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Radiological Protection in Security Screening

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Radiological Protection in Security Screening

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Abstract- The use of various technologies to provide security screening for individuals and objects has been rapidly escalating, in keeping with the significant increase in security concerns worldwide. Within this spectrum of technologies, the use of ionizing radiation to provide backscatter and transmission screening capabilities has also increased. The Commission has previously made a number of statements related to the general topic of deliberate exposures of individuals in non-medical settings. This report provides advice on how the radiation protection principles recommended by the Commission should be applied within the context of security screening. More specifically, the principles of justification, optimization of protection, and dose limitation for planned exposure situations are directly applicable to the use of ionizing radiation in security screening. Further, several specific topics are considered in this report, including the situation in which individuals may be exposed because they are concealed (stowaway) in a cargo container or conveyance that may be subject to screening. The Commission continues to recommend that careful justification of screening be considered before decisions are made to employ the technology. If a decision is made that its use is justified, the framework for protection as a planned exposure situation is to be employed, including optimization of protection and the appropriate provisions for the authorization and inspection.

Keywords: Security Screening, Justification, Optimization

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106

107 # PREFACE

108 Since the discovery of radiation and radioactive materials, there have been
109 deliberate exposures of humans for various purposes. The majority of these have
110 involved some type of medical diagnosis, treatment, or research. However, there
111 have been, and continue to be, examples of situations in which an individual is
112 deliberately exposed for some other purpose. Recent events in global and national
113 security, together with the development of sophisticated security imaging
114 technologies, have heightened interest in such activities. This raises the potential for
115 further increases in exposure to individuals due to the use of these imaging
116 techniques for security purposes.
117 These exposures have often been lumped into a general category of "non-
118 medical" imaging exposures. In some specific instances non-medical imaging
119 involves the use of medical devices (e.g. drug detection, immigration purposes),
120 while in other circumstances it takes place in non-medical facilities or public places
121 involving the use of specialized inspection devices.
122 The Commission has given advice on such situations many times. However,
123 there has been an increased focus upon security for individuals in air travel and other
124 public settings in the wake of the terrorist events of September 11, 2001. Following
125 an attempted aircraft terrorism event in December, 2009, there has been an increased
126 call for the use of security screening systems, including those utilizing ionizing
127 radiation, because of their effectiveness in detecting concealed objects of concern.
128 Such screening involves the direct screening of individuals at various security
129 control points. The broader context of security screening also encompasses the
130 screen of cargo and conveyances at various borders and points of entry.
131 This report was developed to provide advice on the application of the
132 Commission's recommendations to the specific set of cases involved in security
133 applications. Other examples of "non-medical" imaging are not included in this
134 report, although the advice may also be valid for other instances of deliberate
135 imaging of humans, with due consideration of each specific application. The report
136 describes how the radiation protection principles of the Commission should be
137 applied within the context of security screening. While it is not the role of the ICRP
138 to state whether such systems are justified or not, it is appropriate to develop further
139 the aspects to be considered in decisions on whether to employ such systems. The
140 report also describes how the principles of radiation protection in planned exposure
141 situations apply within a security screening context, including optimization of
142 protection with the use of dose constraints.
143 This report is the result of active cooperation and collaboration with the
144 international agencies and organizations that are observers to ICRP Committee 4. A
145 special thanks to those organizations and individuals for their contributions.
146
147 The membership of the Task Group was as follows:
148

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S. Liu	H. Liu	S.M. Magnusson
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MAIN POINTS

- **The use of ionizing radiation to screen individuals for security purposes is an exceptional circumstance which requires careful justification. It should not be presumed that the use of ionizing radiation is generically justified, or acceptable.**
- **Justification decisions should include consideration of all relevant factors, including the definition of the screening objectives (threats, vulnerabilities, and consequences), the degree to which the technology accomplishes the screening objectives, radiological exposure during a screening, and alternatives which may be available to reduce exposures and enable identification of groups of individuals who may incur a significant number of screenings during a year.**
- **In most cases, justification decisions to employ a particular security screening technology will involve many factors outside of radiation protection.**
- **Security screening using ionizing radiation, if determined to be justified, is a planned exposure situation, and should be subject to the appropriate regulatory framework for optimization of protection, authorization, and inspection to ensure radiation safety in operation.**
- **The exposure of an individual to be screened for security purposes is considered to be public exposure.**
- **Optimization of protection for an individual to be screened should include consideration of the number of exposures necessary to accomplish the screening objective, the dose per exposure, and avoidance of additional (or repeated) exposures.**
- **Optimization of protection is to be applied during the design and operation of a screening system for each category of exposure, including: individuals being screened; members of the public who are not being screened but may be in the vicinity of the screening; and occupational exposure.**
- **Appropriate expectations need to be established for training, retraining, and competence of operators, and the management systems to ensure safety during operations.**
- **Dose constraints should be established for each identifiable category of exposure (individuals to be screened, members of the public who are not being screened but may be in the vicinity of the screening, occupational exposure), and used in the optimization of protection.**
- **Appropriate application of the framework of protection, including justification and optimization, will provide adequate protection for more sensitive populations. Thus, if the recommendations in this report are met, it will not be necessary to take separate protection actions for children or pregnant women.**

- **Screening of cargo and materials may pose circumstances of exposure, particularly for drivers of conveyances being screened, that should be avoided. Exposure of such individuals should not be a matter of operational convenience. Drivers should not be allowed to occupy conveyances during screening, except for very unusual circumstances.**
- **Screening of cargo and materials may pose the possibility of exposure to individuals concealed in the cargo containers, which must be factored into the analysis and authorization for use. The Commission recommends that even in such circumstances, protection equivalent to that provided by the dose limits for members of the public should be achieved.**
- **The use of stakeholder dialogue and provisions of information to meet an individual's right to know, are important tools in the justification, optimization, and implementation of a security screening circumstance. Communications need to be accurate, informative, and responsive to the concerns. The Commission recommends that key messages, questions, and answers be developed and readily available during operations, to facilitate stakeholder interactions.**

GLOSSARY

Active detection system

A security screening device using radiation to activate the object being screened that in turn causes radiation emissions that facilitate detection of the material.

Backscatter detection system

A security screening device using low energy ionizing radiation by measuring the radiation scattered from an object to create an image. The radiation source and the detector are located on the same side of the object.

Image

A single view (image) taken by a security screening system as part of the security screening process.

Transmission detection system

A security screening device using ionizing radiation with sufficient penetration power to create an image by measuring radiation transmitted through an object. The radiation source and the detector are located on the opposite sides of the object.

Screening or Screening Event

The collection of one or more images to produce the information necessary to properly screen an individual or object.

Security Screening

An activity undertaken to detect unintended, unwanted, or deliberately introduced objects or materials that could be used for malicious purposes.

