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JNMM Journal of Nuclear Materials Management

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INMM
INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

Growth of Student Chapters Demonstrates Growth in Nuclear Industry

By Steve Ortiz
INMM President

As I reflect on my term as president of the Institute of Nuclear Materials Management, several things stand out as evidence that our industry is continuing to grow. Subtle or not-so-subtle evidence is the growth of our annual meeting. We set records in attendance at our 49th Annual Meeting in Nashville, which kicked off a year-long celebration of our fiftieth anniversary. We surpassed this record the following year in Tucson. In Tucson we also set a record for the number of papers presented at the meeting. This year we have set a record for the number of abstracts submitted to the annual meeting. We expect to, once again, set a record for attendance and number of papers presented.

When I started my term as president I set what at the time I thought was a stretch goal. I set a goal for the Institute to have ten student chapters by the end of my two-year term. At the time the only student chapter we had was at Texas A&M. Just last month the Executive Committee (EC) approved our ninth student chapter. By no means do I take credit for the growth in the number of student chapters. It is really an indication of the resurgence of the nuclear industry. I came across an interesting article in *U.S. News and World Report* that reinforces this belief. An excerpt from the article:

"Nuclear Help Desperately Wanted" could be the sign in front of dozens of engineering colleges across the country. With worldwide interest in nuclear energy and technology skyrocketing, engineers with a nuclear background are feeling very popular these days. It's welcome news for a field that has been long stifled by negative public opinion. The challenge the discipline faces is how to meet this new demand after years of shrinking interest."

The article goes on to say,

"But in recent months, nuclear has re-emerged as a much ballyhooed energy source, and the entire community is scrambling to stave off what could be a massive shortage of qualified workers if the demand for nuclear power does take off. With an aging workforce, including many workers who are near retirement, the ANS estimates that 700 nuclear engineers need to graduate per year to support the potential demand. The organization currently expects only 249 new engineers to be available each year."

Another interesting article from *University World News* cites:

> "The renewed interest in nuclear engineering was driven by a number of factors: But they include the fact that students, who are a leading indicator of opinion in society, think that nuclear power is important and has an important contribution to make to the challenges we face in energy and to the realization that there are a lot of good jobs out there."

To this end, we began strategic planning about a year ago to make sure that our professional organization is serving the needs of its members and the industry. This effort has been lead by Grace Thompson and Ken Sorenson. They have been working with the EC and other leadership within INMM to initiate and implement a strategic plan that will continue to move us forward. More details of strategic planning will be available at this year's annual meeting.

I have enjoyed serving during this time of growth and look forward to working with the next president of INMM to make sure we continue to be the premier organization in nuclear materials management.

Big Picture Look at Physical Protection

By Dennis Mangan
INMM *Technical Editor*

This issue of *Journal of Nuclear Materials Management* has seven articles dedicated to one of our six technical divisions—physical protection. These articles evolved from the 21st International Training Course on the Physical Protection of Nuclear Facilities and Material (known as ITC-21) held in Albuquerque, New Mexico, USA, in spring 2009. A similar issue devoted to physical protection was published back in 1985, (Vol. 14, Issue 3). That issue was based on the sixth ITC. That course included 146 participants from thirty-nine countries.

In the first paper of this issue, John Matter of Sandia National Laboratories, the course director for ITC-21, provides an excellent review of the scope of the ITC. Matter notes the importance of guest lecturers, who focus on an aspect of the physical protection of nuclear facilities and materials in their country.

In the second paper, Jose Lolich of the Instituto Balseiro in Bariloche, Argentia, provides interesting insights in *Nuclear Security at Research Reactors in Argentina.*

In the third article, *Practice of the Physical Protection of Nuclear Materials and Nuclear Facilities in China,* Liu Daming of the China Institute of Atomic Energy in Beijing, China, provides a comprehensive overview of the Chinese approach to physical protection.

Next, Alexander Izmaylov, State Enterprise Eleron, *Russian Federation, in his article Russian Experience in Development/ Upgrades of Physical Protection Systems for Nuclear Materials and Facilities,* discusses the efforts in the Russian Federation to continually improve security systems.

In the fifth article, *Integrated Nuclear Security Model for Nuclear Facilities and Nuclear Material,* Antonio Perez-Baez of the Nuclear Safety Council in Madrid, Spain, provides an overview of the scope and modeling in physical protection approaches in Spain.

In her article, *Combating the Nuclear Terrorists Threat: A Comprehensive Approach to Nuclear Security,* Melissa Krupa of the U.S. Department of Energy's National Nuclear Security Administration (NNSA) provides a comprehensive overview of the NNSA's International Physical Protection Program. She addresses the legal aspects, the obligations, and in my opinion, the positive attitude that the International Physical Protection Program fosters to help in securing nuclear facilities and nuclear material worldwide. This is an aggressive program with many facets.

In the last article addressing physical protection, the article, *Overview of U.S. Nuclear Regulatory Commission Security Activities,* by T. Harris and M. Layton of the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Security and Incident Response, discusses the efforts of the NRC to aggressively pursue improving the protection of NRC -regulated nuclear facilities and nuclear material in the U.S. The Impetus for the improvement activities was the September 11, 2001, attacks, which demonstrated to many with physical protection responsibilities in securing nuclear facilities and nuclear material that the threat has aggressive features which need to be considered.

The *JNMM* staff would like to express appreciation to the authors for their contributions to this issue focusing on the physical protection of nuclear facilities and nuclear materials. The people involved in the protection endeavor know the difficulties associated with attaining success. If one takes a big-picture look at the content of these articles, it is hard not to conclude there is an apparent universal positive attitude to having success, and passing that attitude on to the students in ITC-21. I believe a security culture in security is on a continual upswing.

The final paper in this issue is a policy paper from the American Nuclear Society (ANS), *Nuclear Nonproliferation Policy in a Sustainable Energy Future.* This article was provided to INMM by ANS representatives with a request to publish their article in our *Journal.* Having published policy papers before, the *JNMM* welcomed the opportunity to publish this ANS paper.

I trust you will find this issue interesting. We traveled around the physical protection globe consistent with our international nature.

If you have questions or comments, feel free to contact me.

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

The International Training Course on the Physical Protection of Nuclear Facilities and Materials

John C. Matter
Sandia National Laboratories, Albuquerque, New Mexico USA

Abstract
Education and training are the foundation for a state's development and maintenance of an indigenous capability to conduct a nuclear energy and research program, from both the regulatory perspective and the licensee or operator perspective. The International Training Course on the Physical Protection of Nuclear Facilities and Materials (ITC) is the original international training program in the area of physical protection of nuclear material, which the United States has been conducting since 1978. This course focuses on a systems engineering performance-based approach to requirements definition, design, and evaluation for physical protection systems. During the first twenty-one presentations of ITC, more than 600 national experts from more than sixty International Atomic Energy Agency member states were trained. This paper describes the content, structure, and process of ITC.

Introduction
Human resource development is recognized as the foundation of nationally independent, sustainable nuclear security programs. Education and training are the basis for developing and retaining a national cadre of security experts. Numerous training courses and programs have been developed and are presented nationally and regionally. The original multilateral nuclear security course

Figure 1. 2009 ITC Training Class

is "The International Training Course on the Physical Protection of Nuclear Facilities and Materials," or ITC.

ITC was originally developed and continues to be presented regularly as part of the United States' response to the international commitment to nonproliferation. In the Nuclear Nonproliferation Act of 1978, the United States committed to conducting training programs for participants from other countries in the area of physical protection. Section 202 of the Act, titled "Training Program," states "The Department of Energy…shall establish and operate a safeguards and physical security training program to be made available to persons from nations and groups of nations which have developed or acquired, or may be expected to develop or acquire, nuclear materials and equipment for use for peaceful purposes."

ITC is presented in collaboration with the International Atomic Energy Agency's (IAEA) Office of Nuclear Security. The U.S. sponsors are the Department of State (DOS) and the Department of Energy (DOE)/National Nuclear Security Administration (NNSA) Office of International Regimes and Agreements. DOE funds Sandia National Laboratories (SNL) to develop, update, and present ITC. ITC is conducted in English over a three-week period in Albuquerque, New Mexico, USA, to forty-two participants from IAEA member states.

ITC, which was first presented in 1978, has been conducted twenty-one times, or approximately once every eighteen months. The most recent ITC, ITC-21, was conducted in spring 2009. Figure 1 is the official class photo of ITC-21 participants, subgroup instructors, and guest lecturers. There have been 657 participants from sixty-eight countries trained during this period. Table 1 presents a summary of the dates and number of participants by country for each ITC.

Content

ITC presents a systems engineering approach to the physical protection of nuclear facilities and materials. The three major sections are definition of system requirements, the design or characterization of physical protections systems (PPS), and the evaluation of PPS. This methodology has been named the Design and Evaluation Process Outline (DEPO).

> **The Prize for Longest Continual Association with ITC**
>
> This prize goes to "Professor" Paul Ebel, who has contributed significantly to ITC-2 through ITC-21. His most valued role has been helping train the subgroup instructors and keeping the participants excited and motivated throughout the three grueling weeks of each ITC.

Figure 2 is a pictorial representation of DEPO that illustrates the three parts of DEPO and the set of modules that are currently addressed in DEPO. The following briefly describes the content of each module.

Introduction to ITC

- Course objective
- ITC history
- Course structure
- Administrative matters

The overall objective of the course is for participants to understand the performance-based approach to the design and evaluation of a PPS for nuclear facilities and materials against the threat of theft and sabotage.

Introduction to DEPO and Requirements

- Comparison of prescriptive and performance-based approaches
- Description of DEPO
- Introduction to the first section of DEPO: system requirements definition

Facility Characterization and Target Identification

- Physical, operational, and environmental characterization of nuclear facilities
- Target identification for theft and sabotage
- Nuclear material categories and sabotage significance scale

Introduction to Hypothetical Facility

For confidentiality reasons, a hypothetical facility is used for all subgroup exercises. ITC participants learn DEPO while applying it to the Lagassi Institute of Medical Physics (LIMP).

Threat Definition

- Threat assessment process
- Development, use, and maintenance of a design basis threat
- Motivation, intent, and capabilities of outsider and insider adversaries

Risk Management and Regulatory Requirements

- Introduction to risk equation and conditional risk
- Likelihood of attack, PPS effectiveness, and consequences
- Competent authority and definition of PPS requirements
- PPS effectiveness metrics

Introduction to Design

- Introduction to the second section of DEPO
- Three functions of a PPS: detection, delay, and response
- Concept of timely detection and critical detection point
- System engineering design principles of balanced protection, defense in depth, and reliability

Table 1.

Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TTL
Albania															1							1
Algeria												1	1									2
Argentina	1				1	1	1	3	1	2		2	2	2	1	1	1		1		1	21
Armenia																1			1	1		3
Australia		1		2				1	1	1				1	1	1	1	1	1	1	1	14
Austria																1	1					2
Bangladesh					1	1					1	1	1				1				1	7
Belarus											1	1	1	1	1	1		1			1	8
Belgium																				1	1	2
Brazil	1	1	2			1	2	1	1	2	2	2		2	2	1		2	1		1	24
Bulgaria			1				1	1	1	1	1	1	1	1	1	1		1		1		13
Canada		1	2	2	1	3	3	3	3	4	2	4	2	1	3	2	3	2	1	2	1	45
Chile	1	1	1		1	1			1			1		1			1		1	1		11
China							2	2	1		2	2		2	2	2			1	1		17
Croatia	1										1	1		1	1							5
Cuba										1	1											2
Czech Rep	1	1		1		1		2	1	1	2		1	1	1	1			2		1	17
DR Congo															1				1			2
Denmark		1																				1
Egypt		1	1	1	1	2	3			1		1	1	1	1			2	2	1	1	20
Finland		1			1				1	1					1	1					2	8
France		1	2				1		1	1	1	2	1	1	2		1		1	1	1	17
Germany		1	1							2	1	1	1				2	2		1	1	13
Ghana							1					1					1	1		1	1	6
Greece										1	2											3
Hungary			1								1	1	2		1		1	1			1	9
India	1	1	1	2	1		3	2	1		1	2				1	1		2	2	2	23
Indonesia	1	1		1	1		1		1	1	2	2			1	1	1	2	1	1	1	19
Iran	1																					1
Iraq	1				2	1	1															5
Israel	1	1										1	1		1							5
Italy		1		1			1	1	1												1	6
Jamaica																					1	1
Japan			3	2	3	3		1	2	2	1	1	2				2	1	1	1		25
Jordan															1							1
Kazakhstan											1	1	1		1			2	1	1		8
Korea	1		1	1		2	1	2	1	2		3	1	1			1	2	1	1	1	22
Latvia												1					1					2
Lithuania												1	1	1	2	1	2	2	1	1	2	14
Malaysia	1	1			1	1				1							1	1	1		1	9
Mexico	2	2			2	2	2	2	1		2	1		1	1	1		2		1		22
Morocco								1	1		2								1	1		6
Netherlands		1																	1	1	1	4

Table 1. (continued)

Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TTL
Nigeria																			1			1
Norway																		1				1
Pakistan	2		2	2	1		1	1	1		1	1						1	2	1		16
Philippines	2	1	2	2	3	1		1			1	1				1		1				16
Poland	1		1			1	1	2	1		1		1			1		2	1	1	1	15
Portugal	1															1						2
Romania	1			1	1			1		2	1	1	1	1	1	1	1	1	1	2	1	18
Russia											1	1	3	3	2	3		2	1	1	1	18
Saudi Arabia											1											1
Serbia																				1	1	2
Slovakia						1					1	2	2	1	1	1	1		1	1	1	13
Slovenia				1					1	1	1	1	1	1	1	1			1	1	1	12
South Africa		1	1	2	2			1		1						1	2	1	2	2		16
Spain	1	1		2	1														2	1	1	9
Sweden						1		2	2	2		1	1		1	1			1	2	1	15
Switzerland																		1	1	1	2	5
Syria											1											1
Thailand	1		1			1			1	1	1	1	1		1	1	1	1	1		1	14
Tunisia			1							1					1		1					4
Turkey	1	1	1				1		1							1	1				1	8
Ukraine											2		2	3	1	2			1	1	2	14
Uzbekistan														1								1
Venezuela	1			1														1				3
Vietnam													1	1						1		3
Zaire					1	1	1															3
Observers													2		1			2	1	2	2	10
Total	25	22	25	24	25	25	27	30	27	32	39	44	35	29	37	32	29	39	40	40	41	667

Intrusion Detection
- Probability of detection, nuisance alarm rate, vulnerability to defeat
- Exterior and interior sensor technologies
- Detection system design principles and practices

Entry Control
- Personnel identification by credentials, personal identification numbers, and biometrics
- Personnel identification technologies
- Type I and II identification errors
- Entry control system design principles and practices

