantial nuclear power program which was started very early. It has passed through many different circumstances and steps in the development of physical protection. This has created a body of experience and expertise covering from rather primitive protection systems, human based, to very sophisticated protection systems, mainly instrument based, for the most modern nuclear power plants and related fuel cycle installations.
- *On Regulatory Pyramids for Physical Protection* - Physical protection must be regulated as an aspect of nuclear technology. The corresponding regulatory pyramid should be complete and satisfactory. As many other importers, Spain does not have a complete regulatory pyramid except for a basic law and a safety guide which cover only the fundamental aspects of the matter. To solve the problem, Spain has addressed this aspect on a case by case basis. Spain has been making reference in the corresponding construction authorizations to the regulations in the country of origin of the project. It has also used the standards suggested by the IAEA and the ones used in the most technologically advanced countries.
- *On the Response of Electrical Utilities to Physical Protection Requirements* - Despite their differences, the Spanish utilities have reacted with a high degree of uniformity and efficiency with regards to the requirements on physical protection imposed on them by the evolving circumstances. In all cases, the responsibility for the project has been retained by the owner-operator of the plant, with the participation of appropriate engineering and service companies. For plants under construction, the main reactor supplier and architect-engineer have also participated in ensuring that the design and installation of the physical protection systems and procedures follow the design of the plant. Hardware and software installed have a high degree of similarity, although they are not equal.
- *On the Cost of Physical Protection Systems* - In Spain the reported capital cost of a physical protection system amounts to some $15 million (Ref. to 1984). Approximately one half of it is spent on civil work, and the rest is roughly split between services and equipment. The annual running cost is estimated to be about $2 million (Ref. to 1984), with most of it spent on the police and guard forces. These figures for Spain match fairly well the reported situation in the USA.
- *On the Problems of Special Interest to Developing Countries* - Spain can be considered now as a qualified importer for nuclear technology. It has passed through all preliminary and medium phases in nuclear technology transfer. To recognize the problems countries may be faced with in the areas of regulations, technology, and implementation of the system from the physi-

cal protection side is important. When regulations are incomplete, borrowing regulatory pyramids from the country of origin of the project, or international organizations, while trying to develop the basic and fundamental aspects will be necessary. Technology is not easy to transfer in such a sensitive field. The responsibility for physical protection must remain within the owner-operator. An effort must be made to comply with this responsibility. The implementation of the system includes the problem of how to keep up to date in this fast developing field and how to secure spare parts for the system. On the other side, the training and maintenance of the human elements are not considered a problem.

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Physical Protection Philosophy and Techniques in Sweden

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INTRODUCTION

The techniques applied for physical protection differ among nuclear power plants, other nuclear facilities, and transportation of fissile material. Because introducing all of the different aspects would take too much time, I have chosen to write on what I believe is specific for the physical protection in Sweden.

The circumstances for the protection of nuclear power plants are special in Sweden. A very important factor is that armed guards at the facilities are alien to the Swedish society. We do not use them. The Swedish concept of physical protection accepts that the aggressor will get into the facility.

With this in mind, the Swedish Nuclear Power Inspectorate (SKI) has established the policy that administrative, technical, and organizational measures will be directed toward preventing an aggressor from damaging the reactor, even if he has occupied the facility. In addition, the best conditions possible shall be established for the operator and the police to reoccupy the plant. I believe this policy is different from that of many other countries. Therefore, I will focus on the Swedish philosophy and techniques for the physical protection of nuclear power plants.

Background On Terrorism And Sabotage

Terrorism and sabotage have become a common means of forcing actions for various purposes. The terrorists use hostages and occupation in their actions. Terrorist acts are not necessarily limited to the home country of the terrorists.

Nuclear power plants have been subjected to threats and attacks of different kinds. Terrorists have been using higher technology at a growing rate. Several serious acts of terrorism have occurred in Sweden during the last few decades. Sweden has experienced embassies being occupied, airplanes being hijacked, and kidnappings taking place. In all these incidents explosives, weapons, and hostages have been used. On some occasions people have been killed. Actions and threats against nuclear power plants have occurred, but none of these have resulted in injury to people. Considering this background, providing nuclear power plants with physical protection against illicit actions is necessary.

Threats And Assaults

Threats and assaults can principally be divided into:

- Threat of explosion or other damage;
- Occupation aimed at establishing a threat; and
- Sabotage.

These activities can be carried out separately or in combination.

In all threat situations, the effect of the threat is dependent on the amount of damage done if the threat is realized. For example, in a bomb threat the extent of damage depends partly on the amount of explosives used, on where they are placed, and on the state of the reactor. During a maintenance period, explosives can be placed in areas in the plant where they are inaccessible when the reactor is in operation. Such explosives can be made to detonate at a later date.

