THE ROLE OF THE HEALTH PHYSICIST IN NUCLEAR SECURITY

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Abstract—Health physics is a recognized safety function in the holistic context of the protection of workers, members of the public, and the environment against the hazardous effects of ionizing radiation, often generically designated as radiation protection. The role of the health physicist as protector dates back to the Manhattan Project. Nuclear security is the prevention and detection of, and response to, criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities. Its importance has become more visible and pronounced in the post 9/11 environment, and it has a shared purpose with health physics in the context of protection of workers, members of the public, and the environment. However, the duties and responsibilities of the health physicist in the nuclear security domain are neither clearly defined nor recognized, while a fundamental understanding of nuclear phenomena in general, nuclear or other radioactive material specifically, and the potential hazards related to them is required for threat assessment, protection, and risk management. Furthermore, given the unique skills and attributes of professional health physicists, it is argued that the role of the health physicist should encompass all aspects of nuclear security, ranging from input in the development to implementation and execution of an efficient and effective nuclear security regime. As such, health physicists should transcend their current typical role as consultants in nuclear security issues and become fully integrated and recognized experts in the nuclear security domain and decision making process. Issues regarding the security clearances of health physics personnel and the possibility of insider threats must be addressed in the same manner as for other trusted individuals; however, the net gain from recognizing and integrating health physics expertise in all levels of a nuclear security regime far outweighs any negative aspects. In fact, it can be argued that health physics is essential in achieving an integrated approach toward nuclear safety, security, and safeguards. *Health Phys.* 108(4):468–476; 2015

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INTRODUCTION

THE ROLE of the health physicist in the protection of workers, members of the public, and the environment against the hazardous effects of ionizing radiation dates back to the Manhattan Project (Walker 2000), and in fact the occasionally controversial term “health physics” (Ansari 2013) was born out of the secrecy surrounding the project. This role as protector has continued for the wide variety of applications involving nuclear phenomena such as power production, medical diagnostics, therapy and industrial gauging, process control, and non-destructive testing. Although there is a reactive role for the health physicist (for example, determining the dose to personnel *after* an inadvertent exposure), the role has principally been proactive for prevention of overexposure and keeping radiation doses as low as reasonably achievable, taking economic and social factors into account. Since the terrorist attacks of 9/11 on the U.S., there has been increased emphasis placed upon the role of the health physicist in the aftermath of an adversary attack involving nuclear or other radiological material (Gonzalez 2005). Monitoring exposure, assessing the dose, first response, triage, and medical counter-measures all have become a reactive focus of the health physicist skill set. Although health physicists routinely participate in emergency planning and preparedness, and since 9/11 health physics support has become more integrated into teams of first responders such as fire brigades and police departments, there is not always a direct connection between the responsibilities of the health physicist and operational security. As such, their duties and responsibilities are often not clear, and typically the role of the health physicist is limited to acting as a consultant rather than being a recognized expert fully integrated in the nuclear security decision making process. In addition, the roles of the health physicist in the nuclear security domain are not necessarily similar worldwide.

There are three principal definitions that are required to examine the role of the health physicist in the holistic

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context of the protection of workers, members of the public and the environment, principally against the hazardous effects of ionizing radiation: safety, security and safeguards (often termed S^3). Nuclear safety and security share a common purpose, and often common measures and systems, in protecting workers, members of the public and the environment (IAEA 2010a). The primary difference between safety and security is that safety is concerned with actions taken to prevent unintentional, unforeseen or unplanned events that can lead to hazards such as exposure to radiation or to limit their consequences, whereas nuclear security is concerned with the prevention and detection of, and response to, criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities, generally with the intent to cause economic and social disruption. Essentially, safety protects against accidents, and security protects against malicious acts (IAEA 2007).

It is clear that many safety measures, such as reactor containment or radioactive source encapsulation that are designed to prevent significant release of radionuclides to the environment, also serve as security measures (as a barrier between an adversary and a target, or to limit the consequences of an attempted malicious act).

