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Physical Protection Design and Analysis Training for the Former Soviet Union*

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Abstract

Since 1978, Sandia National Laboratories has provided training courses in the systematic design of Physical Protection Systems (PPS). One such course, the International Training Course (ITC) on the Physical Protection of Nuclear Facilities and Materials, is sponsored by the Department of Energy's International Safeguards Division, the International Atomic Energy Agency, and the Department of State. Since 1978, twelve 3- and 4-week classes have been conducted by Sandia for these sponsors. One- and two-week adaptations of this course have been developed for other customers, and, since 1994, nine of these abbreviated courses have been presented in the Russian language to participants from the Former Soviet Union (FSU).

These courses have been performed in support of the Department of Energy's program on Material Protection, Control and Accounting (MPC&A) for the Russian Federation and the Newly Independent States. The shorter adaptation of the ITC is intended to inform the attendees of the systematic approach to physical protection analysis and system design used in the United States. The result is an understanding between U.S. analysts and designers and their Russian-speaking counterparts that facilitates a cooperative effort in the upgrades of nuclear facilities in the FSU.

The training objectives for the longer ITC courses differ from the shorter courses developed for the MPC&A Program. For the ITC, participants with a broad range of backgrounds are in attendance, and cognitive training approaches, complemented by affective approaches, are emphasized. The ITC training goal is to provide the participants with the knowledge and tools for designing and analyzing a physical protection system.

MPC&A physical protection training assumes participants have more narrowly defined backgrounds. In using affective approaches, the overall goal of training in the context of the MPC&A Program is to develop modern and effective, indigenous capabilities for physical protection system design and analysis within the FSU. This paper contrasts the cognitive and affective approaches to training and indicates why different approaches are required for the ITC and the MPC&A Programs.

Introduction

As a result of the Nuclear Non-Proliferation Act of 1978, the United States committed to transfer physical protection technology to member states of the International Atomic Energy Agency (IAEA). The Department of Energy (DOE) was assigned this task and selected Sandia National Laboratories (SNL) to fulfill the commitment. Out of this commitment, SNL developed the International Training Course (ITC) on the Physical Protection of Nuclear Facilities and Materials. The IAEA and the U.S. Department of State also have played major roles in the presentation of the ITC.

The ITC has been conducted since 1978. In this course, participants are introduced to a methodology for the design and analysis of physical protection systems (PPSs). These systems protect nuclear facilities and materials against the threats of radiological sabotage and theft. Participants are from IAEA member states and represent both developed and developing countries. Since all

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class materials and presentations are in English, students are required to be proficient in English. To date, 12 ITCs have been conducted with 352 attendees from 58 countries.

During the last quarter of 1993, umbrella and implementing agreements for the Nunn-Lugar funded Cooperative Threat Reduction Program were signed with the Russian Federation, the Republic of Ukraine, and the Republic of Kazakhstan. Subsequently, similar umbrella and implementing agreements were signed with the Republic of Belarus. As a result of the agreements, cooperative work on improving the Material Protection, Control and Accounting (MPC&A) systems for nuclear materials within the signatory countries was started.

In 1994, the first physical protection design and analysis training course was taught in Albuquerque, New Mexico, to Russian participants from the Elektrostal Fuel Fabrication Plant. This course drew upon course material from the ITC, but was tailored to fit the needs of the Russian participants. Since the Elektrostal participants were somewhat knowledgeable in the area of physical protection and had similar backgrounds, the overall training objective was more affective (changing an attitude or impression) than cognitive (learning new information). The intent was to develop common understanding and trust among American and Russian specialists. This first ITC course proved to be the basis for building trust and confidence in implementing cooperative physical protection projects at Elektrostal. The first phases of these projects are nearing completion. This affective goal has been the thrust of subsequent physical protection training provided to 200 participants from Russia, Ukraine, Kazakhstan, Belarus, Georgia, Latvia, Lithuania, and Uzbekistan.

What Is Taught

Sandia developed a physical protection methodology in the early 1970s that has been applied to physical protection throughout the DOE community and the world. The methodology takes the three fundamental components of physical protection (detection, delay, and response) and integrates them into a systematic design and evaluation process, outlined in Figure 1. Sandia's physical protection design courses are built around this process, providing a lecture session on virtually every Design and Evaluation Process Outline (DEPO) element. The degree to which each element is stressed depends on the training approach.