Threats must be handled from case to case depending on how they are being delivered. A threat of damage, other than through explosion, can cause damage equivalent to that of an explosion.

Occupation means that an aggressor (one or more persons) takes control of parts of the plant, either by seizing the control room or by occupying other areas within the plant. A prerequisite to achieving the desired effect of an occupation is that the aggressor must take such steps within the plant that the cooling of the reactor, or some other vital function, would be endangered. The result of the aggressor's operations could lead to radioactive contamination of the surrounding areas. This could create serious damage to the plant, to personnel, or to the loss of lives.

Unauthorized operations can be performed from the control room or from local areas of operations, e.g. at a switch gear. However, performing these operations in areas outside the control room is appreciably more difficult. Physical damage can also occur in connection with an occupation. Such damage can be either directly to the systems necessary for cooling the reactor or to the controls of the necessary systems. Intervention capabilities, built into the reactor system design, are clearly important in mitigation of physical damages and unauthorized operations.

One important factor is the amount of time elapsing between the moment when adequate cooling of the reactor ceases and the moment when it can no longer be re-cooled. SKI originally (in the 70's) used the calculations, in the so called Rasmussen study, which estimate this amount of time to be one half-hour to a couple of hours. Later studies have not changed this estimation. The time will not be significantly prolonged even if loss of coolant does not occur until a few days after the reactor has been shut down. Therefore, if the control room is occupied, the cooling of the reactor must be secured from an area other than the control room. This must be done within a couple of hours after the loss of coolant. If the aggressor occupying the control room also has occupied other operative areas, the ability to operate can be endangered. The same situation will arise if trained personnel fail to turn up at these operative areas in order to reoccupy the plant. The reason for this failure can be either that there are no personnel available or that they are being prevented from entering the plant, or delayed by the aggressor. At the time of an occupation, the availability of local operative areas should be secured and plans for the re-manning of these areas should exist. Of great importance, also is that there is a response force available that, with short notice and within limited time, has the capability to reoccupy the plant.

The same conditions apply for sabotage as for a threat to do damage. Sabotage differs from the earlier described threat situation in that it is performed without warning and solely in order to do damage to the nuclear power plant. A nuclear power plant is vulnerable to sabotage even during its shutdown period. The accessibility of the reactor building is greater compared to the normal operation period. Sabotage within the plant can be done in connection with sabotage outside the plant, e.g., to the electrical supply. This can make additional demands necessary on the system engineering measures.

Experience shows that an attack designed only to do damage is less likely than an attack designed to use a threat to achieve goals before the damage is done. This respite in time can then be devoted for negotiations and for undertaking countermeasures.

The Aggressor

To make a threat or an attack against a nuclear power plant successful, the aggressor needs to be well prepared and to have access to certain aids, such as weapons, explosives, knowledge, and possibly hostages. Weapons and explosives are quite easy to come by today, and this is true even for the more specialized kinds. An aggressor needs to have knowledge about the nuclear power plant. He can have the knowledge himself or he can obtain it from someone who is or has been employed at the facility, or from a hostage. Knowledge of the protection system, design of the plant, and function of the plant is necessary.

A special knowledge is required to be able to operate the reactor from areas other than the control room. Only a very few people can be considered to have such knowledge. That documentation is hard to obtain.

Experience shows that the use of a hostage is often used as an aid to achieve certain goals. If the hostage is used at the time of a threat/attack against a nuclear power plant, it can be in order to:

- Obtain entry;
- Obtain knowledge about security, technical systems, locations of buildings, etc.;
- Prevent certain measures from being taken by the persons in charge of the plant, e.g., the re-manning of the controls; and
- Force someone from the plant's personnel to take certain actions.

In addition to plant personnel, a hostage can be an outsider connected to the plant, e.g., staff member families.

Most likely, an aggressor who tries to occupy a nuclear power plant will be well prepared in regard to knowledge, equipment, and assistance from insiders.

SKI's Assessment Of The Threat Situation

The threat situations presented above can occur at a nuclear power plant. When determining the physical protection for such a facility, an assessment of the various aspects of threats has to be made.

SKI has assessed that an attack in which a threat of damage is made and in which the threat later can be realized is more likely than an attack intended solely to do damage. The base for this philosophy is that if the aggressor has the qualifications to occupy a well-protected power plant and he has the knowledge to endanger the safety of the reactor, then he probably also has goals (e.g., political or economical) other than just to damage the reactor. This forces him to get in contact with other people than the operator for negotiations. This will provide time for countermeasures.

