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Experiences with Teaching Nuclear Security Professional Development Courses for Health Physicists

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Abstract

Health physicists are professionals who recognize, evaluate, and control health hazards—an expertise that permits the safe use and application of radiation. These professionals typically have broad knowledge in radiation (ionizing and non-ionizing), biology, ecology, and safety. We believe that health physicists, possessing this wealth of expertise, make useful partners in an effective security culture. Accordingly, we have offered to health physics and radiation protection professionals, during the past three years, seven professional enrichment courses, both nationally and internationally. Five have been through the Health Physics Society meetings, one was through the International Radiation Protection Association meeting, and one was held at the Massachusetts Institute of Technology. This paper will briefly introduce these courses and will include learning objectives and descriptions of courses' content. Although the documented feedback from participants was limited, since only 1 of the 7 courses used formal written course evaluations, both written and verbal feedback (and other forms of written feedback) to the instructors made it clear that the courses were well received.

I. Introduction

The objective of this paper is to present activities in delivering nuclear security professional development courses with the intent to help fulfill an international need for global training and education in nuclear security. Based upon the special training and knowledge health physicists possess regarding nuclear and radiological material, the authors determined that the health physicist would be the ideal target audience for awareness and professional training. To fill this perceived gap in nuclear security awareness for this group, we created professional development, awareness, and enrichment courses to be taught to health physics / radiation protection professionals and students alike.

In a recent paper published in the *Health Physics Journal*, Waller and van Maanen discuss the advantages that health physicists would have in a nation's overall nuclear security program. They explain how health physicists can contribute expertise in the roles of establishing the threat assessment and design basis threat, informed risk management, response force strategies in light of potential radiation exposure, dose guidance, training and demonstrable competence for the nuclear security response force, and with effective communications of the radiological component of an event **[*1*]**. However, although health physicists have long been associated with the safety infrastructure at nuclear facilities, it is not common for them, currently, to play a significant role in nuclear security activities. Although some of this lack of participation has been due, in the past, to existing management barriers separating safety and security functions, much of the lack of involvement is due to lack of awareness and/or training of the health physicists in nuclear security issues (and correspondingly the lack of health physics awareness training with the nuclear security personnel).

Whatever has been the degree of their connection with nuclear security in the past, experts in health physics, with their broad experience in physics, biology, and environment—and their large and prestigious professional organizations—can be important partners in nuclear security. Health physics, or the physics of radiation protection, is the science concerned with the recognition, evaluation, and control of health hazards to permit the safe use and application of radiation **[*2*]**. Health physics professionals promote excellence in the science and practice of radiation protection and safety. These professionals principally work at facilities where radionuclides or ionizing radiation are used or produced, including medical institutions, government laboratories, academic and research institutions, nuclear power plants, regulatory agencies, and industrial manufacturing plants. Nonionizing radiation sources such as lasers, microwaves, and radiofrequency (RF) radiation may also fall under the control of a health physicist. Within the US, the Health Physics Society (HPS) is the primary organization that supports its members in the practice of their profession and promotes excellence in the science and practice of radiation safety. The HPS has a membership of nearly 5,000 and holds two major conferences each year. Worldwide, there are over 15,000 individuals holding the title of health physicist or radiation protection professional.

Some efforts have been made within the last decade to move towards a more informed approach to nuclear security for all facility personnel. The Nuclear Security Summits, starting in 2010, provided an impetus for increased growth in the areas of nuclear security training and education. In 2010, the International Atomic Energy Agency published a Nuclear Security series document outlining an educational program in nuclear security, at both the certificate and master degree level **[*3*]**. The same year, the IAEA International Nuclear Security Education Network (INSEN) was established with a mission to enhance global nuclear security by developing, sharing, and promoting excellence in nuclear security education **[*4*]**. Also, in the same year, the World Institute for Nuclear Security (WINS) was incorporated as an International Non-Governmental Organisation (INGO) with a mission to lead in professional development and certification for nuclear security management **[*5*]**.

