European ALARA Network

European ALARA Newsletter

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12th EAN Workshop - "ALARA issues arising for Safety and Security of Radiation Sources and Security Screening Devices"

Background and objectives

Radiation protection has always included security-related provisions, for example measures to prevent the unauthorised use and illegal transfer of sources, which have contributed to the overall system of radiation safety. In recent years, however, interest in security issues has dramatically increased and the challenge is to ensure that safety and security measures are designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The aim of the Workshop was to consider how the implementation of ALARA, in terms of planned and emergency exposure situations, involving worker and public doses, is affected by the introduction of these new security-related measures. In the case of new equipment and procedures, there is also the question of whether exposures arising from security screening devices can be justified. In addressing these issues, the Workshop aimed to consider how an optimum balance between protection, safety and security can be achieved.

Scope of the Workshop

The workshop programme included the following subjects:

- Introduction and scene setting:
- Safety and security measures:
- Planned exposure situations:
- Emergency situation management (especially due to malevolent acts):
- Justification and optimisation in the use of security screening devices

Working Group Topics

Two afternoons were dedicated on discussion in small groups on the following topics:

- Implementation of the Code of Conduct and HASS – ensuring ALARA
- Balancing security and safety – how to achieve an optimum solution?
- Management of emergency exposure situations from an ALARA perspective
- Justification and optimisation in the use of security devices

Conclusions and recommendations

The conclusions and recommendations of the Workshop were prepared based on the oral presentation and reports of the discussions from the Working Groups. They are available on the EAN website together with the PPT files of the oral presentation and the reports from the Working Groups.

This special issue of the Newsletter includes all the abstracts and/or full papers of the 12th EAN Workshop oral presentations.

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Content of the Special Issue

Session 1 - Introduction and scene setting

EU HASS Directive

V. Tanner (European Commission)

No paper was provided. The PPT file of the presentation is available on the EAN Website (12th EAN Workshop section - www.eu-alara.net).

IAEA activities on control of sources

H. Mansoux (IAEA)

No paper was provided. The PPT file of the presentation is available on the EAN Website (12th EAN Workshop section - www.eu-alara.net).

ALARA in security and safety of radiation sources: an ICRP perspective

J. Lochard (ICRP - Committee 4)

Abstract. As defined by ICRP Publication 103, *safety* is the "*achievement of proper operating conditions, prevention of accident or mitigation of accident consequences*" and *security* is the "*prevention and protection of, and response to, theft, sabotage, unauthorized access, illegal transfer, or other malicious acts involving nuclear material, other radioactive substances or their associated installations*". These definitions are coherent with the respective IAEA definitions.

In normal operation, safety of radioactive sources is ensured by security measures associated with appropriate protection measures. As stated in ICRP Publication 103 (paragraph 271), *security of radioactive sources is a necessary, but not sufficient, condition to ensure source safety. Radioactive sources can be secure, i.e. under proper control, and still not safe, i.e. prone to accident*". When security measures fail, safety is then ensured by protection measures to mitigate the consequences of the event.

The objective of the presentation is to discuss from the ICRP point of view how ALARA is integrated into the management of safety and security of radiation sources. The key points emerging from recent ICRP Publications are the following:

- The new system of radiation protection recommended by ICRP in its Publication 103 and subsequent publications (ICRP 109 and 111) is complete and coherent to manage all exposure situations (planned, emergency and existing) that may result from the handling of radioactive sources.
- ALARA is the cornerstone of the system to control exposures in both normal operations or in case of failure of security measures (emergency and recovery situations).
- ICRP Publications 103, 109 and 111 propose ranges of values to select proper dose constraints and reference levels for the practical implementation of ALARA in these exposure situations.

International initiatives since 09/11 - Feedback from GICNT and other Workshops

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Abstract. On the background of the G8-Summit 2006, the US and Russia launched the Global Initiative to Combat Nuclear Terrorism to expand and accelerate the development of partnership capacity to combat the global threat of nuclear terrorism. More than 70 partner nations already joined the initiative.

In several Workshops, the need to increase security of radioactive sources and radioactive material has been discussed. Keeping control and regaining control, in particular over High-Activity Sealed Sources (HASS), was one of the main topics. In December 2007, Germany organized the Workshop on "Safety and Security of High-Activity Radioactive Sources - Operation of a National Register" in Munich, where the existence of national registers was seen as one important aspect to reach the goal of increased security. The discussion has been continued in June 2008, during the conference "Security of Radioactive Sources" in Ottawa, Canada, which was focused on best practices for the security of risk-significant radioactive sources in academic, industrial and medical applications. The conference included a very good mix of regulators as well as facility operators, to identify a number of best practices as well as lessons learned in the security of radioactive sources. The "Seminar on preventing illicit trafficking in nuclear and radioactive materials", June 2009, Morocco, will give the opportunity to share experiences an best practices on prevention of illicit trafficking, as an important factor to avoid the malicious use of radioactive material.

In 2008 the European Union launched a Task Force to combat the threat of Biological, Chemical, Radiological and Nuclear (CBRN) terrorism. In 2007 the decision was taken to concentrate the efforts on increasing the security of CBRN materials. The issue is also one of priorities of the "pursue" strand of the EU's overall counter-terrorism strategy and one of the top priorities of counter-terrorism officials across Europe as well as the world. The aim of the radiological/nuclear sub-group was to identify concrete actions which would need to be taken at EU level and at Member State level concerning prevention, detection and response to radiological and nuclear terrorism. The work of the sub-group was designed to contribute to the development of a policy package to be put forward by the Commission in 2009.

The example of Co-60 contaminated stainless steel (~180 tons) found in Germany shows, that control over radioactive sources is an important issue, not only for the prevention of radiological terrorism but for the protection of the public as well.

Session 2 - Security and safety measures

Operation of the register on High Activity Sealed Sources in Germany 4 years of experience

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Abstract. With the Act on the Control of High-Activity Radioactive Sources of 12.08.2005 Germany has set several regulations into force to comply with the European Council Directive 2003/122/EURATOM of 22.12.2003. As part of the new requirements a national register of high-activity sealed radioactive sources (HASS register) has been introduced and is operated now since about four years at the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS).

The presentation will give a short introduction on the legal framework, the security measures and the electronically basis of the German HASS register, which is established as an encrypted Internet communication system. Several local authorities, source users and the BfS have access and maintain source data and the information about the transfer of HASS sources. The experience of the last years induced a lot of improvements, which are incorporated into the next software revision that is scheduled to be implemented in the next month.