Nuclear safeguards are measures and systems to verify that countries comply with their international obligations not to divert nuclear materials, associated facilities, or associated activities to the development and production of nuclear weapons through measures and systems for nuclear material accountancy and control. As such, safety, security, and safeguards share many of the same systems and measures depicted in Fig. 1. Also depicted in Fig. 1 is the location of health physics (HP) support as it generally stands (i.e., as primarily a safety function with some security responsibilities), and the authors' perception of where it should be—playing a more central role between safety, security, and safeguards.

It should be noted that the IAEA's mandate excludes the military domain and implies that its definition of nuclear security (and thus the scope of this article, strictly speaking) does not cover nuclear weapon security and the security of associated (military) facilities and activities, although it can be argued that the applicability is no less relevant. Also, given the definitions of *adversary* (i.e., any individual performing or attempting to perform a malicious act) and *nuclear security threat* (i.e., a person or group of persons with motivation, intention and capability to commit criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities or associated activities), nuclear security in the context of this article deals with threats exerted by non-state actors. Thus, protection against a military strike, espionage or sabotage conducted by states does not fall within the nuclear security and safety domains as meant in this article.

In most facilities and activities involving nuclear or other radioactive material, health physics is firmly entrenched in the safety domain, and although radiation protection is one of the rubrics in the IAEA education programme on nuclear security (IAEA 2010b), it is not clear that it has a distinguishing role in nuclear security. The IAEA has noted, however, lessons learned in their nuclear security plan (IAEA 2009) regarding the importance of the interface between safety, security and safeguards by stating, "*Account should be taken of the synergies between safety security and safeguards...integrating, where appropriate, relevant features of the national legal and regulatory systems.*"

Given that health physics is so firmly entrenched in nuclear safety, it is reasonable that, through the IAEA argument of synergies, health physics should become an integral part of safety, security, and safeguards. The focus of this work is on health physics and nuclear security, and therefore safeguards will not be discussed in detail any further.

Employees of any nuclear facility, or those who are otherwise associated with activities involving nuclear or

Fig. 1. Health Physics related to S^3 .

other radioactive material, have incumbent responsibilities for nuclear security, ranging from ensuring doors are closed and locked, to inventory control of radioactive sources, to control of nuclear materials. However, the question that arises is, “What are the roles of the health physicist with respect to nuclear security?”

PROBLEM STATEMENT

Health physics is the field of science dealing with the safety of workers, members of the public and the environment in relation to ionizing (and non-ionizing) radiation. Since nuclear and other radioactive materials can be used maliciously to inflict both physical and psychological harm and thus also have the potential to cause economic and social disruption, nuclear security is germane, albeit not necessarily obvious, within the lexicon of the health physicist. However, nuclear security is not typically taught to health physicists either formally or informally, and input from health physics personnel in the nuclear security domain at a facility or an activity involving nuclear or other radioactive material may be minimal. Some aspects of health physics are, however, taught to nuclear security personnel, bridging the gap in a minimal fashion by providing personal dosimetry, instruments and minimal recurrent training, and often personnel dealing with nuclear security are far removed in an organizational sense from safety personnel such as health physicists. Given the fact that there is overlap between safety and security (and safeguards) with respect to purpose, measures, and systems as outlined earlier, these are typically separate departments organizationally, and tensions with respect to who has authority over what are not uncommon. Also, whereas safety personnel including health physicists tend to have a scientific background and thus approach challenges and assignments academically, security personnel are typically more affiliated with law enforcement and the military, where orders are passed hierarchically and are expected to be executed without questioning. These fundamental differences in background, technical language, and culture generally do not enhance communications, reciprocal respect, or understanding.

The art and science of nuclear security is more of a systems engineering problem, and since health physicists tend to have a broad knowledge base of engineering, physics, chemistry and biology, along with in-depth operational knowledge of a facility or an activity, the health physicist is an expert who can obviously contribute valuably to a variety of topics and challenges in the nuclear security domain.

