ICRP Publication 125: Radiological Protection in Security Screening

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Guest Editorial

THE ETHICS OF RADIOLOGICAL PROTECTION – GETTING THE FOUNDATIONS RIGHT

The International Commission on Radiological Protection (ICRP) has developed and systematically updated the system of radiological protection, which now recommends optimisation of protection measures within or guided by appropriate restrictions, such as dose constraints or reference levels, in all circumstances. This applies to all exposure situations (planned, emergency and existing) and all categories of exposure (occupational, medical, and public). Optimisation of protection is intended to reduce exposures to levels that are as low as reasonably achievable, economic and societal considerations being taken into account, and to manage medical exposures commensurate with the medical purpose.

The system of radiological protection is built on solid foundations of current scientific knowledge, more than a century of experience, and fundamental ethical and social values. The latter includes consideration of prudence and equity; doing more good than harm, and the most good for the most people; fulfilling obligations to provide an appropriate level of protection for each person; and favouring human dignity and the well-being of people. At the present time, an ICRP Task Group is actively engaging with professionals around the world to examine the ethical basis of the system of protection, and to provide further elaborations as appropriate. Symposia on this topic are currently being organised jointly by ICRP and radiation protection societies affiliated to the International Radiation Protection Association (IRPA) in Asia, Europe and in North America. The many advantages of re-examining the ethical foundations include ensuring that our decision making is sound and logical, and that we can relate effectively to the issues, concerns, and needs of the wide range of stakeholders who come into contact with radiation and radioactive materials. In addition to ensuring that the science is correct, we must also rely on universal values and address the concerns that are part of the complex and, for many, unknown technologies that impact our lives.

The Commission has also embarked upon an approach to identify areas where the need exists to provide recommendations focussed on specific fields, and then work with stakeholders in those fields to develop publications to meet those needs. The current publication on radiological protection in security screening is the first result of this effort. Fittingly, it is an example of a situation in which the usual set of ethical values and approaches is challenged because of an identified need to protect groups from threats to their security. It is also an example of a situation in which the

optimisation of protection from radiological hazards is only one small consideration in a much larger decision-making process.

The Commission looks forward to continuing its active engagement with radiological protection professionals, international organisations, and many other types of stakeholders to provide timely and useful advice to improve our dialogue and understanding of how radiological protection fits into our daily lives.

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Radiological Protection in Security Screening

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Abstract–The use of technologies to provide security screening for individuals and objects has been increasing rapidly, in keeping with the significant increase in security concerns worldwide. Within the spectrum of technologies, the use of ionising 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 radiological protection principles recommended by the Commission should be applied within the context of security screening. More specifically, the principles of justification, optimisation of protection, and dose limitation for planned exposure situations are directly applicable to the use of ionising radiation in security screening. In addition, several specific topics are considered in this report, including the situation in which individuals may be exposed because they are concealed ('stowaways') in a cargo container or conveyance that may be subject to screening. The Commission continues to recommend that careful justification of screening should 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 should be employed, including optimisation of protection with the use of dose constraints and the appropriate provisions for authorisation and inspection.

Keywords: Security screening; Justification; Optimisation

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PREFACE

Since the discovery of radiation and radioactive materials, there have been deliberate exposures of humans for various purposes. The majority of these have involved some type of medical diagnosis, treatment, or research. However, there have been, and continue to be, examples of situations in which an individual is deliberately exposed for purposes other than their personal benefit. Recent events in global and national security, together with the development of sophisticated security imaging technologies, have heightened interest in such activities. This raises the potential for further increases in exposure to individuals due to the use of these imaging techniques for security purposes.

These exposures have often been placed in a general category of 'non-medical' imaging exposures. In some instances, non-medical imaging involves the use of medical devices (e.g. drug detection, immigration purposes), while in other circumstances, it takes place in non-medical facilities or public places involving the use of specialised inspection devices.

The Commission has given advice on such situations many times. However, there has been an increased focus upon security for individuals in air travel and other public settings in the wake of the terrorist events of 11 September 2001. Following an attempted aircraft terrorism event in December 2009, there has been an increased call for the use of security screening systems, including those using ionising radiation, because of their effectiveness in detecting concealed objects of concern. Such screening involves the direct exposure of individuals at various security control points. The broader context of security screening also encompasses the screening of cargo and conveyances at borders and points of entry.