Some workshops and discussions at the international level (IAEA) took place already to exchange information about different national source registers. It was obvious, that a general difference occurred between the European Union, where the activity level for sources to be recorded in a register was adopted from the transport regulation (A_1/100), and the regulations from the IAEA (Code of Conduct), which incorporated an activity level according to the IAEA D-value concept. Meanwhile, the differences are well known and have been part of the discussion at some institutions. A short summary of the results of the last workshop in Berlin and the current international discussion on that topic will be presented.

Introduction

Against the background of several terrorists attacks the problem of malicious use of sealed radioactive sources came into focus and a set of measures were discussed in order to enhance the safety and security of radioactive material. Among other things expert groups considered a national source tracking system and a central source registration appropriate, especially in order to regain control over orphaned sources. However, in modern industrial and medical applications thousands of radioactive sources are used and an entire tracking system would therefore make a huge effort. But only sources with a higher activity represent a significant radiological hazard, so that it would be practicable and sufficient to register only sources above a certain activity level. These recommendations are laid down in international documents such as the Code of Conduct [4] by the International Atomic Energy Agency (IAEA) and the European Council Directive 2003/122/EURATOM [1] (HASS-Directive). Meanwhile, most European Countries incorporated the HASS-Directive into their national legislation and maintain a source register on a national level.

German Regulations

With the Act on the Control of high-activity sealed radioactive sources (HASS) of 12.08.2005 Germany has set into force several regulations to comply with the international recommendations. All conditions are integrated into two basic German provisions: the Atomic Energy Act (Atomgesetz [2]) and the Radiation Protection Ordinance (Strahlenschutzverordnung [3]). Although most of the requirements were already fulfilled by the existing provisions some regulations had to be added or specified. Explicitly, regulations for the identification and documentation of HASS, an obligation for manufacturers to recycle or dispose sources, specific regulations for the leakage test of HASS and financial precautions for orphaned sources have been incorporated. The standard record sheet of the European HASS-Directive has been adopted in detail by the German Radiation Protection Ordinance. Moreover, the regulatory background for a central national register of high-activity sealed radioactive sources (HASS register) at the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz - BfS) has been laid down. Because there is traditionally a federal organizational structure of the radiation protection offices in Germany, some responsibilities had to be reorganized. Thus, the HASS register is authorized to record receipt and transfer of a HASS, to provide information for security agencies (i.e. Federal and State Police, Secret service) and to cooperate with local authorities to verify the information supplied by licensees. If HASS are going to be im- or exported, the Federal Office for Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle) will be involved.

Operation of the German HASS Register

The HASS register is realized as a communication system via encrypted Internet connection between licensees, state authorities and the BfS. All data are recorded in a database (ORACLE) that can be accessed by authorities only. Thus, because of security reasons licensees do not have direct access to the database. To notify the register in case of receipt, transfer or control of a HASS the licensee uses an Internet browser and his network login. He can report all relevant data using an input mask, that adopted all fields of the standard record sheet of the HASS-Directive. All notifications are stored into the database and will be verified by the local state authority, who had issued the concerned radiation license. In case an error was detected, the licensee is obliged to send revised data. The entire information exchange between register, authorities and licensees is performed via email communication. Additional read access to the register is authorized for security agencies (Federal and State Police, Secret services, etc.).

In order to prevent unauthorized access and malicious use of data about high-activity sealed sources several security measures have to be considered. The following essential measures have been implemented with the German HASS register:

- Licensees have access only to a communication client via SSL to login with username and password, they don't have direct access to the HASS database.
- Authorities can access the database directly via SSL using a private key certificate, which is send to them personally, they login with username and password too. Local state authorities and the BfS have read and write access, security agencies have only read access.
- Staff at BfS working with the database is sworn to secrecy and all computers at the BfS to be used for the HASS database have restricted access.

The German HASS register currently (October 2009) manages data of approx. 43,000 notifications about 16,000 sources. 580 licensees and 100 authorities are authorized to work with the database. Since initial operation no lost or found HASS have been announced to the register. Further statistical data are shown in Figures 1 and 2.

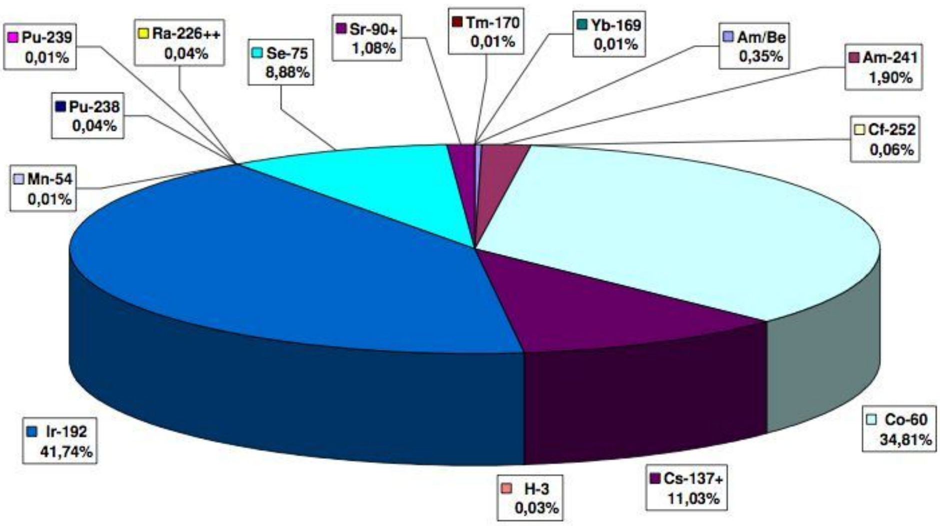

Figure 1. Nuclides of sources in the HASS Database

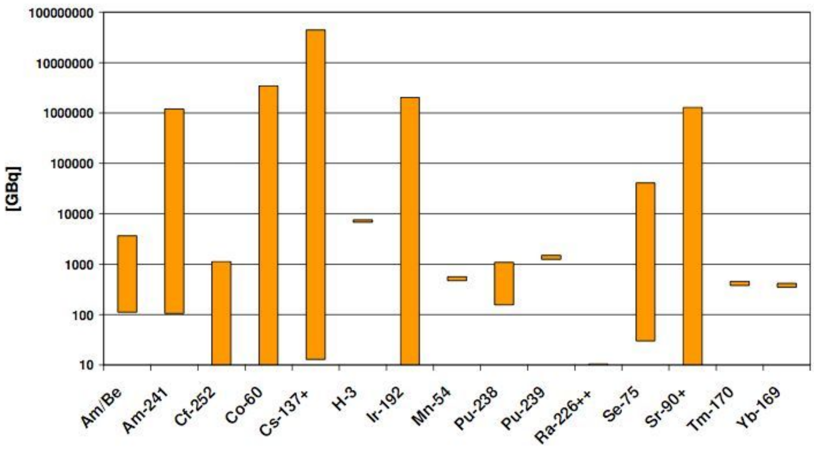

Figure 2. Range of activity of sources in the HASS database

Experience and Development

The HASS register is in operation now for approximately four years. The software is accepted by most of the users and several bugs of the first revision were eliminated with the currently operating second revision. Some still existing problems are summarized in the following categories.