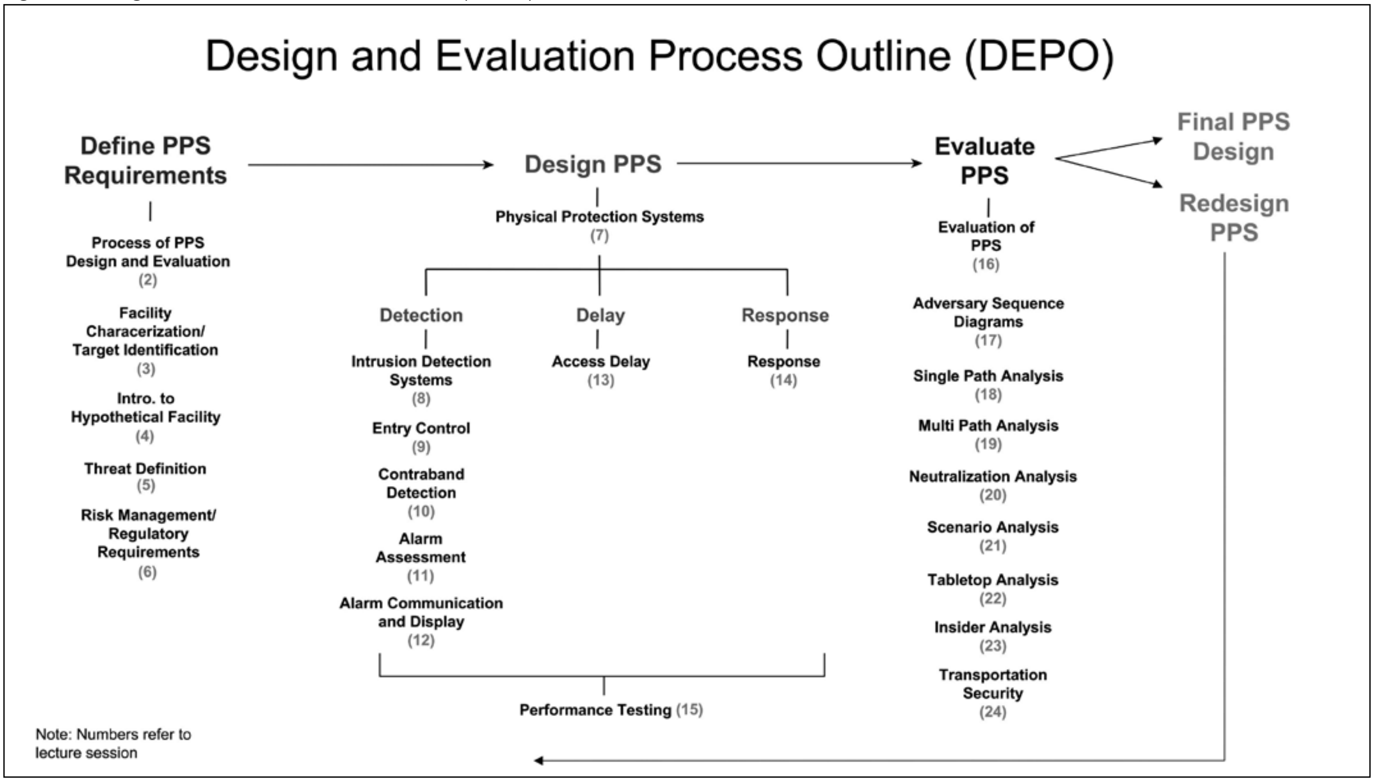
Contraband Detection
- Person, package, and vehicle searches
- Entry searches for metal and explosives
- Exit searches for nuclear material and shielding
- Search equipment technologies
- Contraband system design principles and practices

Alarm Assessment
- Surveillance and assessment
- Video alarm assessment system and components
- Camera and lighting coverage and layout
- Video alarm assessment system design principles and practices

Alarm Control and Display
- Alarm communication networks
- Alarm recording and display equipment
- Human factors and ergonomic design
- Alarm control and display system design principles and practices

Delay
- Delay time
- Passive and active delay technologies and components
- Delay system design principles and practices

Figure 2. Design and Evaluation Process Outline (DEPO)



Response

- Response time
- Guards and response forces
- Use of force continuum
- Equipment and training
- Response system design principles and practices

Performance Testing

- Performance testing of detection and delay components
- Types of tests
- Test objectives and test plans
- Probability of detection and confidence levels

Introduction to Evaluation

- Metrics of probability of system effectiveness, probability of interruption, and probability of neutralization
- Path analysis using adversary sequence diagram model
- Scenario analysis using tabletop exercises, computer simulations, and force-on-force exercises

Adversary Sequence Diagram

- Nuclear facility, target, and PPS modeling
- Protection layers, elements, and components
- Detection and delay values of components

Single Path Analysis

- Probability of interruption calculation using principle of timely detection, critical detection point, and cumulative detection probability
- Strategy for adding detection and delay to improve interruption

Multi-Path Analysis

- Overall system effectiveness
- Most vulnerable path determination
- Sensitivity and upgrade analysis

Neutralization

- Response force effectiveness after interruption
- Simple numerical model depending on numbers of adversaries, and response forces, time of arrival, and weapons

Scenario Analysis

- Credible scenario identification
- Direct and indirect scenarios
- Dependency of detection, delay, and response on scenarios
- Collusion of outsider adversaries with insiders

Tabletop Analysis

- Simulation of system effectiveness
- Scenario definition
- Role playing
- Introduction to randomness

Insider Protection

- Five-stage model for insider protection: screen, monitor, compartmentalize, detect, and respond
- System effectiveness analysis methodology

Transport Security

- DEPO methodology applied to nuclear material transport security
- Similarities and differences with respect to nuclear facility protection

Final Exercise

- ITC participants apply DEPO to a (second) LIMP hypothetical facility
- Each subgroup makes a presentation of vulnerability assessment and upgrades to PPS

Caricatures of ITC (and INMM) Leadership

During the period that the JNMM Technical Editor Dennis Mangan served as ITC course director, an artist was engaged to sketch caricatures of the instructors and students.

Structure

The structure of ITC is designed to enhance the learning experience. It consists of the following:

Lectures

Learning objectives have been defined for each of the topical modules listed and described above to focus and facilitate learning the major ideas associated with each subject. Many different subject matter experts from SNL present these lectures.

Subgroup Exercises

The class of forty-two participants is divided into seven subgroups, which consist of six students and one subgroup instructor. A subgroup exercise is associated with most of the modules. The subgroups begin with a review and discussion of the lecture material, followed by exercises to learn to apply the subject matter to the (first) hypothetical facility, and end with some additional practical discussion questions related to the subject. At the beginning of the course, the subgroup instructor is expected to lead the subgroup. During the ITC's three-week period, the instructor will encourage the subgroup members to lead their own exercises. In the final exercise, the group members work as a team with one of their own serving as leader; the subgroup instructor serves only as the consultant and monitor.

Daily Reviews

At the start of each day, one of the instructors presents a brief summary of the previous day's major points, based on the lectures, subgroups, and results of the daily quizzes.

Daily Quizzes

At the end of each day, the participants are tested on the major lecture points that are based on the modules' learning objectives. The quizzes contain true-false, multiple choice, and fill-in-the-blank questions. These quizzes are conducted anonymously but still provide useful feedback to the instructors and participants about the level of learning.

Daily Feedback

The participants are also requested to complete a daily feedback form that covers the lectures and subgroup exercises. This vehicle provides useful feedback to the ITC staff regarding usefulness and quality of the lectures, subgroups, training materials, and instructors.

Hands-on Test Experience

One hands-on subgroup exercise focuses on performance testing of sensor and delay components. This provides a practical experience that reinforces the performance testing module, provides several participants a first exposure to security equipment, and serves as a break from the classroom.

Field Trips

Field trips provide opportunities to observe in-the-field test and operational environments at U.S. nuclear facilities. In recent years, ITC participants have visited the SNL exterior and interior sensor and video test facilities, and the DOE National Training Center's Live Fire Range. Most classes have also included a visit to a U.S. Nuclear Regulatory Commission (NRC) licensed facility to observe an operational PPS at a nuclear power plant or a nuclear fuel cycle facility. These activities have generally been the most valued and appreciated aspect of ITC.

Guest Lectures

A set of guest lectures are incorporated into ITC prior to the Final Exercise. The objective is to provide the participants with the opportunity to hear and learn from U.S. and international guest lecturers regarding their best practices in the physical protection of nuclear material in their countries. The IAEA ITC Course Representative usually gives an overview of the IAEA Office of Nuclear Security program for member states. The IAEA also invites four international experts to make presentations about physical protection in their countries. Similarly, the United States provides four experts from DOS, DOE, (domestic and international), and NRC to present their approaches and programs to the participants. After the presentations, there is a significant period devoted to questions and answers so that the participants can have more interaction with the experts.

Team-building Events
Because the success of ITC learning depends on both individual learning and team performance, team-building experiences are built into the course agenda. The primary event is a picnic that is typically held in a National Forest group area during the first weekend. Participants often play volleyball and soccer and are introduced to some friendly informal U.S. sports, such as softball.

Cultural Events
The two weekends are a time for the participants and instructors to experience the tri-cultural environment of New Mexico. The instructors arrange trips to such places as museums and parks, and activities such as hiking and shopping in the areas of Albuquerque, Santa Fe, and Los Alamos.

Final Exercise
In the final two-day exercise, each subgroup uses the DEPO process a second time from start to finish by analyzing a second LIMP hypothetical facility and then recommending upgrades. Each subgroup then presents its analysis and solution to a small panel of SNL experts in the presence of the full class, with each member of the subgroup required to make part of the presentation. The panel asks a few questions to help reinforce key DEPO points. The presentations and solutions of each subgroup are unique and each subgroup learns from and applauds the solutions of the others.

Process
The process for preparing for each new ITC begins with the conclusion of the previous ITC. The ITC Instructional System Designer (ISD) analyzes the daily quizzes and course evaluations, adding those from the instructors and subgroup instructors, and prepares a report with recommendations for changes and improvements for the next ITC. The ITC course director reviews, prioritizes, and selects the revisions to be made for the next ITC and then meets with the ISD and selected subject matter experts to initiate the change process.

Meanwhile, the IAEA sends out the ITC Prospectus and invitation to nominate participants to all (non-U.S.) member states with nuclear programs. The ITC later selects the participants from the nominations with review and confirmation by the U.S. Selection criteria include some experience working in the field of nuclear material security and proficiency in the English language. Those who are ineligible include former ITC participants or recent participants (within five years) from the similar IAEA Regional Training Course (RTC) on the same topic.

The ITC course administrator also must begin selecting the Albuquerque hotel venue for the next ITC at an early date, and must work with the IAEA course coordinator to help address participants' questions and obtain foreign national access approval. Local arrangements continue up to and throughout the new ITC.

After the course material revisions are completed and peer-reviewed, the ITC course director selects SNL technical staff and sometimes managers to serve as subgroup instructors. Approximately two months before ITC begins, there is a two-week dry run of all the lectures for the lecturers and the subgroup instructors. In addition, the subgroup instructors are trained to lead the subgroup exercises by working through each one as a group themselves.

The ITC ISD, along with editorial and communications specialists, prepares the course materials twice—once for the subgroup instructor training and then again for the actual ITC, the latter incorporating final changes resulting from the dry run.

The last major step for the ITC course director prior to ITC is to form each subgroup from the set of selected nominees. The key to success is building diversity into each group based on nominees' job category, years of experience, and geographical balance. This leads to strong subgroups with the complementary skill and experience that provide for productive discussions, learning, and results.

Smoke but No Smoke Alarm
Equipment demonstrations are always better than showing pictures of equipment. One ITC access delay expert and lecturer decided to demonstrate the visual obscurant cold smoke. He opened the generator valves to let a small quantity escape into the front of the classroom. But when he went to turn off the valve it continued to spew smoke into the room. As the classroom continued to fill with smoke those present opened the windows to try to disperse the smoke outside. The course director had visions and an expectation that the hotel fire alarms and sprinkler system would activate, followed closely by the arrival of the fire department. He was greatly relieved at that time when the smoke detectors did not go off but often wondered later why they did not.

Conclusion

The planning and preparation for the next ITC is well underway. Course materials are being revised and updated. The dry run and subgroup instructor training will take place in August 2010. ITC-22 will be conducted in Albuquerque, October 17–November 5, 2010.

The author acknowledges the expert support received during recent ITCs from Amanda Ramirez for instructional system design and course materials revision, Loretta Humble for administrative management and international protocol, and Paul Ebel for training of subgroup instructors and critique of lecturers. There have been many subject matter experts, lecturers, and subgroup instructors too numerous to name who know that they have contributed to the success of ITC.

John Matter became ITC course director beginning with ITC-18. He was a lecturer and subject matter expert for several ITCs previous to that. He has been working in domestic and international physical protection for more than thirty years doing equipment testing, system design and implementation, assessment of physical protection systems, project and program management, and training. He is a technical manager at Sandia National Laboratories and a Fellow and past president of INMM.

Biker and Bike in the Classroom

For several ITCs it was customary to help break down cultural barriers and to promote social dialogue for the subgroup instructors to make brief presentations about their activities outside of work. One subgroup instructor was an avid biker and was persuaded by an instructor well known to be a prankster to ride his Harley Davidson into the classroom, which just happened to be adjacent to the hotel parking lot. Unbeknownst to the subgroup instructor, the jokester then called hotel security to report he had just seen a biker ride into the hotel meeting rooms. Fortunately, all's well that ends well: there was a lot of explaining to do but no charges were filed. Their names are being withheld to protect the guilty.

Nuclear Security at Research Reactors in Argentina

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Introduction

Research reactors are less powerful than nuclear power plants; nevertheless they could be a target for terrorists determined to steal the reactor fuel for:

- nuclear weapons, or
- dirty bombs.

Or terrorists could sabotage the reactor to disperse radiation into neighboring communities. For that reason, the nuclear security of research reactors, nuclear material and the facilities themselves must be protected against theft or sabotage.

Research Reactor

The regulations developed to protect nuclear power plants or other relevant nuclear installations (e.g., enrichment or reprocessing facilities) cannot easily be applied to research reactors, since there are important differences between them. Research reactors are often part of a larger research center or university where there are potentially many users representing various scientific disciplines and/or the research reactor is more likely to be located in or near a city for easy access by the users.

Persons not part of the reactor operation staff, e.g., researchers, should be able to easily access the facility.

In many cases, the perimeter protection of a research reactor, if there is such protection, is typically a wire fence without anti-vehicle barriers, motion sensors, or electronic/computer-based detection and assessment systems.

Research Reactor Conversion

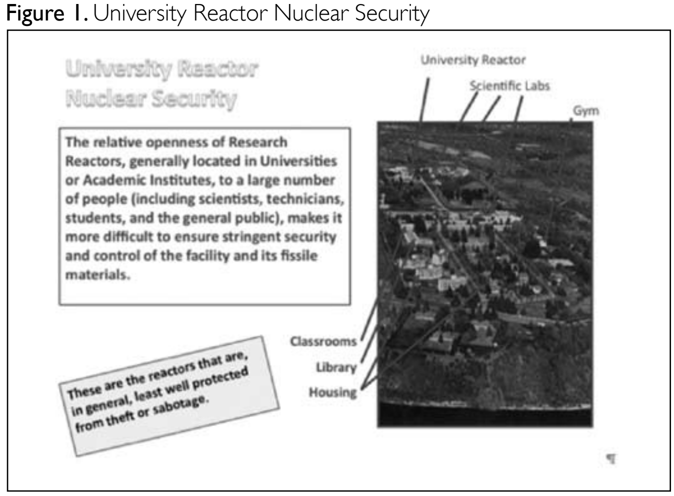
To minimize the risk associated with "nuclear security" of research reactors, an international program to convert all reactors using high enriched uranium to low enriched uranium (enrichment less than 20 percent in ^{235}U), was launched some years ago. Nevertheless there are still many research reactors using highly enriched uranium.

Note: In Argentina, there is no reactor fuel using enrichment higher than 20 percent in ^{235}U.

University Research Reactors

University research reactors, located in universities or academic institutes, are an easier target, due to their relative openness to a large number of people (including scientists, technicians, students, and the general public). It is more difficult to assure stringent security and control of the facility and its fissile materials.

Figure 1. University Reactor Nuclear Security



Argentina Nuclear Players

In Argentina, in the nuclear sector, there are three main players:

1. *Argentina Atomic Energy Commission (Comisión Nacional de Energía Atómica – CNEA).* It was created in 1950 and is mainly a research and development organization. CNEA is the owner and operator of all research reactors in Argentina, and most relevant nuclear facilities (excluding nuclear power plants). CNEA has the responsibility for a safe management of all Argentinean "radioactive waste"; through the Safety and Radiological Protection Department (Argentina National Law N° 24804)
2. *Nucleoeléctrica Argentina, Sociedad Anónima (NA S.A.).* NA S.A. is the operator of both nuclear power plants in operation in Argentina. NA S.A. also has a third nuclear power plant under construction, which is expected to be in operation in 2010.
3. *Argentina Nuclear Regulatory Authority (Autoridad Regulatoria Nuclear – ARN).* ARN performs all the nuclear regulatory activities in Argentina.

To this aim, the ARN has established a regulatory framework for all nuclear activities including physical protection. Its Standard AR 10.13.1 ("Physical Protection of Nuclear Materials and Installations") has the goal of establishing criteria and methods to prevent the commission of intentional events that may lead to severe radiological consequences or the unauthorized removal of nuclear materials.