This report was developed to provide advice on the application of the Commission's recommendations to the specific set of cases involved in security applications. Other examples of non-medical imaging are not included in this report, although the advice may also be valid for other instances of deliberate imaging of humans, with due consideration of each specific application. The report describes how the radiological protection principles of the Commission should be applied within the context of security screening. While it is not the role of ICRP to state whether or not such systems are justified, it is appropriate to further develop the aspects to be considered in decisions on whether or not to employ such systems. The report also describes how the principles of radiological protection in planned exposure situations apply within a security screening context, including optimisation of protection with the use of dose constraints.

This report is the result of active cooperation and collaboration with the international agencies and organisations that are observers to ICRP Committee 4. A special thanks to those organisations and individuals for their contributions.

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MAIN POINTS

- **The use of ionising radiation to screen individuals for security purposes is an exceptional circumstance that requires careful justification. It should not be presumed that the use of ionising radiation for security screening is generically justified or acceptable.**
- **Decisions regarding whether or not to justify security screening using ionising radiation 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 screening, alternatives that may be available to reduce exposure, and the possibility that some groups of individuals may incur a significant number of screenings per year.**
- **In most cases, justification decisions to employ a particular security screening technology will include many factors outside of radiological protection.**
- **The exposure of an individual to be screened for security purposes is considered to be public exposure. This applies irrespective of whether individuals are being screened as a result of their personal choices or as a consequence of their work duties.**
- **Optimisation 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 the avoidance of additional (or repeated) exposures.**
- **Optimisation of protection should be applied during the design and operation of a screening system, and should consider the exposure of individuals being screened, individuals who are not being screened but may be in the vicinity of the screening, and individuals who operate and maintain the screening system. Dose constraints should be established and used in the optimisation of protection for each of these groups of individuals.**
- **Individual occupational monitoring of individuals operating the security systems should not be necessary, other than as part of the ongoing quality control programme to ensure that the systems are functioning as designed.**
- **Appropriate regulatory expectations need to be established and enforced for operator training, retraining, and competence; and for management systems to ensure optimised safety during operation.**
- **Appropriate application of the framework of protection, including justification and optimisation, will provide adequate protection for anyone exposed by the security screening system, including sensitive populations. Thus, if the recommendations in this report are met, it will not be necessary to take specific protection actions for the security screening of children or pregnant women.**
- **Screening of cargo and materials may expose individuals concealed in the cargo containers. This possibility must be factored into decisions considering justification of such screening, and the optimisation of protection.**
- **The use of stakeholder dialogue and the provision of information to meet an individual's right to know are important tools in the optimisation and implementation of**

security screening using ionising radiation. Communications need to be accurate, informative, and responsive to stakeholder concerns.

The Commission recommends the following:

- **The justification of screening should be considered carefully before decisions are made to employ the technology. The justification for screening should be reviewed periodically, given the rapid evolution in the potential threats and the technologies available for screening.**
- **Security screening using ionising radiation should be regarded as a planned exposure situation. The exposure of an individual screened for security purposes should be considered as a public exposure. If determined to be justified, screening should be subject to the appropriate regulatory framework for optimisation of protection, authorisation, and inspection to ensure radiation safety in operation. If screening is not justified, it should not be conducted.**
- **Systems that achieve the design specifications in the consensus standards, such as the International Electrotechnical Commission, International Standards Organization and American National Standards Institute, for various types of security screening devices, should be employed.**
- **Key messages, questions, and answers should be developed and readily available during operation to facilitate stakeholder interactions.**
- **Drivers or others involved in conveyance of goods subject to security screening should not be allowed to occupy conveyances during screening, except in very unusual circumstances. Exposure of such individuals should not be a matter of operational convenience.**
- **Protection equivalent to that provided by the dose limit for members of the public should be used to assess the consequences of exposure of individuals concealed in cargo containers.**

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 ionising 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.

Transmission detection system
: A security screening device using ionising radiation to create an image by measuring radiation transmitted through an object. The radiation source and the detector are located on opposite sides of the object.

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

Security screening
: An activity undertaken to detect unintended, unwanted, or deliberately introduced objects or materials that could pose a security threat or be used for malicious purposes.

1. INTRODUCTION

(1) The deliberate exposure of humans dates back to the initial discovery of radiation and radioactive materials. Historically, in most cases, this has been in the context of medical exposure of patients, intended either for diagnosis or treatment. In these cases, the benefits to the patient from the radiation exposure are expected to 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 increased the consideration and use of radiation in this non-medical context significantly. Increasing numbers of individuals may be exposed deliberately, 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 ionising radiation, at the entrance of an area or other point of access control, to detect unintended, unwanted, or deliberately introduced objects or materials that could pose a security threat or be used for malicious purposes before being brought into the area. When the object of the screening is an individual (e.g. to determine if a weapon is being carried secretly), the conditions of exposure are categorised as deliberate exposure of the individual. This application is being considered or used to screen individuals before allowing entry into restricted areas such as airport secure areas, large public events, court houses, and jails. Screening may consist of a single image or multiple images to obtain the information required for security purposes.