Quality control of data

Exact and detailed data are essential for a storage system. Unfortunately, some licensees do not hold a proper documentation (source certificate) and announce incorrect source data, especially for old sources. Most of these cases can usually be clarified with the aim of the state authority and the source manufacturer, but it would be preferable to avoid inconsistency of the database. Thus, apart from requirements concerning the documentation addressed to source manufacturers, an inherent periodical screening of the source data might be helpful. Additionally, in order to avoid problems with differing serial source numbers due to typing errors, a barcode system helping to identify sources from the database should be designed.

Software problems

The direct access of licensees to the HASS database has been restricted for security reasons. On the other hand, this impedes the user to reload or change the data he send before and these restrictions reduce the acceptance of the system considerably. Future improvements will introduce a local file management for the user to access his own data. Though, a general access to the HASS register for licensees is still not considered.

International data exchange

Based on the HASS-Directive every member state of the European Union holds a system to trace back high-activity sealed radioactive sources. Besides, the data kept in storage might be fairly similar, since all systems record information, that was notified using the standard record sheet. The exchange of data and - thus - to pursue each national tracking system abroad might be possible. These questions have been discussed already at some workshops and led to a recommendation to introduce a formal information about the receipt of a HASS in the foreign country. Unfortunately, cross border movements of sources are still not recorded - even between European Countries. Further improvements and conditions for an international exchange of data should be developed and a broad political commitment is needed to establish an international source tracking system.

International harmonization of the regulatory background

With the HASS-Directive the level for the activity of a HASS was set to A1 / 100, where A1 is an activity limit for radioactive material in special form according to transport legislation. Against this, the activity level for sources to be recorded in a national register set by the Code of Conduct [4] is 10 x D (corresponding to category 2), where D is a certain nuclide specific value defined by “Dangerous quantities of radioactive material”

[5]. Since the levels of the European HASS-Directive for most of the nuclides used for HASS are lower than the levels of the IAEA, a European register usually comprises more sources. This problem was discussed at former workshops and first steps to adopt the D-value system of the IAEA for the European Union have already been undertaken. Thereby sources of an activity of at least 1 x D (corresponding to category 3) shall be included.

Summary

Following international recommendations or directives a lot of countries operate a national registry of sealed radioactive sources of different types. Germany established its national register as a central communication system via encrypted Internet connection between licensees, state authorities and the BfS, who maintains the system. The German register is in operation now for about 4 years and has already been revised in order to eliminate some software bugs. The general acceptance of the system by the users is good, although future improvements will still enhance user- friendliness.

Some workshops and discussions took place already to exchange information about different national source registers. It was obvious, that a general difference concerning the activity levels occurred between the European Union and the regulations from the IAEA. Meanwhile, the differences are well-known and first steps to adopt the D-value system of the IAEA for the European Union have been made. Further international cooperation and data exchange is still a future challenge.

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[3] Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung – StrlSchV) of 20.07.2001 (BGBl. I, p. 1714 and BGBl. 2002 I, p. 1459), last amendment of 13.12.2007 (BGBl. I S. 2930)

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Improved security measures for radiation sources in Norway
A case study of irradiation facilities in hospitals

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Abstract. The main focus in this article is on the recently improved security requirements on high activity radioactive sources. A number of these sources represents significant risk and are placed in non-nuclear facilities such as hospitals. This article describes the process going from a regulatory regime where security was mainly associated with nuclear facilities, to a regime including more dedicated security measures also outside typical nuclear facilities. Concerns for the security of hazardous radioactive material led to assessments of the impact of a hypothetical malevolent act at one of the typical commercial high activity source used in a hospital environment. The result from these considerations was a significant enhancement of the regulatory activities in relation to security. This includes i.a. regulatory orders to improve security at irradiation facilities in hospitals, and an improved register for the control and overview of sources in use in industrial and medical applications. The regulatory orders will also be followed up by an intensified inspection program. This process has been influenced by international efforts in this field, such as the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, the EU HASS directive and other IAEA documents.

Irradiation facilities in Norway

Radioactive sources have a large range of applications in industry, research and medicine. Most of the radioactive sources in Norway are radionuclide gauges in permanent installations that are used for taking measurements or for process control. There are approximately 2500 sources of this kind, classified as IAEA category 3 – 4 sources. There are also roughly estimated about 100 IAEA category 3 sources in Norway at all times due to well logging activities. The number can vary since the international well logging companies continuously relocate their radioactive sources between Norwegian sites and sites abroad. In the industry, the use of radioactive sources with high activity, typically IAEA category 2 sources, is mainly related to industrial radiography. This activity is first of all connected to the oil industry, and the range of use is relatively comprehensive. More than 200 gamma radiography containers are registered, divided on about 50 licensees. However, the highest active radioactive sources, the IAEA category 1 sources, are placed in irradiation facilities used for blood irradiation, sterilization or research purposes.

In the later years it has been an increased focus on security of radioactive material. Consideration of the security of the radioactive sources in different applications has shown that especially the blood irradiators have been insufficiently secured.

Cesium-137 blood irradiators

The purpose of blood irradiation is to destroy T-lymphocytes, a type of white blood cells, which may cause transfusion associated graft versus host disease (GVHD). GVHD is a severe transfusion complication that might occur when the T-lymphocytes from the donor attack the recipient's tissue. If sufficiently irradiated, the T-lymphocytes in the transfusion blood are hindered from replication and proliferation, and GVHD is thus prevented [1]. Irradiated blood is used in cases with strong immunosuppressant's patients, premature children, patients with severe immune defects and at transplantations [2]. To assure rapid supply of recently irradiated blood with high quality, blood irradiators in Norway are located at hospitals and blood banks, and not in centralized blood centers. This means that the blood irradiators are spread over a large geographic area as single units.

Cesium-137 blood irradiators can be replaced by less hazardous alternatives, like metallic cobalt-60 irradiators or X-ray irradiators. These alternatives are, or has been, commercial available. On one side, cobalt-60 has considerable resistance to dispersion and the solubility is limited. On the other side, cobalt-60 requires more shielding, which means increased weight, which in turn would require installation at the bottom-floor of the building. The half-life of cobalt is also much shorter than the half-life of cesium, which means a shortened useful life of the irradiator. Commercial x-ray blood irradiators are another alternative that can deliver the necessary radiation dose with sufficient uniformity and stability [3]. However, both alternatives are considered to be more expensive than the standard cesium-137 blood irradiator. Other possible alternatives, like using different material forms of cesium-137, like cesium containing ceramic etc., have so far not become commercial available.