Argentina Nuclear Power Plants, Research Reactors, and Critical Facilities in Operation

Nuclear Power Plants:

1. Atucha-1, PHWR, pressure vessel, 350 MWe, in operation since 1973 (Buenos Aires)
2. Embalse, PHWR, CANDU6, 600 MWe, in operation since 1984 (Córdoba)
3. Atucha-2, PHWR, pressure vessel, 700 MWe, under construction; expected to be in operation in 2010

Critical Facilities:

1. RA-0, Córdoba
2. RA-4, Rosario
3. RA-8, Bariloche

Research Reactors:

1. RA-1 (120 kW), Buenos Aires
2. RA-3 (10 MW), Buenos Aires
3. RA-6 (3 MW), Bariloche

Armed Forces of Argentina

Argentina has the traditional armed forces, depending on the Ministry of Defense:

- Argentina Army;
- Argentina Air Force; and
- Argentina Navy

But Argentina has another two armed forces, depending on the Department of Justice, Human Rights, and Homeland Security (Ministerio de Justicia, Seguridad y Derechos Humanos):

- Argentina National Gendarmerie; and
- Argentina Naval Prefecture

Argentina National Gendarmerie

The Argentine National Gendarmerie (Gendarmería Nacional Argentina; GNA) is the gendarmerie and corps of border guards of Argentina. The Argentine National Gendarmerie has a strength of 12,000. The Gendarmerie is primarily a frontier guard force but also fulfills other important roles.

Gendarmerie's main missions are:

- To provide security for Argentina's borders
- To provide security for places of national strategic importance (e.g., nuclear installations).

Gendarmerie is also used for other security missions, which include:

- Assisting provincial police services in maintaining public security in rural areas
- Preventing smuggling
- Fighting drug trafficking
- Fighting terrorism
- Fighting crimes "against life and freedom" (children and organ trade, slavery, etc.)
- Dealing with economic crime
- Dealing with environmental crime
- Dealing with illegal immigration

The Argentina National Gendarmerie is the guard force specifically responsible for providing nuclear security at nuclear facilities in Argentina.

Among others, this has the following advantages:

- They have been trained as protective forces and security guards.
- They are well trained and rewarded, retrained, and kept motivated.
- They have a career opportunity as well as redeployment possibilities in order to maintain the workforce and competence.

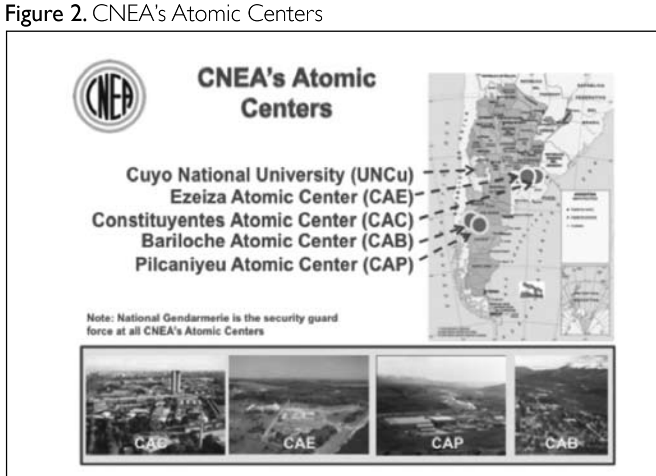
Note: In order to standardize (optimize) nuclear security across the country and facility types, the physical protection of Argentina is relevant nuclear facilities is performed by a unique national organization—the National Gendarmerie. National Gendarmerie is also the security guard force at all CNEA's Atomic Centers and at all Argentinean nuclear power plants.

Argentina Atomic Research Centers

The Argentina Atomic Energy Commission operates the following atomic research centers:

- Ezeiza Atomic Center (CAE)
- Constituyentes Atomic Center (CAC)
- Bariloche Atomic Center (CAB)
- Pilcaniyeu Atomic Center (CAP)

Figure 2. CNEA's Atomic Centers



In Argentina the license-holder's obligation is to assure "nuclear security" and emergency planning and other arrangements, necessary to ensure the limitation of potential nuclear damage.

The "license-holder" of all research reactors (critical facilities are not included) is the Argentina Atomic Energy Commission.

For licensing a research reactor, the Argentina Regulatory Authority requires the facility to follow its nuclear security regulations.

Argentina Research Reactors "Nuclear Security" System

At all research reactors, deterrence is achieved by implementing a physical protection system that adversaries perceive as too difficult to defeat; the nuclear security measures make the protected nuclear material or facility an unattractive target.

Atomic Center and Research Reactors Access Control

- All Argentinean research reactors are located inside an atomic center.
- At the entrances of all atomic centers (there is a unique entrance at each atomic centers) there is access control, with at least two guards, one from a private guard security organization and the other(s) from the National Gendarmerie.
- All research reactors have only one entrance to their building.
- At all research reactors, at any given time, there is an entrance guard, a private guard during working hours and an armed guard from Gendarmerie during non-working hours.
- All research reactors are located adjacent to a response force (Argentina Gendarmerie) with a reliable communications system between the reactor and the response force.
- At all research reactors the armed guard is a member of the National Gendarmerie. Note: Having personnel belonging to the same armed force (same personnel of the nuclear power plants) upgrades safety due to the standardization.
- All research reactors have at least two fences and there are at least two access control points before reaching the facility.
- At night all atomic centers have mobile Gendarmerie guards (patrols).

Note: The members of the private guard security organization do not carry arms.

Research Reactor RA-6

Research Reactor RA-6 is special because it is a university reactor. It is located on the campus of Instituto Balseiro. Instituto Balseiro was created in 1955 as a result of an agreement signed between the newly created National Atomic Energy Commission (CNEA) and the youngest of the six national universities in the country at that time, the National University of Cuyo (UNCu). It has the only undergraduate degree nuclear engineering career path in all Latin America (since 1977).

At Reactor RA-6, a new safety assessments study ("design basics threat" is identified) is done when required by the regulatory authority or when there is a change in the external conditions.

For its physical protection, RA-6 Reactor has:

- Twenty infrared movement detector sensors.
- Six TV camera/monitor safety systems, with monitors at:
  - the Reactor Control Access room and
  - at the Gendarmerie-Fence 2 Control
- Communication at the Reactor Control Access:
  - Landline phone
  - Mobile phone
  - Handy
- Every six months, the regulatory authority checks the physical protection system (e.g., fences).

Argentina Critical Facilities "Nuclear Security" System

Because critical facilities operate at zero power levels they have a limited amount of radioactive material on site; the standard for nuclear security regulation of these reactors is different.

Argentina regulations apply the minimum regulation needed, just to protect the public health and safety at critical facilities so they can effectively conduct education and research. These facilities pose minimal risk to public health and safety.

Critical Facility RA-8

- Not in operation
- No fuel at the site
- Hot stand-by

This facility was used for the verification of the CAREM Project calculation methods (different core configurations-thermal coefficients, etc.).

The owner and operator of Critical Facility RA-8 is the Argentina Atomic Energy Commission.

Critical Facility RA-0

The operator of Critical Facility RA-0 is the National University of Cordoba.

Its physical protection system has the following characteristics:

- Fence and window grills
- Infrared sensor (a passing of an animal would not trigger it)
  - Local alarm (sirens)
  - Remote (police station)
  - Periodical intrusion mock attack analysis and practices

Critical Facility RA-4

The operator of Critical Facility RA-4 is the National University of Rosario.

Its physical protection system has the following characteristics:

- Fence and window grills

- Two independent infrared detectors
  - Both local alarm (sirens) systems:
    - Remote (federal police station at 300 meters)
    - Remote to a private guard security organization of the university
- Periodical intrusion mock attack analysis and practices

Improvements

At most research reactors some improvement on nuclear security should be done since:

- Perimeter protection
  - Typically a wire fence. Anti-vehicle barriers should be added.
- Day-time protection
  - Access control by unarmed security guards. One armed security guard should be added.
- Night-protection
  - Locked doors and windows. One armed guard should be added.
- Access control
  - Screening is imperfect (handguns easy to bring through).
  - Explosive detection systems are less than optimal.

New Research Reactor Design

After the intentional airline crashes on September 11, a terrorist attack with airplanes on research reactors must be considered during its design. A study should be carried out to determine the possibility of a deliberate impact of an aircraft on the reactor.

If necessary an aircraft protection should be included in the building design.

OPAL Research Reactor

During the research reactor design:

- ARPANSA (Australian Regulatory Authority) requested an *assessment of the potential sabotage or terrorism and the consequences of successful attacks on these targets* from Australian Nuclear Science and Technology Organization (ANSTO). The assessment included an examination of the irradiation and experimental facilities and the consequences of the impact of a large commercial aircraft on the facility.
- The design basis threat and the reviewed site assessment of potential targets form the basis for evaluating the adequacy of the nuclear security and security arrangements.
- In addition, ARPANSA called for an assessment by ANSTO on the potential physical damage and radiological consequences of *acts of sabotage or terrorism.*

Some measures taken during the OPAL Reactor construction at the access to controlled area:

- Reduced door widths
- Bullet proof walls (stainless steel sheets)
- Bullet proof windows

Figure 3. OPAL Research Reactor

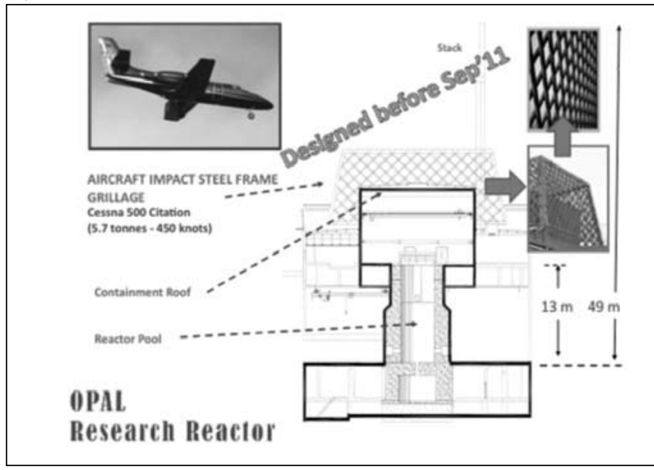


Figure 4. OPAL Research Reactor

- Steel bars on the ventilation ducts
- Further secret security measures (which are only known by authorized personnel).

Suggested Improvements at Argentina Research Reactors

- Increased patrols
- Visitors escorted access to protected area
- Better security forces and capabilities
- Additional physical barriers
- New vehicle bomb blast analysis to determine if enhanced protection (blast shields, greater setbacks) are needed
- Wire fence with anti-vehicle barriers, and with motion sensors or more restrictive site access
- Visitors to the research reactor enter through the reactor administrative offices, located in a building next to the reactor building (e.g., MIT research reactor)
- Visitors should not be allowed to bring into the reactor building:
  - Backpacks or bags, (they should be left at the administrative offices)

- Cameras and recording instruments

- Reactor access control should be hardened, i.e., constructed and located in such a manner so as to allow it to continue operating at all times, even when under attack (as the presence of adversaries may neutralize guards, preventing them from alerting response forces).
- Electronic/computer-based detection and assessment systems should be

Practice of the Physical Protection of Nuclear Materials and Nuclear Facilities in China

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Introduction

China has had a nuclear industry for many years. Since the 1980s, when the reform and opening-up policy was adopted, China has been making efforts to enhance the peaceful uses of nuclear energy to promote the sustainable development of energy. Thus far, six nuclear power plants (eleven power reactors) are in operation and several other nuclear power plants are under construction in mainland China. According to the national mid-long-term nuclear power development plan, the target will be 40GW installed capacity and 18GW constructed capacity by 2020.

Physical protection is important to ensure the safe operation of nuclear facilities and to protect the security of nuclear materials in lawful use, production, storage, and transportation, and it plays an important role in China's national nuclear materials control system.

Nuclear terrorism is a serious threat to the security of the public and nuclear facilities and the international community has placed great attention on nuclear terrorist activities and adopted preventive measures. China supports the International Atomic Energy Agency (IAEA) in its role in preventing potential nuclear terrorist activities and made active contributions to the amendment to the Convention on Physical Protection of Nuclear Material (CPPNM) for strengthening the international regime on physical protection.

The Legal Framework of Nuclear Materials Physical Protection

Physical protection is a key component of China's national nuclear materials control system. The objectives of the Chinese national regime on nuclear materials control and security are:

- to ensure the security and lawful use of nuclear materials;
- to prevent theft and illegal removal of nuclear materials;
- to protect nuclear materials and nuclear facilities against sabotage.

Before China concluded the CPPNM in 1989, the Chinese State Council had already promulgated the Regulations on Nuclear Materials Control (hereinafter referred to as the "Regulations") in June 1987. The Regulations are the legal basis of the Chinese national nuclear materials control system and set forth rules to ensure the security and lawful use of nuclear materials and to prevent theft, sabotage, loss, illegal use, and removal of nuclear materials.

According to the Regulations, Plutonium-239, Uranium-233 and 235, Tritium, enriched Lithium-6, and the materials containing the isotopes above, are the nuclear materials to be controlled.

To implement the Regulations and fulfill the international obligations in keeping with the CPPNM, the Rules for the Implementation of Regulations on Nuclear Materials Control (hereinafter referred to as the "Implementation Rules") and the Rules of Physical Protection for International Transfer of Nuclear Materials were issued by the competent authorities in 1990 and 1994 respectively.

The Implementation Rules define the responsibilities of administrative authorities and the operators of nuclear facilities, the procedures of license application and review, and the fundamental requirements of national nuclear materials control and security.

The major regulation documents on nuclear materials control and physical protection are:

- Regulations on Nuclear Materials Control (1987)
- Rules for the Implementation of Regulations on Nuclear Materials Control (1990)
- Rules on Physical Protection for International Nuclear Materials Transport (1994)
- Rules on Inspection of Nuclear Materials Control (1997)
- Rules on Security of Nuclear Power Plants (1997)

Based on the Regulations and Implementation Rules, the technical guidelines on the *Physical Protection of Nuclear Facilities, the Physical Protection of Nuclear Materials during Transport and the Access Control at Nuclear Facilities* are also made to guide implementation of physical protection measures effectively.

Measures for Nuclear Materials Control and Security

The China Atomic Energy Authority (CAEA) is a Chinese governmental agency in charge of implementing and managing national nuclear materials control and physical protection measures, and has the responsibilities of:

- Maintaining a state system of accounting for and control of nuclear materials (SSAC);
- Establishing a national system on physical protection of nuclear materials and nuclear facilities;

- Formulating the rules and technical guidelines on nuclear materials control and physical protection;
- Managing licenses of nuclear materials safeguards and physical protection;
- Conducting domestic inspections to verify compliance of licensees on nuclear materials control and security.

Licensing

According to the Regulations, licensing is the basic requirement of China's national nuclear materials control system to ensure lawful and safe use of nuclear materials. Any organization or individuals intending to use, produce, or store nuclear materials must apply for the licenses and get approval from state competent authorities. The necessary information about types, characterizations, and quantities of nuclear materials, operation location, and the nuclear materials control and security management system at facilities must be described in the license application documents. Other information such as facility plans for nuclear materials accounting and control (NMA&C) and physical protection (PP), and the implementation measures on NMC&A and PP also is required to be provided as attachments.

Based on the requirements of the Regulations, the licensee has the responsibility to establish a facility-level SSAC system and a physical security system within the facilities. The functions of SSAC are to prevent unlawful use and unauthorized removal of nuclear materials. The functions of physical protection are to protect the security of nuclear materials and nuclear facilities against malevolent activities, for example, theft of nuclear material and sabotage of nuclear facilities.

Inspection

Inspection is an important measure in China's national nuclear materials control system. The National Office of Nuclear Materials Control of CAEA is responsible for implementing the domestic inspection regime to verify the compliance of licensees. The objectives of inspection are to verify if the measures of nuclear materials control and physical protection are reliable and effective and to prevent the unauthorized removal or unlawful use/taking of nuclear materials.

Reporting

The facility operator has the responsibility to submit the nuclear materials accounting documents to the National Office of Nuclear Materials Control on time and reporting as soon as possible in case of theft, loss, illegal removal, or sabotage of nuclear materials and facilities, and implementing measures to locate and recover missing or stolen nuclear materials and mitigating or minimizing the radiological consequences of sabotage.