SKI has also assessed that sabotage in the plant during periods of normal operation will not, in most cases, lead to more severe situations than those for which the plant is designed to handle safely.

A nuclear power plant can be protected against a majority of threats and attacks. Only when considering the probability and consequences of a realized threat or attack against a nuclear power plant it is possible to provide it with sufficient protection. However, a plant's physical protection must be based on a number of assumptions as to the threat situation. Only when considering the probability and consequences of a realized threat or attack against a nuclear power plant is providing the plant with sufficient protection possible.

SKI has also assessed the question of having armed guards at the facilities to neutralize an aggressor. It has come to the conclusion that the benefit of having such a force does not outweigh the drawbacks. Having an armed plant security force in addition to the police would not be in compliance with the public spirit. We also agree that the deterring effects of armed guards are minor since the force we could have at the plant has to be quite limited. Even with armed guards at the plant, we cannot assure that an aggressor will not be able to occupy the plant. The force probably would not have the power to reoccupy it. Therefore, the guards at the Swedish facilities are not armed; rather, they are considered as watchmen and have no obligation to neutralize an aggressor if such would endanger their lives. The responsibility to reoccupy the plant lies instead with the Swedish police. With this in mind we automatically come to the conclusion that the reactor has to be protected against unauthorized maneuvers and that we need a well-organized response force outside the plant trained to reoccupy it.

SKI has based the regulations for physical protection of nuclear power plants on the following threat situation:

- The aggressor has knowledge of the design of the plant, its technical function, and its surveillance routines.
- The aggressor is armed and has explosives. The types of weapons and amounts of explosives are based on national experience.
- The aggressor can be several people who force their way into the plant.
- Upon entry by the aggressor an alarm is sounded and verified.
- The aggressor will, some time after a verified alarm has sounded, occupy the plant's most vital area of operation, the control room.
- A hostage may be used. The hostage is assumed to perform ordered operations within his knowledge, but without access to hard-to-obtain information.
- The aggressor may have help from someone within the plant.
- The aggressor is able to get control of the rest of the plant's vital areas after a defined time limit. The time limit is based on the time needed to get control of the areas outside the control room and the time needed to assure the operation of the reactor, to get personnel to the spot and to take over the operation of the reactor from these areas.
- Explosions outside vital areas may occur.

• Simultaneous sabotage of the outer perimeter may occur.
• The plant personnel are unarmed.

Protection Level

The purpose of the protection of a nuclear power plant is to neutralize the threat or attack. The threat is neutralized when the aggressor is unable to do damage which would lead to the fuel not being cooled. No protection level can assure that the reactor can be protected from a maximum attack. SKI's assessment is that if the reactor is protected against the assumed threat situations, there is a high probability that attacks likely to occur can be neutralized. The details of the assumed threat help to establish a level for the design of the protection of the reactor e.g., the kind of hardware that has to be built in. SKI's regulations also lead to certain protection against threat situations more severe than those above since the operator has to take into consideration such situations in his software, e.g., action plans.

The various parts of the protection system must be coordinated to reach the overall goal. On the whole, the protection can be said to consist partly of protection barriers and partly of system engineering measures. The protection barriers include area protection, entrance protection, and building strengthening. This makes them resist damage for certain periods of time. A considerable part of the total picture of the physical protection consists of administrative measures such as the organization of the actions to be taken by the response force when reoccupying the plant. Of course, there is still a probability that the aggressor will succeed in damaging the reactor. This would cause a core melt down with the risk of releases of fission products into the environment. In this case the physical protection goes hand in hand with what in Sweden is called the mitigation of consequences from severe accidents and which also demands system engineering measures such as containment cooling and filtered venting.

Protection Barriers

Access to the nuclear power plant must be controlled. The plant must be surrounded by a physical barrier. An alarm device must be placed at the barrier to detect an unauthorized entry. In order to establish whether an alarm indicates a threat or attack, it first must be verified. For this purpose the surveilled areas of the plants in Sweden are surrounded by fences, detectors are placed on the inside of the fences, and an alarm from the detectors is verified by cameras covering the surveilled area.

Normally, there shall be only one place for entering and leaving the surveilled area.

Areas that contain equipment for the safe operation of the reactor must be placed inside a protected area. Walls, ceilings, doors, windows, etc., enclosures to a protected area are to consist of a sturdy construction with strength enough to stop or to make an unauthorized entry difficult. Entrances to the protected area must be closed, locked, and equipped with an alarm.