(4) Security screening also encompasses the use of ionising 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 (e.g. a conveyance driver) or unknowingly present. Individuals or groups of individuals concealed in a cargo container, aiming to avoid detection, are sometimes referred to as 'stowaways'.

(5) The aim of this report is to summarise the relevant concepts and guidance of ICRP, and to provide advice on the application of the Commission's recommendations for radiological protection in the context of security screening. The scope of this report does not include any other instances of deliberate exposure of individuals, for medical or 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 of individuals using ionising 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 screened individual from a backscatter system is much lower than the dose from a transmission system. Some systems that 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 those used in screening of individuals, to provide adequate images of the objects. Screening activities for materials and cargo may also, in specific situations, use active detection technologies. A brief description of the current screening technologies is provided in Section 3.

2. BACKGROUND

(7) Considering human exposure to ionising radiation, 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, such as screening of individuals for various security purposes. The screening of objects would not normally include deliberate exposures of individuals, but exceptional circumstances may arise in which the possibility of such exposures may need to be considered. ICRP has provided statements on the deliberate exposure of individuals in non-medical contexts since the 1960s. Other organisations have also produced information, specifications, performance standards, and recommendations.

(8) *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, *Publication 15* (ICRP, 1969) allowed for exceptional circumstances under which these activities could be performed; namely, if permission was granted by the competent authority, the examinations were considered to be essential, and the examinations were undertaken under the supervision of a radiologist.

(9) International events at the time, namely a spate of aircraft hijackings, led ICRP to state that they believed security screening of airline passengers could be justified, but no elaboration or viewpoints were provided with respect to responsibilities, processes, or the role of radiological protection in the justification of exposures (ICRP, 1971).

(10) The 1977 Recommendations (ICRP, 1977) did not supersede some of the previous ICRP publications, including the abovementioned *Publication 15* (ICRP, 1969), but considered additional situations with respect to non-medical human imaging beyond security screening.

(11) The 1990 Recommendations (ICRP, 1991) did not contain any recommendations with respect to human imaging for non-medical purposes, or more specifically, security screening practices.

(12) *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* (ICRP, 1991)] to include exposures for medico-legal purposes, and made reference to screening, although this reference was only made in the context of medical screening, not screening for other purposes such as security.

(13) *Publication 103* (ICRP, 2007) described a set of conditions 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 proposals for use of ionising radiation in security screening have raised questions about the application of the Commission's recommendations, in that security screening is a deliberate exposure of an individual that is not motivated by the health of the individual.

(14) Other organisations, particularly the National Council on Radiation Protection and Measurements (NCRP) in the USA, have also provided information on aspects of security screening. 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, and NCRP Commentary 21 (NCRP, 2011a) and NCRP Commentary 22 (NCRP, 2011b) address radiological protection aspects of active detection technologies.

(15) National or regional authorities have, in some cases, taken specific stances to prohibit the use of ionising radiation on the human body, except for medical purposes. In other cases, there have been decisions regarding the justification and use of a particular type of security scanner, and there have been several independent evaluations of doses from various commercially available systems. Some organisations, such as the US 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 the use of ionising radiation for security screening have also been examined in the work of international organisations. For example, in 1977, the World Health Organization addressed the use of ionising radiation on human beings for non-medical purposes, including weapons detection, in a technical report (WHO, 1977). The report concluded that this should only be done when there are no satisfactory alternative methods with lower risks, and emphasised the need to manage the dose to optimise protection. More recently, an information paper by the Inter-Agency Committee on Radiation Safety (IACRS, 2010) outlined some of the pertinent issues, trends, and national requirements. The Heads of the European Radiological Protection Competent Authorities 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), together with international co-sponsoring organisations, has 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 standards include 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 only be justified 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 has recently proposed a revision of The European Atomic Energy Community (EURATOM) legislation on radiological protection (EURATOM, 2012) containing legal provisions on exposure of humans for non-medical imaging, including the use of ionising radiation for security screening; once adopted, this will be legally binding for the 27 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 ionising radiation, as a primary security screening method at airports in the EU.

(19) Various national and international consensus standards organisations, 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 objects of security concern.