Figure 1: IBL 437C. Foto: NRPA
Photo: NRPA

Figure 2: Gammacell 3000 Elan.

There are in total thirteen self-shielded cesium blood irradiators in Norway, located in hospitals or in blood banks in conjunction with hospitals. The source activities range from 14 TBq to almost 200 TBq. Among these irradiators, one is an IBL 437C from CIS-US Inc. while the remaining twelve are Gammacell irradiators from MDS Nordion.

Based on concerns for the security in combination with few or none good alternatives, the Norwegian authorities decided in 2006 to improve the security requirements at blood irradiation facilities placed in hospital environment instead of replacing them.

Other irradiators

In addition to commercial blood irradiators, a few other types of high activity irradiators are in use for research, calibration, sterilization and radiotherapy purposes. One of these facilities is a cobalt panoramic dry source storage irradiator, mainly used for sterilization and research purposes. Two high activity cobalt sources are used for research and calibration, and there is one cobalt Gamma Knife machine used for radiosurgery.

National and international regulatory framework

Security has traditionally been associated with nuclear facilities. This comprehension has changed, and the security of radiation sources placed outside nuclear facilities is now implemented in the new Norwegian regulations. The process developing new regulations was influenced by the international framework in this field, such as the IAEA Code of Conduct on the Safety and Security of Radioactive Sources [4].

Following several serious incidents and accidents involving radioactive sources in the 80-ties and 90-ties, the first international conference on the safety of radiation sources and the security of radioactive materials was held in Dijon, France in 1998. The major findings of the conference led in turn to the International Atomic Energy Agency (IAEA) developing an action plan for the safety of radiation sources and the security of radioactive materials, which was approved by the board of governors and endorsed by the general conference in 1999 [5]. The Action Plan called for the development of a Code of Conduct on the Safety and Security of Radioactive Sources, which was first published by the IAEA in 2001. Following the events of 11 September 2001 more attention was given to the security of radioactive sources against malicious acts, and as a consequence the *International Conference on Security of Radioactive Sources* was held in Vienna in 2003. The findings from this conference in turn led to the Code of Conduct being revised, and approved by the IAEA Board of Governors in September 2003 [6].

One of the seven points of the Action Plan was to develop a document on the categorization of sources on the basis of their associated potential for exposures and radioactive contamination. This categorization system has now been published as an IAEA Safety Guide. Among the goals for the categorization system was to provide more coherent regulatory and security measures for radioactive sources representing similar potential harm to human health. The categorization system has placed the cesium-137 sources used in blood irradiators in category 1, the most 'dangerous' category, which can pose a very high risk to human health if not managed safely and securely [7].

In parallel to this international process, new regulations on radiation protection were in development in Norway. Following the new Norwegian Act on Radiation Protection and Use of Radiation in 2000 [8], new regulations were needed and the Code of Conduct provided input to this effort. New Norwegian Radiation Protection and Use of Radiation regulations went into effect from 2004 [9], for the first time setting requirements to the security of radioactive sources. While the Norwegian Atomic Energy Act [10] had set requirements to security at nuclear installations for a long time, the earlier regulations covering radioactive sources had less focus on security.

Upgrading security for blood irradiators in Norway

Blood irradiators represent the only high activity self shielded irradiators in Norway. While other irradiation facilities used for research and calibration/dosimetry has had security features (such as access control and a secure location) implemented as a consequence of their stringent safety requirements, no special provisions were given to the blood irradiators since they were not considered to represent any safety issues. The physical weight of the blood irradiators also meant that theft was seen as a highly unlikely scenario.

In 2006 an order was issued from the Norwegian Radiation Protection Authority (NRPA) requiring all blood irradiators in Norway to strengthen their security measures. This action originated partially as a consequence of the high-lighting of blood irradiators in the work towards a categorization system for radioactive sources, but mainly because of new considerations when it came to the possible threats from malevolent acts such as sabotage or other targeted attacks against these installations.

Previous requirements stated two independent security measures; access control to the department where the blood irradiator was placed and that use of the blood irradiator required a key or a code. To strengthen the security, the order of 2006 required an extra physical barrier to prevent sabotage. This physical barrier meant that the irradiator should be placed in a separate room with access control. At present there are in total two physical independent barriers that must be passed to reach the irradiator, in addition to the code or key that is needed to start/use the device. However, physical barriers are not enough alone to secure the irradiator properly. A possible inside threat must also be taken into account. To reduce the threat of an insider, it was required in the order of 2006 to make a reliability check of users of the irradiator. In addition it was stressed that strict access control should be practised. Only users of the blood irradiator should have access to the irradiator.

Along with requirements in the Act and Regulations on Radiation Protection, the licensees were imposed to make a thorough evaluation of the justification of use and assess the x-ray blood irradiator as an alternative. Results from the assessments showed that is was a general comprehension that x-ray irradiators were more expensive than the caesium irradiator, and that it was important to be able to provide irradiated blood within a certain time window. Transportation over large distances that would delay the delivery was not ideal. These were acceptable arguments for the NRPA.

At present, all the licensees have given a written statement that the necessary measures have been carried out in order to fulfill the new requirements. The process has taken some time because most of the licensees had to go through some time-consuming work in order to comply with the new requirements, making changes in building constructions etc.
The next step in the process is to complete the recently started site inspection program.

Register for sources in industrial and medical applications

The Code of Conduct on the Safety and Security of Radioactive Sources states that all states should establish a national register for radioactive sources. Earlier practice at the NRPA was that radiation sources of all categories above the national exemption levels (typically IAEA categories 1-4) were registered through paper forms submitted by end-users, some of this information was in turn transferred to internal database systems. This process, however, required much work and was error prone. As a consequence, the NRPA started developing and using a web-based source registration tool. Here, end-users are able to register and update information about themselves, such as contact information, and their sources. This information is then verified by NRPA personnel. The web-based interface will enable the NRPA as well as the end user to have access to the same information about their registered sources, something which will hopefully improve the quality of the register. The register covers not only radioactive sources, but also x-ray, UV- and laser sources.

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Safety, dose optimisation and security: the quadrature of the circle

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Abstract. The growing concern for potential terrorist acts has lead to a number of new ideas about storing radiological and nuclear materials that are not always compatible with existing practices or infrastructures. This is valid in normal, routine circumstances, but may especially pose problems in case of accidents. As such, the management of nuclear safety, radiological protection and security within an evolving world such as a nuclear research centre sometimes looks like implementing the quadrature of the circle. Just a few examples. First: infrastructure related problems: from a security point of view, fuel storages or radioactive sources are better stored in the heart of a well protected zone, while in case of criticality, fire, etc. a more peripheral location is more appropriate. Strong protection infrastructure may lead to difficulties of evacuation in case of emergencies. Second: safety related problems: access limitations to some areas may be a burden in the management of safety interventions, maintenance, etc. Third: administrative contradictions: inventories of fuel storages and high active sealed sources are a cornerstone of inspections and verifications; yet, this information is also a treasure for terrorists aiming at actions to obtain special materials. Fourth: dose management: some of the measures taken to secure sources may lead to an increase in dose (e.g. labelling of old sources). Many more concrete examples of daily experience can be given.