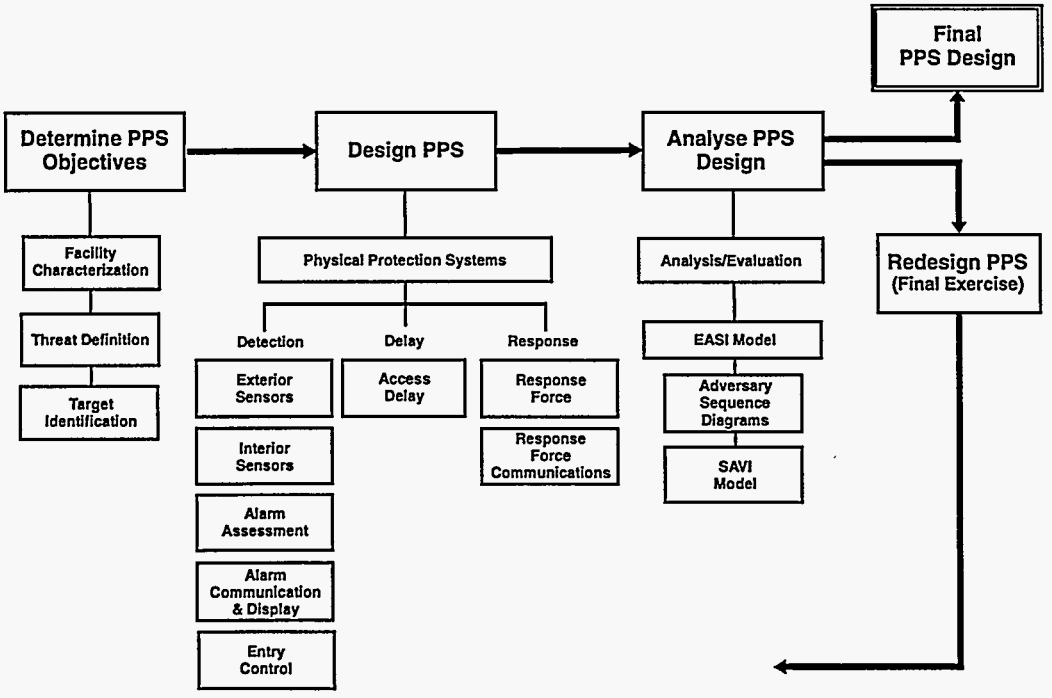

Fig. 1. Design and Evaluation Process Outline (DEPO)

Training Approaches

Two widely recognized approaches to training are *cognitive* and *affective*. Optimum learning is attained when both approaches are used simultaneously. However, several factors determine which approach should be emphasized. These factors include the make-up of the students, the time allotted for the subject matter to be taught, and the overall training goals.

Cognitive

In the *cognitive* approach to teaching, a hierarchy of six cognitive objectives (also referred to as Bloom's Taxonomy of Educational Objectives) ranges from basic to advanced. Each objective serves as a building block to the next objective on the hierarchy. These cognitive objectives, from basic to advanced, are *knowledge*, *comprehension*, *application*, *analysis*, *synthesis*, and *evaluation*. Truly effective cognitive teaching incorporates all six objectives and results in learning mastery and retention of information.

- The *knowledge* objective is achieved when the student can remember or recall information such as facts, terminology, problem-solving strategies, and rules.
- To attain the *comprehension* objective, the student is expected to be able to change the form of a communication, translate, restate what has been presented, see connections or relationships among parts of a communication (translation), or draw conclusions or consequences from information (inference).
- The results of the *application* objective should enable students to use previously acquired information in a setting other than the one in which it is learned.
- The *analysis* level requires students to identify logical errors or to differentiate among facts, opinions, assumptions, hypotheses, and conclusions.
- At the *synthesis* level, students are expected to solve an unfamiliar problem in a unique way or to combine parts to form a unique or novel solution.
- Finally, at the *evaluation* level, students form judgments and make decisions about the value of the methods, ideas, people, or products that have a specific purpose.

Affective

The *affective* approach to training deals with interaction among participants and course instructors. The intent is to create an environment in which students feel comfortable and motivated to participate in the learning process and to accept new concepts and methods that could be incorporated into existing value systems. Activities are designed so that students can "fail safely" and learn from past mistakes. Students demonstrate confidence in their abilities, and learning potential is enhanced. In a clinical sense, there are five categories in the affective domain: *receiving*, *responding*, *valuing*, *organizing*, and *characterizing*.