Areas outside the control room, from which the reactor can be operated, are very important in the Swedish physical protection system. From these areas threats against the reactor can be neutralized. These areas are included in the plant's vital areas which are to be mechanically protected and have boundaries of sufficient strength to resist an attack for a defined time limit. Entrances to vital areas must be equipped with an alarm. Also, areas where equipment of importance for the safe shutdown of the reactor, e.g., the containment, are defined as vital areas. If these areas are protected by an acceptable level of redundancy, they do not need a higher degree of mechanical protection than what is required for protected areas. They are then called safely closed areas.

In order to facilitate control and surveillance within the plant, mainly during shutdown periods, movements within the plant are restricted by dividing the plant into sections. During normal periods, the plant is also divided into sections suitable from a working point of view. The sections are physically cut off and have an entrance check. Access to the different sections is limited to people who need to enter to perform their duties.

The target for an attack is likely to be the reactor control room. Therefore, this room must be especially protected in order to allow the personnel time to take the actions necessary to prevent the aggressor from damaging the reactor. Entrances to the control room must be closed, locked, and equipped with an alarm. The personnel on duty must be able to sound the alarm indicating an attack. Admission to the control room must be protected from being fired at by firearms. Before an aggressor can enter the control room, three barriers must be passed: the surveilled area, the protected area, and the entrance to the control room. The entrance to the control room is locked to give its personnel full control over who gets in. From the time an alarm indicating a threat or attack against the plant is verified, point zero, the aggressor must be stalled at least long enough for the control room personnel to take necessary operational steps and to have the option to evacuate the control room. For the safety of the personnel, there shall be more than one way to evacuate the control room.

System Engineering Measures

System engineering measures are meant to prevent the aggressor from damaging the reactor and to make recovering control over the reactor easier for the operator. The goal is to have the plant designed in such a way that necessary areas of the plant can be kept under safe control in the event of deliberate damage or occupation of the control room. This can be done with the aid of automation or operation personnel.

Since we have assumed that the aggressor will be able to occupy the control room, certain steps have to be taken to assure that the reactor will be in a safe mode when the personnel leave the control room. We also have to make the aggressor's attempt to make operations or to influence the safety of the reactor difficult by damaging parts of the control room. Other parts vital for the safe operation of the reactor have to be considered and protected. These parts of the reactor shall be protected by redundant systems and by physical separation of the systems. This can be done by installing adequate equipment in the control room and in other parts of the reactor. Later, the operator has to re-man the reactor to be able to take control of it again. This has to be done within the time limit discussed above. To reoccupy the control room within this time is not considered feasible, and the control room may also be damaged. To be able to control the reactor, the operator needs information on the status of plant conditions like cooling and subcriticality. For this reason, instrumentation for the surveillance of the plant conditions is installed at many local areas in the plant. The information is used to operate the reactor from local operating areas. A local operating area is meant to be a place from where you can take over the operation of equipment such as a feed water pump. These operations shall be difficult to perform, and the area shall be physically protected. The local operating areas shall be spread all over the plant to get redundancy as high as possible. This means that a second control room is not acceptable. Occupying and damaging both control rooms would be too simple for an aggressor. The concept of local operating areas also facilitates the re-occupation of the plant. It makes defense of a great number of areas difficult for an aggressor.

The foundation for the system engineering measures are:

- The built-in natural protection obtained in a plant as a consequence of the conventional safety demands;
- The technical specifications for the use of the plant; and
- The plans for evacuation of the control room and the manning of other operating areas in the plant intended to be used, e.g., in case of fire in the control room.

The physical protection might mean that additions to the system engineering measures are necessary. An example of what has been done in Swedish reactors is making unauthorized operation in the control room after an evacuation more difficult to perform. The supply of water to the reactor has been made safer by adding extra feed water pumps and by adding alternate methods of containment cooling. In the later reactors all safety-related systems are four-subbed, each subsystem with 50% redundancy according to design and with a high degree of physical separation. This leads to higher safety in case of sabotage, as well as other failures. Additional instrumentation at local operating areas for surveillance of plant conditions has been installed.

Although you install a protection system at a reactor, situations where the aggressor is able to realize his threat with a core melt down as the result may occur. In this case there must be engineered measures installed for mitigation of the consequences. Such measures are containment cooling and filtered venting of the containment. These measures are also needed for protection against other severe accidents.

Response Forces

The intention is to re-man the areas of the plant necessary to secure the cooling of the reactor after a possible occupation. As mentioned, we cannot be sure we can prevent the aggressor from occupying the facility. Furthermore, we cannot be sure that the personnel working at the facility will be available when an operator re-mans the reactor. They may have been taken as hostages. Therefore, the operator must have reserve personnel who, at short notice, can be available for the re-manning. Of course, personnel reoccupying the plant by themselves is impossible because of the danger caused by the aggressor.