There are some very unique characteristics of facilities like nuclear power plants, research reactors, nuclear fuel cycle, and waste disposal facilities with respect to security. These include: (a) nuclear facilities are iconic, (b) the target cannot be generally hidden from an adversary, (c) they have

a long lifetime (from commissioning to decommissioning), and (d) they can be made into “hard targets” (that is, fortified against malicious attacks). Nuclear security is managed through *defense in depth*—the combination of successive layers of systems and measures for the protection of targets from nuclear security threats—and using a *graded approach*—where the protection is proportional to the potential consequences of a malicious act. Nuclear security must therefore be risk managed to be effective and proportionate to both the threat and its potential consequences and thus not be unduly constraining. As a result, nuclear security must adopt an intelligent customer focus.

The first step in acknowledging nuclear security is to realize that there is a need for security. The need for nuclear security can be determined in many ways; i.e., by state edict, facility nuclear materials audit, and assessing the threat and its potential consequences. Once the need is established, a *nuclear security regime* must be put in place, comprising:

1. the legislative and regulatory framework and administrative systems and measures governing the security of nuclear and other radioactive material, associated facilities and associated activities;
2. the institutions and organizations within the state responsible for ensuring the implementation of the legislative and regulatory framework and administrative systems of nuclear security; and
3. *physical protection systems and measures* at the facility and activity level for detection of, and response to, malicious acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities.

Physical protection measures encompass personnel, equipment, and procedures such as guards, cameras, and physical barriers (walls, fences, turnstiles, and the like) and procedures governing authorizations and restrictions. An integrated set of *physical protection measures* constitutes a *physical protection system (PPS)*, such as an access control system, often comprised of guards, barriers, cameras, means of identification, and applicable procedures governing (levels of) authorization and restrictions.

First, a set of planning assumptions must be made. These planning assumptions are known as the design basis threat (DBT). The DBT is defined by the IAEA (2011) as, “*The attributes and characteristics of potential insider and/or external adversaries, who might attempt unauthorized removal (of nuclear or other radioactive material) or sabotage, against which a physical protection system is designed and evaluated.*” After the DBT is defined, physical protection systems (PPS) must be designed. The designs then need to be evaluated for efficacy and, based upon that evaluation, either a final design is put in place or the

physical protection systems must be redesigned. Finally, the security systems must be validated as being appropriate for the DBT (for example, through force-on-force exercise), and periodic review of the DBT must be performed and physical protection efficacy re-evaluated (Garcia 2008). The security design process is outlined in Fig. 2.

Obvious areas in which the health physicist can contribute in the nuclear security design process are the threat assessment (design basis threat definition), PPS definition and design and how they relate to radiological hazards, and participation in exercises, discussed below.

VISION AND CHALLENGE

Nuclear security is based on threat assessment, which relates to adversaries and targets. Assessments of potential adversaries and their capabilities are translated into the design basis threat and are primarily the result of intelligence gathering. As such, this is a matter of national security and thus the State. The assessment of the target, taking into consideration the characteristics of adversaries and their capabilities, and the specifications of recovering target material, however, requires security experts that understand nuclear phenomena in general and nuclear or other radioactive materials and their associated facilities and activities specifically. The natural question then arises as to who knows the most about the target, and which aspects of the target are most important or critical, taking into account the characteristics of adversaries and their capabilities. The simple answer is that the prime reason for theft of nuclear or other radioactive material, or sabotage of an associated facility or activity, is to do harm, whether it be psychological or physical, generally with the intent to cause economic and social disruption. The health physicist is uniquely qualified and positioned to address all of these end-points, and there are a number of areas where the health physicist can contribute valuably to nuclear security.