Professional enrichment course offerings for societies, such as the HPS in the US, have a competitive selection process in which proponents of a topical course must submit an abstract and proposed duration of the training. The American Board of Health Physics (ABHP) assesses continuing education credits (CEC) for the courses, dependent upon the training duration. This is an important concept, as persons holding the ABHP certification entitled Certified Health Physicist (CHP) require a certain number of credits per certification cycle (5 years) in order to retain the certification. Other bodies offering certification credentials, such as the World Institute for Nuclear Security (WINS) Certified Nuclear Security Professional (CNSP), have similar requirements for certification maintenance. For the offerings of professional enrichment program courses at HPS meetings, the ABHP assignment is generally 4 CEC per 2-hour course. The ABHP requires 80 CEC be obtained over a 5-year recertification cycle (and it is worthy to note that there are other ways to obtain CEC aside from course attendance).

Health physicists are a motivated group for professional development, and courses in nuclear security that cover both nuclear and radiological material management are desirable. The scope of this paper encompasses a discussion of the authors' recent offerings in professional development for nuclear security. We have structured the paper to outline the details of specific courses, share a model syllabus for a professional development course in nuclear security, consider the materials used in the courses, and discuss the results obtained—with reference to limited participant feedback.

II. Professional Enrichment Course Offerings

During the past three years, the authors have offered seven professional enrichment courses to health physics and radiation protection professionals, both nationally and internationally. Five have been through the Health Physics Society (HPS) meetings, one through the International Radiation Protection Association (IRPA) meeting, and one at the Massachusetts Institute of Technology (MIT). Not included in this list are the dozens of presentations we have given on nuclear security at meetings and conferences throughout the world.

In the Appendix of this article, we present a mapping of lectures against specific course offerings in nuclear security. The modules (see appendix) taught for any given course reflect the time available and the approved course proposals to the venue organizers.

A. Syllabus

Although the syllabi are slightly different for each offering depending upon the exact content and context as given above, we present below a model syllabus consisting of an abstract and an 8-hour lesson plan. Here is a typical abstract for our course entitled Nuclear Security for Health Physicists:

Health physics is an essential function in most nuclear facilities and the primary responsibility is a safety function. Nuclear security is, however, extremely important for all nuclear facilities, especially after the September 2001 attacks on the USA. The role of the health physicist in nuclear security matters is not clearly defined despite the fact that a fundamental understanding of radiological hazards of adversary target material is required for understanding the total risk to the facility and/or material. Health physics can be integrated into nuclear security during design basis threat definition, through risk management exercises, participation in response force activities, developing dose guidance criteria, radiological training and in communicating hazard and risk to security personnel, facility operators and regulatory bodies. When integrating health physics into nuclear security, it is important that health physics management or the responsible/senior health physicist establish dialogue early with nuclear security personnel in generating the design basis threat. The dialogue must include the advantages of considering radiological hazard as part of the comprehensive response plan. Health physicists are multi-capable scientists, engineers and systems integrators that can contribute greatly at multiple levels for effective and efficient nuclear security. To be an effective partner in the nuclear security objective, health physicists must embrace the nuclear security culture. As such, this course serves as an introduction to the basic elements of nuclear security, with specific emphasis on prevention, detection, and response. The following key elements will be covered in the course:

1. Prevention consists of all such security measures that may serve as deterrence or that prevent an unauthorized access to a protected nuclear facility or nuclear material. These preventive security measures could be adopted or implemented at facility level or at State level.

2. Detection consists of all techniques that may help in detection of an unauthorized access by someone to a protected nuclear facility or nuclear material. These detections measures could be implemented at facility level or at State level.
3. Response is used to defeat an adversary by preventing it from accomplishing its tasks either by containment or neutralization. These response measures can also be implemented at facility level and at State level.