1. INTRODUCTION

(1) The deliberate exposure of humans dates back to the initial discovery of radiation and radioactive materials. In most cases historically, this has been in the context of medical exposures of patients, intended either for diagnosis or treatment. In these cases, the benefits to the patient from the radiation exposure are expected to more than outweigh any radiation detriment that may ensue.

(2) However, recent events in global and national security, together with the development of sophisticated security imaging technologies, have significantly increased the consideration and use of radiation in this non-medical context. Increasing numbers of individuals might be deliberately exposed, typically in order to produce an image of objects that may be concealed on the individual.

(3) In the context of this report, security screening may be considered as any activity using ionizing radiation to detect unintended, unwanted, or deliberately introduced objects or materials that could be used for malicious purposes before allowing entry into an area. When the object of the screening is an individual, for example to determine if some weapon is being secretly carried, the conditions of exposure are that of a deliberate exposure of the individual. This application is being considered or used to screen individuals before allowing entry into airport secure areas, large public events, court houses, jails, and other areas. Screening may consist of a single image, or multiple images to obtain the information necessary for security purposes.

(4) Security screening also encompasses the use of ionizing radiation to examine materials, cargo, and conveyances, at various ports of entry, border crossings, etc, for security related items. This application does not, in most cases, fall within the category of deliberate exposure of individuals. However, certain circumstances may exist in which individuals are knowingly present (such as a conveyance driver), or may be unknowingly present. The latter case, where an individual or group of individuals may be concealed in the cargo container seeking to avoid detection, is sometimes referred to as “stowaway”.

(5) This report is intended to summarize the relevant concepts and guidance of the ICRP, and to provide advice on the application of the Commission’s recommendations for radiation protection in the context of security screening. The scope of this report does not include any other instances of deliberate exposure of individuals, either for medical or for other purposes, although the advice may also be valid for other instances, with due consideration of each specific application.

(6) There are two main imaging technologies in use today for security screening using ionizing radiation: backscatter and transmission. Backscatter technology is used mainly to image objects hidden under clothing while transmission systems are also used to image objects that have been ingested, hidden in body cavities, or implanted under the skin. Generally, the radiation dose to the scanned individual from a backscatter system is much lower than the dose from a transmission system. Some systems which employ a combination of the two technologies are also available. Screening activities for materials and cargo generally employ transmission systems, usually with higher energy than that used in screening of individuals, to provide adequate images of the objects. Screening activities for materials and cargo may also, in certain specific situations, use active detection technologies. A brief description of the current screening technologies is provided in Section 3 to this report.

2. BACKGROUND

(7) The use of radiation for the exposure of individuals, in a deliberate manner, has usually been within the context of medical exposures. However, there are other circumstances in which such exposures may take place. Screening of individuals for various security purposes is one of those circumstances. The screening of objects normally would not include such deliberate exposures, but exceptional circumstances may arise in which such exposures may need to be considered. The ICRP has provided statements on the issues of deliberate exposure of individuals in non-medical contexts since the 1960's. Other organizations have also produced information, specifications, performance standards, and recommendations.

(8) ICRP *Publication 15* (ICRP 1969), strongly disapproved of human imaging for non-medical purposes, citing the two examples of anti-crime fluoroscopy and customs examinations. From this default position, the recommendation then allowed for exceptional circumstances under which these activities could be carried out – namely, permission by the competent authority, that the examinations were considered essential, and that they would be carried out under the supervision of a radiologist.

(9) International events at the time, namely a spate of aircraft hijackings, led the ICRP (ICRP, 1971) to state that they believed security-screening of airline passengers could be justified, but did not provide any elaboration or viewpoints with respect to responsibilities, processes, or the role of radiation protection in the justification of exposures.

(10) The general Recommendations of the ICRP in *Publication 26* (ICRP, 1977), did not supersede some of the previous Commission publications, including the above mentioned *Publication 15*. *Publication 26* also considered additional situations with respect to non-medical human imaging beyond security screening.

(11) The Recommendations of the ICRP in *Publication 60* (ICRP, 1990) did not contain any recommendations with respect to human imaging for non-medical purposes, or more specifically, security screening practices.

(12) ICRP *Publication 73* (ICRP, 1996) was dedicated to radiological protection and safety in medicine. The scope of medical exposure was expanded (with respect to *Publication 60*) to include exposures for medico-legal purposes, and made reference to screening, although this reference is only in the context of medical screening, not screening for other purposes such as security.

(13) The Recommendations of the ICRP in *Publication 103* (ICRP, 2007) described a set of conditions in paragraph 210 for which the exposures should be deemed to be unjustified without further analysis, unless there are exceptional circumstances. The described circumstances did not specifically include applications of security screening. However, the condition of exceptional circumstances would remain applicable to the context of security screening, in that it is a deliberate exposure of an individual that is not motivated by the health of the individual.

(14) Other organizations, particularly the National Council on Radiation Protection and Measurements (NCRP), in the United States, have also provided information on aspects of security screening. In particular, NCRP Commentary 16 (NCRP, 2003) provides advice on security screening of humans. NCRP Commentary 20 (NCRP, 2007) provides advice on some aspects related to security screening of cargo with accelerator produced high-energy x-rays. NCRP

Commentary 21 (NCRP, 2011a) and Commentary 22 (NCRP, 2011b) address radiation protection aspects of active detection technologies.

(15) The relevant national authorities of various countries have, in some cases, taken specific stances to prohibit the use of ionizing radiation on the human body except for medical purposes. In other cases there have been decisions regarding the justification and use of a particular security scanner, and there have been several independent evaluations of doses from various commercially available systems. Some organizations, such as the U.S. Interagency Steering Committee on Radiation Standards (ISCORS, 2008) have provided guidance on the justification of screening systems, and the operational radiological protection steps to be taken if screening is justified. The landscape of decisions will continue to evolve, with both the continued evolution of the threat environment, and the technologies available to counter those threats.

(16) The issues surrounding use of radiation for security screening have also been examined in the work of international organizations. For example, in 1977 the World Health Organization addressed the use of ionizing radiation on human beings for non-medical purposes, including weapons detection, in a technical report (WHO, 1977). The report concluded that this should be done only when there are not satisfactory alternative methods presenting lower risks, and emphasizing the need to manage the dose to optimize protection. More recently, an information paper was prepared by the Interagency Committee on Radiation Safety (IACRS, 2010), which outlined some of the pertinent issues, trends, and national requirements. The Heads of the European Radiological protection Competent Authorities (HERCA) also published a statement on the justification of full-body scanners using x-rays for security purposes in December, 2010 (HERCA, 2010).

(17) The International Atomic Energy Agency (IAEA), and other international co-sponsoring organizations, have recently completed a revision of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (IAEA, 2011). The revised standard includes a provision that human imaging using radiation for the detection of concealed objects that can be used for criminal acts that pose a national security threat shall be justified only by the government. If the government decides that the justification of such human imaging is to be considered, further requirements related to the justification decision, and provision for regulatory control, are applicable.