Physical Protection

The facility operators have the responsibility to establish a facility-level organization in charge of the security of facilities and nuclear materials in the process of use, production, and storage.

The physical protection system consists of three elements—detection, delay, and response. To ensure the security of nuclear materials and radioactive sources, the facility should set up a strict management system for nuclear materials security and multiple layers of protection are required for the important targets to be protected.

Detection is the first line of defense; technical measures of perimeter detection, access control, video camera assessment, and personnel identification are applied. The physical barrier is the second line of defense to delay the adversary to reach the targets effectively; technical measures such as fences, hardened doors, meshed windows, locks, fixed devices, balance magnetic switches, etc. are installed in the materials storage areas.

An emergency plan is created to respond to unauthorized removal of nuclear materials or sabotage of nuclear facilities. The response forces at nuclear facilities consist of armed forces and security guards. The armed force is in charge of the security of the entire area within the facility and combating the malevolent activities of outside adversaries. The security guards are in charge of the security of specific locations inside the facilities and managing the physical protection system operation.

Personnel management is an important security assurance measure at nuclear facilities. Facility operators are asked to establish a set of rules that define the responsibilities for nuclear safety and security for different management and work positions.

To accommodate the requirements of Regulations, the following principles are required to be used in the process of physical protection system design and evaluation:

- The physical protection system is required on the basis of the threat evaluation;
- The concepts of detection balance and defense in depth should be applied;
- The graded protection measures, according to the relative attractiveness, the nature of nuclear materials, and the potential consequences; should be followed;
- Emergency plans should be considered to respond to unauthorized removal of nuclear materials or sabotage of nuclear facilities or nuclear materials; and
- There should be protection of confidential information.

Similar to the IAEA recommendations on physical protection of nuclear materials, the different levels of protection requirements are set up for three categories of nuclear materials depending on the form, quantity and harmfulness.

The features of physical protection measures for category I nuclear materials site are:

- Vaults or specially designed security containers for storing nuclear materials;
- At least two complete and reliable physical barriers;

Table 1. Categorization of nuclear materials

Material	Form	Category		
		I	II	III
Plutonium	Unirradiated	More than 2kg	10g-2kg	Less than 10g
Uranium	Unirradiated, ^{235}U enrichment is 20% or more	More than 5kg	1kg-5kg	10g-1kg
	Unirradiated, ^{235}U enrichment to 10-20%		More than 20kg	1kg-20kg
	Unirradiated, ^{235}U enrichment is less than 10% (not including natural uranium and depleted uranium)		More than 300kg	10kg-300kg
Tritium	Unirradiated, counted by quantities of tritium	More than 10g	1g-10g	0.1g-1g
Lithium	Enriched lithium, counted by quantities of lithium		More than 20kg	1kg-20kg

- A technical protection system with detection sensors, alarms and monitoring stations;
- Access control system, special pass or badge, rule of "double men and double lock"; and
- Armed forces.

For category II nuclear materials site, the measures of protection are:

- Strong rooms or solid containers;
- Two physical barriers, at least one is complete and reliable;
- Alarm and monitoring equipments should be installed to protect vital areas; and
- Security guards twenty-four hours a day.

For category III nuclear materials site, one complete and reliable physical barrier and security guards are required.

Each nuclear facility in China has its own professional security organization in charge of the physical protection of nuclear materials and facilities. China's major nuclear facilities are protected by the armed forces.

Materials Balance and Accounting

To prevent the unlawful use and illegal removal of nuclear materials, the licensee has the responsibility to establish a facility-level NMC&A system. The principle of nuclear materials accounting is on the basis of closed materials balance. Each facility should set up different materials balance areas and key measurement points according to the characteristics of the facility and the flow of nuclear materials, the necessary measurements and verifications are applied at different key measurement points to measure the mass, concentration, and isotopic composition of nuclear materials.

Improvement of the Effectiveness of Nuclear Security System

The performance of a physical protection system should be evaluated to maintain its effectiveness. Facility operators are asked to take appropriate steps to improve their physical protection systems. The improvement of system effectiveness is focused on enhancing the deterrence capability to discourage an adversary from attempting to commit a crime, which is considered through the evaluations based on the system vulnerability analysis, which are made on a credible estimation of risk and threat.

The performance test of detection and assessment and using reliable and compensatory techniques (intrusion detection/surveillance devices, radiation measurement/special nuclear materials detection, and communication) are the technical approaches to strengthen the reliability of the system.

NMC&A and physical protection are two lines of defense for protecting the security of nuclear materials. So the integration of physical protection and NMC&A, and combination of guard forces and technologies should be considered as an important role in the security management.

Technical Training and International Cooperation on Physical Protection

Training plays an important role in China's national nuclear materials control and security management system. It also is an important way to renew the knowledge on nuclear security for facility operators to upgrade their safeguards and security system. In cooperation with the IAEA, China has held a number of regional and national training courses on physical protection and nuclear security.

Under the framework of the China-U.S. bilateral agreement on peaceful uses of nuclear technology, a technical demonstration on integrated nuclear materials management on safeguards and physical protection was jointly organized by CAEA and the U.S. Department of Energy/National Nuclear Security Administration (DOE/NNSA) in October 2005 to introduce modern technology development on nuclear safeguards, materials accounting and control, and physical protection.

To support the security of the 2008 Beijing Summer Olympic Games, CAEA, worked with the IAEA and the DOE/NNSA to conduct a number of trainings for officials from the Ministry of Public Security, Border Control and Customs, for strengthening the response capabilities for major public events and implemented physical security system upgrades and radioactive sources recovery at facilities near Olympic venues.

As a partner state of the Global Initiative to Combat Nuclear Terrorism, the Ministry of Foreign Affairs and CAEA, in cooperation with the U.S. DOE/NNSA, organized a scenario-based workshop on radioactive detection and emergency response in December 2007. More than sixty participants from twenty countries attended the workshop.

To strengthen the training capability on nuclear safeguards and security, CAEA and the IAEA jointly established a "CAEA-IAEA Joint Training Center on Nuclear Safeguards and Security" in December 2006, located at the China Institute of Atomic Energy (CIAE).

Conclusion

Physical protection against the theft or other unlawful taking of nuclear materials and the sabotage of nuclear materials and facilities by individuals or groups is a matter of national and international concern. The Chinese government has attached great importance to the physical protection of nuclear material and nuclear facilities by formulating the relevant regulations and establishing an effective system on nuclear material control and physical protection to ensure the safe use of nuclear material and the security of nuclear facility.

China supports strengthening the international regime on the physical protection of nuclear material and nuclear facilities. The Chinese government encourages international cooperation on physical protection and is willing to make continuous efforts toward promoting the development of nuclear security through international cooperation.

Russian Experience in Development/Upgrades of Physical Protection Systems for Nuclear Materials and Facilities

Alexander Izmaylov
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Abstract

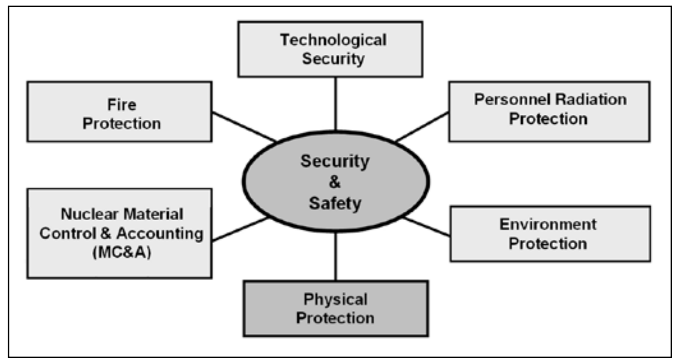
This paper deals with the Russian experience in the area of the physical protection systems (PPS) development (improvement) for nuclear materials and facilities. The PPS life cycle is analyzed. Special emphasis is placed on a pre-design stage of the PPS development connected with a vulnerability analysis, a PPS effectiveness assessment, and a conceptual design. It is pointed out that a wide range of high-efficiency security equipment integrated in a PPS for nuclear sites has been developed in Russia. Special attention is given to the development of the Automated Transportation Security System (ATSS) and the State Corporation Rosatom Information System designed to ensure monitoring of the PPS operation at Rosatom sites. Issues related to the training of personnel and professional improvement in the area of physical protection both at the national and international level are emphasized. This paper has been produced based on the proceedings used by the author in his presentation on the 21st International Training Course in Albuquerque in April 2009.

Introduction

The potential for nuclear terrorist actions is a serious threat to international peace and security that might lead to negative political, economic, and social consequences both for individual states and for the whole of mankind. Therefore, the urgency of the development and implementation of counterterrorist operations is vital today. The international organizations, such as the International Atomic Energy Agency (IAEA) and the United Nations Security Council, have developed and adopted appropriate documents including the documents on nuclear security.[1-4] The IAEA has developed a global plan of activities on nuclear security.[5] The stated tasks are also being solved at the national level by the IAEA participating countries. In particular, the corresponding laws, regulations, and other documents related to physical protection of Russian nuclear materials and facilities have been developed and are being continuously updated. Considerable practical efforts are applied to enhancement of physical protection at the state and site level in the Russian Federation.

The present paper illustrates the Russian experience in the area of the PPS improvement for the protection of nuclear materials and installations at the sites of the State Corporation for Atomic Energy Rosatom that places special emphasis on the problem. The PPS improvement at the Russian nuclear sites is carried out based on the system approach that primarily suggests the definition of a purpose and objectives of physical protection of the site from potential threats followed by the development of general concepts including organizational and technical measures and appropriate documents (provisions, instructions, etc.). A process of the PPS development culminates with the equipment procurement, installation, acceptance testing, and commissioning. More detailed description of the issues is given below.

Figure 1. Physical protection as a part of nuclear site safety and security



It is important to note that the PPS is considered as a part of the security system of the site but not as an independent system. Figure 1 shows the PPS interaction with other security systems (radiation, fire protection, security, control and accounting of nuclear materials, and others).

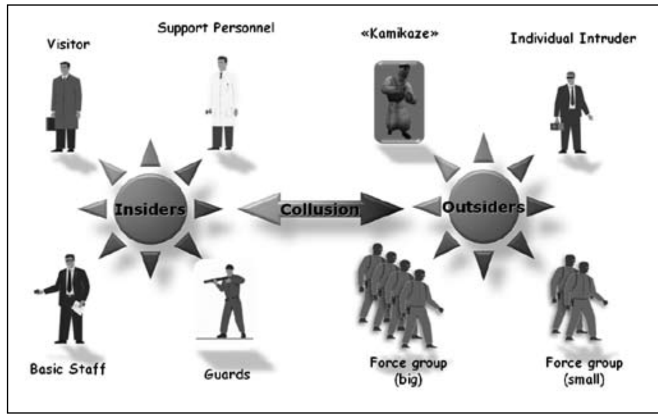
Potential Threats

The PPS development for new sites or its upgrade at the existing nuclear sites starts with the assessment of potential threats. There are different types of potential threats, the realization of which, relative to nuclear materials and installations, might lead to serious after-effects depending on the geopolitical position of a nuclear site and its technological features. Natural disasters and technogenic troubles, as well as a sabotage act at the site or a theft of nuclear and radioactive materials can lead to incident or disaster. The current regulatory documents in Russia applied to any nuclear site design incorporate the requirements considering natural disasters (earthquakes, floods, hurricanes, etc.). Technogenic troubles are connected with equipment unreliability, personnel (operators) incorrect operations, lack of safety culture, and not least, a set of unfavorable circumstances (a dramatic example is the Chernobyl catastrophe).

Any act of terrorism or sabotage is a result of purposeful activities of adversaries (a person or a group of persons) aimed at causing damage to the site or achieving political ambitions. Nuclear material theft might lead to disturbance of the nonproliferation regime. The theft of radioactive materials might be purposed for the development of a dirty bomb.[6] All of these aspects will refer both to stationary sites and nuclear shipments. The performance of any of the threats itemized above might lead to different after-effects: malfunction of site operation and even a global catastrophe such as Chernobyl. An evaluation of a scope of consequences in combination with the risk assessment of any of the threats should allow for efficient use of funding allocated to the security of a nuclear site. It is very important to provide balanced protection of the site from different threats. Protection of nuclear materials and installations from terrorism/sabotage and nuclear thefts is a primary and challenging task.

To provide a success in this area it is necessary to determine a so-called "design basis threat" (DBT) at the state, agency, and site levels. The state-level DBT describes a general character, more like the declarative one due to the need to cover the whole variety of the Russian nuclear sites including nuclear power plants (NPP) and different sites of the nuclear fuel cycle. The agency-level design threats are mostly particular and reflect a specific character of the nuclear site. The agency-level DBT concretizes the threats and adversary profiles even more and reflect a specific character of the site (type, nuclear material category, geopolitical position, criminal situation in the region, etc.). Figure 2 shows different types of adversaries trying to realize the potential threats. Specific threats and adversary profiles are considered for each site individually when upgrading the existing PPS at Rosatom sites based on the approved documents and regulations containing the state-level design DBT.

Figure 2. Adversary classification



Regulatory and Legal Base in the Area of Physical Protection

All the procedures and requirements of PPS upgrades should be determined in the appropriate regulatory and legal documents (laws, decrees of the Russian Federation government, orders of agency headquarters that control the nuclear sites, orders of nuclear site administration, etc.). Therefore, it is important to highlight the international fundamental documents[3,4] as well as methodological recommendations (guidance) on different aspects of physical protection of nuclear materials and installations, nine of which have already been developed, adopted, and may be used by the IAEA participating countries.

The following Russian federal-level documents are primarily used for PPS upgrade in Russia:

- Federal laws[7, 8] directly related to physical protection
- Federal laws implicitly connected with this subject ("On national security," "On transportation security," etc.)
- Basic regulatory document[9] adopted by the Russian Federation government

Hereupon, a wide range of agency-level regulations have been developed in Rosatom providing the details of the mentioned above federal level documents. Examples include:

- General requirements to PPS and its components
- Provisions on interactions between all organizations responsible for assurance of physical protection
- Provision on PPS status monitoring
- Recommendations on PPS design, implementation, and operation management
- Methodologies of vulnerability analysis, PPS effectiveness assessment, conceptual design, and others.

Most of these documents were developed under the Materials Protection, Control, and Accounting (MPC&A) Russian-American Cooperation Program.

Main Principles of PPS Development

The following principles are the basis for the PPS development for the Russian nuclear sites:

- Physical Protection Adequacy to DBT
- Protection-in-depth. (Separation of Protection Layers)
- Timely Response to Accepted Threat
- Protection Uniformity
- Scheduled Monitoring of PPS
- General Technical Principles (Reliability, Survivability, Compatibility of Elements, Standardization, etc.).

All these principles are incorporated in the regulatory and legal documents and are obligations that should be observed when developing and operating a PPS.

Figure 3. Life cycle of the physical protection system

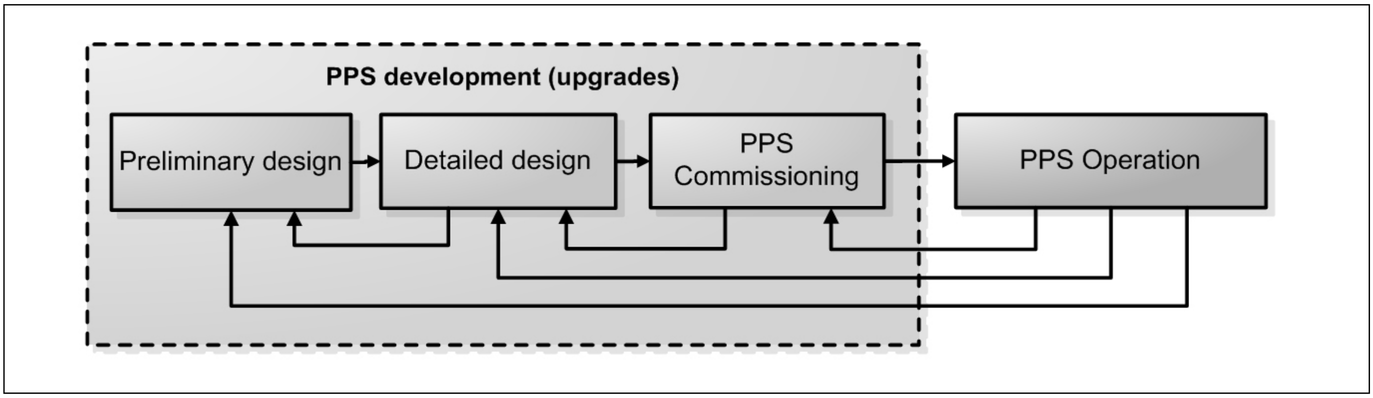


Figure 3 shows the **stages of PPS development** for the Russian nuclear sites. The PPS development includes a pre-design, design and implementation stage. "Feedback links" between the stages reflect the need for performance of repeat activities caused by different factors (change of location and content of physical protection subjects, etc.).