Nuclear and other radioactive materials range from common, everyday sources such as those found in smoke detectors, to high activity industrial and medical sources, to special nuclear material, such as plutonium and enriched

uranium. The potential consequences of various types of obtainable nuclear and radiological material are depicted qualitatively in Fig. 3. The figure relates that the consequence increases greatly as a function of the amount of radiological material that might realistically be obtained. For low quantities, the principal consequence is psychological terror that may be inflicted. For moderately large sources of radiation, the principal consequences are their potential use in a radiological dispersal device (RDD) or a radiological exposure device (RED). For the category of special nuclear material, the potential exists for the material to be used in an improvised nuclear device (IND). Fresh fuel may be a target from a nuclear security perspective; however, the potential health consequence from using this material directly in an RDD is relatively small, and therefore this source of nuclear material has impact only for financial motivation, as raw material for enrichment, or, if its enrichment is already high enough, use in an improvised nuclear device (IND). Fig. 3 also depicts the type of adversary capability required to obtain the target material and to modify, use, weaponize and/or deploy it effectively. For larger activity/enrichment sources with more elaborate safety/security/safeguards measures and systems in place, the adversarial capability in general must be greater and in proportion to the source activity or enrichment grade. For example, the type of adversary that may target smoke detectors could be an unskilled loner possibly acting impulsively. An industrial gauge may be targeted by an adversary with some non-nuclear specific skills and might still be a loner. For a medical or industrial source, some degree of technical and organizational skill is required. A target of used nuclear fuel would require a trained and skilled adversary that can rely on support by an organized group proficient in planning and coordination, and that may require an insider. For special nuclear material targeted for the construction and use of an IND, the adversary should be considered to consist of a group of multidisciplinary, well organized, and networked (groups of) experts who are capable of multidimensional planning and coordination, using insiders and possibly even having some form of direct or indirect State support.

Fig. 2. Nuclear security design process flow.

Fig. 3. Relative potential health consequence for various sources.

The overall vision is for the role of health physicist to be essential for safety, security, and safeguards as depicted in Fig. 1; the challenge is that health physics is typically considered a safety function and not essential to nuclear security. There are numerous similarities between applications of safety and security, such as:

1. use of defense-in-depth for design;
2. protection of the nuclear/radiological material, hence the public, is the priority;
3. use of human performance indicators to reduce error; and
4. inherent importance on individual accountability.

There are, however, some significant differences that challenge the integration of health physicists; for example:

- a. increased security requirements for personnel;
- b. control of sensitive information (especially the DBT) is very important;
- c. physicists prefer to have as much information as possible, whereas security personnel prefer to limit information (so-called “need-to-know”); and
- d. concern over malicious acts is the priority (as opposed to accidents).

As alluded to above, a conundrum exists between health physicists and security personnel insofar as a health physicist prefers to have as much information as possible about measures and systems to make informed decisions, whereas security personnel prefer to compartmentalize information so that very few individuals have access to the complete view of the security measures and systems. Both health physics and security goals can be achieved as long as there is a mechanism by which all pertinent security-related data is accessible by appropriate health physics staff (that is, the definition of “need-to-know” is clearly delineated).

It is clear that health physicists are the most knowledgeable personnel with respect to assessing potential consequences of a malicious act involving nuclear or other radioactive material, associated vital safety systems, and with respect to the radiological emergency response to such an event. Strategies for incorporating health physicists into nuclear security are presented below.

STRATEGY

Despite the belief that security personnel exercise control over nuclear or other radioactive materials, the operational, health physics and research staff are actually in physical control of these materials. This suggests that these personnel understand the facility or activity, the nature of the nuclear or other radioactive materials, and also account for the material inventory. However, this also suggests that these personnel are in a better position, compared to security personnel, to act as an insider adversary, which is of concern to nuclear security personnel. Therefore, there is a balance that must be achieved between the requirements for expert health physics support with regard to nuclear or other radioactive material and the need for integrated nuclear security.