(20) In 2002, a consensus standard was published by ANSI that established a limit for the effective dose from one scan of 0.1 μSv (ANSI, 2002). This standard also established a limit of no more than 0.25 mSv effective dose in any 12-month period to an individual from any single security screening facility. This standard was subsequently updated and modified to refer to a 'screening' (which might involve several scans or views), rather than a single image (ANSI, 2009).

(21) In 2010, the IEC published an international standard IEC 62463 for x-ray systems for screening of individuals for security (IEC, 2010a). This standard provides radiological performance criteria for security screening systems. Another standard project, IEC 62709, 'Radiation instrumentation – measuring the imaging performance of x-ray and gamma-ray systems for security screening of humans' protection' was also published (IEC, 2014). Further, the IEC has published an international standard, IEC 62523 (IEC, 2010b), covering cargo and vehicle radiographic inspection systems.

(22) Despite the considerable history, and the presence of various specifications and performance standards, debate continues regarding the use of radiation in security screening, the role to be played by radiological 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 radiological 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 or not the equipment used is specifically designed for such purposes, or has been repurposed to a security screening circumstance from some other original purposes, such as medical radiological equipment.

3. SECURITY SCREENING SYSTEMS

(23) A variety of systems employing ionising radiation are currently available for screening of 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 have generated considerable public debate. Much of this discussion has been focussed 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 systems using ionising radiation. This has resulted in 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 such as microwaves, and thus are not unique to systems using ionising radiation.

(25) The categories and types of equipment are described below to explain 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 a certain purpose, such as medical diagnosis and treatment. The issues of importance are the actual conditions of exposure and use that 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 of the order of 0.1 μSv per image of the front of the body; images of the back or sides of the body may produce lower effective doses. Furthermore, the exposure distribution with depth in tissue may be predominately to the skin, because the energies used may not penetrate the body significantly. The specifics of the exposure will be dependent upon the specifications of the equipment under consideration. It may be necessary to image an individual multiple times – from the front, from the back, and from the sides – to obtain the information required 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 ionising radiation that scans the subject in a raster pattern at high speed. Large detectors on the same side of the subject as the x-ray source detect radiation scattered back from the body of the individual being scanned. A schematic of such a system is shown in Fig. 3.1.

(28) The dose to an individual screened with a backscatter system is a very small fraction of the exposure received from other sources in daily living. For example, a backscatter screening dose is of the order of 1000 times smaller than a typical chest

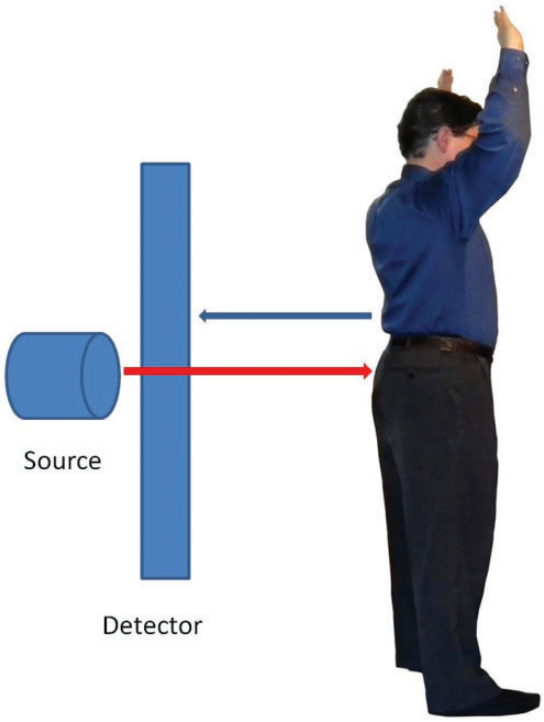

Fig. 3.1. Backscatter x-ray method of operation.

x-ray, and is approximately the same as the cosmic radiation dose received during a few minutes of airline flight at cruising altitude.

(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 the 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 from approximately 2 to 5 μSv or more, depending upon the equipment. However, transmission images show objects and body parts superimposed. For this reason, image interpretation is more complex than for a backscatter image.