(18) The European Commission (EC) has recently proposed a revision of the Euratom legislation on radiation protection (EURATOM, 2011) containing legal provisions on exposure of humans for non-medical imaging, including the use of ionizing radiation for security screening, which once adopted will be legally binding for the twenty seven member states of the European Union (EU). A recent revision of the EU aviation security legislation (EU, 2011) authorises the use of security scanners, excluding those using ionizing radiation, as a primary security screening method at airports in the EU.

(19) Various national and international consensus standards organizations, including the International Standards Organization (ISO), the International Electrotechnical Commission (IEC), and the American National Standards Institute (ANSI), have developed performance standards for radiological exposure, and specifications of performance in the detection of the objects of security concern.

(20) In 2002, a consensus standard was published by the American National Standards Institute (ANSI, 2002) that established a limit for the effective dose from one scan of 0.1 μSv. This standard also established a limit of no more than 0.25

mSv annual effective dose to an individual from any one security screening venue. This standard was revised and updated (ANSI, 2009), and modified to refer to a "screening" (which might involve several scans or views), rather than a single image.

(21) In 2010, IEC published an international standard IEC 62463 for x-ray systems for screening of individuals for security (IEC, 2010). This standard provides radiological performance criteria for security screening systems. Another standard project, IEC 62709, "Radiation protection instrumentation – Measuring the Imaging Performance of X-ray and Gamma-ray Systems for Security Screening of Humans" is in progress.

(22) Despite the considerable history, and the presence of various specifications and performance standards, there continues to be a debate on the use of radiation in security screening, the role to be played by radiation protection in the decision process, and the application of the Commission's framework for protection if such screening is employed. The objective of this report is to provide advice on how the radiation protection principles of ICRP should be applied within the context of security screening if a decision is made that its use is justified. This advice is applicable irrespective of whether the equipment utilized is specifically designed for such purposes, or has been re-purposed to a security screening circumstance from some other original purpose, such as medical radiological equipment.

3. SECURITY SCREENING SYSTEMS

(23) A variety of systems employing ionizing radiation are currently available for screening individuals at a security checkpoint. The systems may use backscatter, transmission, or a combination of the two technologies to form an image.

(24) The introduction and use of scanning systems has generated considerable public debate. Much of this discussion has been focused on non-radiological considerations. For example, concerns have been raised about privacy because of the ability of these systems to "see" through clothing. Such concerns certainly need to be addressed, but are not unique to the systems using ionizing radiation. This has resulted in a continuing refinement of the systems, including software processing systems, to remove the detailed image of the individual's body, and only display possible items of security concern on a generic outline of the individual. Likewise the legal questions of image retention, documentation, and retrieval have been raised and must be addressed in the overall decision process. These same issues have also been part of the dialogue on the use of systems based on alternative technologies like microwaves, and thus are not unique to systems utilizing ionizing radiation.

(25) The categories and types of equipment, described below, are useful to understand the possible radiological contributions from each type of technology. From the standpoint of radiological protection, it is not important whether the device or system was originally intended for some purpose, such as medical diagnosis and treatment. What is important is the actual conditions of exposure and use which are being considered.

3.1. Backscatter technology

(26) Backscatter systems designed for security screening of humans are used mainly to image objects hidden under clothing. The effective dose from such systems is on the order of 0.1 μSv per image of the front of the body; images of the back or sides may produce lower effective doses. Furthermore, the exposure will be predominately to the skin, because the energies used do not significantly penetrate the body. It may be necessary to image an individual multiple times, from the front, from the back, and from the sides, to obtain the information necessary to satisfy security interests. Thus the "total dose" during a screening event may be greater than the dose from a single exposure. In certain circumstances, backscatter systems may also be useful in the scanning of cargo and materials.

(27) These systems use a narrow beam of ionizing radiation that scans the subject in a raster pattern at high speed. They use large detectors on the same side of the subject as the x-ray source that detect radiation scattered back from the body of the individual being scanned. A schematic of the system is shown in Figure 1.

(28) Dose to an individual being screened with backscatter systems is a very small fraction of the exposure received from other sources in daily living. For example, a backscatter screening dose is on the order of 1000 times smaller than a typical chest x-ray, and is about the same as the cosmic radiation dose received during a few minutes of flight.

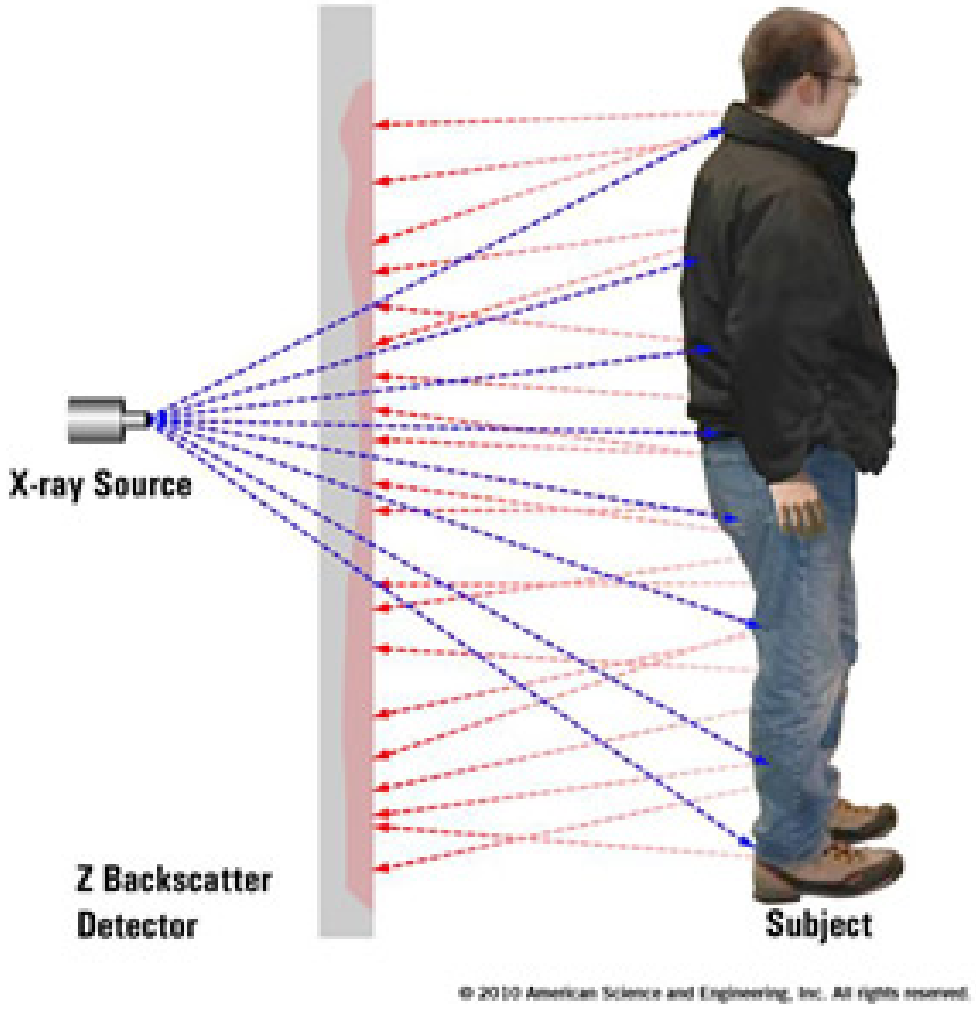

Fig. 1. Backscatter x-ray methods of operation

(29) These systems have been placed into service at national borders and in prisons for interdiction of drugs, weapons, and contraband. Following an attempted aircraft terrorism event in December, 2009, there has been considerable increased pressure to implement use of imaging systems for screening of airline passengers.