As a conclusion, it is indispensable that some people, both at the level of regulators and operators dispose of a helicopter view on this subject, in order to achieve optimal solutions taking into account all aspects: safety, security and dose optimisation.

Introduction

In many organisations dealing with nuclear and/or radioactive materials, there have been considerable efforts since a long time to implement an adequate policy for avoiding nuclear accidents (nuclear safety), serious accidents with the workforce (mainly industrial safety) and to reduce doses and to limit contaminations (radiation protection). While nuclear and industrial safety got a lot of attention already in the fifties and sixties of the previous century, also via the regulation put into place, it took longer before institutes started implementing systematic “ALARA” policies. A real breakthrough here was obtained mainly in the nineties despite earlier guidance of e.g. the ICRP [1, 2, 3, 4]. Breakthrough certainly was supported from the publication “ALARA, from theory towards practice” [5].

Security issues received a growing attention in the past few years only, to a large part as a consequence of the 9/11 event leading to new concern, later on followed by new legislation on e.g. the management of sealed sources [6]; these have led to many organisational measures such as reinforcement of intrusion prevention, surveillance, administrative and technical measures to reinforce access control.

In parallel, the "safety culture" approach developed, mainly based on IAEA guidance in the aftermath of the Chernobyl disaster and the activities of the so-called INSAG, the International Nuclear Safety Advisory Group (a.o. [7, 8]). This safety culture concern has developed first in nuclear power plant, while other nuclear facilities followed later.

The management of prevention of accidents in nuclear facilities requires a holistic approach taking into account safety of facilities, workforce safety, environmental impact, security of materials, safeguards issues. All these aspects require the necessary attention, however, in practice there are many difficulties. This paper focuses on the fields of enhancement of this management, but also on contradictory conclusions to be taken, making a coherent policy to be as searching for the quadrature of the circle. Although we are convinced that the difficulties mentioned certainly are also of relevance for industrial or medical applications with radioactivity, we will focus on nuclear facility related issues.

Safety culture, ALARA culture, security culture

Safety culture has been defined in many papers, but the most frequently used definition can be taken from INSAG-4 [7]:

> *Safety culture is defined as "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance"*

Security culture has also been defined in documents of the IAEA, also making an attempt to be in line as much as possible with the definition above of safety culture (e.g. [9]):
For the purposes of this report, nuclear security culture is defined as:

> *The assembly of characteristics, attitudes and behaviour of individuals, organizations and institutions which serves as a means to support and enhance nuclear security. An appropriate nuclear security culture aims to ensure that the implementation of nuclear security measures receives the attention warranted by their significance.*

ALARA management has less well been defined so far, although it has also been discussed in terms of a state of mind, an attitude, a culture. Work on defining ALARA culture better has already been planned via the European ALARA Network, e.g. during the 10th ALARA workshop in Prague [10].

Synergy between safety, ALARA and security culture

A number of characteristics of the 3 cultures show synergy, as is highlighted below.

1. An individual dimension: each individual working with radioactive or nuclear materials should show skills and attitudes contributing to the limitation of risks. As an example: a questioning attitude; adequate planning; think before you act. Risk conscious co-workers not only performing a task, but being critical towards what they are told to do and having adequate social relations with their colleagues to observe non-acceptable behaviour are supporting all three cultures.
2. An organizational dimension: the entire picture should fit: management should be supportive of all aspects, be aware of risks, be setting the right policy priorities. A right balance between risk averted and effort made is important for all three issues.
3. A common objective: avoid harm in a broader sense, a.o. by putting organisational measures into practice to avoid or to limit the consequences of technical failures and human error.
4. A technical component that needs specialised knowledge, investments, adequate maintenance.

Fundamental differences between safety, ALARA and security culture

Nature of the risk

The main difference between Safety and ALARA culture on the one hand, and Security culture on the other hand is the nature of risk. While one can assume that normal people strive to avoid accidents and do their best to mitigate them, security related issues clearly have a dimension of malicious intend. This has important consequences for the policy to be implemented. Security issues furthermore have an external dimension, i.e. an event starting outside the fence of the facility: a threat of theft, sabotage, intrusion, etc. originating from the outside. This is much less the case for safety issues (although external events also may lead to difficult circumstances), and much less for ALARA culture. However, security may also have an in-house dimension: malevolent intentions of members of the workforce, contractors, apprentices, students, visitors. In this respect, safety culture and ALARA culture can be considered to be based on trust, coaching, respect and reinforcement of ideas between staff, hierarchy and operators, prevention advisors and managers. Security may lead to distrust, control instead of supervision, and suspicion instead of support.

Probabilistic aspects

Probabilistic arguments are important for assessing the risk of an activity and its acceptability; in terms of design of facilities or judgements in a context of approval processes, this is important. Probability however is not useful in a context of intentional harm.

However, in this respect, safety culture and ALARA culture are not really in line. Nuclear safety often deals with very improbable events, why ALARA often concerns daily tasks and assessments. Nuclear safety rather deals with low probability – high consequence events, while ALARA is mainly regarding high probability – low consequence actions. This has practical implications for e.g. the validity or non-validity of statistical follow-up and other quality assurance related techniques [11] and in the mind set of people. Dealing with very low probability events may lead to lack of awareness or over-confidence (it never went wrong). In case of ALARA, it may rather be negligence (in day-to-day work doses in nuclear facilities often are very small).

Acceptability

The acceptability issue is apparent in many cases. A first example is related to the acceptability of consequences in emergency conditions. While it is appropriate to apply stringent intervention levels for the application of countermeasures related to a radiological release (e.g. in Belgium 5-15 mSv effective dose is the intervention level for sheltering - [12]), it is much less evident to use these values in case of terrorism. It is obvious that the nuclear industry wants to be top in all safety related issues, but application of these very low values as the upper bound for the maximum acceptable doses in case of e.g. theft of a source appears to be excessively stringent, and imposes protective measures beyond the reasonable, certainly if one compares to the ease by which other means can be used to cause dead to victims (explosives, toxics, weapons of all nature).