Special emphasis in the Russian experience is put at a pre-design stage including the following milestones:

- Vulnerability analysis of site incorporating the assessment of DBT
- Categorization of physical protection subjects including nuclear materials and critical elements of nuclear installations
- PPS effectiveness assessment
- PPS conceptual design
- Development of formal requirements to PPS (statement of work).

The PPS optimization by the cost-effectiveness criterion is being carried out in particular at this stage. With this view special methods and computer programs have been developed to evaluate the effectiveness of proposed organizational and technical solutions.

Vulnerability Analysis of Nuclear Sites, PPS Effectiveness Assessment and Conceptual Design

To perform a vulnerability analysis, it is necessary to determine the subjects of physical protection (SPP), potential threats, and adversary profiles for each subject. In other words, it is important to specify—what, and from whom the subject should be protected. The methods of the SPP determination are well-developed both in Russia and the United States and, as a rule, are based on mathematical tools of a graph theory. The appropriate regulatory document has been developed and is in use now in Rosatom.[10]

The results obtained at a stage of the vulnerability analysis are applied as initial data for an evaluation of the PPS effectiveness for each SPP, where we can get the answer—how do we protect the SPP? The tools for the PPS effectiveness assessment have been developed in Rosatom and are widely used. The Vega-2 computer program was designed and approved[11] to provide computerized calculations with regard to the stated analysis.[12,13] The program is based on the mathematical tools of Markov chains and the Monte Carlo method. More emphasis is put on initial data collection (equipment probabilistic characteristics, time needed to defeat physical barriers by adversaries, and others).

Figure 4. Computer program "Polygon" as a training simulator

The "Polygon" computerized simulation program has been designed to assess the results of combat operations between adversaries and the guard personnel in conflict situations.[14] Under Russian-American cooperation, the Polygon program, as a training simulator for the guard personnel training, has been delivered to the MVD military units, who ensure protection of Rosatom sites (Figure 4). Both programs are certified, registered in the state register of computer programs, and are widely used at Rosatom sites, and in other agencies and organizations.

The methods of a conceptual design are based on the results of an assessment of the PPS effectiveness. Once the results

Figure 5. Vehicle radiation monitor

Figure 6. Access control system

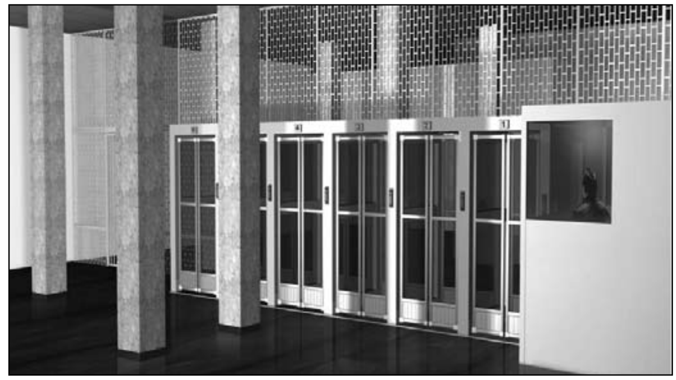


Figure 7. Central alarm station

detect the weak points in the PPS, conceptual proposals will be developed to eliminate them. The effectiveness of these proposals is justified by the above-mentioned tools providing a choice of cost-effectiveness options.

Russian Technical Security Systems and Equipment

It is necessary to have a certain range of technical security systems (intrusion detection devices, monitoring, access control, communications systems) to implement the conceptual design proposals and engineering solutions. In fact, all the necessary security equipment has been developed and is widely used in Rosatom. Proceeding from the importance of the purpose of their use the systems are subject to careful choice, testing, and certification for implementation at nuclear sites. Figures 5, 6, 7 show some examples of such security equipment.

It is no secret that assurance of physical protection during transportation is the weakest link in security provision for any country of the world. To this point the Automated Transportation Security System (ATSS) has been developed and implemented in Russia under the MPC&A Program. ATSS is presented in the figures. Some activities in the area of the PPS development at specific Rosatom sites are funded by the U.S. Department of Energy.

PPS Operational Status Monitoring at Rosatom Sites

To monitor PPS operability at the Rosatom sites, a two-level information system has been designed.[15] At the upper level (Rosatom HQ), a workstation (WS) has been deployed to receive and treat all site information including PPS operation, results of the agency inspection, etc. At the lower level Rosatom sites, WSs have also been deployed to receive necessary information and provide continuous monitoring of the PPS operational status by the security analyst. Such information system will allow for monitoring the protection of Rosatom nuclear sites in full and, if necessary, introducing corrective actions aimed, for example, to optimize funding distribution allocated for physical protection enhancement.

Physical Protection Personnel Training

It is necessary to have trained personnel to effectively develop and operate a PPS. Special attention is placed on this problem in Russia. The Moscow Engineering Physics Institute (Nuclear University) trains engineers and masters of science for the qualification of nuclear nonproliferation (physical protection, control, and accounting of nuclear materials). Repeat and advanced training of physical protection specialists is conducted in the Rosatom training centers (the Inter-agency Specialized Training Center in Obninsk and others).

Under the auspices of the IAEA the Russian physical protection experts take an active part in the development of training courses and delivering lectures in different countries.

Summary

In Russia, great emphasis is placed on the problem of physical protection of nuclear materials and facilities. Regulatory and legal documents have been developed based on IAEA international documents and taking into account the Russian specific conditions.

The PPS development (improvement) for nuclear sites is performed based on the system approach. The design basis threats have been determined. A vulnerability analysis, assessment of the effectiveness, and a conceptual design of PPS are being conducted allowing to optimize them by the cost-effectiveness criterion.

A wide range of technical security systems have been designed, produced, and, in practice, are extensively used at nuclear sites and during nuclear transportation.

Training and advanced training of physical protection personnel is carried out in the Russian high school institutes and universities and agency training centers. The information system has been developed in Rosatom to ensure monitoring of PPS operational status at the specific nuclear sites.

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Integrated Nuclear Security Model for Nuclear Facilities and Nuclear Material

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Abstract
As in many other countries, Spanish nuclear security has undergone a substantial change, increasing requirements and implementing measures since the events of September 11, 2001. Spain, following international recommendations and implementing the Fundamental Principles of the Convention on Physical Protection of Nuclear Material and Nuclear Facilities has established a national nuclear security regime to protect the public and environment against the malevolent use of nuclear and radioactive material. This regime is structured in three lines of defense, and the first, called the Integrated Nuclear Security Model, deals with protecting nuclear facilities against radiological sabotage and theft of nuclear material. This document gives open and basic information about responsibilities of licensees and Spanish competent authorities, the regulatory framework, and the process of improving nuclear security.

Introduction
First, it is necessary to distinguish between the Spanish Nuclear Security Regimen (SNSR or Regime) whose scope, goals, and structure are larger than the Integrated Nuclear Security Model (INSM or Model).

Secondly, in order to know more details about INSM, this paper presents a brief nuclear security history, starting[1] in 1995 when a royal decree was issued, then goes through the important changes because of international terrorist attacks, the new regulation on physical protection (PP) issued by the Nuclear Safety Council (CSN) in 2006, and ending with the project of integrating the security cornerstone into the Spanish Reactor Oversight Project.[2]

Finally, in order to be more pragmatic, some details about the PP systems in Spanish nuclear facilities are introduced along with brief answers to the three basic physical protection questions:

- What must Spain protect?
- From what or whom?
- What level of protection is needed?

Spanish Nuclear Security Regime
In November 2007, Spain accepted the *Amendment of the Convention of PPNM* and its fundamental principles, which means the responsibility for the establishment, implementation, and maintenance of a PP regime rests with the state through an appropriate legislative framework[3] for granting authorization and assigning three competent authorities (the Ministry of Interior, the Ministry of Industry, and CSN) with adequate authority, competence, and financial and human resources. In this PP regime, the prime responsibility for implementing the various elements of a PP system rests with the holders of the licenses who contract private security companies to carry out the PP functions according to national laws on civil security and private security, respectively.

This Spanish regime has a basic objective, which is to protect the public and environment against the malevolent use of nuclear or radioactive material, but its specific objectives are:

- protecting nuclear and radioactive materials and facilities against theft and sabotage;
- preventing and fighting against nuclear and radiological crime and terrorism;
- detecting trafficking of nuclear and radioactive materials and orphan sources;
- complying with the international agreements; and
- protecting these national strategic and critical infrastructures.

Following the principle of *Defense in Depth* and the concept of developing several layers and methods of protection that an adversary has to overcome or circumvent in order to achieve his objectives, the Spanish Regime is structured in three defense lines:

- **First line of defense,** with the purpose of achieving the first objective mentioned before, is protecting nuclear and radioactive materials and facilities against theft and sabotage, what has developed the *Integrated Nuclear Security Model (INSM)* focus on nuclear facilities.
- **Second line of defense**, has the goal of preventing malicious acts involving radioactive material, detecting illicit trafficking, and recovering orphan sources at the ports, borders and other facilities.[4]
- **Third line of defense** is through emergency plans to respond against any security event and minimize or mitigate their consequences.

What Spain Has to Protect

The following nuclear facilities or practices are included in the first line of defense on nuclear materials and nuclear facilities in Spain:

- Eight nuclear reactors (all of them light water Westinghouse, GE, and Siemens technology although there was one graphite and gas, which closed twenty years ago) in six sites that produce around 20 percent of Spain's electric energy demand.
- Independent spent fuel storage installation (ISFSI) with HI-STOR type containers.
- A fuel factory that imports uranium with an enrichment below 5 percent and makes fuel assemblies to national and other European NNPs.
- Regarding radioactive waste repositories, Spain has low- and medium-storage and meanwhile it is going to build a central storage to keep high radioactive waste.[5]
- As in other nuclear countries, Spain must protect one of the most vulnerable steps in this business, nuclear transport, most of which is category III but some is category II.[6]
- Finally, several hundred high active sealed sources in hospitals, industry, and research, fixed and mobile.

Threat Definition: To Protect From What?

Although the Convention on Physical Protection of Nuclear Materials (CPPNM) Fundamental Principle G says that the Physical Protection systems (PPS) should be based on the state's current evaluation of the threat, Spain has not defined a formal design basis threat (DBT). However, in order to cover this important gap, which is necessary to design the PPS, the CSN has incorporated a catalog of scenarios in the new security regulation *Security Instruction IS-09* for which a nuclear power plant(NPP) must be able to defend against.

However, in order to comply with the CPPNM, there is a formal agreement between the Ministry of Interior and the CSN to define and maintain a DBT for nuclear material and facilities and other radioactive material.

It is necessary to point out that in Spain there is a nationalist terrorist group (ETA) that since the beginning of 1970 has used terrorism to gain its independence. ETA did not allow starting[7] the operation of the NPP Lemoniz built in Bilbao in the 1980s.

Another threat against the PP of nuclear facilities is Greenpeace, whose activists have been able to jump fences, avoid being caught by guards, and climb to the top of the reactor building spreading banners against nuclear power. That happened in the oldest Spanish NNP[8] in April 2002.

Brief History of Spanish Nuclear Security

Although the *Nuclear Energy Law* was published in 1964 and several nuclear safety and radiological protection regulations have been issued, only one Royal Decree from 1995 addresses the PP requirements for protecting materials and nuclear facilities against radiological sabotage and theft of nuclear material.

Royal Decree 158 puts into effect Spain's obligation from the original CPPNM categorizing the nuclear material in three groups (Spain only deals with Category III because of the low-enriched uranium of the fresh fuel and Category II because of the spent fuel) established that any activity involving nuclear material require specific authorization, valid for two years, granted by Ministry of Industry after requiring technical reports[9] from CSN and Ministry of Interior. The holder of the authorization is made legally responsible for the security of nuclear material under his control and must report loss or theft to the security forces.

Worldwide the September 2001 attacks opened the nuclear sector's eyes showing another issue to be concerned with and regulators and licensees realized the cause of a nuclear accident could come from outside.

On April 26, 2002—coinciding with the Chernobyl anniversary—there was a security event: a Greenpeace intrusion at the Jose Cabrera NPP, which had a significant impact on public opinion and showed the lack of security by allowing trespassing on a strategic facility and provoke an important radiological sabotage.

In June 2002, the *Security Integrated Model for Physical Protection of Nuclear Power Plants* was approved and a working group composed of personnel from the competent authorities and from private nuclear companies started to develop down a new regulation of nuclear security criteria and measures to improve the PP systems to avoid any attacks or intrusion.

In July 2006, after inspection campaigns jointly performed by CSN's security inspectors and law enforcement agencies' (LEAs) agents with the purpose of verifying the feasibility and adequacy of the implementation of such criteria into the PP systems of nuclear facilities, the CSN issued the new nuclear security regulation called the *Security Instruction IS-09*[10] and all the nuclear facilities had one year to set up those security measures.

Security Integrated Model

The Security Integrated Model is working in the first line of defense and has three basic elements:

1. **On-site Security System.** Design, implementation, operation, and maintenance is the responsibility of the licensee who must accomplish the security criteria following the IS-09 combined approach.[11] This system has to deter, detect, assess, delay and give the first response against a malicious act until the deployment and response of the local LEA.
2. **Off-site Response Plan.** This is the responsibility of the local LEA and its objective is to interrupt and neutralize adversaries. The command post in the province where the NPP is located will lead the response. An interface between on-site PPS and off-site response plan is needed and the licensee is responsible for facilitating and maintaining it with local LEA.

3. **Intelligence Program.** This is performed by the Ministry of Interior and provides analysis of national security status and gives early warning to the licensees about changes in the level of the threat, who will reinforce specific security measures in accordance with the official declared level.

Three Competent Authorities

Regarding radiological protection and nuclear safety there is one Spanish nuclear regulatory agency (CSN), which is somewhat similar to the U.S. Nuclear Regulatory Commission. However, in Spain there are two other competent authorities in nuclear security: the Ministry of Industry and the Ministry of Interior.

The Ministry of Industry is responsible for granting authorization after the Ministry of Interior and CSN issue technical and binding reports, and it's the national point-of-contact for the Convention of Physical Protection of Nuclear Materials and Facilities. Finally, it is responsible for the control and accounting of the nuclear materials.

The Ministry of Interior has responsibility for public and private security subjects, issuing rules and regulations, and granting authorization to those private security services contracted[12] by the NPP. National law enforcement agencies[13] belonging to the ministry are the response forces to interrupt and neutralize the adversary in a security contingency and they participate in performing inspections with CSN's staff. The local LEAs are responsible for establishment, implementation and maintenance of the off-site response plans.

The third competent authority, CSN, issues nuclear security criteria and regulations to require measures and improvements to the use of nuclear and radioactive materials and facilities, transport, and storage. CSN performs inspections of PPS, audits training programs, evaluates security documents, such as plans, procedures, programs, etc.

New Nuclear Security Regulation: Security Instruction IS-09

This new regulation is the outcome of the working group started in 2002 and reflects the need for stricter and more rigorous nuclear security requirements due to new perception of the threat and new intentions, motivations, and capabilities showed by the adversaries. Although it was issued in 2006 with a period of one year to be implemented, the nuclear facilities began their implementation some years before, and it took a huge amount of money, human resources, and great effort.

The *Security Instruction IS-09* lists several scenarios that the PPS of nuclear facilities must protect against; it is based on a graded approach and places the prime responsibility for the implementation, operation and maintenance of PP measures on the licensee. It establishes security criteria for material resources (physical barriers, access control facilities, intrusion detection systems, and alarm assessment), for human resources (private security service, training, exercises, and equipment) and organizational resources (PP Plan, procedures, preventive and corrective program and compensatory measures) and finally encourages the effective implementation of security culture in the entire licensee's organization.