Two very important areas of nuclear security are discussed in detail: (i) physical protection system (PPS), and (ii) IT/Cybersecurity. Physical Protection can be defined as ensuring the detection, delay and response to the malicious acts against nuclear materials and nuclear facilities through an integrated system of people, technology and procedures. Physical protection systems discussion will include concepts, approaches, design and evaluation methodologies for physical protection delay (i.e. barriers), detection (i.e. sensors) and response (i.e. guards). IT/Cybersecurity will be discussed in terms of IT security domains for nuclear operations, and hardware (instrumentation & control) implications. The STUXNET virus will be generally discussed to demonstrate threats to I&C systems that may be part of nuclear operations.

At the end of this course, the participant should have a high-level overview of nuclear security, and be able to formulate possible roles of the health physicist in security functions.

A typical lesson plan for Nuclear Security for Health Physicists follows below.

Module #	Time (Start)	Time (stop)	Topic
1	0800	0815	Instructor introductions and outline of the course
2	0815	0915	Introduction to nuclear security
3	0915	1000	Design Basis Threat (DBT)
-	1000	1015	Break
4	1015	1045	Safety, Security and Safeguards
5	1045	1130	Terrorist threat, non-state actors, RDD/IND/NW
6	1130	1200	Consequence management
-	1200	1300	Lunch
7	1300	1400	Facility, Border and Source Security
-	1400	1430	Exercise – detection
8	1430	1500	Physical Protection Systems I
-	1500	1515	Break
9	1515	1600	Physical Protection Systems II
10	1600	1645	IT/Cybersecurity
-	1645	1700	Wrap-up

It is impossible to teach all the elements of nuclear security in 8 hours, and as a professional enrichment course is reduced to 4 or 2 hours, the material becomes increasingly more like awareness material. But given 8 hours, there is time to conduct some limited exercises with the course participants in an interactive fashion, whereas in 2-4 hours instruction is more didactic. In any case, for the purpose of the health physicist gaining knowledge and basic understanding of nuclear security issues, the length of the course is secondary to the goal of familiarizing learners with this material.

Although we made available the primary teaching materials (generally speaking, lecture slides) prior to the courses, we also prepared and distributed USB sticks with both native application (Microsoft Powerpoint) and PDF versions of the materials, as well as other related materials that may have been referenced in the training—for example case studies, IAEA or other documents for supplemental reading, and freely available software tools (i.e. customized spreadsheets). This added-value material was designed to maximize the possibility that learners would continue to investigate and be aware of nuclear security issues that may be related to their jobs.

B. Materials

The resources used for the training were primarily sourced from INSEN educational materials and from a variety of teaching materials the individual instructors have developed as part of their own teaching duties. INSEN members have access to a large repository of teaching materials, hosted on an internal IAEA website. The materials are arranged according to the courses outlined in IAEA Nuclear Security Series Publication 12 **[*3*]**, and include lecture slides, course notes, instructor notes, scenarios, and tabletop exercises.

Specifically, INSEN members have developed a number of materials that were used as part of the courses delivered by the authors. Textbooks and/or manuscripts that have been completed include: NS-8 (Physical Protection Technologies and Equipment), NS-9 (Security of Nuclear and other Radioactive Material in Transport), and NS-22 (IT/Cyber Security) **[*6*]**.

Along with the textbooks, portions of the following modules from NS 1 (Introduction to Nuclear Security) were used in the course content: NS 1.3 (Interrelationships between safety, security, and safeguards), NS 1.4 (Nuclear threat by non-state actors), NS 1.6 (CBRN weapons), NS 1.7 (Basic elements of nuclear security), NS 1.8 (Planning nuclear security at the State level), NS 1.9 (Planning nuclear security at the nuclear/radiological facility), NS 1.10 (Introduction to detection of, and response to, criminal or unauthorized acts involving nuclear and other radioactive material out of regulatory control), NS 1.11 (Information Security), and NS 1.12 (Security culture: Concept and Model).