In terms of behaviour, it is very uncomfortable if not unacceptable to people to feel being systematically controlled and supervised by colleagues, chefs, guarding personnel. Social control and adequate supervision by hierarchy are well accepted and part of an adequate safety culture, but suspicious control to identify malevolent actions leads to social tensions. The systematic use of personal data, cameras, all types of sensors, checks by intelligence services etc. is also a negative side effect of the security policy that is imposed.

Safety, radiation protection and security require important investments in means, staff, maintenance, administrative support. For many people, it appears much more acceptable and ethically more justifiable to spend this money in safety enhancing measures as compared to measures to counteract malevolent use of radioactivity or nuclear material.

Time dependence

The risk of nuclear, radiological or industrial safety depends on the inherent aspects of the products dealt with; there may be fluctuations over time due to variability in operations (e.g. routine operation or maintenance), variability in potential impact (quantities of products, nature of experiments). This time dependence however depends on in house planning and processes, and if some change in policy is desired to adapt to particular circumstances, this can be anticipated in house.

The security issue is different. The threat of an intrusion or sabotage depends on external situations, and as such is beyond control of the operator. The protective measures required depend not only on the radioactive inventory, but also on the external circumstances (such as presence of terrorists on the territory, events in conflict areas), even at a global level. This dependence on external, hard to predict events makes policy making very difficult.

Reason

The aspect of reason is very obviously part of ALARA-culture. But both the safety and security culture definitions by the IAEA refer to "reason" as well, albeit formulated a little differently ("warranted by their significance", cf. supra). As stated above, the "significance" of security is very hard to assess, which is a fundamental difficulty in the definition of STI/PUB/1347 [9]. As the external risk can hardly be assessed, this situation leads very often to over dimensioning of the security protection put in place. It is very difficult to obtain an adequate balance between the risk of terrorism (radiological consequences) and the efforts put into place for protection, the target often being "zero risk". There is maybe need for an "ASARA" approach: as secure as reasonably achievable.

Practical difficulties in stimulating the synergy between safety, security and ALARA culture

Practicalities

In many organisations nuclear safety and security are managed by different services or sections, and often radiation protection and/or industrial safety may belong to still different ones. This of course hinders a joint policy, though striving for an integrated approach seems highly recommendable.

Technical competence is also an issue: the knowledge needed to avoid reactor excursions or criticality incidents (nuclear safety) is much different from the knowledge needed for an adequate radiation protection policy (justification and optimisation of exposures), for preventing an industrial safety related event, and has nothing to see at all with knowledge of security related technical measures such as identification of persons, strengths of fences, etc.

Legislation - relation to regulator and authorities

Much legislation is applicable to working in nuclear facilities. Often this legislation originates from different regulators. As an example, even at the European level, Radiation protection and nuclear safety are not well linked to general safety on the workplace and to environmental impact neither. Nuclear security issues mainly originate from IAEA guidance [13], with less implication of the European regulator.

In many countries, regulations including licensing and inspections have been attributed to different authorities. This may lead to different visions, and different expectations being imposed on the plant. As a consequence, implementation of an integrated approach is often made difficult.

Some practical cases inspired by daily practice in a nuclear research centre

The examples below do not intend to be exhaustive; they are just examples showing that integration of safety, radiation protection and security policies is often difficult, and that the requirements imposed on people may be contradictory.

Communication and information

Openness is a key feature of an adequate safety culture, and access to information is a cornerstone of modern management, supporting adequate safety and ALARA policies. As an example, it is good safety practice to clearly label radioactive products, to make inventories, to indicate where radioactive products are found. However, from the viewpoint of security, this helps potential terrorists in identifying the areas of interest to them.

Concrete examples are the requirements in the context of sealed sources: it is clearly an advantage in the management of sources to have adequate descriptions and to have a policy of evacuation of sources that are no longer used. On the other hand, the inventories of these sources may be a point of orientation to potential terrorists. Therefore, restrictions on information such as inventories are to be imposed. For a broader discussion, we refer to IAEA STI/PUB/1437. Excessive regulation to enhance the security of e.g. sealed sources may also be against the ALARA principle. High active sealed sources must be checked somehow, but imposing to possess pictures, to check labels on the source itself etc. may require important interventions having only a marginal impact on enhanced security.

Design of facilities

In terms of limiting the impact of criticality incidents, fires, etc. in places where nuclear and radioactive materials are stored or used, it is optimal to have some isolated or peripheral rooms. On the other hand, such places are much harder to protect against intrusion, and a central position in the building is often preferred.

Emergency circumstances

In case of technical difficulties in a controlled area, fast access can be important. This can be hindered by authorisation checks or procedures. This is true for normal interventions after technical failures and in real emergency conditions where external emergency workers are called in. A compromise must be sought between hermetic isolation of some rooms, and adequate measures to have people evacuated in emergency situations, knowing that each system to bypass the protection system is an extra opportunity for abuse by terrorists.

Conclusion

The integration of adequate policies to simultaneously enhance safety culture, ALARA or radiation protection culture and security culture is a complex task, which may lead to situations in which one has to invent the quadrature of the circle. Besides some technical arguments, there is a big mental impact on the people, both in the decision making and in the daily application. The contradictory nature of some of the rules that need to be imposed may lead to discomfort and cognitive dissonances [14].

In order to facilitate this process of enhancing all components of safety, radiation protection and security, there definitely is a need of a helicopter view by international advisory bodies and regulators. It is the merged policy that needs optimisation, and not various pillars safety, security and ALARA culture separately. An ASSARA-approach (As Safe and Secure As Reasonably Achievable) is what we all should be aiming for.

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Reclassification of security at a waste disposal repository

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Abstract. The National Nuclear Waste Disposal Repository in the UK, a nuclear licenced site which has been in operation since 1959, has recently been able to reclassify its security status. This has been made possible by the removal of the bulk inventory of Plutonium Contaminated Material (PCM) from temporary storage, and the transport of this material to a suitable Intermediate Level Waste store at the nearby, but separate, Sellafield nuclear licenced site.

This paper describes the necessary steps involved in reclassification of the Repository site to a lower security category, involving UK regulators, in particular the Office of Civil Nuclear Security. It also discusses the issues associated with reclassification, such as public acceptability and reassurance, policing, data quality, and other issues unique to the site.

With regard to ALARA, an essential element in the declassification was the confidence that assurances could be given to the nuclear and environmental regulators that doses to the workforce and the general public will remain as low as reasonably achievable, despite the potential greater access of personnel to the site.