In Sweden, only the police have the means to organize a response force with the power to reoccupy a nuclear power plant occupied by terrorists. For this purpose the police are equipped and trained to respond on short notice and to act within a limited time. As a matter of fact, the police continuously have the opportunity to train together with the operator, even inside the reactor buildings.

Cooperation With The Authorities

The steps to be taken by plant management in cooperation with the police, fire department, coast guard, and national and regional defense authorities at the time of a threat or attack are to be planned in advance. This needs to be documented in a procedure manual. The procedures are to be coordinated.

Conclusions

On the whole a good physical protection system must consist of the following four parts:

- A high loyalty level within the personnel of the facility;
- A good system of protection barriers and detecting devices;
- System engineering measures to neutralize unauthorized operations and sabotage; and
- A response force, well organized and well trained, with the obligation to reoccupy the reactor and to re-man the controls.

A physical protection system where one or more of these four parts are not fully developed, or are not considered at all will not give the operator the best opportunity to cope with an attack against his reactor.

I have not really touched upon the question of the loyalty of the personnel earlier, but in fact, getting a good protection system is almost impossible if it is not accepted by the people working within it.

The role of the physical protection system is to deter and, hopefully, to prevent an aggressor from getting into the plant. If the physical protection system fails to do so, then at least it shall minimize the aggressor's opportunities to damage the reactor or to release radioactive material. The system shall also give the operator as many options as possible to operate the reactor safely, even with parts of the reactor occupied by an aggressor. Only a system which has a great deal of system engineering measures will fulfill all these demands.

What an acceptable physical protection system shall look like when it is implemented is contingent on many factors. In fact, so many that to say: "what is good for us is good for you" is impossible. Important factors are, for instance, the actual threat situation in the country, or even in the part of the country where the reactor is sited, the social order of the country, and the type of reactor. Therefore, to make the system as effective as possible, the physical protection system for a reactor should be developed based on the conditions valid in the country where the reactor is sited.

Björn Dufva is Head of the Section of Safeguards at the Swedish Nuclear Power Inspectorate. He has worked in the nuclear field since 1979, primarily with nuclear safety and physical protection, and most recently safeguards. He earned his M.S. degree in Chemistry at the Royal Institute of Technology.

Physical Protection Philosophy and Techniques in the United States of America

Elizabeth Q. Ten Eyck
U.S. Nuclear Regulatory Commission
United States of America

INTRODUCTION

Nuclear materials and facilities must be protected from hostile acts which could possibly impact public health and safety or national defense and security. The US Nuclear Regulatory Commission (NRC) is responsible for regulating the safeguards of commercial nuclear facilities within the United States of America, and it issues and enforces requirements for safeguards at privately owned and operated nuclear facilities. The US Department of Energy (DOE) performs these functions for government-owned nuclear facilities. Domestic safeguards includes 1) physical protection measures to control access to nuclear material and facilities and 2) material control and accounting procedures to ensure that only authorized activities take place, to account for materials, and to conform with the US-IAEA Treaty. Physical protection measures (the focus of this article) contain the sensitive materials and activities within concentric physical barriers controlled by armed guards, who grant access to authorized individuals and prevent access by force or stealth.

HISTORY

The Atomic Energy Act of 1946 created the US Atomic Energy Commission (AEC) and provided for government ownership and control of all nuclear materials and facilities. By 1953 considerable progress was being made on the development of nuclear power and other peaceful applications of nuclear technology. The Atomic Energy Act of 1954 was designed to encourage private participation in peaceful developments by authorizing the AEC to lease nuclear materials to private institutions, subject to appropriate license conditions. Later, private ownership of nuclear materials was permitted, with material control and accounting and physical protection measures being required for those possessing nuclear materials. The licensing and regulation of the non-government activities within the AEC were separated from offices responsible for research and development. In 1974 the US Congress passed the Energy Reorganization Act of 1974 which replaced the AEC with the NRC, to regulate and control all privately owned nuclear activities, and the Energy Research and Development Agency (ERDA), to continue the research and development activities and the government nuclear weapons programs. In 1977, the latter agency was redefined, with minor changes, as the US Department of Energy (DOE). In 1982 the United States signed and ratified a treaty with the IAEA to accept Agency safeguards on any and all non-military nuclear facilities under both of the regulatory agencies.