III. Results

The HPS has standard course evaluation forms, which we distribute to course participants. However, completion of the form is voluntary, and as is often the case, course evaluation and feedback tends to suffer from low participation (therefore poor statistics) and weak inferences. The most useful feedback is often obtained by talking with participants after the training; however, this is unscientific and may suffer from bias (selective presentation of feedback).

The most complete feedback was received from the three courses offered during the 60th Annual Meeting of the Health Physics Society in 2015. For each course, the percentage of completed evaluations was greater than 60%. Combining the responses from all three courses, a total of 46 responses were tabulated. The overall course ratings were as follows: 59% (27 respondents) rated the course as "Excellent," 28% (13 respondents) rated the course as "Very Good," 9% (4 respondents) rated the course as "Good," and 4% (2 respondents) rated the course as "Fair" or "Poor."

The other offerings at IRPA and at MIT did not have evaluation forms and therefore no documented feedback was available.

A consistent message that was relayed to instructors very early was that the course participants were very pleased that a course in nuclear security was being offered to them in the context of health physics. We perceived this had as much to do with a general interest in the subject material as it did with the introduction of a new topic to the continuing education training cohort. One might infer that there is, therefore, a general desire for health physicists to increase their awareness about nuclear security and determine where they may actively participate. We determined that this was a very good indication because it demonstrated a willingness of health physicists to broaden their horizons and look beyond a "safety silo."

IV. Conclusion

Health physicists, with their diverse experience in radiological sciences, can play vital roles in nuclear security. Reaching out to this community of professionals, the authors have presented seven enrichment courses at both national and international meetings of professional societies. These courses focused on giving health physicists a greater insight into the many challenging areas of nuclear security and how they might cooperate with other professionals working in nuclear security. This paper has described the courses, their objectives, and how they were delivered. Although there was limited documented proof of the success of these courses, we have various indications that the courses were well received by attendees. We must more actively distribute and collect course evaluations, and we recommend this to anyone teaching such courses. It may also be useful to reach out to past participants of courses in order to collect data on how those professionals are now participating in nuclear security efforts.

V. Appendix

Course title	Introduction to Nuclear Security I & II	Introduction to Nuclear Security for the Health Physicist	Physical Protection for Nuclear and Radiological Security	Terrorist Threat and Consequence Management in Radiological Security	Introduction to Nuclear and Cyber Security for the Health Physicist	Nuclear Security, Alternative Technologies and Consequence Management for the Health Physicist	Nuclear Security for the Health Physicist
Venue (year)	47th HPS Midyear Meeting	59th HPS Annual Meeting	60th HPS Annual Meeting	60th HPS Annual Meeting	60th HPS Annual Meeting	MIT	14th IRPA Congress
Location	Baton Rouge, Louisiana, USA	Baltimore, Maryland, USA	Indianapolis, Indiana, USA	Indianapolis, Indiana, USA	Indianapolis, Indiana, USA	Cambridge, Massachusetts, USA	Cape Town, South Africa
Year	2014	2014	2015	2015	2015	2015	2016
Duration (hrs)	4	8	2	2	2	3 days	4
Course participants / total at meeting	20 / 300	40 / 1300	25 / 1100	25 / 1100	25 / 1100	25 / 25	50 / 1100
Lecture modules							
Basic elements & definitions of nuclear security	X						
Introduction to nuclear security		X			X	X	X

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Interrelationships between safety, security and safeguards (S^3)	X	X			X		X
International nuclear security framework							
Threats by non-state actors & terrorism	X	X		X			
Planning nuclear security at the state level	X						
Role of the health physicist in nuclear security	X	X			X		X
Design Basis Threat (DBT)		X	X				
Physical protection systems		X	X			X	X
Consequence management		X		X			
Facility, border and source security		X	X				
Exercise on detection		X		X			
IT/Cyber security		X					X
US NRC and DOE nuclear security regulations		X			X		
High Activity Sources and Alternatives in Medicine						X	
Alternative Technologies: Policies and Paths Forward						X	
Nuclear security culture							X

VI. Notes and References

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