1. The Radiation Risks from Low Level Waste in the UK

The UK has 24 Magnox (uranium metal fueled, graphite moderated, gas cooled) reactors at 10 sites, all scheduled to be shut by 2011, 14 AGR (Advanced Gas-cooled reactors - uranium oxide fueled, graphite moderated) at 6 sites and one Pressurised Water Reactor. It has two reprocessing plants at Sellafield and a fully functioning weapons industry. In addition, nuclear materials used at hospitals, research and medical facilities constitute the remaining parts of the nuclear industry. As a result of the above activities, nuclear waste is generated, the vast majority of which is classified as solid Low Level Waste (material containing contaminants below 12 GBq/te beta, and below 4 GBq/te alpha). The destination for this waste is ultimate disposal at the UK Low Level Waste Repository (LLWR) situated in Cumbria, near the Sellafield site.

The radiation dose levels in the vicinity of the LLWR are dominated by the nearby Sellafield site. The highest public dose from Sellafield, is 0.22 mSv or 220 µSv; however over 99% of the public receive less than 1 µSv from activities at Sellafield. Maximum public dose levels from the LLWR discharges itself are much less than 1% than those from Sellafield, and are too low to measure due to the background, but have been modelled at around 0.00001 mSv or 0.01 µSv. Direct radiation from the LLWR site is below 40 µSv to a theoretical most exposed household.

In collective dose terms, the total annual public dose committed by the entire UK nuclear industry is 6.3 man.Sv, implying (at the current ICRP recommendation of 6% of a statistical fatality per man.Sv) of some 0.4 fatalities at some time in the future.

2. The Low Level Waste Repository (LLWR)

The LLWR is a low-level solid radioactive waste disposal facility covering some 100 hectares, located around 6 km south-east of Sellafield, near to the village of Drigg, in Cumbria. Initially, the site was operated by the UK Atomic Energy Authority, and transferred to British Nuclear Fuels Limited in 1971. In 2007 the Nuclear Site Licence holder and operator became LLW Repository Ltd.

The LLWR is certificated under both the international Environmental Management standard ISO14001 (2004), the Quality Management standard ISO9001 (2008) and the Health and Safety standard BS OHSAS 18001 (2007).
In the early years of waste disposal at the LLWR, wastes were "landfilled" according to conventional practice (i.e. tipped into open trenches before being covered with a layer of earth). The trenches benefited from clay lining, both natural and enhanced. The last trench was filled in 1995. All trenches have now been covered with an impermeable membrane and landscaped. A final site cap will be installed as part of the eventual site closure.

Since 1995, waste materials are, wherever possible, compacted and placed in containers before transfer to the LLWR; for the majority of wastes, this is done at Sellafield. Non-compactable wastes are placed directly into the disposal containers, and immobilised by the addition of grout in the LLWR Grouting Facility. All wastes, in their containers, are placed in an engineered concrete vault. A new vault is currently under construction and will provide 100,000 m^3 extra capacity, although with the construction of additional vaults it will be capable of being extended to give additional capacity until 2050. Final site closure is expected to be in 2059, and will include the decommissioning of remaining facilities and the installation of an engineered cap and other measures to ensure the long term isolation of the site.

With regard to solid wastes arriving on the site for disposal at the LLWR, all waste is dispatched in accordance with the consignors' own disposal authorisations issued to them by the Environment Agency and the Scottish Environment Protection Agency. In addition, all waste disposals must comply with LLW Repository Ltd's Conditions for Acceptance. These include requirements that ensure compliance with the authorisation applicable to the LLWR site itself and a requirement that consignors have their own appropriate quality assurance arrangements in place. Quantitative limits are set on the levels of total radioactivity, and of specific radionuclides, disposed of to the LLWR.

The monitoring, retrieval and transfer to Sellafield of a quantity of Plutonium Contaminated waste Materials (PCM), both drums and larger items, which had been stored at the LLWR awaiting conditioning and treatment, was completed in July 2007. The PCM is now being stored at Sellafield prior to final disposal. The decommissioning of the old PCM storage facilities has now commenced and is due for completion in 2010. It is the existence of PCM on the LLWR site that has, until 2007, demanded a site security status of Category III, by the UK Office of Civil Nuclear Security (OCNS), the security regulator.

3. Environmental Releases of Radioactive Materials from LLWR

The principal source of liquid effluent is leachate from the trenches predominantly from earlier, less contained, waste disposal practices. These arise from rainwater ingress and groundwater movement, and could potentially migrate from the waste burial site. The leachate is collected in holding tanks for monitoring prior to discharge to sea via a pipeline, subject to the site authorisation which places regulatory controls on such discharges.

Effluent minimisation has been actively managed through capping of trenches to reduce rainfall infiltration. Radioactivity concentration in leachate is minimised through isolation of the waste from rainwater and groundwater infiltration by emplacement in containers within the engineered vault.

Low level waste disposals and PCM transfer operations undertaken at the LLWR have not given rise to any significant aerial discharges of radioactivity, as confirmed by monitoring of discharges on stacks associated with the LLWR Grouting Facility and the PCM Retrieval Facility. High Efficiency Particulate Air (HEPA) filtration for authorised aerial discharge points is in place.

The discharges of aerial and liquid effluents are considered so low as to not warrant quantified limits, however, the authorisation requires the LLWR to apply the 'Best Practicable Means' to minimise waste generated on the site and to ensure that the radiological impacts of wastes disposed of to the site will be As Low As Reasonably Achievable.

4. Security Arrangements at LLWR until July 2007

Security categories for UK Nuclear sites range from I to IV, with I being the highest category. This categorization is determined by the Office of Civil Nuclear Security (OCNS) depending on particular radioactive material inventory characteristics. From the time when radioactive materials were first stored on the Low Level Waste Repository, the site was categorized as a Category III site and the security of the site was the responsibility of the United Kingdom Atomic Energy Authority, who employed the UKAEA police force as an integral part of the Site Security Plan, to guard the site. Later the ownership of the site and the Nuclear Site Licence transferred to British Nuclear Fuels, but the security category remained at category III and guarding was carried out by the Civil Nuclear Constabulary, an armed force.

The primary reason for the Categorisation as III was due to the inventory of PCM, strictly speaking an Intermediate Level Waste, stored at the site pending transfer to Sellafield for storage. This transfer of all the bulk PCM packages and drummed waste was completed by July 2007, however, minor contamination of the storage areas remained.

In order for the site to be re-classified, the first step was for the Nuclear Site Licence holder to provide assurances to the Nuclear Installations Inspectorate and OCNS that all the bulk PCM had indeed been transferred to Sellafield, and that the remaining contamination inventory was below the maximum quantity for Category IV. The Security Category IV threshold for plutonium contaminated waste in the UK is defined by the Nuclear Industry Security Regulations 2003 – Technical Requirements Document. The limits are stated by weight of nuclear material (plutonium and uranium), the form of the waste and its containment. Further requirements apply to the quantity and nature of radioactive sources on the site.