- In the *receiving* category, students should be aware of or passively aware of certain phenomena and stimuli.
- At the *responding* level, they are required to comply with given expectations by attending or reacting to certain stimuli. They are expected to follow directions, participate, or respond willingly.
- The objectives at the *valuing* level are for students to display behavior consistent with a single belief or attitude in situations in which students are not forced or asked to comply.
- At the *organizing* level, students commit to a set of values. This commitment involves formulating a reason why certain things and not others are valued and making appropriate choices among things that are and are not valued.
- *Characterization* is the final objective. At this level, all behavior displayed by students should be consistent with their values. At this level, students will have integrated their values into a system, representing a complete and persuasive philosophy.

Cognitive Approaches for the ITC

The overall goal of the training provided in the ITC is to transfer technology for preventing radiological sabotage and theft of nuclear materials. Upon completion of the course, participants should be prepared to design and analyze a physical protection system that meets their needs. To achieve this goal, cognitive training approaches, complemented with affective approaches, have been integrated into virtually every aspect of the ITC. Successful achievement of this goal has been demonstrated through continuing interactions with past participants.

Throughout the 29 ITC lecture sessions, simple, but consistent examples and problems are used to move the participants through the cognitive levels of knowledge, comprehension, application, and analysis. Figure 2 shows a typical training session. To progress from the analysis to synthesis level, a hypothetical facility is introduced and gradually developed into a final exercise. The final exercise requires the participants to analyze the situation, sort through the information provided, and differentiate between the good and bad aspects of the existing design. As a final step in the exercise, ITC participants infer modifications that will improve the physical protection system of the exercise facility.

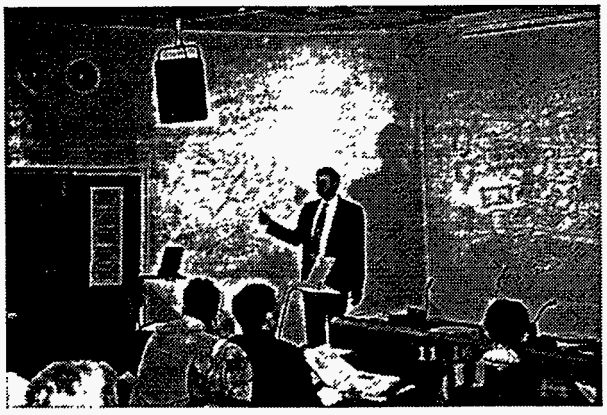

Fig. 2. MPC&A Training Class in Progress

Achievement of the *evaluation* objective is a declaration that the course material is valuable to the participant. To facilitate this objective, students are asked to fill out critiques of each session on a daily basis as well as a critique of the course as a whole. These critiques ask the participants to rate the value of the information presented and to assess its usefulness in relation to their profession. In addition to providing useful feedback to the course instructors, the critiques also act as tools to solidify the value of the course material in the minds of the participants.

Affective Approaches for the MPC&A Program

An objective of physical protection training for the MPC&A Program is to *transfer methodology* on U.S. approaches to system design and analysis. The desired outcome of this transfer of methodology is to change the participants' impression of how to design and implement physical protection systems. This is in contrast to the ITC goal of *transferring the technology* to design and analyze a physical protection system and equipping the participants to actually do a design and analysis task. Though this difference is subtle, the outcomes are significant and diverse. Following successful completion of the ITC, participants will have the ability to design and analyze a physical protection system. The goal of physical protection training within the MPC&A Program is the development of modern and effective, indigenous MPC&A capabilities within the FSU.

Prior to the dissolution of the Soviet Union, manpower-intensive physical protection systems were effective deterrents against the theft of nuclear materials from Soviet nuclear facilities. At the present time, these systems have lost their effectiveness. Although other aspects of the MPC&A Program are directed toward providing hardware implementation of upgraded MPC&A systems, such approaches only provide short-term solutions. Only through the development of updated, effective, indigenous MPC&A capabilities will long-term needs be met. Indigenous capabilities must be developed as a replacement for more traditional attitudes and methods to physical protection design.