3.2. Transmission technology

(30) Transmission systems are used to image objects that have been ingested, hidden in body cavities, or implanted under the skin. The effective dose per scan from this type of system, when designed for security screening of humans, is greater than the dose from backscatter systems, and ranges roughly from 2 to 5 μSv or more, depending upon the equipment. An example, not directly related to security, has been the use of transmission systems to screen workers in diamond mines to prevent theft. However, transmission images show objects and body parts superimposed. For this reason, image interpretation is more complex than for a backscatter image.

(31) These systems create an image by passing ionizing radiation through the subject to a detector. The detector is placed on the opposite side of the subject from the ionizing radiation source. The radiation may be machine-generated x-rays or

gamma-emitting radioactive isotopes. Figure 2 shows a transmission scanning system.

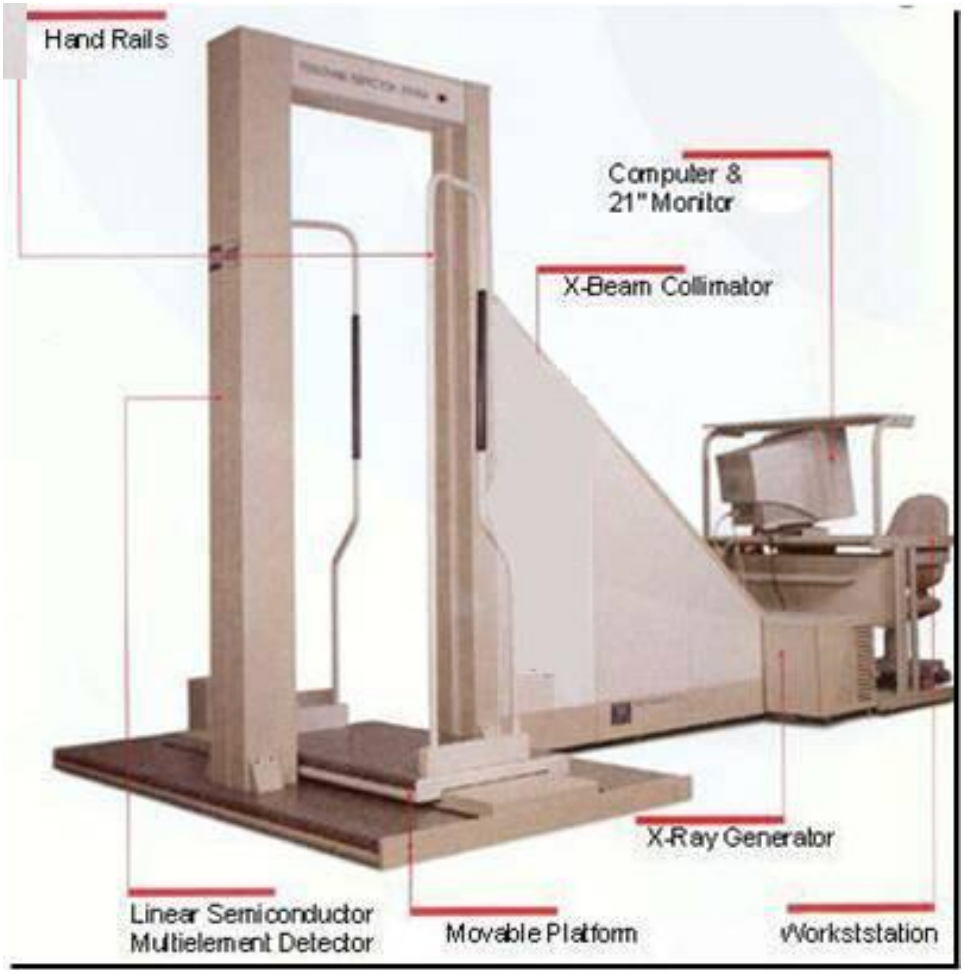

Fig. 2. Transmission x-ray scanner

(32) Transmission systems are also used to screen cargo and unoccupied vehicles for interdiction of drugs, weapons, and contraband. Cargo scanning systems usually employ radiations of significantly higher energy to obtain the necessary penetration to create an image of large objects. Such systems are not intended for the screening of individuals. However, special circumstances may arise in their use which results in the possibility of exposures to individuals. This circumstance is dealt with in Chapter 5 of this report.

(33) Security screening systems will continue to evolve. For example, some manufacturers are now offering systems that employ both backscatter and transmission technologies. Such systems may offer additional radiological challenges, particularly in the assessment of doses to individuals who may be screened, and individuals in other areas near the screening venue.

3.3. Active detection technology

(34) Active detection technologies use various beams of particle radiation to stimulate material to emit detectable radiation in situations where the materials of interest are not radioactive, the naturally emitted radiation energy levels are very low, or where there is shielding in place. The systems operate by using a beam of

radiation to interrogate an object or location suspected of containing fissionable nuclear materials. As a specific example, if certain types of explosive materials are present, such interrogation will activate the material, causing the release of characteristic radiation energies that, ideally, will allow identification of type, quantity, and location of the materials. These devices are intended to allow identification of those materials from a distance. These systems are being considered for situations in which the objective is to detect special nuclear material, particularly fissionable materials, which could be diverted from safeguards control.

4. SYSTEM OF PROTECTION

4.1. Exposure situations

(35) The recommendations in *Publication 103* organize radiation protection according to three exposure situations: planned exposure situations, emergency exposure situations, and existing exposure situations. Planned exposure situations are situations resulting from the deliberate introduction and operation of sources. Planned exposure situations may give rise both to exposures that are anticipated to occur (normal exposures) and to exposures that are not normally anticipated to occur. Emergency exposure situations are situations that may occur during the operation of a planned situation in case of loss of control of the source, or from a malicious act, or from any other unexpected situation, and urgent action is necessary in order to avoid or reduce undesirable consequences. Existing exposure situations are situations that already exist when a decision on control is taken. They include naturally occurring exposures as well as exposures from past events and accidents, and practices.