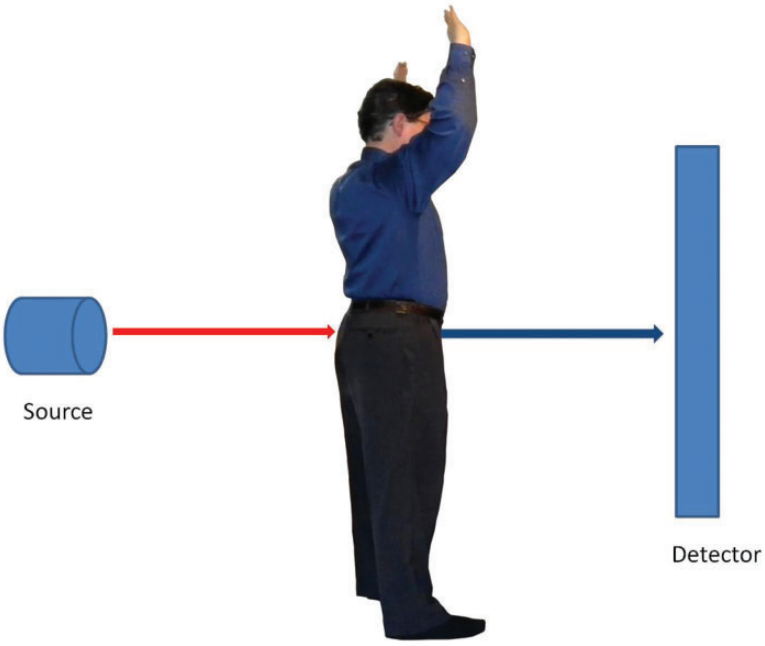

Fig. 3.2. Transmission x-ray method of operation.

(31) These systems create an image by passing ionising radiation through the subject to a detector. The detector is placed on the opposite side of the subject from the ionising radiation source. The radiation may be machine-generated x rays or gamma-emitting radioactive isotopes. Fig. 3.2 shows a schematic of a transmission scanning system.

(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 that result in the possibility of exposures to individuals. This circumstance is discussed in Section 5.

(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 shielding is in place. The systems operate by using a beam of radiation to interrogate an object or location suspected of containing fissionable or explosive 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 the type, quantity, and location of the materials. These devices are intended to allow identification of these materials from a distance.

4. SYSTEM OF PROTECTION

4.1. Exposure situations

(35) The 2007 Recommendations (ICRP, 2007) organise radiological protection according to three exposure situations: planned, emergency, and existing. 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 (potential exposures). Emergency exposure situations are situations that may occur during the operation of a planned situation in the 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 where the source already exists when a decision to control the related exposure is taken. They include naturally occurring exposures, as well as exposures from past events, accidents, and practices.

(36) The Commission views the use of radiation in security screening as 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 ionising radiation before activities commence. Certain circumstances which may not be part of the normally expected and planned activity may arise; these are discussed in Section 5.

4.2. Categories of exposure

(37) The Commission distinguishes between three categories of exposure: occupational, medical, and public. 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. Medical exposure is exposure incurred by patients as part of their own medical or dental diagnosis or treatment; by persons, other than those occupationally exposed, knowingly, while voluntarily helping in the support and comfort of patients; and by volunteers in a programme of biomedical research involving their exposure. 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 and 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 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 personal choices, such as flying on holiday, or as a consequence 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, generally not the responsibility of the individual's operating management, and are not directly related to either work with radiation or radioactive materials or the health of the individual. Thus, it becomes even more important that full and careful consideration be given to the justification for the exposure, and, if justified, to the optimisation of protection. In this regard, the security needs should be defined clearly, including the types and magnitude of the threat and the risks associated with not conducting the screening effectively. The exposure of individuals who may be exposed directly as a result of screening of materials is also considered to be public exposure, and is discussed further in Section 5.

4.3. Justification

(40) The principle of justification is one of the two fundamental source-related principles that apply in all exposure situations. *Publication 103* (ICRP, 2007) requires, through the principle of justification, that any decision which alters the radiation exposure situation should do more good than harm. For planned exposure situations, the Commission goes on to emphasise that when introducing a new radiation source, one should achieve sufficient individual or societal benefit to offset the detriment it causes. It is important to emphasise that the benefits that accrue to society should be factored into the justification decision, 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 society as a whole.

(41) Justification is a multi-attribute process that 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. Given the issues of security that must be included in the process, justification of the use of ionising radiation in security screening is almost always a governmental function.

(42) *Publication 103* (ICRP, 2007) further states 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 is 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 recommends that justification requires that the benefits outweigh the risks. It is important that radiological protection authorities are part of the decision process, but searching for the best of all the available alternatives is a task beyond the responsibility of the radiological protection authorities.

(43) It is not the role of ICRP to state whether or not the use of radiation and radioactive materials in security systems is justified. The Commission believes that the use of ionising radiation to screen individuals is an exceptional circumstance that requires careful justification. It should not be presumed that such screening is generically justified or acceptable. As noted in *Publication 103* (ICRP, 2007), it is necessary to consider all of the benefits and impacts of a proposed activity. In the case of security screening, a number of factors must be considered. If screening is not justified, it should not be conducted.