PHILOSOPHY

From a physical security perspective, the NRC and the DOE are responsible for ensuring that nuclear materials and facilities are protected from adversaries ranging from a disgruntled employee to a terrorist group. The two organizations, with support from other government agencies, continually assess the threat environment to determine any potential impact on nuclear activities.

The NRC and the DOE issue and enforce regulations which describe the objectives and activities to be performed. NRC regulations are contained in Part 10 of the Code of Federal Regulations. Originally, these regulations told licensees what their physical security systems should consist of rather than what they should accomplish. Now the NRC's requirements for physical protection of nuclear power reactors and special nuclear material define hypothetical threats which licensees must design their physical protection systems to guard against. These design basis threats are somewhat like the design basis events that are used as a basis for safety requirements for nuclear plant designs. In the case of physical protection, the hypothetical design basis threats consider theft or radiological sabotage by an armed external adversary with or without the assistance of an "insider" or employee holding any position in the company. The threat of theft or radiological sabotage could also be committed by an "insider," as well as by a non-violent conspiracy between individuals to commit theft or diversion of special nuclear material. The NRC also publishes documents which provide guidance as to how the regulations could be implemented. After physical security measures are in place, the facilities are inspected for conformance, and special reviews are performed to evaluate the effectiveness of the regulations and their implementation at the facility.

REACTOR PROTECTION APPROACH

At present, about 112 nuclear power reactors are licensed by the NRC to operate in the United States. Approximately 16 more permits have been granted for construction.

The physical protection system for power reactors is designed to restrict access of unauthorized persons from those areas of a plant in which a saboteur could cause a significant off-site release of radioactivity. Such areas are designated vital areas and are protected by two concentric rings of physical barriers and access controls. The outer ring is called the protected area. Individuals entering a power plant at the protected area entry point are searched for items such as weapons or explosives.

In order to enter the inner ring (a vital area), an individual must first be screened and authorized by licensee management to have access. Entry into vital areas is made through controlled access points typically equipped with electronic badge readers. Vital areas are locked and alarmed when unoccupied. All alarms annunciate at two redundant alarm stations.

The protective force at a typical reactor site is armed with handguns and shotguns or semiautomatic rifles and is trained in all aspects of nuclear security. Protective forces maintain vigilance over both the vital area and the protected area barriers, which are alarmed. The protective force is equipped with two separate means of calling for local law enforcement assistance, if necessary.

Planning is used to ensure that the on-site protective force and the assisting local law enforcement officers will function well together in a variety of scenarios.

PROTECTION OF FUEL CYCLE FACILITIES

At the four commercial US fuel cycle facilities which possess formula quantities of special nuclear material (Category I facilities), the focus of physical protection is primarily on theft. In this case the physical protection system is designed to prevent unauthorized removal of special nuclear material.

Areas that allow access to special nuclear material are designated as material access areas and are protected by two concentric rings of physical barriers and access controls. As at reactors, there is an outer protected area with an alarmed barrier, access controls, and entry searches. In order to enter the inner ring (a material access area), an individual must first receive a US government-issued clearance and then be authorized by licensee management to have access. Entry into a material access area is made through controlled access points. All individuals exiting material access areas are searched for special nuclear material and shielding material, typically with a portal special nuclear material monitor and metal detector. Material access areas are locked and alarmed when unoccupied. Members of the protective force are trained and deployed at fuel cycle facilities in basically the same way as at reactors except that the protective force may have to be greater in size to counter a larger external threat and to handle additional tasks related to searches for special nuclear material.

As can be seen, the protection system at a fuel cycle facility has many similarities to that required for nuclear power reactors, especially with regard to protection against external adversaries. There are some important differences related to insider protection. Two independent alarm systems are used to prevent collusion between alarm station operators. Also, control and search of persons, packages, and vehicles must involve two or more individuals to prevent collusion by search or control personnel.

OTHER LICENSED FACILITIES AND ACTIVITIES

For the protection of nuclear material during transportation, the NRC established the levels of physical protection required to meet or exceed the recommendations of INFCIRC/225/Rev.1. A graded safeguards policy that recognizes the strategic value of various types and quantities of nuclear material is the basis for the NRC's requirements.

With regard to international transport of nuclear material, the responsibilities of US government agencies are shared. The Convention on the Physical Protection of Nuclear Materials has been negotiated, and this important multilateral treaty is now open for signature and ratification by all nations. The Convention recognizes the importance of peaceful nuclear cooperation among nations and is intended to improve the protection of nuclear materials in international transport and to promote international cooperation in response and recovery operations in the event of theft of nuclear material. The Convention provides for advance notification among states on international shipments and establishes a system for the exchange of information. Parties are also obligated to make certain activities, such as theft, embezzlement, and threats involving nuclear materials, a punishable offense under national law. The United States ratified the Convention and enacted enabling legislation in 1982. On January 9, 1987 Switzerland became the 21st country to ratify the Convention, and the Convention became effective in the United States on February 8, 1987. The DOE and the NRC are responsible for ensuring that levels of physical protection in their respective areas of responsiblity are adequate.