(36) The Commission views the use of radiation in security screening, when justified, to be a planned exposure situation. In such situations the introduction of the source is clearly and deliberately planned, and there is the opportunity and obligation to provide controls to ensure proper protection against ionizing radiation before activities commence. Certain circumstances, which may not be part of the normally expected and planned activity may arise, which are discussed in the chapter on special circumstances.

4.2. Categories of exposure

(37) The Commission distinguishes between three categories of exposure: occupational exposures, public exposures, and medical exposures. Occupational exposure is radiation exposure of workers incurred as a result of their work. However, because of the ubiquity of radiation, the Commission limits the definition of ‘occupational exposures’ to radiation exposures incurred at work as a result of situations that can reasonably be regarded as being the responsibility of the operating management. Public exposure encompasses all exposures of the public other than occupational exposures and medical exposures.

(38) The use of radiation and radioactive materials in security screening may lead to both occupational exposure, and to public exposures. Occupational exposure would be incurred by individuals who are operating the screening equipment, including maintenance, surveillance, and other activities that are necessary for proper control and operation of the source. Exposure of other individuals, who are not being screened, but may be in the vicinity of the screening activity, is considered to be public exposure.

(39) The exposure of the individuals who are being screened for security purposes is also considered to be public exposure. It is the Commission’s view that this statement applies, irrespective of whether individuals are being screened as a result of their work duties, such as aircraft crew, individuals travelling for business, couriers transporting documents or materials, or individuals who require access in order to work within the secured area. All such exposures are deliberate, and not directly related to the health of the individual. Thus, it becomes even more

important that a full and careful consideration be given to the justification for the exposure, and, if justified, to the optimization of protection. In this regard, the security needs should be clearly defined, including the types and magnitude of the threat and the risks associated with not effectively conducting the screening. The exposure of individuals who may be directly exposed as a result of screening of materials is also considered to be public exposure, and is elaborated further in the section on special circumstances.

4.3. Justification

(40) The principle of justification is one of the two fundamental source related principles that apply to all exposure situations. *Publication 103* requires, through the principle of justification, that any decision that alters the radiation exposure situation should do more good than harm. The Commission goes on to emphasize that this means that, by introducing a new radiation source, one should achieve sufficient individual or societal benefit to offset the detriment it causes. It is important to emphasize that the benefits that accrue to the society are to be factored into the justification decisions, and that from an ethical point of view, there needs to be an explicit consideration of both the benefits and detriments to the individual, and the benefits that may accrue to groups of individuals and the society as a whole.

(41) Justification is a multi-attribute process which must examine all of the possible benefits and impacts of a particular proposal taking into account the various alternatives that may be available, to determine if there is a net benefit to the conduct of the activity.

(42) The Commission further states in *Publication 103* that the consequences to be considered are not confined to those associated with the radiation – they include other risks and the costs and benefits of the activity. The radiation detriment will be only one of the risks that must be considered. Justification thus goes far beyond the scope of radiological protection. It is for these reasons that the Commission only recommends that justification require that the net benefit be positive. It is important that radiological protection authorities be a part of the decision process, but to search for the best of all the available alternatives is a task beyond their responsibility.

(43) It is not the role of the ICRP to state whether the use of radiation and radioactive materials in security systems are justified or not. The Commission believes that the use of ionizing radiation to screen individuals is an exceptional circumstance which requires careful justification. It should not be presumed that such screening is generically justified, or acceptable. As noted in ICRP Publication 103, it is necessary to consider all of the benefits and impacts of a proposed activity. In the case of security screening, there are a number of factors that must be considered.

4.3.1. Justification for screening of individuals

(44) The exposure of an individual during security screening is not, as in medical exposures, intended to directly contribute to the health of the individual. However, it could be concluded that there are individual benefits from knowing that they are in an environment that has been secured from certain threats, and that there are societal benefits that may result from such exposures, including the protection of society from threats, protection of groups of individuals in various meetings,

gatherings, or in public transportation, and prevention of damage to infrastructure and significant landmarks from malicious attack.

(45) Justification decisions regarding the use of ionizing radiation in screening will, of necessity, also include consideration of alternative techniques that may be available for accomplishing the specific goals of screening. This may include alternative technologies to the use of ionizing radiation, as well as various procedural alternatives and options. Again, it is not the role of the ICRP to state whether non-radiological alternatives should take precedence to use of ionizing radiation for a particular activity. Factors other than the radiological criteria, such as the efficiency of detection of target objects, the time necessary to conduct scans, reliability, etc. may influence the overall benefit delivered by the systems using ionizing radiation. Furthermore, non-radiological systems may also present risks to the individuals being scanned, and such risks must be also taken into account. The Commission does not wish that its recommendations be construed as implying any preference for or against the various available alternatives to using ionizing radiation. Systems must obviously be judged on the basis of their effectiveness in accomplishing the intended purpose for security screening.

(46) An issue is often raised with respect to whether a particular screening technique is “voluntary”, and whether there is a provision of an alternative technique. Such a provision for alternative screening is required by a number of jurisdictions, and could take the form of a hand search, etc. The Commission recognizes that arrangements for alternative techniques are common place at security screen venues, such as airports, and are appropriate, irrespective of the types of technologies being employed. The role of radiation protection is to provide information on the risks of using ionizing radiation, and thus contribute to a well informed discussion during the justification of use, and if justified, during the operational activities. The latter takes the form of ensuring that there is sufficient information and opportunity for an informed consent on the part of individuals to be screened. Communication and stakeholder interactions are further addressed in Chapter 4.

(47) Security screening systems using ionizing radiation need to be designed to deliver useful information with the minimum exposure necessary. Factors that come into play will usually include the number of scans or views that are necessary to sufficiently screen the individual. It is also important that systems can be reliably operated so that additional exposures are not necessary because of re-screening of an individual due to lack of sufficient information. Thus, the justification process needs to include the expectations regarding system performance and average dose delivered in determining the radiological impacts to be considered. Similar considerations and expectations will also be important in the optimization of protection, if use of ionizing radiation is determined to be justified.

(48) The Commission recognizes the ongoing development of consensus standards related both to the performance of the screening system (ability to detect the intended objects that may be considered as threats), and the expected dose to screened individuals from various types of systems. The Commission recommends that such standards be used in the justification process, and, if a decision is reached that systems using ionizing radiation are justified, that a preference be given for the lowest levels of exposure consistent with achieving the intended performance (i.e., that protection is optimized).

(49) The Commission is of the view that systems for screening of individuals, if justified and employed, should only contribute a very small fraction of the dose limit

for members of the public. The Commission's views are consistent with the recommendations of several other organizations, such as the NCRP (NCRP, 2003), for backscatter systems. Guidance has also been included as part of the consensus performance standards for equipment developed, or under development by such organizations as the American National Standards Institute (ANSI, 2009) and the International Electrotechnical Commission (IEC, 2010). The Commission recommends that such values be viewed as dose constraints, representing a boundary for planning purposes, with a clear relationship drawn between the dose per image or per screening event and the assumed expectations regarding the number of exposures which may occur during a year.