The overall strategy proposed to integrate health physics into nuclear security is a grass roots approach wherein the duties and responsibilities of health physicists are made clear at all levels of a nuclear security regime, and they are an integral part of the decision making process. Specific areas to consider for health physicist integration are as follows:

1. Input to the design basis threat (DBT)—the design basis threat, which is a set of planning assumptions, is subject to the famous Moltke (1897) observation, “*No plan survives first contact with the enemy.*” However, a plan can be made generic enough such that the goal of the plan is achieved. A thorough understanding of the target in a radiological sense and the potential for adverse consequences can assist in the design of physical protection systems and response assets, which is the overarching goal of the DBT. The health physicist is the most knowledgeable about radiological matters at a facility activity involving nuclear or other radioactive material and should therefore be on the critical path for establishing and evaluating the DBT;
2. Policy, legislation, and regulation—The necessary changes to achieve the goal of a more integrated approach toward safety and security (and safeguards) are not limited to facilities or activities involving nuclear or other radioactive materials themselves. As the state is responsible for policy development, implementation in the legislative framework and enforcement, it also needs to align its various departments toward an integrated approach to safety and security (and safeguards) to prevent overlapping, incompatible,

compartmentalized, inconsistent or even conflicting policies, legislation, oversight, and enforcement. For this, experts that have a holistic understanding of both safety and security are required. Concretely this means that security experts will need to move toward health physics experts and vice versa. The obvious conclusion then, in light of this article, is that the profession of health physics becomes much broader and more integrated than it is currently in the nuclear security domain;

3. Risk management—Health physics personnel are very capable at balancing risk management so that appropriate protection is achieved while not constraining activities (ALARA principle, taking economic and social factors into account). This is essential for efficient operation of a nuclear facility and ensuring that nuclear security does not hinder the mission of the facility. Since radiation protection is an essential component of all areas in a nuclear facility, and indeed facility access to radiation areas is under the authority of health physics, it is natural that health physics personnel can assist nuclear security personnel in establishing physical protection systems. Risk, as related to nuclear security response capability, is discussed below; and
4. Response to an adversarial threat—health physicists are not generally trained to be armed responders to an adversarial threat. However, this does not imply that health physics personnel cannot be trained and integrated into a responding force to rapidly assess and determine countermeasures for radiological hazards. As discussed above, health physicists are highly trained risk managers. In nuclear security, risk may be quantified as the likelihood of a set of consequences, given as eqn. (1):

$$R = P \times C, \quad (1)$$

where R is the risk, P is the probability of occurrence, and C is the consequence. When the event being considered is a successful adversarial attack, eqn (1) can be written as

$$R = [P_A \times P_{S|A}] \times C, \quad (2)$$

where P_A is the probability of attack, $P_{S|A}$ is the probability of successful attack given that an attack has occurred, and C is the consequence of the successful attack. If the attack occurs, the outcome is binary, in that it either occurs or it does not occur. Defining P_E as the probability that a physical protection system (including responders) will be effective in thwarting an attack, eqn (2) may be written as

$$R = [P_A \times (1 - P_E)] \times C, \quad (3)$$

which is the physical protection risk equation. In eqn (3), nuclear security personnel determine P_A (although health physics personnel may advise on the likelihood that a material would be a good candidate for an RDD or IND). The

consequence, C , might be determined jointly by security, facility management, health physics personnel and the State. The probability of effectiveness, P_E , is typically determined by security personnel, and is given by