US authorities responsible for coordinating response and recovery operations within the United States in the event of unauthorized use or handling of nuclear materials are the DOE, the NRC, the US Department of Justice and the Federal Bureau of Investigation. For response and recovery operations concerning incidents outside the United States, the US Department of State (DOS) is the designated the point of contact. The DOS will ensure that appropriate US persons or agencies are notified so that response and recovery operations may be undertaken. Routine communications from other nations concerning transportation and matters related to physical protection of nuclear material should be addressed to the DOS.

For less than formula quantities of licensed special nuclear material, the NRC requires physical security consistent with that suggested in INFCIRC/225/Rev.1.

Elizabeth Q. Ten Eyck joined the Nuclear Regulatory Commission in 1978 and is currently the Deputy Director, Division of Safeguards and Transportation, having assumed this position in July 1985. During her tenure with NRC she has held progressively more responsible management positions with emphasis on safeguards effectiveness evaluation and threat assessment. Prior to joining NRC, Mrs. Ten Eyck was a security engineer for the U.S. Secret Service for eight years, developing sophisticated security systems and law enforcement investigative equipment. Immediately after graduation from the University of Maryland, in 1968, as an electrical engineer, she worked in private industry developing electronic countermeasurers systems for defense applications.

Catalog for Health Physics Instruments and Accessories

A new 33-page catalog of Health Physics equipment is available from Nuclear Associates. It describes dozens of items including survey meters, radiation monitors, instrument calibrators, air samplers, radiation protection devices, remote handling tools, warning signs, decontamination kits, and lead-lined storage containers.

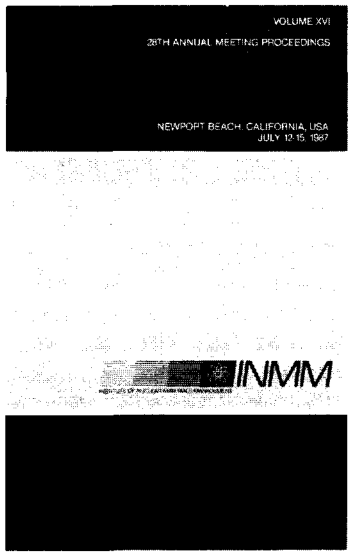
Other featured products include CLEAR-Pb® transparent lead-plastic panels for secondary x-ray shielding in CT, x-ray and special procedures rooms, x-ray diffraction enclosures, mobile x-ray barriers and shields for personal protection . . . and more. Call 516/741-2166.

1988 EG&G ORTEC Calendar

The new 1988 EG&G ORTEC wall calendar features striking, four-color photographs from physics research laboratories throughout the world; Argentina, Canada, France, the United Kingdom, West Germany, and the U.S.A. are included. Like last year's, the calendar is non-commercial. To obtain one free, call the hotline, 800/251-9750.

INMM 28th Annual Meeting Proceedings

The Proceedings of the 28th Annual Meeting of the Institute of Nuclear Materials Management are now available. These proceedings are a reference guide containing the complete text of the 170 technical papers presented at the meeting, "Safeguards — A Mature Technology?" held in Newport Beach, Calif., July 12-15, 1987. The papers represent the work of safeguards professionals from around



the world. The 800-page text is available free to INMM members. Additional copies are available to members and non-members for $50. Contact INMM Headquarters, 60 Revere Dr., Suite 500, Northbrook, Ill. 60062 U.S.A., Phone 312/480-9573.

CALENDAR

January 20-22, 1988
INMM Spent Fuel Storage Seminar V, Loew's L'Enfant Plaza Hotel, Washington, D.C. *Sponsor*: Institute of Nuclear Materials Management *Contact*: Beth Perry, INMM, 60 Revere Drive, Suite 500, Northbrook, Ill. 60062 U.S.A., Telephone (312) 480-9573.

January 31-February 3, 1988
ANS Executive Conference on Thinking on Your Feet When Your Back is to the Wall II, Sonesta Village Resort on Sand Lake, Orlando, Fla. *Sponsor:* American Nuclear Society *Contact:* ANS Meetings Department, 555 N. Kensington Ave., La Grange Park, Ill. 60525, Phone 312/352-6611.