Nuclear Security Inspections and Reactor Oversight Process

In 2004 the CSN began to work out the process of evaluating the nuclear facilities' performance adapting the *U.S. Reactor Oversight Process (ROP),* but concerning the key strategic areas of *Reactor Safety* and *Radiation Safety*, and left the *Physical Protection* cornerstone undeveloped.

Currently, after developing specific nuclear security regulations, increasing the human resources working in this field, and improving the physical protection systems in the nuclear facilities, the CSN made a decision on the integration of security cornerstone into the ROP following one of the International Atomic Energy Agency's suggestions reported on the *Integrated Regulatory Review Service (IRRS)* carried out on February 2008.

Regarding nuclear security inspections and following the annual program, CSN carries out basic, supplemental, and special[14] inspections. In addition, every two years, specific inspections are undertaken by a team composed by CSN's staff (two or three security inspectors) and the Ministry of Interior's staff (Civil Guard and National Police Forces) in order to renew the specific license required by regulations. In this inspection the team checks if the PPS complies with the general nuclear security requirements and national regulation on private security.

During the ten days following each inspection, an impartial[15] report is issued and sent to the licensee to notify them of the findings and allow them to comment or disagree with the report.

Conclusion

The huge effort carried out in Spain during the last years to improve nuclear security has enabled the establishment of a national nuclear security regime adequate to reduce significantly the risk associated with likely malicious acts threatening the nuclear facilities and nuclear material.

The improvement in the design and implementation of the nuclear security regime is the result of the efforts of the competent authorities and licensees, and of course, the exchange of information and best practices among the international community, and bilateral agreements.

End Notes

1. There were several nuclear security requirements during the construction stage.
2. CSN named *SISC* or *Sistema Integrado de Supervisión de Centrales.*
3. Some details of the former *Royal Decree 158* from 1995 and the new regulation *IS-09* from 2006 are given in this report.
4. Scrap metal factories have portal detectors at the entrance and there are dozens of positive detections every year.
5. Spent fuel is kept in the pools except at two sites where there is an ISFSI.
6. When spent fuel has been transported.
7. The fuel was loaded in the reactor to perform the first tests.
8. José Cabrera NPP, in Guadalajara province, started its operation in 1968 and closed in 2006.
9. Those reports evaluate the applicants' compliance with standards set by these two competent authorities, and are binding if the final conclusion is not positive.
10. Details of this security instruction are given in chapter 8 of the *Security Instruction IS-09.*
11. The *Security Instruction IS-09* is a more prescriptive approach .than performance-based.
12. This private security service does not belong to the NPP organization.
13. National Police and Civil Guards.
14. Reactive inspections responding to special events or when significant changes are introduced into the PPS when there has been an important issue that requires additional review.
15. Based on the results of the tests, checks and audits carried out.

Combating the Nuclear Terrorist Threat: A Comprehensive Approach to Nuclear Security

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Abstract

In his first speech on nonproliferation as president, Barack Obama addressed the threat of nuclear terrorism[1] as "the most immediate and extreme threat to global security." He stated that the need to provide greater security for nuclear material and facilities is a global imperative. As terrorists have demonstrated their willingness to inflict mass casualties and announced their intention to acquire nuclear material, states around the world must join together to help ensure that the threat of nuclear terrorism does not become a reality.

The U.S. Department of Energy (DOE) plays a crucial role in helping the United States meet this mandate. Together with other interested U.S. governmental offices, the DOE and its predecessor organizations have worked, in cooperation with other states and the International Atomic Energy Agency (IAEA), to prevent terrorists and other non-state actors from obtaining a nuclear weapon or the nuclear materials needed to develop one. Today, DOE's National Nuclear Security Administration's (NNSA) International Physical Protection Program, within the Office of International Regimes and Agreements (NA-243), conducts various activities, including bilateral visits to states that have received U.S.-obligated nuclear material, to support domestic and international obligations. This paper will first review the aforementioned legal obligations and then discuss the actions taken by the program to uphold U.S. laws and ensure international commitments are met.

Obligations and Criteria for Nuclear Material Security

Although nuclear security has received greater recognition in recent years, the need for adequate physical protection of nuclear materials and facilities has long been known. Beginning with the Atomic Energy Act of 1954 (AEA), the United States and other countries around the world have worked to ensure that nuclear materials and facilities are adequately protected against theft and sabotage. Recognizing the attractiveness of such material to terrorists, rogue states, and non-state actors, the United States has worked to ensure that states could receive the peaceful benefits of nuclear energy while guarding against its inherent dangers. Domestic and international laws on physical protection have not only provided the foundation for today's nuclear security practices; they have helped create greater security for many generations.

Each of the projects that the NA-24 International Physical Protection Program oversees today—bilateral physical protection assessments, development of international nuclear security policy, documents, and training programs, and multilateral cooperation with other states—were created and implemented to meet the requirements of local and international edicts. The next two sections will review these requirements, which ensure consistency among physical protection systems worldwide.

U.S. Law

Physical protection is rooted in U.S. law. Soon after former U.S. President Dwight D. Eisenhower introduced the concept of peaceful nuclear cooperation in his momentous "Atoms for Peace" speech, the legal basis and conditions for bilateral and multilateral nuclear cooperation were established in Section 123 of the AEA. This section delineates the procedure for establishing nuclear cooperation with other states and introduces an important requirement for states that receive U.S.-obligated nuclear material. States that receive U.S.-obligated nuclear material must provide a "guaranty…that adequate physical security will be maintained with respect to any nuclear material transferred pursuant to such [an] agreement."[2] The exact parameters on what constitutes "adequate physical security" are clarified in the 123 Agreements for Peaceful Nuclear Cooperation between the U.S. and the recipient states. As recognized in these documents, physical security for U.S.-obligated nuclear material must be equal to or greater than the requirements contained in the current version of INFCIRC/225, "*The Physical Protection of Nuclear Material and Nuclear Facilities.*"

The U.S. requirements for physical security were further expanded and codified in the Nuclear Nonproliferation Act of 1978 (NNPA). In section 305 of the NNPA, the protocol for assessing a state's nuclear security system is established. As stipulated by this act, nuclear security systems must be assessed in light of established physical protection standards.[3] It is important to recognize that although the NNPA calls for the use of physical protection standards, it does not specify what framework should be used for the legal basis for assessments. Such information is instead found in the Nuclear Regulatory Commission (NRC) regulations on the *"Export and Import of Nuclear Equipment and Material."* In 10 CFR Part 110.44, it is established that, prior to issuing an export license, the physical protection of the facilities where nuclear material will be supplied must be assessed on the basis of recommendations contained in the IAEA guidance document, INFCIRC/225.[4]

As required by U.S. law, the DOE leads U.S. technical assistance, as necessary and appropriate, throughout the length of bilateral agreements for peaceful nuclear cooperation.[5] Among other things, technical assistance includes the review of states' physical protection systems. The DOE leads these bilateral assessments and is joined by a team of experts from the U.S. interagency.[6] During these technical exchanges, the adequacy of physical protection is compared with INFCIRC/225 recommendations to ensure adequate physical protection is maintained for Category I, II, and III nuclear materials. In addition to meeting the legal requirements found in the AEA and NNPA, the visits help identify areas for improvement and promote technical cooperation between countries.

NNSA also develops and hosts training courses to meet requirements stipulated in Section 202 of the NNPA. Here, the DOE is tasked with "establish[ing] and operat[ing] a … physical security training program to be made available to persons from nations and groups of nations which have developed or acquired, or may be expected to develop or acquire, nuclear materials and equipment for use for peaceful purposes."[7] The physical protection training courses are largely conducted in concert with the IAEA; however, the program also consults with states on a bilateral and multilateral basis. Collaboration in these areas has often led to the development of a number of key physical protection concepts and new courses on the physical protection of nuclear materials and facilities. U.S. involvement in the IAEA physical protection training program is a long-term global investment that helps ensure nuclear security officials worldwide have sufficient knowledge of current physical protection concepts, and practices.

International Conventions

The NA-24 International Physical Protection Program also works to ensure U.S. commitments to international agreements and conventions are met. The United States is responsible for drawing on the recommendations of INFCIRC/225 and the requirements of the amended Convention on the Physical Protection of Nuclear Material (CPPNM/A), which form the basis by which the physical protection of nuclear materials and facilities is measured worldwide. These are also the standards that U.S.-obligated nuclear material is measured against under 123 Agreements for Peaceful Nuclear Cooperation. To better understand the value of the guidance that is contained in each of these documents, it is important to review their relationship to each other and other international physical protection requirements.

The line that connects each of the international obligations begins with INFCIRC/225. This is not surprising, considering it is the first set of international recommendations on physical protection of nuclear material that was established. Since the first draft was published in 1975, the guidance document has provided recommendations and guidance for states to use to meet and maintain their physical protection obligations. INFCIRC/225 is not a legally binding framework; however, states often incorporate its recommendations into their national laws and regulations, thus making it binding. International bodies, such as the Nuclear Suppliers Group (NSG), rely on instruments like INFCIRC/225 as the standard for exports of Trigger List items. Given the wide reach of this document, it has been reviewed and revised periodically to ensure its recommendations reflect the current threat environment. INFCIRC/225 is currently undergoing its fifth revision.[8] Further information about the revision is provided in the next section.

In 1980, another international physical protection instrument was established—the Convention on the Physical Protection of Nuclear Material (CPPNM). In contrast to INFCIRC/225, the CPPNM produced the first and only legally binding requirements for the physical protection of nuclear materials. It is important to note these legal obligations have changed over time. The 1980 Convention only required signatories to take necessary measures for the prevention, detection, and punishment of offenses relating to nuclear material. These responsibilities were expanded in 2005 when the CPPNM was amended to address the nuclear terrorist threat that emerged after the September 11, 2001, terrorist attacks. Prior to its amendment, the CPPNM only obligated states to protect nuclear materials during international transport. Today, signatories must protect nuclear materials against theft and sabotage during production, use, storage, and transport, both domestic and international.

The remaining three international physical protection obligations—NSG Guidelines and UNSCR 1540 and 1887—do not create additional responsibilities beyond INFCIRC/225 and CPPNM/A mandates; they merely require adequate physical protection of nuclear materials and facilities and cite the aforementioned frameworks for guidance on how to implement and maintain adequate physical protection. As discussed in the first part of its guidelines, the NSG recognizes the physical protection of nuclear materials and equipment to be of the utmost importance. Similar to U.S. laws on the export of nuclear materials and equipment, items that are listed in the agreed Trigger List are subject to confirmation by the exporting state that recipients will maintain adequate security of all items exported. Security is determined to be "effective appropriate" if it meets or exceeds internationally agreed standards such as the recommendations of INFCIRC/225 and the CPPNM/A.[9] UNSCR 1540 requires states to establish adequate physical protection to prevent the proliferation of nuclear, chemical, or biological weapons and their means of delivery. This UNSCR calls on states to implement the guidelines of the recently amended CPPNM.[10] The recently adopted UNSCR 1887, calls for states to create better security for nuclear weapons materials to lessen the risk of nuclear terrorism. Here, the amended CPPNM is referenced.[11]

Many of the international nuclear security obligations referenced above have similar requirements to ensure states can easily meet international physical protection obligations. However, at the present time, a gap exists between the two structures that lie at the heart of the nuclear security—the current revision of INFCIRC/225 and the 2005 amendment to the CPPNM/A. When the CPPNM was amended in 2005, it was revised to address the post-September 11, 2001, threat environment and called on states to ensure the physical protection of nuclear materials in domestic use, storage and transport. The amended CPPNM also introduced 12 Fundamental Principles that states shall include when implementing a physical protection regime. Given that INFCIRC/225 and the CPPNM/A are used by states for guidance and the legal basis for international security, it is important that there is consistency between the two. The United States recognized need for such revisions, soon after the CPPNM was amended and has led the international effort to revise INFCIRC/225. Further information on this effort is provided in the next section.

INFCIRC/225

The methods by which the United States and other states assess the physical protection of nuclear materials and facilities will soon be updated when the current revision of the IAEA guidance document INFCIRC/225 is complete. Last updated in 1999, the recommendations document is being revised to reflect the current threat environment, which changed dramatically after September 11. Another driving force behind the revision is to ensure INFCIRC/225 supports and provides implementing guidance for the amended CPPNM, UNSCR 1540, and UNSCR 1887, all of which reflect current threats to nuclear materials and facilities. It will also provide guidance to newcomers on nuclear energy programs. The recommendations document is in the final stages of the revision and has already undergone many changes. To ensure the new guide supports the amended CPPNM, it is being restructured to build on the Four Physical Protection Objectives and 12 Fundamental Principles of the amended CPPNM.[12] Content has also been expanded to include new sections and provide greater depth on topics that were not sufficiently covered in the current version.

An example of new or clarified topics we hope will be introduced in the forthcoming version includes stand-off distance. This term is important to define, as it addresses the physical protection vulnerability of nuclear reactors and sites to vehicles and explosive devices. By understanding this relationship, states can take the appropriate countermeasures, including vehicle barriers and stand-off distances.

The concept of a physical protection *regime*—an interactive system that includes a legislative and regulatory framework, and competent authority—will also be added to the forthcoming document, which will help ensure consistency with the CPPNM/A. The addition of this concept helps further establish the concept of an interactive system. A third concept is a denial response strategy to prevent sabotage. The current version was developed based on the use of a containment strategy; however, this strategy does not address the most likely threat of today—nuclear sabotage.

Clarifying certain terms will also provide great benefits. One anticipated change to the content of the recommendations is a discussion of the differences and relationship between the terms design basis threat (DBT) and "current evaluation of the threat." Another term that will be refined is the "self-protecting" principle. The current version permits a lower level of protection for irradiated material that has a relatively low radiation level and, thus, the current definition is problematic as it would not realistically deter or incapacitate terrorists. Although this provision will not be deleted as it appears in the CPPNM/A, cautioning against the use of it in a high threat environment may help reduce the threat of incidents that could occur as a result. Additionally, it is expected that a performance-based system will be strongly emphasized in the revised document. Real-life scenarios such as force-on-force training will accompany this definition.

NNSA's International Physical Protection Program has led the effort for the current revision of INFCIRC/225 and continues to play an important role in the revision of this document. Following the July 2005 amendment to the CPPNM, DOE/NNSA formed a U.S. government interagency working group for the revision. Shortly thereafter, the United States invited a small number of IAEA member states (MS) to assist in this effort. Following a 2007 meeting between a small group of states and the IAEA Office of Nuclear Security (NSNS), the IAEA began to call meetings involving additional IAEA MS on the INFCIRC/225 revision. The IAEA has subsequently convened a series of Consultants Meetings (CM) of IAEA MS for the revision process. The revision process is nearing completion. The first Technical Meeting (TM) was held in February 2010, which began the final stages of the document development. Although it is possible there will not be a need to hold more than one TM before the document is finalized, the United States anticipates the IAEA will publish INFCIRC/225/Rev.5 in late 2010. This revision comes at a crucial time, given the exponential growth of nuclear energy facilities that has been predicted worldwide. An updated document will greatly assist states that have begun to develop or are interested in developing civil nuclear programs, as INFCIRC/225 provides the basic concepts and recommendations for the physical protection of nuclear material and nuclear facilities to states around the world.

Activities to Implement Obligations and Further Global Nuclear Security

As discussed above, the unifying factor across all U.S. laws and international obligations on physical protection is the need to provide adequate security for nuclear materials and facilities. Beginning with the first bilateral visit to France in 1974, the DOE and its predecessor organizations have led 120 technical visits to forty-five countries[13]—all of which have received U.S.-obligated nuclear material under 123 Agreements for Cooperation. Today, the NA-24 International Physical Protection Program supplies the technical expertise required by the AEA and leads a U.S. interagency team on such visits. Although the frequency of these visits has recently decreased as fewer states now have U.S.-obligated highly enriched uranium (HEU), the value of these visits has far from diminished. In fact, a heightened threat environment has increased the need and importance of such visits.