$$P_E = P_I \times P_N, \quad (4)$$

where P_I is the probability of interruption (i.e., the likelihood that a response force will arrive to defend a facility/material prior to the adversary completing an attack and is based upon timely detection of an adversary's actions) and P_N is the probability of neutralization (i.e., the likelihood that a response force will prevent an adversary from completing an attack and logically follows timely interruption of the attack). The determination of P_I is typically constructed using adversary sequence diagrams (ASD) and is used to find the most vulnerable paths for an adversary to gain access to the nuclear asset. A single path analysis tool that is commonly used for determining P_I is the EASI (Estimate of Adversary Sequence Interruption) tool. The tool considers parameters such as detection probabilities for external and internal sensors, communication probabilities of an alarm to a response force, response time, and all delays (Garcia 2008). However, not explicitly considered in a tool such as EASI is the influence of the potentially harmful radiological characteristics of the target material or facility. In the post-9/11 environment, the asymmetrical threat of an adversary willing to martyr itself to reach the goal is significant, and therefore it may not be assumed that sufficient radiological protection will exist for response force members. This same consideration is required when determining the probability of neutralization, P_N . Health physicists can be of assistance in the evaluation of physical protection measures (as outlined in Fig. 2) for identification of delays or turn-back criteria in various response scenarios involving radiological material. As an integral part of the security response team, a health physicist would ensure that appropriate decisions can be made in an ad hoc fashion as related to emergency turn-back guidance.

5. Emergency radiological guidance—Health physicists are crucial in developing, maintaining, executing, and evaluating emergency procedures related to facility radiological material and are therefore essential in the training of security response personnel. The International Atomic Energy Agency provides default emergency worker turn-back dose guidance (IAEA 2000) primarily for accidental release radiological scenarios. Scenarios that might affect nuclear security response personnel are added in Table 1, along with the IAEA emergency worker guidance and hypothetical response force dose guidance presented by the authors. To the response force, the implication of injury prevention and life-saving action applies here to facility personnel

Table 1. Emergency worker (EW) turn-back guidance (adapted from IAEA 2000) presented with author hypothetical response force (RF) guidance.

Tasks	EW turn back dose (mSv)	RF turn back dose (mSv)
Type 1		
• Life saving (EW)	250	
• Prevention of IND (RF)		1,000
Type 2		
• Prevent serious injury (EW)	50	
• Prevention of RDD (RF)		500
Type 3		
• Short term recovery operations	25	100

and off-site civilians from both the immediate hazard from the material and the potential use of the material (for example, RDD or IND). The response force guidance for a Type 1 task (which is related to the target material) is based upon a practical threshold for deterministic effects of approximately 1 Sv, whereas the Type 2 guidance is based upon minimizing response force personnel stochastic effects while preventing potentially large collective doses from an RDD weapon fabrication and deployment. A higher guidance level (compared to emergency workers) for response force Type 3 activities is based upon the immediate need to secure material and protect against potential Type 1 and 2 events. It is worthy to note, however, that security personnel, first responders and other emergency services personnel routinely accept (stochastic) risk of personal harm in carrying out their duties, and it may be determined in an event that the benefit of defeating an adversary (elimination of consequence) outweighs risk of exposure to radiological material. Therefore, although Table 1 outlines guidance, there is in practice no dose limit (with the assumption that security/response force personnel have been informed of the risks).

6. Nuclear forensics support—Health physicists typically have a certain degree of day-to-day experience with nuclear forensics; for example, investigating issues as simple as a contaminated laboratory or work place, and answering questions such as “Who did it?” “Which isotopes and concentrations are involved?” and “Was anyone exposed or injured?” Some prospective nuclear forensic knowledge residing within the skill set of the health physicist include (i) planning and preparedness (such as in-house equipment necessary for first response, training with that equipment, what needs to be contracted with external labs, subject matter experts, defining materials and methods) and (ii) knowledge of the characteristics, advantages, and limitations of one analysis technique/device over the other (i.e., gamma spectrometry versus mass and/or alpha spectrometry,

contamination monitors, proportional counters, etc.). Some retrospective nuclear forensic capabilities include (a) evaluating results; (b) understanding the meaning of the uncertainties, potential biases, and systemic errors in analytical results; (c) based on analyses performed, translating the results in such a way that scenarios of what happened can be confirmed or eliminated, or how their likelihood changes; (d) technical results can be translated so that non-technical experts (managers, response force personnel, members of the public) may understand the implications; and (e) radiation protection aspects during forensic investigations.