(50) Consensus standards have also been developed for use of transmission systems, which generally deliver more significant doses in each scan. The Commission notes that because of the increased dose to screened individuals, the benefit necessary to justify such systems would also need to be greater. Unlike medical exposure, non-medical imaging does not directly contribute to the health of the individual, and the justification should explicitly describe the connection of the assumed benefits to the individuals receiving the exposure. While this does not mean that such systems are not to be justified, it does mean that there is an even more significant burden of proof that should be demonstrated prior to use.

(51) One of the most important considerations is the frequency with which an individual may be screened. For individual screening in airports, it is possible that a single individual, such as a frequent flier or courier, may receive screening multiple times per day, week, or month. Further, it is necessary and appropriate to consider whether there are other groups of individuals who may, as part of their duties, be screened with some significant frequency. Such groups might include various ground personnel in airports who may enter and exit the security area multiple times per day, flight crews, etc. It might be argued that such scanning be considered as occupational exposure, because entry into secure areas subject to screening is required as part of the job requirements. Conversely, the exposures are not necessarily directly related to their occupational duties, and they may, or may not, be employed by the operating management. The Commission therefore recommends that they be provided protection consistent with that provided for a member of the public. This expectation should be included in the justification process for the different groups of individuals who may be present, and in the planning of sufficient strategies to ensure their protection.

(52) The collective dose from a screening activity also needs to be considered. The Commission believes that the use of the appropriate individual dose constraints, as given above, provide for adequate protection. Collective effective dose is an instrument for optimisation, for comparing radiological technologies and protection procedures. In the case of security screening systems, the collective dose may also be useful in comparing the implications of different systems during the justification process. As discussed in *Publication 101* (ICRP, 2006), it may be useful to disaggregate the components to provide more useful information to make decisions in the justification and optimization process. However, *Publication 103* (ICRP 2007) states that the collective dose should not be used to compute hypothetical numbers of cancer deaths, and that it is a misuse of the concept to multiply large numbers of persons times a very small individual dose to project a hypothetical and misleading number of potential health effects. .

(53) Justification decisions need to be informed by several distinct types of consideration. First, there should be a governmental determination to ensure that all

relevant factors have been taken into account. It is also at this level that the inputs from security and intelligence organizations can be effectively integrated to develop a sufficiently clear picture of the threat environment to support decision making. In most instances, this means that the decisions on justification and use on ionizing radiation will need to be taken at governmental levels where the inputs from regulatory and operational viewpoints can be weighed with the security and intelligence positions. In most cases, the final decision to employ a particular security screening technology will involve many factors outside of radiation protection.

(54) While justification draws upon governmental level inputs and decisions, there will also be a need to consider the proposal on a sufficiently case specific basis to understand the particular benefits and impacts of a proposal. It is generally not appropriate to decide that the use of ionizing radiation is justified in any and all screening activities. The organization proposing and operating the screening system may also be a governmental organization, but usually focused on specific sectors, such as transportation. Consideration needs to be given to the particular classes or circumstances of screening situation, based on the threat environment, the objects of concern to be detected, numbers of individuals to be screened, cumulative impacts, etc. For example, there could be a justification of security screening for passengers at airports. A different set of considerations would be needed if systems were employed in other venues, so as to determine if the exceptional circumstances result in the positive net benefit to justify the exposures. This is not to say, however, that a separate justification would be needed for each separate airport where screening is considered. A balanced approach, which ensures that there is sufficient information to support decision making, should be taken. As is the case with other examples of the Commission's recommendations, a sufficiently detailed matrix of factors needs to be considered to ensure a well informed decision.

(55) If a use of security screening is determined to be justified, then it should be considered as a planned exposure situation under the Commission's recommendations, and the necessary controls and radiation protection program implemented to ensure that the framework of radiation protection recommended by the Commission is properly implemented.

4.3.2. Justification for screening of materials and cargo

(56) The screening of materials, including cargo containers, conveyances, etc. involves a different type of justification process, because normal operational practices and parameters can and should be considered which are intended to minimize or eliminate the exposure to individuals during the screening activities. Thus screening of materials is much more similar to other uses of radiation and radioactive materials, where protection and safety strategies are established, and deliberate exposure of individuals to create an image is not intended. However, experience to date has shown that there can be certain situations in which individuals can, or have been exposed. Examples of this include when drivers have been present in the conveyance during scanning of the cargo and when individuals are concealed in the cargo container to avoid detection. A further discussion is provided in Chapter 5 related to these special circumstances.

4.4. Optimization of protection

(57) When decisions have been made regarding the justification of a proposed use of ionizing radiation in a specific security screen setting, the Commission's recommendations for optimization of protection become critical to ensuring that the activity is conducted in a manner that most effectively protects the health and safety of individuals.

(58) The principle of optimization requires that the likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.

(59) This means that the level of protection should be the best under the prevailing circumstances, maximizing the margin of benefit over harm. In order to avoid severely inequitable outcomes of this optimization procedure, the Commission recommends the use of dose constraints for planned exposure situations to restrict the doses or risks to individuals from a particular source.

(60) Optimization of protection is applicable during the design and equipment specification phase, the installation and setup of the screening environment, and during the operation of the screening systems. Acceptance testing during installation, periodic measurements during operation, and other quality control measures are important to ensure that the assumptions used in the optimization of protection are valid, and maintained during operations.

(61) The Commission continues to recommend that the appropriate operational quantities, including the use of ambient dose equivalent H*(10) for area monitoring and Hp(10) for individual monitoring, be utilized in the development assessment, and operation of such systems (ICRP 2007). For backscatter security systems, the exposure will be predominately to the skin, because the energies used do not significantly penetrate the body. Transmission systems, which utilize higher energies, will contribute to effective dose, and the equivalent dose in various organs and tissues. Individual occupational monitoring of individuals operating the security systems should not be necessary, other than as part of the ongoing quality control program to ensure the systems are functioning as designed.

4.4.1. Optimization of protection for screened individuals

(62) In the case of deliberately planned exposures of individuals for security screening, the concept of optimization needs to include some additional considerations. Because an image is being obtained for a specific purpose, exposures could be too low to accomplish the objective. Conversely, the exposure could be greater than necessary to deliver the necessary information. Neither one of these circumstances would be considered to be optimal. For security screening, since it is not possible to eliminate exposures, the optimized situation will be the one which essentially is the lowest exposure consistent with obtaining the necessary information.