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 provide information that will contribute to the health of the individual. However, it could be concluded that there is a benefit to an individual from knowing that they are in an environment that has been secured from certain threats. Furthermore, 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 ionising radiation in screening will also include consideration of alternative techniques that may be available to accomplish the specific goals of screening. These may include alternative technologies to the use of ionising radiation, as well as various procedural alternatives and options. Again, it is not the role of ICRP to state whether or not non-radiological alternatives should take precedence over the use of ionising radiation for a particular activity. Factors other than 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 systems using ionising radiation. Furthermore, non-radiological systems may also present risks or inconveniences to the individuals being scanned, which must also be taken into account. The Commission does not wish that its recommendations be construed as implying any preference for or against the various alternatives to the use of ionising radiation. Systems must obviously be judged on the basis of their effectiveness in accomplishing the intended purpose for security screening for a particular context.

(46) An issue is often raised with respect to whether a particular screening technique is 'voluntary', and whether there is 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 recognises that arrangements for alternative techniques are commonplace at security screening venues, such as airports, and are appropriate, irrespective of the types of technologies being employed. The role of radiological protection is to provide information on the risks of using ionising radiation, and thus contribute to a well-informed discussion during the justification of use. If use of security screening is determined to be justified, information on risks of using ionising radiation also contributes to discussions

during the operational activities. The latter takes the form of ensuring that there is sufficient information and opportunity to address an individual's right to know as part of the screening process. Communication and stakeholder interactions are further addressed in Section 4.6.

(47) Security screening systems using ionising 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 screen the individual sufficiently. It is also important that systems can be operated reliably, so that additional exposures are not necessary because of rescreening 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 optimisation of protection, if use of ionising radiation is determined to be justified.

(48) The Commission recognises the ongoing development of consensus standards related 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 should be used in the justification process, and that, if a decision is reached that systems using ionising radiation are justified, a preference be given for the lowest levels of exposure consistent with achieving the intended performance (i.e. that protection is optimised).

(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 organisations, such as NCRP (2003), for backscatter systems. Guidance has also been included as part of the consensus performance standards for equipment developed, or under development, by organisations such as ANSI (2009) and IEC (2010a). The Commission recommends that such values should 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 that may occur per year.

(50) Consensus standards have also been developed for the 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 exposures, non-medical imaging does not contribute directly to the health of the individual, and the justification should describe explicitly the assumed benefits to the individuals receiving the exposure. While this does not mean that such systems are not 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 be screened 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 should 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 screened individuals may, or may not, be employed by the operating management of the screening equipment. The Commission therefore recommends that such exposures should be considered as public exposure, and that individuals thus exposed should 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 and implementation of sufficient strategies to ensure their protection.

(52) The collective dose from a screening activity also needs to be considered. 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 optimisation processes.

(53) Justification decisions need to be informed by several distinct types of consideration. First, there should be 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 organisations can be integrated effectively 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 of ionising radiation will need to be taken at a governmental level, 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 radiological protection.

(54) While justification draws upon governmental level inputs and decisions, there is also 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 ionising radiation is justified in any and all screening activities. The organisation proposing and operating the screening system may also be a governmental organisation, but usually focussed on a specific sector, such as transportation. Consideration needs to be given to the particular classes or circumstances of screening situation, based on the threat environment, 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, in order to determine if the exceptional circumstances result in a 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 the use of security screening is determined to be justified, it should be considered as a planned exposure situation under the Commission's recommendations, and the necessary controls and radiological protection programme should be implemented to ensure that the framework of radiological protection recommended by the Commission is implemented properly. The Commission also recommends that the justification should be reviewed periodically, given the rapid evolution in the potential threats, and the technologies available for screening.

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 that are intended to minimise or eliminate the exposure to individuals during the screening activities can and should be considered. 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 be, or have been, exposed. Examples of this include when drivers are present in the conveyance during scanning of the cargo, and when individuals are concealed in the cargo container to avoid detection. In some cases, national authorities have deliberately used scanning devices to search actively for concealed individuals, with a specific justification analysis taking into account the relevant doses and safety concerns. Periodic reviews of the justification decision are appropriate, given the rapid evolution in the potential threats, the technologies available for screening, and operational experience. Further discussion related to these special circumstances is provided in Section 5.

4.4. Optimisation of protection

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

(58) The principle of optimisation 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, maximising the margin of benefit over harm. In order to avoid

severely inequitable outcomes of this optimisation 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) Optimisation of protection is applicable during the design and equipment specification phase, the installation and set-up of the screening environment, and the operation and maintenance 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 optimisation of protection are valid and maintained during operation.