But, the assessment of physical protection systems is not the only step that must be taken to ensure the security of nuclear materials worldwide. The aforementioned bilateral visits can only improve the security of nuclear materials and facilities if their evaluation method accurately reflects the current threat environment. If this is not the case, it is likely that problems will be either unseen or, worse, seen but action will not be taken, as there is inadequate understanding on how to remedy the problem. The threat to nuclear materials and facilities is not constant, and, thus, it is important for states' approach to the physical security of nuclear materials and facilities to be equally dynamic. It is only through on-going re-evaluation of the threat and frequent revision of international recommendations and obligations that we can decrease the probability of malicious acts by terrorists and other non-state actors. The final sections will provide greater detail on Program projects actions in these areas, given its role to help ensure the prevention of nuclear terrorist attacks.

Policy and Guidance Development

The International Physical Protection Program does more than adhere to the guidance of international physical protection frameworks—it has played an important role in their development. Together with U.S. experts from other agencies and the national laboratories, the NA-24 International Physical Protection Program provides crucial technical and policy support to strengthen and improve legally binding nuclear security frameworks and other non-binding international instruments concerning the physical protection of nuclear material and nuclear facilities. Current and past efforts include, but are not exclusive to, the following: the development and revision of INFCIRC/225, IAEA Nuclear Security Series (NSS) documents, participation in the Convention on the Physical Protection of Nuclear Material (CPPNM), and a diplomatic conference held in 2005 to strengthen the document.

It is important for the U.S. to actively participate in the development of international frameworks and guidance documents. Such efforts provide the opportunity to improve the security of nuclear materials and facilities, while ensuring U.S. equities are appropriately represented in international documents. The latter is of particular importance considering how such documents are interwoven with U.S. laws and other international instruments. In sections below, current and past efforts to improve existing documents will be discussed; as such revisions are important now and will continue to increase in significance.

Convention on the Physical Protection of Nuclear Materials

In addition to work on the development and revision of INFCIRC/225, the NA-24 International Physical Protection Program provided key technical and policy support to the CPPNM and its revision in 2005. Similar to the current revision of INFCIRC/225, the CPPNM was amended to address new challenges to the security of nuclear materials and facilities. As previously discussed, the new legal framework introduced a host of new responsibilities for states. Together with the new thematic responsibilities, states that are signatories to the amended CPPNM (CPPNM/A) are required to apply the 12 Fundamental Principles, insofar as reasonable and practicable, and ensure their physical protection system meets four objectives. The four physical protection objectives that were introduced in this document required the following from states: protect against the theft of nuclear material in use, storage, and transport; ensure the rapid location and recovery of stolen material; protect nuclear facilities and nuclear material against sabotage; and mitigate or minimize the radiological consequences of sabotage.

Following the 2005 conference, the program worked to ensure that the fundamental principles introduced in the CPPNM/A are mirrored in other international physical protection documents. While not all states are signatories to the CPPNM or CPPNM/A, as it is a legally binding document, they may have made legal commitments to implement various recommendations documents, such as INFCIRC/225. Working to ensure these documents contain similar recommendations is crucial for improving the physical protection of nuclear materials and facilities, as consistency helps achieve the highest degree of security.

Nuclear Security Series Documents

The NA-24 Physical Protection Program plays an important role in the creation of the IAEA's Nuclear Security Series (NSS). Together with other IAEA member states, the United States provides subject matter experts (SMEs) to supply technical input for these documents. Although other members of the U.S. interagency submit experts for these meetings, much of this information originates from DOE/NNSA and the national laboratories. This comprehensive set of international nuclear security guidance documents, created by the IAEA's Office of Nuclear Security, is consistent with and complements other international nuclear security instruments. The office has participated in the development of several of these guidance documents, including Nuclear Security Culture; Preventive and Protective Measures Against Insider Threats; and Development, Use, and Maintenance of the Design Basis Threat.

Physical Protection Training

As required by Section 202 of the 1978 NNPA, the NA-24 International Physical Protection Program has developed or co-developed, through national laboratory expertise and in cooperation with other member states, several physical protection courses that are now part of the IAEA training program. In FY2009, under the auspices of the IAEA, DOE/NNSA trained 464 officials from eighty-one states on thirteen topics. The year before, DOE/NNSA provided training for 626 students from sixty-seven states. Many officials that received training during this two-year period, did so through the landmark physical protection training course – the International Training Course on the Physical Protection of Nuclear Facilities and Materials (ITC), held once every eighteen months in Albuquerque, New Mexico. Although the International Physical Protection Program trains officials in other subject areas, this course is significant, as the program has worked with Sandia National Laboratories (SNL) over the past thirty-two years to develop, present, and host this course.

In addition to the ITC, the office also supports regional and national training courses (RTCs and NTCs) on several topics, including DBT Methodology, Insider Protection, Vital Area Identification, Physical Protection of Research Reactors, and Foundations of Physical Protection Systems. These classes are conducted, together with the IAEA or bilaterally, to educate stakeholders and new security professionals on how to protect their nuclear materials and facilities from theft and sabotage. DOE/SNL developed the pilot Insider Protection course together with France's Radioprotection and Nuclear Safety Institute (IRSN) to help states guard against the insider threat. DBT methodology courses provide instruction on the process and steps to conduct a threat assessment and define a state's design basis threat, followed by its implementation. The Vital Area Identification workshop presents a methodology to determine the set of areas and equipment that must be protected to prevent sabotage of a nuclear power plant. The class on the Foundations of Physical Protection Systems provides an introduction to new workers in the field or those whose job function interface with security. The information that is presented in these workshops and training courses is consistent with and supports physical protection systems that support the Fundamental Principles contained in the amended CPPNM. We also envision the development of training for the revised INFCIRC/225 once it is published.

Conclusion

The threat posed to the security of nuclear materials and facilities has changed greatly over the past decade; with the greatest change taking place after the September 11 terrorist attacks. Further changes should be expected, especially when considering the expectation that many more states will join the nuclear energy renaissance and dramatically increase the number of nuclear plants worldwide. Regardless of the threat at hand, nuclear security has helped prevent the threat of nuclear terrorism from becoming a reality. We must continue current efforts to ensure this is true in the years to come.

NNSA has held a leadership role in efforts to ensure that reigning physical protection frameworks for nuclear materials and facilities address the current threat environment. And, it is important to continue to lead the way forward. Through the regular assessment of nuclear facilities, development and revision of guidance documents and international frameworks, and education of new nuclear security personnel, the NNSA's International Physical Protection Program has played an important role in helping ensure nuclear security personnel in the United States and abroad can respond to the threat at hand. In order to strengthen nuclear security worldwide, we must continue to reach out to states that have begun to develop or are interested in developing nuclear energy. Not only will the United States be able to provide valuable guidance to these states, but such efforts will help ensure that the international nonproliferation community is able to create greater nuclear security by moving forward together.

The views expressed in this article are those of the author and do not necessarily reflect those of the U.S. government, U.S. Department of Energy, or the National Nuclear Security Administration.

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End Notes

This article summarizes the information presented at the 21st International Training Course (ITC-21), held in Albuquerque, New Mexico on May 4, 2009. The activities described here only represent the physical protection activities that are specific to the National Nuclear Security Administration's Office of International Regimes and Agreements (NA-243). They should not be understood to include all the efforts the Department of Energy undertakes to ensure the security of nuclear materials and nuclear facilities.

1. U.S. Congress, "The Atomic Energy Act of 1954," *Public Law* 83-703 68 Stat. 919, August 30, 1954, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf (accessed on December 30, 2009), 1–52-53.
2. U.S. Congress, "Nuclear Non-Proliferation Act of 1978," *Public Law* 95-242 92 Stat. 120, March 10, 1978, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/v2/sr0980v2.pdf#pagemode=bookmarks&page=769, (accessed on December 30, 2009), 1060.
3. Nuclear Regulatory Commission, "§ 110.44 Physical security standards," *Code of Federal Regulations* 10 CFR 110.44, amended April 9, 2004, http://www.nrc.gov/reading-rm/doc-collections/cfr/part110/part110-0044.html, (accessed December 30, 2009).
4. "Memorandum of Understanding between the Department

of State and the Department of Energy Concerning the Conducting of Foreign Physical Security Reviews," signed in 1978.

5. The Office of Nonproliferation and International Security is joined on such visits by representatives from other DOE offices, Nuclear Regulatory Commission, Department of State, Department of Defense's Defense Threat Reduction Agency, DOE National Laboratories and the U.S. Embassy in the country visited.
6. U.S. Congress, "Nuclear Non-Proliferation Act of 1978," *Public Law* 95-242 92 Stat. 120, March 10, 1978, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/v2/sr0980v2.pdf#pagemode=bookmarks&page=769, (accessed on December 30, 2009), 1047-1048.
7. IAEA document INFCIRC/225 was revised in 1977, 1989, 1993, and 1999.
8. "Communication Received from the Permanent Mission of Brazil Regarding Certain Member States' Guidelines for the Export of Nuclear Material, Equipment and Technology," *IAEA Information Circular* INFCIRC/254/Rev.9/Part 1a, November 7, 2007, http://www.nuclearsuppliersgroup.org/Leng/PDF/infcirc254r9p1-071107.pdf, (accessed January 4, 2010), 4.
9. United Nations Security Council, "Nonproliferation of weapons of mass destruction," *United Nations Security Council Resolution* 1540, April 28, 2004, http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N04/328/43/PDF/N0432843.pdf?OpenElement, (accessed January 4, 2010).
10. United Nations Security Council, "Maintenance of international peace and security: Nuclear non-proliferation and nuclear disarmament *United Nations Security Council Resolution* 1887, Sept. 24, 2009, http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N09/523/74/PDF/N0952374.pdf?OpenElement, (accessed January 4, 2010).
11. The 12 Fundamental Principals are as follows: Responsibility of the State, Responsibilities during International Transport, Legislative and Regulatory Framework, Competent Authority, Responsibility of the License Holders, Security Culture, Threat, Graded Approach, Defense in Depth, Quality Assurance, Contingency Plans, and Confidentiality.
12. The United States has conducted bilateral physical protection assessments in the following forty-five states: Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Columbia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Malaysia, Mexico, Morocco, the Netherlands, Norway, Pakistan, Paraguay, Peru, the Philippines, Romania, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom, Uruguay, Venezuela, and Yugoslavia.

Overview of U.S. Nuclear Regulatory Commission Security Activities

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Abstract

The U.S. Nuclear Regulatory Commission (NRC) regulates both the safety and security of special nuclear material and by-product materials. As such, it has a well developed and robust safety and security regulatory framework. Following the events of September 11, 2001, security was enhanced in a graded risk-informed manner for NRC licensees. Significant activities include issuing an order that required licensees to enhance security, updating design basis threats for radiological sabotage and theft/diversion, updating security regulations for nuclear power plants and developing security regulations for by-product materials. Today, NRC-regulated nuclear facilities are among the most secure in the nation's critical infrastructure.

Overview

The U.S. Nuclear Regulatory Commission (NRC) is an independent regulatory agency created to enable the nation to safely and securely use radioactive materials for beneficial civilian purposes while ensuring that people and the environment are protected. The NRC regulates commercial nuclear power plants, the civilian fuel cycle, and other uses of radioactive materials (i.e., by-product materials), such as in nuclear medicine and industrial practices, through rules, licensing, inspection and enforcement of these requirements. The NRC requires safe and secure operations at nuclear facilities. *Safety* refers to operating the facility in a manner that protects the public and the environment. *Security* refers to ensuring that the licensed facilities or materials will not be used for malevolent purposes by adversaries who wish to harm people and the environment. Following the events of September 11, 2001, the NRC has taken measurable steps to enhance the security of regulated activities.

The terrorist attacks on September 11, 2001, reaffirmed the need for collective vigilance, enhanced security, and improved emergency preparedness and incident response capabilities across the United States' critical infrastructure. As a result, the NRC conducted thorough evaluations of the agency's security programs and enhanced security at NRC-regulated facilities. The NRC used a risk-informed approach and focused efforts on the most risky licensees first.

- Shortly after 9/11 the commission issued security advisories to major licensees.
- In February 2002, orders were issued to nuclear power plants enhancing security.
- In March 2002, orders were issued to uranium enrichment facilities.
- In May and June 2002, orders were issued to decommissioning reactors and gaseous diffusion plants.
- In October 2002, orders were issued for spent fuel.
- In January 2003, orders were issued to nuclear power plants requiring enhanced access authorization.
- In June 2003, orders were issued to large panoramic irradiators.
- In January 2004, orders were issued to manufacturers and distributors (facilities with larger quantities of radioactive materials).
- In December 2005, orders were issued for the increased controls of radioactive sources.
- The design basis threats were revised in April 2003 and March 2005.

For nuclear power reactors and Category I fuel cycle facilities, the orders required the following enhancements: 1) additional armed security officers, patrols, and checkpoints, 2) increased surveillance of owner-controlled and protected areas, 3) increased access authorization controls, 4) enhanced barriers, 5) intensified search procedures, 6) reassessed access authorization lists, 7) improved liaison with local agencies, and 8) enhanced coordination with federal agencies.

New security requirements were placed on by-product materials licensees (i.e., irradiators, manufactures and distributors, and source users) by orders. These orders require licensees to develop and implement a program to monitor and immediately detect, assess, and respond to unauthorized access to radioactive material to enhance prompt discovery of lost, stolen, or missing risk-significant materials. This program includes a security plan and coordination with local law enforcement. In order to ensure the safe handling, use, and control of licensed material in use and in storage, licensees are required to control access at all times to radioactive material quantities of concern and devices containing such radioactive material sources, and limit access to such radioactive material and devices to only approved individuals who require access to perform their duties. These individuals must undergo fingerprinting and trustworthiness/reliability determinations.

In addition to the new security requirements issued by order, NRC security regulations are codified in the Code of Federal Regulations (CFR). The security regulations are predominately performance-based, that is they describe the required outcome or what must be achieved, not necessarily how to accomplish the outcome. We have found that performance-based requirements are the best approach to enhancing security, because licensed activities include such a wide variety of operations. Licensees develop security plans based on the regulations and implement a physical protection system. NRC inspects the licensee's facilities to verify compliance with the requirements and takes enforcement actions for non-compliances. For nuclear power reactors and certain special nuclear material facilities, NRC conducts performance evaluations or force-on-force exercises to demonstrate compliance with the requirements. As discussed above, NRC issued orders to enhanced security. To integrate the order requirements into its regulations, NRC initiated rulemaking to make the regulations effectively equivalent to the requirements in the orders. As discussed below, the regulations for physical protection of special nuclear material have been amended; and the rulemaking to develop regulations for the physical protection of by-product materials is ongoing.

Physical protection requirements for special nuclear materials at fixed sites and in transit, and of plants in which special nuclear materials are used, are provided in Title 10 of the Code of Federal Regulations (10 CFR) Part 73. Physical protection systems are designed to protect against acts of radiological sabotage and to prevent the theft of special nuclear material. A key component of the NRC's risk-informed and performance-based regulatory approach is the use of design basis threats (DBT). The DBT describes the basic adversary force characteristics (e.g., motivation, intention, size, skills, knowledge, and tactics), against which a facility must defend. The DBTs are based on realistic assumptions about the threat capabilities of terrorist groups and organizations. The NRC has developed DBTs for radiological sabotage at nuclear power plants, and for theft and diversion at Category I fuel cycle facilities.

The NRC's staff reviews and analyzes threat information, coordinates that information with the intelligence community, and distributes threat and intelligence information about the U.S. civilian nuclear sector only to individuals with a need to know and who have security clearance. In addition, the staff annually reviews and briefs the commission on recommended changes to the NRC's DBT based on the evolving capabilities of terrorists. A DBT is not applied to lower consequence activities, such as low-enriched uranium fuel production, transport and export of low-enriched uranium (quantities of low to moderate strategic significance of HEU or PU), spent fuel storage, or transport of spent reactor fuel and by-product materials (i.e., radioactive sources).

The NRC's comprehensive security programs for the protection of special nuclear materials include: 1) physical security (e.g., barriers, detection and assessment systems, access control, alarm stations, well-trained guard force, and response strategies), 2) personnel security (e.g., background checks, access authorization, insider mitigation, and fitness for duty), 3) information security, and 4) cyber security.