(63) The optimization of protection for screened individuals is largely determined by considerations of design, and installation. Once the scanning system is installed and becomes operational, there may be limited opportunities to further improve radiation protection, on an individual exposure basis. Selection of the most appropriate equipment, and verification of the design meeting the appropriate standards for performance, is an important component of this process. Once

operation has commenced, quality control activities, and the training of operators are the primary contributors to ensuring that exposures are kept As Low as Reasonably Achievable. In comparing the possible options and designs, and in the absence of other factors, optimization would suggest that a preference would normally be given to designs that deliver lower doses for each exposure, or which require fewer scans or views to complete a screening. In this regard, the collective dose for a specified scenario of use, may be useful in comparing protection options for a particular system, and thus contribute to the decision making process. However, the demands for performance in detecting security important materials, and the impact of the time needed to conduct the screening, may also be important in the optimization process. Further, the design and operation of the equipment should consider, and avoid to the extent possible, the need for repeating a screening exposure.

(64) For systems used to screen individuals, various values of effective dose have been set in a consensus standard (ANSI, 2002, ANSI, 2009). Nominally, ICRP has described dose constraints in terms of an annual exposure from the source. However, because of the unique and episodic nature of security screening, specifications on a "per screening event" are appropriate as starting points, particularly since they are established in reference to a clearly identifiable circumstance. The process of justification will have already considered the cumulative implications of scanning for individuals, and thus the cumulative levels of exposure that would be considered acceptable or unacceptable for planning purposes. It is therefore logical to pursue optimization on a more design specific and operational level to further reduce exposures, using practical and measurable criteria as dose constraints. The Commission views criteria such as those in the ANSI standard to be dose constraints, serving as a boundary for optimization of protection, not as some type of "allowed" or design criterion.

(65) The Commission recommends that systems be employed that achieve the design specifications in the consensus standards, such as IEC, ISO or ANSI, for various types of security screening devices. Assuring that devices have this engineering and operational pedigree is an important component in ensuring that radiation protection will be within expected ranges during operations.

(66) Optimization during the operations of the screening system will primarily rely on ensuring that the equipment is functioning as intended, including periodic verification of various operational parameters, surveys, and other measures. Further discussion is provided below.

4.4.2. Optimization of public and occupational exposures

(67) Optimization includes planning the installation of the equipment, to provide for appropriate distance, shielding, access controls, and other measures to prevent individuals from coming into contact with radiation that is not part of the expected operations. The details of each installation can be examined from the standpoint of radiation protection, and every opportunity should be utilized to reduce exposures to individuals who may be working in the screening area, in the queue to enter the secured area, and other individuals who may be in the vicinity of the scanning activity. Scanning of individuals at airports, for example, may pose challenges due to the physical layout of security areas, and the presence of multiple queues of individuals in proximity of the scanning systems.

(68) As with other types of equipment, a variety of pre-operational acceptance tests must be performed to ensure that the systems are functioning as designed. This

includes measurements of the dose that would be received by an individual who may be screened, and the exposures at various locations in the vicinity of the installation. This obviously needs to include the possibility of scattered radiation. Care must be taken to analyze and optimize the installation before operations commence, and to validate ongoing operations through quality control.

(69) The principle of optimization, namely to continue to review the operational situation and determine if there are opportunities for improvement, remains in effect as the installation begins operation. At a minimum, this would entail ensuring that the bounds considered in the justification of the exposure remain valid, and that the operation and use of the device is within the bounds and specifications approved.

(70) The information needed for ongoing operations will most often be based on periodic surveys and reviews to ensure that the systems are operating as designed, reviews of the radiological conditions and physical arrangements in the vicinity of the scanning systems to determine if there have been changes in any exposure of any individuals (occupational or public), and adherence to a maintenance schedule to ensure that equipment is functioning properly. Periodic tests and surveys will be needed. Verification of radiological parameters following maintenance and calibration is also important, particularly for any functions that may impact the exposure conditions. This includes the software systems used to control the scanning systems and process the images for examination.

(71) The radiation protection framework to review operations and installations will resemble in many respects those that are commonly established for other types of facilities using ionizing radiation. International organizations such as the IAEA and competent authorities have created requirements and practical guidance for similar types of facilities, including optimization of protection, authorization for use, and inspection, and this experience should be used in establishing requirements for security screening. The unique aspects in security screening relate to the conduct of operations in much more public venues and the operation of the equipment by organizations that may not have experience or expertise in radiation protection. The Commission recommends that additional emphasis is be placed on training, retraining, and the management system to ensure the safe conduct of activities as described in the requirements of the IAEA.

(72) Occupational exposure may be received by operators, technicians doing service and maintenance, surveys and calibration, and other similar activities. The Commission is limiting the definition of occupational exposures to those which are reasonably under the control of the operating management, as all workers continue to be exposed to background radiation irrespective of their activities. The Commission emphasizes that optimized protection means achieving levels of exposure that are as low as reasonably achievable, irrespective of the category of exposure, and notes that it is a fallacy to assume that categorization of an exposure as occupational automatically means that it is acceptable for the exposure to be greater than that allowed for public exposure.

(73) Dose constraints for occupational exposure of individuals operating security screening systems should be set at a small fraction of the constraints recommended by the Commission for occupational exposure. Experience has shown that when well-designed systems are used, including adequate shielding and the provision of adequate distance from the source, there should be little or no radiation in areas where operators are present. Experience is helpful, particularly in field or mobile settings, to establish the appropriate arrangements and control of areas to avoid unnecessary exposures. The results of installation testing and

monitoring used to modify radiation protection provisions also should be used as appropriate. Thus the Commission expects that such individuals are protected to levels consistent with protection of members of the public, even though their exposure meets the definition of occupational exposure. The Commission also expects that the same levels of protection would be afforded to other individuals, who may be working in areas near the security screening systems, but who are not in any way involved in the operation of the system.

(74) Constraints for public exposure should be established at small fractions of the public dose limits. This is particularly important because the individuals receiving exposure are not receiving any direct benefit from the radiation, but rather the indirect benefit of a secure environment as a result of the security activities, etc. The nominal expectation would be that exposure of individual, while not being screened, would be essentially indistinguishable from background ambient dose rates.

(75) The Commission recommends that security screening systems, if considered to be justified, be treated as planned exposure situations, and subjected to control with the appropriate regulatory framework, including authorization and inspection, by the designated competent authority. Given that such systems may be utilized by organizations that may not have experience in radiation protection programs, there should be sufficient interactions between the competent authority and the responsible operational management to ensure that expectations for radiation protection are clear. The International Atomic Energy Agency, in the International Basic Safety Standards (IAEA 2011), have established requirements for regulatory systems and controls of sources, including appropriate expectations for training and competence of operators, and appropriate management systems to ensure that the prime responsibility for safety is effectively discharged.

4.4.3. Optimization of protection for screening materials and cargo

(76) Scanning for materials, cargo, etc., poses a different opportunity for optimization. The nominal expectation would be that individuals would not be included in the screening. Circumstances in which this might not be the case are covered in Chapter 5 under special circumstances. During the screening of cargo and conveyances, the possibility for exposures outside of the scanning area, and at some distance from the scanning system, may be increased due to the increased strength of the sources, and the scatter of the radiation in the materials being scanned. However, measures should be taken to restrict members of the public from the vicinity of scanning areas, as is typically the case in the use of radiation sources. Optimization of protection should be pursued as it is for any other planned exposure situation.