(61) The Commission's recommendations for constraints are in terms of effective dose. 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, should be used in the development, assessment, and operation of such systems (ICRP, 2007). For backscatter security systems, the exposure may be predominately to the skin, because the degree of penetration will be dependent upon the specifications of the equipment being considered. Transmission systems, which use higher energies, will contribute more significantly to effective dose and equivalent dose in various organs and tissues. Occupational monitoring of individuals operating the security systems should not be necessary, other than as part of the ongoing quality control programme to ensure that the systems are functioning as designed.

4.4.1. Optimisation of protection during design and installation

(62) In the case of deliberately planned exposures of individuals for security screening, the concept of optimisation needs to include some additional considerations. As 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 using ionising radiation, as it is not possible to eliminate exposures, the optimised situation will be the one with the lowest exposure consistent with obtaining the necessary information.

(63) Optimisation includes planning the installation of the equipment to allow appropriate distance, shielding, access controls, and other measures to prevent individuals from coming into contact with radiation that is not part of the expected operation. The details of each installation can be examined from the standpoint of radiological protection, and every opportunity should be taken to reduce exposures to individuals who may be working in the screening area, in the queue to enter the secured area, and in the vicinity of the scanning systems. 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 the area of the scanning systems.

(64) The optimisation 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 radiological 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. In comparing the possible options and designs, and in the absence of other factors, optimisation 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 protective options for a particular system, and thus contribute to the decision-making process. However, the demands for performance in detecting materials of importance to security, and the impact of the time needed to conduct the screening, may also be important in the optimisation process. Further, the design of the equipment should consider, and avoid as much as possible, the need for repeating a screening exposure.

(65) 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 measurement of the dose that would be received by an individual being screened, and 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 analyse and optimise the installation before operation commences.

(66) For systems used to screen individuals, various values of effective dose have been set in a consensus standard (ANSI, 2002, 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 as they are established in reference to a clearly identifiable circumstance. The process of justification will have 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 optimisation on a more design-specific and operational level to reduce exposures further, 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 optimisation of protection, not as some type of 'allowed' or design criterion.

(67) The Commission recommends that systems which achieve the design specifications in the consensus standards, such as those of IEC, ISO, and ANSI, for various types of security screening devices, should be employed. Ensuring that devices have this engineering and operational pedigree is an important component in ensuring that radiological protection will be within expected ranges during operation.

4.4.2. Optimisation of protection during operation and maintenance

(68) Optimisation during the operation 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. 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.

(69) The principle of optimisation, 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, that the operation and use of the device are within the boundaries considered in justifying the use of the screening system, and that the system is operated in a manner that avoids the need for repeating screening exposures.

(70) The information needed for the optimisation of ongoing operations will most often be based on periodic surveys and reviews conducted by the operating management 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. Independent regulatory verification of surveys and tests would be integral parts of optimisation, and are important to ensure that the framework of radiological protection recommended by the Commission is being implemented properly.

(71) The radiological protection framework to review operations and installations will, in many respects, resemble those that are commonly established for other types of facilities using ionising radiation. International organisations such as IAEA and competent authorities have created requirements and practical guidance for similar types of facilities, including optimisation of protection, authorisation for use, and inspection; 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 organisations that may not have previous experience or expertise in radiological protection.

(72) Occupational exposure may be received by operators and technicians undertaking servicing and maintenance, surveys and calibration, and other similar activities. The Commission limits the definition of occupational exposures to those that can reasonably be regarded as being under the control of the operating management, as all workers continue to be exposed to background radiation irrespective of their activities. The Commission emphasises that optimised protection means achieving levels of exposure that are as low as reasonably achievable, irrespective of the category of exposure. The Commission also emphasises that it is a fallacy to assume that categorisation 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 normally be set at a very 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 radiological protection provisions should also be used as appropriate. Thus, the Commission expects that such individuals are protected to levels consistent with protection of members of the public, despite the fact that 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 normally be established at very small fractions of the dose limit for members of the public. 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 individuals, 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, should be subjected to control with the appropriate regulatory framework, including authorisation and inspection, by the designated competent authority. IAEA has established requirements for regulatory systems and control of sources, including appropriate expectations for training, retraining, and competence of operators; and appropriate management systems to ensure that the prime responsibility for safety is discharged effectively (IAEA, 2010, 2011).