In 2006, the NRC published a proposed rule to amend 10 CFR Part 73, "Physical Protection of Plants and Materials," to enhance security at nuclear power plants. As part of the rulemaking process, the proposed rule was published for stakeholder comments. The stakeholder comments and the draft final rule language have been reviewed and approved by the commission. This rule, which amended existing security regulations and added new security requirements pertaining to both current and future nuclear power plants, was published as final on March 27, 2009. This rule made generically applicable security requirements similar to those previously imposed by the commission orders issued after the terrorist attacks of September 11, 2001. The rule enhanced requirements for security activity coordination, event reporting, access controls, contingency planning, radiological sabotage protection, cyber security, safety/security interfaces, and security personnel training. Additionally, this rule added several new requirements developed as a result of insights gained from implementation of the security orders, reviews of site security plans, implementation of the enhanced security baseline inspection program, and NRC evaluation of force-on-force exercises. The rule also updated the NRC's security regulatory framework for the licensing of new nuclear power plants. Some of the key aspects of the amendments to the regulations are discussed below.

Mitigative Strategies and Response Procedures for Potential or Actual Aircraft Attacks

These new requirements establish the necessary regulatory framework to facilitate consistent application of commission requirements for preparatory actions to be taken in the event of a potential or actual aircraft attack and mitigation strategies for loss of large areas due to fire and explosions. 10 CFR 50.54(hh)(2) requires licensees to develop guidance and strategies for addressing the loss of large areas of the plant due to explosions or fires from a beyond-design basis event through the use of readily available resources and identification of potential practicable areas for the use of beyond-readily-available resources.

Access Authorization Enhancements

10 CFR 73.56 has been substantially revised to improve the integration of the access authorization and security program requirements. The requirements include an increase in the rigor for many elements of the pre-existing access authorization program requirements. In addition, the access authorization requirements include new requirements for individuals who have electronic means to adversely impact facility safety, security, or emergency preparedness; enhancements to the psychological assessments requirements; requires information sharing between reactor licens-

ees; expanded behavioral observation requirements; requirements for reinvestigations of criminal and credit history records for all individuals with unescorted access; and five-year psychological reassessments for certain critical job functions.

Physical Security Enhancements

These new requirements impose new physical security enhancements. Significant new requirements include a requirement that the central alarm station (CAS) and secondary alarm station (SAS) have functionally equivalent capabilities so that no single act in accordance with the DBT of radiological sabotage could disable the key functions of both CAS and SAS. Additions also include requirements for new reactor licensees to locate the SAS within a site's protected area, ensure that the SAS is bullet resistant, and limit visibility into the SAS from the perimeter of the protected area. Revisions to 10 CFR 73.55 also include requiring uninterruptible backup power supplies for detection and assessment equipment, video image recording capability, and new requirements for protection of the facility against waterborne vehicles.

Cyber Security Requirements

These new requirements are designed to provide high assurance that digital computer and communication systems and networks are adequately protected against cyber attacks up to and including the DBT as established by 10 CFR 73.1(a)(1)(v). These requirements are substantial improvements upon the requirements imposed by the February 25, 2002, order. In addition to requiring that all new applications for an operating or combined license include a cyber security plan, the new requirements also require currently operating licensees to submit a cyber security plan to the commission for review and approval by way of license amendment. In addition, applicants who have submitted an application for an operating license or combined license currently under review by the commission must amend their applications to include a cyber security plan. For both current and new licensees, the cyber security plan will become part of the licensee's licensing basis in the same manner as other security plans.

Safety/Security Interface Requirements

The new safety/security interface requirements explicitly require licensees to manage and assess the potential conflicts between security activities and other plant activities that could compromise either plant security or plant safety. The requirements direct licensees to assess and manage these interactions so that neither safety nor security is compromised.

Training and Qualifications Enhancements

These new requirements are modifications to training and qualification program requirements and include additional requirements for unarmed security personnel to assure these personnel meet minimum physical requirements commensurate with their duties. The requirements also include a minimum age requirement of eighteen years for unarmed security officers, enhanced minimal qualification scores for testing required by the training and qualification plan, enhanced qualification requirements for security trainers, armorer certification requirements, program requirements for on-the-job training, and qualification requirements for drill and exercise controllers.

The NRC has begun the rulemaking process for the physical protection of by-product material. Although a security order is legally binding on the licensee receiving the order, a rule makes requirements generally applicable to all licensees. In addition, notice and comment rulemaking allows for public participation and is an open process. In developing the proposed rule the staff considered the various security orders, lessons learned during implementation, the recommendations of the Independent External Review Panel and the Materials Program Working Group, and stakeholder comments on the preliminary rule language. The staff posted preliminary proposed rule language for subparts B, C, and D of 10 CFR Part 37 on http://www.regulations.gov for public comment. The staff considered the comments received on the preliminary language and is developing the proposed rule language. Similar the revision to 10 CFR Part 73, the proposed rule will be published for public comment, the comments will be considered, and a final rule will be published with an effective date.

Consistent with the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and in accordance with the Energy Policy Act of 2005, the NRC has developed and implemented the National Source Tracking System (NSTS). The NSTS provides a life-cycle account of sources from manufacture to use, to disposal, decay or disassembly. The system contains source information including manufacturer, model number, serial number, radionuclide, activity, manufacture date, and source status, as well as information on the source owner. Each licensee is required to report transactions involving its sources by the close of the next business day and perform an annual reconciliation of the information in NSTS against its onsite inventory. The NSTS contains information including import/export notifications, lost/stolen radioactive source event reports, radioactive source destruction, and radioactive source abandonment (e.g., irretrievable in a well).

Conclusion

In conclusion, the NRC has taken effective steps in enhanced or toward enhancing security for special nuclear and by-product materials. Safety and security have always been the primary pillars of the NRC's regulatory programs. However, in the current heightened threat environment, there has been a renewed focus on security, and the NRC has issued enhanced security requirements through the issuances of security advisories and orders to those licensees who possess and utilize nuclear materials and radioactive sources and associated facilities. Using a graded risk-informed approach, the NRC has amended its regulations for the physical protection of plants and materials for special nuclear materials and is developing regulations for the physical protection of by-product materials. Today, NRC-regulated nuclear facilities are among the most secure in the nation's critical infrastructure.

Nuclear Nonproliferation Policy in a Sustainable Energy Future

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Introduction

In the twentieth century, mankind made amazing strides in nuclear science and technology. Those advances have provided enormous benefits. Controlled nuclear fission provides reliable large-scale energy production around the world (currently 20 percent of electrical generation in the United States, and 16 percent globally), and radioisotopes are indispensable for various basic research techniques, industrial processes, and many medical procedures.[1] In fact, approximately one-third of all patients entering hospitals in the U.S. will have some form of nuclear medical diagnostic or therapeutic procedure.

In contrast, nuclear weapons of enormous destructive power have been developed and pose a threat to international security. Since the first and only use of nuclear weapons in 1945, the U.S. and many other countries have striven to limit the spread of such weapons, with the ultimate goal of their elimination.[2-4] The goal of nuclear nonproliferation, as embodied in the Treaty on the Nonproliferation of Nuclear Weapons (NPT), has been widely accepted in the international community and continues to be a cornerstone of international security. However, the threat of nuclear proliferation has evolved with the changing state of international affairs.[5,6]

An effective nonproliferation policy must deal with the following broad-based threats:

- Diversion of fissile material from the nuclear fuel cycle;
- Theft of fissile material by sub-national or terrorist groups;
- Clandestine operation of a fissile material production facility.

Proliferation of nuclear weapons can occur through sovereign states, with a recent notable example being North Korea. Proliferation to sub-national groups must also be prevented; this is primarily a concern with respect to theft of a nuclear weapon or the fissionable material from which a weapon can be fashioned. Effectively dealing with these threats requires the active leadership and involvement of the U.S. This will require a flexible U.S. approach in dealing with diverse situations and possible new threats, and with the emergence and application of new technologies.

Historically, nations have only utilized un-safeguarded research reactors, special-purpose reactors, or isotope separation facilities to produce the quantities of the high quality plutonium and highly enriched uranium desired for nuclear weapons.[2-4] Other materials and technology used in the civil sector can potentially be utilized to make nuclear weapons.[7-11] Accordingly, there is widespread agreement that if the world is to realize the many benefits of nuclear power in the future, it is imperative that this peaceful nuclear technology continue to be applied in such a way that it does not contribute to the spread of nuclear weapons, and that the public has confidence that the diversion of civil nuclear materials into weapons programs will not take place. This is one of the prime objectives of the global nonproliferation regime, which the U.S. has played a key role in promoting.

Nonproliferation Position Points

The American Nuclear Society's (ANS) Special Committee on Nuclear Nonproliferation (SCNN) was formed in 1995 to make specific recommendations to decision-makers, its membership, and the general public regarding nuclear nonproliferation issues. The Committee originated as a special panel, led by Glenn Seaborg, commissioned by ANS to assess the measures needed to protect and manage plutonium,[7] both from the dismantling of nuclear weapons by the Russian Federation and the U.S. as well as from the operation of nuclear reactors throughout the world.

In 2001, SCNN developed an ANS Position Statement on nonproliferation that emphasized the need for U.S. leadership and collaboration to enhance global nuclear proliferation management.[12] Recently, the Special Committee has updated that statement based on the changing state of international affairs related to nuclear technology, national defense, and energy security. This updated Position Statement on Nonproliferation[13] reflects the views, knowledge, experience, and insights of numerous members of the nuclear science professional community in the U.S.

The key position points and recommendations are:

1. **Nuclear science and technology can be applied for peaceful purposes in a manner that fully supports and is compatible with achieving nonproliferation goals, as embodied in the NPT**. To prevent proliferation, sovereign states should adhere to the NPT and its safeguards system, including the Additional Protocol, and adopt effective export controls.[14] Incentives to acquire nuclear weapons must also be addressed through foreign policies that discourage clandestine nuclear weapons programs in all nations. ANS endorses the steps to strengthen the NPT contained in UN Security Council Resolution 1887,[15] which call "for further progress on all aspects of disarmament to enhance global security." If they are applied effectively, the technical, political, and institutional factors that constitute the key elements in a global nonproliferation regime will provide a continued high confidence that civil nuclear facilities and materials will not be diverted to military programs.

2. **Successfully addressing current and evolving proliferation threats requires that the U.S. work effectively with both industrialized and developing nations and with established international institutions such as the International Atomic Energy Agency (IAEA).** The Nuclear Suppliers Group also plays a key role in nonproliferation by helping to preclude inappropriate access to nuclear technology. The imperative need for active U.S. involvement arises from its broad global responsibilities, extensive nuclear weapons stockpile, and status as the world's leading generator of energy from nuclear power. Given the varying energy needs around the world and the diversity of fuel cycle options today and in the future, the nonproliferation regime cannot practically be tied to one particular fuel cycle. U.S. governmental policy and actions should accept the variety of approaches towards nonproliferation chosen by other countries, including the use of alternative fuel cycles.

   In particular, European nuclear power programs have demonstrated that effective safeguards can be designed into programs that involve the separation of plutonium in the fuel cycle.[16] Industrial-scale reprocessing has been carried out at La Hague in France and Sellafield in the United Kingdom for decades, and significant amounts of the resulting plutonium have been fabricated into mixed oxide (MOX) fuel and used in commercial nuclear power reactors in Belgium, France, Germany, and Switzerland. The ANS strongly endorses an orderly transition to a U.S. policy that encompasses nuclear fuel recycling[17] in parallel with the establishment of a high level waste repository.[18]
3. **The ANS encourages the U.S. government to establish a policy which definitively endorses peaceful applications of nuclear technology.** A strong domestic nuclear industry and supporting infrastructure is essential to the credibility of the U.S. in working effectively with other countries in meeting the proliferation challenges of today and tomorrow.[19-20] If the U.S. is not actively involved in all aspects of the nuclear fuel cycle, it loses much of its ability to influence the outcome. The ANS applauds[21] efforts by agencies of the U.S. government to revitalize the nuclear workforce and to support education programs in nuclear science and technology.
4. **The U.S. should continue to explore and develop technologies that will further enhance the proliferation resistance of nuclear power systems.** The safeguarded civilian nuclear fuel cycle needs to remain an unattractive route for acquiring nuclear weapons. U.S. research and development policy should recognize the widely held view that the long-term benefits of nuclear power will depend on utilizing more fully the vast potential energy resources in uranium[17] and thorium.[22] Consequently, research and development of recycle options is warranted to ensure a secure and sustainable energy future with reduced proliferation risk.[17]

   However, all nuclear fuel cycles involving fissile material are potentially vulnerable to theft or diversion of that material. Intrinsic attributes alone are not sufficient to prevent the spread of nuclear weapons; extrinsic safeguards measures must be employed effectively and consistently around the world in order to achieve nonproliferation goals.[8-10]
5. **The U.S. should continue to invest in the development of technologies to monitor and safeguard nuclear materials.** This includes strengthening material accountability and physical protection of nuclear materials in cooperation with other countries and IAEA.[10] The ANS endorses the principles and objectives of UN Security Council Resolution 1540, which requires nation states to implement "effective measures to establish domestic controls to prevent the proliferation of nuclear, chemical, or biological weapons, and their means of delivery, including by establishing controls over related materials...." The resolution requires states to criminalize the proliferation of Weapons of Mass Destruction (WMD) and all related materials; to enact and enforce strict export controls; and to secure sensitive materials within their borders. This resolution promotes more effective laws and enforcement measures.[23] Resolution 1673 (2006)[24] and then Resolution 1810 (2008)[25] extended the mandate of the 1540 Committee to April 2011, strengthening the role of the Committee in facilitating technical assistance, including by engaging actively in matching offers and requests for assistance, therefore confirming its clearinghouse function.
6. **Significant quantities of weapons-grade plutonium and high-enriched uranium (HEU) pose a continuing proliferation threat to the world community.** Important efforts to secure these materials and to transform them into more proliferation-resistant forms require and warrant substantial attention and resources. Significant progress has been made with HEU. Essential programs such as plutonium disposition[26] have been initiated in the U.S. and Russia but are still some years away from full implementation as proposed by several organizations and individuals.[7,27-29] Anticipated future reductions in nuclear weapons stockpiles will add to the magnitude of this challenge. The benefit can be substantial—not only does the disposition of former weapons material preclude its theft or diversion, but it sends a powerful message regarding the commitment of nuclear weapons states to nonproliferation goals. Efforts underway in the U.S. and Russia should be extended to other states as well.

Conclusion

The continued support of a strong nuclear nonproliferation regime is a vital national security objective for the U.S. In order to be effective, U.S. nonproliferation policies must be developed and implemented in a manner that ensures broad and bipartisan national support and carried out with the dedication and constancy that is essential in meeting challenging, long-term objectives.

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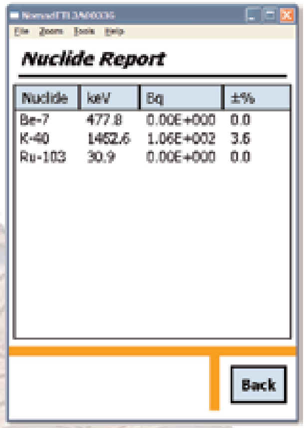

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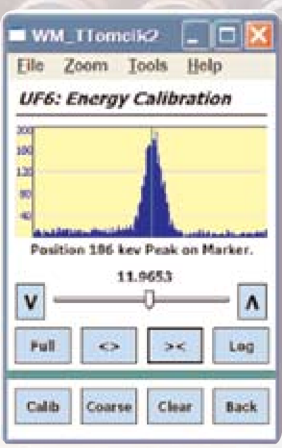

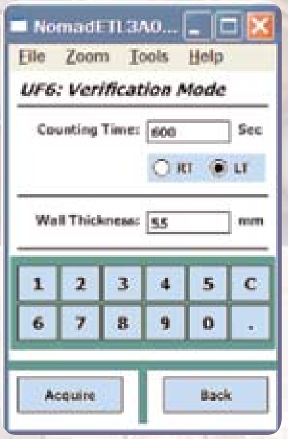

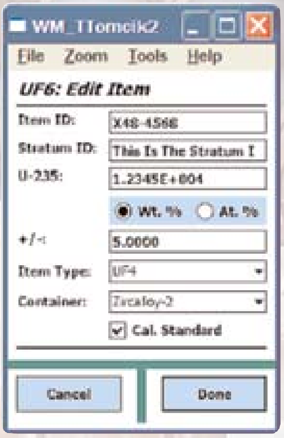

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