7. Training security personnel—The health physics staff understands the systems to control and prevent exposure, whether they are located at the source or the worker. Training of radiological basics, dose guidance, instrumentation, and personal protective equipment to nuclear security personnel (including the response forces) is an essential duty of health physics. Health physics personnel, through their expertise in emergency planning, can assist in preparing and participate in nuclear security exercises. In addition, the health physicist can participate actively in achieving demonstrable competence in nuclear security.
8. Risk and hazard communications—Health physicists are generally trained to communicate radiological risk to workers, regulators, operators, and members of the public. It is clear, therefore, that health physicists should be incorporated into communicating nuclear or other radioactive material hazards to nuclear security personnel, regulators and operators, and members of the public and provide bridging communications to foster support for nuclear security culture.

Although it has been presented that health physicists can make important contributions at all levels of a nuclear security regime in order to achieve nuclear security objectives, there are a number of practical issues to be addressed. For example, the design basis threat is a restricted document with “need to know” access. In the model above, health physicists would require access to the DBT. However, at most nuclear facilities, health physics personnel have gone through an enhanced screening process. For those personnel that require elevated clearances to access the DBT, the process should be straightforward. The possibility of a health physicist being an insider threat must also be considered. However, the probability is no different than that of any other trusted individual or group associated with a facility or activity involving nuclear or other radioactive material, its regulators, or other government bodies. Although the risk of a health physicist being an insider threat is elevated due to proximity to, and knowledge of, the nuclear or other radioactive material on hand and the associated safety systems, this risk should be addressed.

DEMONSTRABLE COMPETENCE

In the nuclear security domain, there is increasing need for demonstrable competence for the variety of roles responsible for nuclear security functionality (Johnson and Howsley 2013). There are a variety of pathways through which personnel can achieve competence in their respective fields: through formal education, professional training, experience, and certification. In the field of nuclear security, there are a limited number of graduate university programs available (INSEN 2014). The International Masters degree program in nuclear security that is delivered by a consortium of European universities (MINS 2013) may provide the necessary educational background in nuclear security on the path to competence. The World Institute for Nuclear Security (WINS) has established the WINS Academy to provide guidance in certification of nuclear security professionals (Johnson and Howsley 2014) and has recently deployed a program of certification for a variety of roles that require demonstrable competence (WINS 2014). Regarding certification, an example of well-developed demonstrable competence in health physics in the United States is the designation of Certified Health Physicist (CHP) through the American Academy of Health Physics (AAHP 2014). In the Netherlands, the profession itself and its (varying levels of) knowledge and competence requirements, duties, and responsibilities are firmly incorporated in the legislative framework. Worldwide, there are a variety of state agencies and academies that certify competence in health physics to varying levels, but the subject of nuclear security is not, either specifically or elaborately, covered. Depending on the specific nuclear security role, there should be rubrics in health physics essential to demonstrable competence in nuclear security. For example, radioactive material managers should have fairly well developed knowledge and practice in radiation safety. The role of the health physicist in this area can be both to help develop the rubrics for certification pathways and to become a subject matter expert.

SUMMARY

The nuclear security umbrella incorporating the role of health physics is depicted in Fig. 4. It is typical for a facility or activity involving nuclear or other radioactive material to have in-house and onsite health physics support as part of the essential safety mission. Therefore, there is already a strong connection between health physics and management of any facility or activity involving nuclear or other radioactive material.

Health physicists are qualified, multi-capable scientists, engineers, and systems integrators that can contribute valuably at all levels of an effective and efficient nuclear security regime. Issues regarding security clearances and

Fig. 4. Health physics roles under the nuclear security umbrella.

insider threats must be addressed; however, the net gain from recognizing and integrating health physics expertise at all levels of a nuclear security regime far outweighs any negative aspects. In fact, it has been shown that the role of the health physicist is essential in achieving a more integrated approach toward nuclear safety, security, and safeguards.

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