4.4.3. Optimisation of protection for screening materials and cargo

(76) Scanning of materials, cargo, etc., poses a different opportunity for optimisation. 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 Section 5. During the screening of cargo and conveyances, the possibility for exposures outside 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. Optimisation 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 radiological

protection considerations are similar to those industrial exposure uses when a source is used in a temporary location (e.g. industrial radiography), and specific requirements need to be included in an authorisation for appropriate surveys, establishment of controlled areas, and other provisions to minimise public exposure.

4.5. Dose limits

(78) The Commission expects that the operation and use of security screening systems, under the appropriately optimised radiation control programme for planned exposure situations, should not challenge any of the dose limits recommended for occupational and public exposure during expected activities. The protection of drivers and individuals who may be concealed in cargo containers from exposure as a result of cargo screening is treated in Section 5.

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 effective implementation of the Commission's system of protection. These include communications regarding the risk of very small levels of exposure, provision of alternative screening methods, and an individual's right to know. These may be addressed from the standpoint of radiological protection, but other challenges will also need to be taken into account with local stakeholders.

(80) Systems that are justified and used 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 radiological protection programmes and controls must be established to ensure that the systems operate as designed, and that exposures are not greater than analysed and predicted. Many stakeholders have raised concerns 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 undertaken voluntarily or the individual has some degree of control. Comparisons with other types of similar risk may be useful, but care must be exercised in making such comparisons. The Commission recommends that such communications should 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 radiological protection programme and implementation of any screening activity. The Commission recognises that there has been a great deal of press coverage and debate regarding security screening. Much of this has focussed on the ethics and other issues surrounding screening, such as individual rights, privacy, and the individual's right to know. Therefore, the focus must be on making reasonable provisions of information, such as posting information, so that the individual's right to know has been met. Radiological protection, focussing 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 recognising 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 may have very different perceptions of risk and the ethical basis for protection from radiation protection specialists or security specialists. The Commission recommends that key messages, questions, and answers should be developed in advance, and be 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 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 optimisation 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 that may result in the exposure of all ages of individuals, and the possibility of exposure of the embryo/fetus. The Commission believes that the appropriate application of the framework of protection, including justification and optimisation 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 protective actions for children or pregnant women from the standpoint of prospective radiological protection. Justification and optimisation may explicitly include consideration of sensitive populations in the decision-making process as one of the matrix of factors in an analysis (ICRP, 2006), and provide documentation on the results of such considerations.

5. SPECIAL CIRCUMSTANCES

(84) The use of ionising 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 minimised 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 radiological protection standpoint, exposure of drivers should not be necessary when screening cargo. The Commission believes that such exposures are not generally justified, unless specific justifications show that there is a positive net benefit to conducting operations in a manner that results in some exposure. Exposure of such individuals should not be a matter of operational convenience, and the Commission recommends that drivers should not be allowed to occupy conveyances during screening, except in very unusual circumstances.

(86) In the very unusual circumstances where exposure of drivers is specifically justified, all possible measures should be taken to eliminate or reduce the exposures through the use of interlocks and other systems to prevent exposure. In particular, consideration should 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 exposure. The considerations described should be reflected in specific requirements and conditions that become part of the authorisation from the competent authority. Periodic reviews of operational experience, and the need for continued operational practices resulting in exposures, are appropriate.

(87) If the very unusual circumstance of exposure of drivers is allowed to occur, these exposures should be treated as occupational exposure, and subject to the relevant recommendations of the Commission. Specific dose constraints on exposure need to be established. Further, given the very unusual circumstances, the Commission recommends that constraints should be selected within the band recommended in *Publication 103* (ICRP, 2007) for public exposure in planned exposure situations.

5.2. Exposure of concealed individuals

(88) 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 this 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.

(89) The Commission recommends that this scenario should be considered in the design and construction of scanning systems, and estimates should be made of possible exposure if concealed individuals are present in a container or conveyance to be screened. The Commission further recommends that systems should be designed and operated such that the dose to a concealed individual would be unlikely to exceed the recommended dose limit for members of the public. In most cases, this would be 1 mSv/year, which in the case of screening a concealed individual could be considered as equivalent to a per-event criterion.

(90) The Commission believes that the above criteria can be achieved 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 recognises that such individuals are, by the very nature of their act, behaving in a way that the normal expectations of radiological protection cannot be assumed. Although such behaviour may, in fact, be illegal, individual ethics and equity considerations lead to the conclusion that the level of risk assumed for design and operation should not substantially exceed that recommended for members of the public. Similar recommendations can be found in the commentaries of NCRP (2003, 2007). If a national authority deliberately chooses to use ionising radiation scanning devices to search actively for concealed individuals, a specific justification analysis taking into account the relevant doses and safety concerns is necessary.

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