(77) For cargo screening systems, and other systems that may not be in fixed locations, the physical arrangement, and areas where radiation fields may be present, need to be specifically identified and controlled. In this respect, the radiation protection considerations are similar to those industrial exposure uses when a source is used at a temporary location (such as industrial radiography), and specific requirements need to be included in an authorization for appropriate surveys, the establishment of controlled areas, and other provisions to minimize public exposure.

4.5. Dose limits

(78) The Commission expects that the operation and use of security screening systems, under the appropriately optimized radiation control program for planned exposure situations, should not challenge any of the dose limits recommended for occupational and public exposure during expected activities. The exceptional circumstances of drivers and individuals who may be concealed (stowaway) in a cargo container, and be exposed as a result of cargo screening, are treated in the following chapter under special circumstances.

4.6. Communication and stakeholder interactions

(79) The use of radiation and radioactive materials in security screening presents a number of communication and stakeholder interaction challenges. Nevertheless, while challenging, they are a critical component of effectively implementing the Commission's system of protection. These include communications regarding the risk of very small levels of exposure, and provisions of alternative screening methods and informed consent. These may be addressed from the standpoint of radiation protection, but other challenges will also need to be taken into account with local stakeholders.

(80) Systems that are justified and utilized in accordance with the Commission's recommendations present a very low risk due to the radiation exposure that may be incurred by an individual being screened. While small, such risks cannot be assumed to be zero, and radiation protection programs and controls must be established to ensure that the systems operate as designed, and that exposures are not greater than analyzed and predicted. Many stakeholders will raise concerns simply because of the involuntary nature of exposures, and the uncertain nature of any possible consequences. In such circumstances, individuals tend to desire a greater degree of protection than when exposure is voluntarily undertaken, or under some degree of control by the individual. Comparisons with other types of similar risks may be useful, but care must be exercised in making any such comparisons. The Commission recommends that such communications be planned so that the messages are accurate, informative, and responsive to the personal nature of the concerns.

(81) Communications with stakeholders continue to be an important component of the radiation protection program and implementation of any screening activity. The Commission recognizes that there has been a great deal of press coverage, and debate, regarding security screening. Much of this has focused on the ethics and other issues surrounding screening, such as individual rights, privacy, the right to know, and informed consent. In most security screening situations, it is not practical to have each individual sign a consent document. Therefore the focus must be upon making reasonable provisions of information, such as posting information, so that the individual's right to know has been met. Radiation protection, focusing on the more specific questions of radiation safety, contributes to a more complete discussion of all of the issues that need to be considered. Decision makers should make efforts to engage stakeholders, while recognizing that many "security decisions" are made for reasons that are not subject to the same degree of public consultation, due to the sensitive nature of the threats and possible responses.

(82) A continuing opportunity for communication occurs during the normal conduct of activities, as individuals who may be screened may have questions or

concerns about the procedure, the risks, and the alternatives. Such individuals are likely to have a very different perception of risk and the ethical basis for protection than the radiation protection specialist or a security specialist. The Commission recommends that key messages, questions, and answers be developed in advance, and readily available, to improve these interactions. In situations in which screening may be conducted, careful consideration should be given to different means of communication with stakeholders in understandable and plain language.

(83) As in the case of all exposure situations for members of the public, it is important to consider the populations that may be exposed in the planned exposure situation, and consider additional factors in the justification and optimization of protection when more sensitive populations may be involved. The risk of exposure to radiation varies with a number of factors, including age and gender. The screening of individuals poses a situation which may result in the exposure of all ages of individuals, and the possibility of exposure of the embryo/foetus. The Commission believes that the appropriate application of the framework of protection, including justification and optimization as described in this report, will provide adequate protection for these more sensitive populations. Thus, if the recommendations in this report are met, it will not be necessary to take separate protection actions for children or pregnant women. It will be important to explicitly include these considerations in the decision making process, as one of the matrix of factors in an analysis, and provide documentation on the results of such considerations.

5. SPECIAL CIRCUMSTANCES

(84) The use of ionizing radiation in screening of materials and cargo may result in exposure of individuals. While there is the nominal expectation that exposures of individuals can be minimized or avoided entirely, there are two examples of special circumstances in which individuals may be receiving exposures when cargo is screened.

5.1. Exposure of drivers

(85) The Commission is aware that there have been proposals for the drivers of trucks and other conveyances to be present as cargo is moved through the security screening system, due to various operational considerations. From a radiation protection standpoint, exposure of drivers should not be necessary when screening cargo. The Commission believes that such exposures are generally not justified, unless specific justifications show that there is a positive net benefit to conducting operations in a manner that result in some exposure. Exposure of such individuals should not be a matter of operational convenience, and the Commission recommends that drivers not be allowed to occupy conveyances during screening, except for very unusual circumstances. In such circumstances, all possible measures should be taken to eliminate or reduce the exposures through the use of interlocks and other systems to prevent exposure. Consideration should particularly be given to the possibility that individuals may be moving cargo through screening systems multiple times per day, thereby negating an assumption of infrequent exposure. Even in situations where interlocks and other devices may prevent the primary scanning beam from exposing the individuals, scatter radiation will need to be considered in the dose assessment. Furthermore, consideration must be given to the possibility of failure of the interlocks or other systems intended to prevent exposures.

(86) In situations where exposure of drivers may be considered, specific dose constraints on exposure are to be established. The Commission recommends that constraints consistent with protection of members of the public be utilized.

5.2. Exposure of concealed individuals

(87) Experience has shown that there is a possibility that an individual may be concealed or hiding in a cargo container that is screened. Such an individual is sometimes referred to as a “stowaway”, and is a specific case of the more general concern for inadvertently exposed individuals. There are, in fact, many examples where this has been the case.

(88) The Commission recommends that this scenario be considered in the design and construction of scanning systems, and estimates made of possible exposure if there are concealed individuals present in a container or conveyance to be screened. The Commission further recommends that systems be designed and operated such that the dose to a concealed individual would not exceed the recommended dose limits for members of the public. In most cases, this would be the 1 mSv per year level, which in the case of a screening of a concealed individual could be considered

as equivalent to a per event criterion. The Commission's dose limits further provide for a value of 5 mSv for highly infrequent situations. Experience to date has indicated that this is possible for most systems, although more powerful advanced systems may be challenged. Such a level of protection remains consistent with the Commission's recommendations for members of the public, but recognizes that such individuals are, by the very nature of their act, behaving in a way that the normal expectations of radiation protection cannot be assumed. Even though such behaviour may, in fact, be illegal, the level of risk still should not substantially exceed that recommended for members of the public. Similar recommendations can be found in the commentaries of the NCRP (NCRP, 2003 and NCRP 2007)

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