February 22-23, 1988
National Symposium on Atomic Energy, Tokyo, Japan *Sponsor:* Atomic Energy Society of Japan and 39 related societies *Contact:* Minoru Masamoto, Secretary General, AESJ, No. 1-13, 1-chome, Shimbashi, Minato-ku, Tokyo 105 Japan.

February 28-March 3, 1988
Waste Management '88, Tuscon Community Center, Tuscon, Ariz. *Sponsors:* University of Arizona, American Nuclear Society, Electric Power Research Institute, Radwaste Systems Committee of the American Society of Mechanical Engineers, and others *Contact:* M.E. Wacks, Department of Nuclear and Energy Engineering, University of Arizona, Tuscon, Ariz. 85721, Phone 602/621-6160.

March 2-4, 1988
INMM Technical Workshop on Process Hold-up of Special Nuclear Materials, Ramada Hotel Rockville, Rockville, Md. U.S.A. *Sponsor*: Institute of Nuclear Materials Management *Contact:* Beth Perry, INMM, 60 Revere Drive, Suite 500, Northbrook, Ill. 60062 U.S.A., Telephone (312) 480-9573.

March 21-25, 1988
General Meeting of the American Physical Society, New Orleans, La. *Sponsor:* American Physial Society *Contact:* The American Physical Society, 335 East 45th St., New York, N.Y. 10017 U.S.A.

April 4-6, 1988
Annual Meeting of the Atomic Energy Society of Japan, Tokyo, Japan *Sponsor:* Atomic Energy Society of Japan.

April 11-14, 1988
INMM Technical Workshop, "Security Personnel Training," Marriott Hotel, Albuquerque, N.M. *Sponsor:* Institute of Nuclear Materials Management *Contact:* Beth Perry, INMM, 60 Revere Dr., Suite 500, Northbrook, Ill. 60062 U.S.A. Telephone (312) 480-9573

April 11-15, 1988
Materials Accounting for Nuclear Safeguards, Los Alamos, N.M. *Sponsor:* U.S. Department of Energy Safeguards Technology Training Program and Los Alamos National Laboratory *Contact:* Charlene McHale/MS E541, Los Alamos National Laboratory, Los Alamos, N.M. 87545 Telephone (505) 667-7777

April 17-20, 1988
International Topical Meeting on LWR Fuel Performance, Williamsburg Hilton, Williamsburg, Va. *Sponsor:* ANS Fuel Cycle and Waste Management and Materials Science and Technology Divisions and the ANS Virginia local Section *Contact:* Technical Program Chair Lewis A. Walton, Babcock & Wilcox Co., P.O. Box 10935, Lynchburg, Va. 24506, Phone 804/385-3436.

April 25-28, 1988
9th International Conference on Nondestructive Evaluation in the Nuclear Industry, Tokyo, Japan *Sponsor:* ASM International in cooperation with 16 international societies and a number of Japanese utilities.

May 23-25, 1988
International Conference on Transportation for the Nuclear Industry, Stratford-on-Avon, Warwickshire, U.K. *Sponsor:* Institution of Nuclear Engineers *Contact:* Mrs. S.M. Blackburn, Institution of Nuclear Engineers, Allen House, 1 Penerley Rd., London SE6 2LQ U.K. Telephone 01-698-1500.

May 24-26, 1988
Uranium Hexafluoride — Safe Handling, Processing, and Transporting, Oak Ridge, Tennessee *Sponsor:* U.S. Department of Energy and Martin Marietta Energy Systems, Inc. *Contact:* Sheila G. Thornton, Administrative Coordinator, Martin Marietta Energy Systems, Inc., Building K-1020, MS 403, P.O. Box P, Oak Ridge, Tenn. 37831, Phone 615/574-9200.

June 12-17, 1988
Annual Meeting of the American Nuclear Society, San Diego, Calif. *Sponsor:* American Nuclear Society *Contact:* Meetings Dept, American Nuclear Society, 555 N. Kensington Ave., LaGrange Park, Ill. 60525 U.S.A.

July 26-29, 1988
INMM 29th Annual Meeting, Bally's Hotel, Las Vegas, Nev. U.S.A. *Sponsor:* Institute of Nuclear Materials Management *Contact:* Beth Perry, INMM, 60 Revere Dr., Suite 500, Northbrook, Ill. 60062 U.S.A. Telephone (312) 480-9573.

The events listed in this calendar were provided by Institute members or taken from widely available public listings. We urge INMM members, especially those from countries outside the United States, to send notices of other meetings, workshops or courses to INMM headquarters.

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