In the process of meeting this goal, the training objectives should strive to develop: (1) a sense of "buy-in" from the recipient country, in that their specialists are involved in developing system designs and acquire an understanding of the U.S. methodology for designing physical protection systems, (2) a common understanding between

U.S. designers and their FSU counterparts, and (3) greater insight into specific facility needs than could not otherwise have been obtained.

To meet these objectives and the resultant goal, affective training approaches, complemented by cognitive approaches, comprise the appropriate training regime. Affective approaches are further prescribed by the homogeneous background of the prospective participants, scheduling and time constraints for training, and other resource limitations. When possible, cognitive training approaches are incorporated into MPC&A training, but affective approaches are the key to achieving the training goal and objectives. The following environmental factors are included in the training regimen to ensure an affective learning environment:

- Participants have a homogeneous background;
- Training is held in Russian;
- Actual case studies are used;
- Training is performed by instructors with expertise in the subject matter; and
- Critiques are used to determine value.

Homogeneous Background

In coordination with the DOE national laboratories, nuclear facilities or state agencies within the FSU develop agreements and schedules for physical protection training and select the training participants. The training, which typically lasts 5 to 7 days, can be held in either the U.S. or overseas at a host facility. The participants usually consist of physical protection specialists with a homogeneous background who are cognizant of physical protection technology, but who use physical protection methodologies that are out-dated, ineffective, or limited by available resources. Many of the participants also may have professional relationships with each other and may share common professional goals and interests. However, the participants may not be convinced that the U.S. methodology of systematic design is best suited for their needs.

Training in Russian

Since the initial implementation of the MPC&A Program, SNL has provided physical protection design and analysis training to 200 participants from Russia, Ukraine, Kazakhstan, Belarus, Georgia, Latvia, Lithuania, and Uzbekistan. Of the nine training courses held to date, two were held in Albuquerque, while the remainder were held in Russia, Ukraine, and Lithuania. Although the courses are taught by English-speaking instructors, interpreters are present to translate what is spoken into Russian, and all training material is translated into Russian. Although simultaneous interpretation could be used, instructors have found it more beneficial to make their presentations through sequential interpretation, which is less rigid and tends to allow more discussion and interaction among the participants and the instructors.

Use of Case Studies

The DEPO shown in Figure 1 is used as a topical outline to introduce the U.S. methodology for physical protection design. As is done during the ITC, a lecture session is presented on each of the topics identified in the DEPO. However, since the MPC&A participants are assumed to have at least a basic understanding of physical protection technology, the cognitive objectives are not stressed. Rather than introduce a hypothetical facility, as is done in the ITC, the instructors present case studies and actual examples based on personal experience. Case studies and examples are provided throughout the 18 lecture sessions. This is a very powerful training technique since the participants will be able to relate their personal experiences to those of the instructors.

Subject Matter Expertise

Affective training is further enhanced through the use of knowledgeable instructors who can serve as experts on the subject matter and who have experience working on cooperative projects within the MPC&A Program and within former Soviet nuclear facilities. Such instructor qualifications add credibility and help to foster an environment in which participants are more willing to incorporate U.S. physical protection approaches into their current approaches. Participants also are more receptive to instructors who understand their needs and can see things from their perspective.

Use of Critiques

As is the case for the ITC, MPC&A participants are asked fill out critiques of the course. These critiques have the dual purpose of providing feedback to the course instructors and helping the participants to assess the value of the training in relation to their experiences in the field of physical protection. This valuing aspect is clarified through one-on-one discussions among participants and among participants and course instructors.

Affective training approaches have proved effective in implementing cooperative physical protection projects in the FSU. U.S. physical protection specialists have noticed a marked improvement in interaction with their counterparts who have undergone this training Based on improved mutual trust and confidence, U.S. specialists have gained greater insight into what is needed, and the development of a common physical protection language has led to "buy-in" from Russian-speaking colleagues.

Conclusion

Twenty years experience in developing and implementing physical protection systems for facilities located world-wide, has enabled Sandia to develop and present effective training courses on the design and analysis of physical protection systems to deter radiological sabotage and theft of nuclear materials. This training incorporates both cognitive and affective training approaches. While optimum learning occurs when both approaches are used simultaneously, as is done in the ITC, time constraints and training goals may dictate the need to stress one approach over the other. For the ITC, cognitive and affective approaches are used to train participants on the technology of physical protection design and analysis. For the MPC&A Program, affective approaches are used to help achieve the goal of developing effective, indigenous MPC&A capabilities within the FSU.