This required physical examination of the storage areas, followed by radiological measurement and assessment monitoring. The monitoring reports were assessed and approved by the LLWR Management Safety Committee prior to the request for reclassification. Following verification of the nuclear material inventory LLW Repository Ltd was required to submit a Site Security Plan to the NII and OCNS. This Site Security Plan reflects the Security Category and the perceived risk for security of the nuclear material. It places requirements for physical security, information security and personnel security.

The final key step in reclassification of security category was to agree a change in the Nuclear Site Licence to enable a private security guard force to secure the site rather than the Civil Nuclear Constabulary.

It should be noted that not only the Site Operators and Nuclear Regulators have a stake in the security of the site. The public, in particular the local public, also need to be reassured that the site is safe, and poses the minimum threat to residents from the effects of theft or terrorist activity. Until July 2007 the continuous presence on the site of an armed Police force provided this.

5. Stakeholder Engagement

Initial discussions with stakeholders, particularly those local to the site, revealed strong opposition to the idea of moving away from a police force. Adverse press coverage by the local media was initially observed. To address this public opinion a specific sub group of the sites stakeholder liaison group was established.

The members of this group were relevant representatives from the local community, the relevant local and county government sections, the relevant government agencies, the CNC, the proposed guard force and LLWR.

The main concern held by the local communities was that the reduction in security was being driven by a desire to reduce costs and that the security of the site would be adversely affected. The sub group met several times prior to the transfer and the concerns of the stakeholders were discussed openly and in detail. The site personnel ensured that the reduction in inventory and hence security risk was well understood by the group.

The involvement of CNC in this group allowed the stakeholders to understand that the CNC police were a finite resource focused on counter terrorism of high security sites. The site was very open about the cost savings associated with the change but made it clear that this was not the main driver for the change.

The main concerns held by the stakeholder group were that the 'powers to arrest' potential law breakers held by CNC would be lost and the security of the local communities would be reduced. It was explained that the vigilance of the guard force would not reduce and ongoing support from CNC would ensure an appropriate response to any suspicious occurrence observed on or around the LLWR site

The remaining concerns surrounded jobs for local people, this was addressed by the new guard force who were committed to providing a significant proportion of the positions to local people.

Early stakeholder engagement proved very successful with the sub group reporting back to the main stakeholder liaison group that they were comfortable with the proposed changes in security for the LLW Repository site. At the present time, after more than one year of using the contract Guard Force, stakeholders appear to be satisfied with their performance

6. Security Arrangements at LLWR from July 2007

The downgrading of the security categorisation from Category III to Category IV, once approved by the various organisations described above, had considerable advantages both for the site Operator, the Regulators, and the Civil Nuclear Constabulary.

The primary change was the recruitment of a privately owned security guard force in the place of the Civil Nuclear Constabulary. This new guard force had to meet the requirements of the Security Industry Authority (SIA) The SIA is the organisation responsible for regulating the private security industry in the UK. It reports to the UK Government Home Secretary. Training in both conventional and nuclear safety, as well as a detailed understanding of the security issues within the site, was required. The LLWR Security Manager, an employee of the Site Licence Company, issues working instructions to the Guard Force and controls their security duties.

The double benefit of the significantly reduced cost of using the private guard force, as well as releasing the scarce resources of the Civil Nuclear Constabulary to police nuclear sites of higher security classification, is appreciated by the site Owner and OCNS. In addition, reduced regulatory costs from the NII and Environment Agency should, in time, be evident, releasing their resources into more relevant roles.

7. Future Reassurance of Security Arrangements at LLWR

The Owners, Operators, Regulators and the Public require reassurance that security measures to prevent unauthorized access to the site and to nuclear materials, is maintained at acceptable levels. This is achieved by:

- Close management of the private guard force by LLW Repository Ltd
- Regular reviews of the duties and performance of the Guard Force
- Inspections by the Regulator, OCNS
- Undertaking of witnessed emergency exercises.

8. Conclusions and Recommendations

It is concluded that despite the significant amount of work involved in the reclassification of security at the LLWR, the long term benefits to all concerned will outweigh any perceived or actual detriments, and it is recommended that other European nuclear facilities in a similar position review their security arrangements.

ALARA principle in collecting radioactive sources: the Spanish experience

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Abstract. Safe collection and transport of spent radiation sources to temporal storage before their disposal or return to a supplier requires an adequate application of the radiation protection rules. The activities to be performed vary widely and they are sometimes carried out in abandoned installations and outside regulated installations. Apart from that, it could also be necessary to handle the source in order to find out what its characteristics are or to put it inside a container which is suitable for the transport. This paper describes the activities, which the Spanish National Waste Management Company (ENRESA) is carrying out in this field, together with the established Radiation Protection and ALARA Programme.

1. General

The Spanish National Waste Management Company (ENRESA) was established in 1984 as responsible entity for radioactive waste management in Spain. Wastes produced in Nuclear Power Plants are conditioned at the installations that generated them, but wastes generated in radioactive installations, resulting from application of radioisotopes in research, medicine, industry and agriculture are conditioned by ENRESA. These conditioning activities are mainly carried out in the existing disposal facility. Sometimes it is necessary to handle these wastes to make sure the Transport Regulations are fulfilled. Before transportation it is also necessary to demonstrate that wastes meet the specific acceptance criteria of the disposal facility or any applicable regulations for temporal storage in other facilities.

These activities are easy to carry out in authorised radioactive installations, where there is good knowledge about the radioactive material, but in many cases wastes result from old practices and they could be found in old installations that have never been authorised. This is the case of radiation spent sources that have been found in areas and buildings of hospitals, process industries and research institutes where these spent radiation sources had been used in the past. Some of these had never been subject to regulatory control; or they had, but had been abandoned, lost or misplaced. In this context in February of 2007 started, in Spain, a campaign for the recover of orphan sources. This campaign continues until now and more than 200 sources has been reviewed, conditioned and removed by ENRESA.

Also from 1999 there is in Spain a protocol for collaboration on the radiological surveillance of metallic materials. Applying this protocol in the melting facilities and in the scrap yards radioactive materials can be detected. These materials are characterized and removed by ENRESA. Most of these materials are pieces contaminated with NORM and can be processed in the facility but a certain percentage are radioactive sources, some of them without shielding, so high dose rates can be measured.

The best option, for spent radiation sources management is return to the supplier, but this is not possible for many sources because the original supplier is unknown or no longer exists. Also, in some cases the owner says that he has not money to finance the returning of the spent source to the supplier. In these cases it is ENRESA's responsibility to collect the sources and transport them to a temporal storage or to return them to the supplier or to another organisation with proper recovery or disposal facilities.

The ENRESA personnel who carry out all the activities of collecting and transporting sources have good training in radiation protection. They are properly instructed in operational aspects and are controlled, from the radiological point of view, by personnel of the Radiation Protection Technical Unit (RPTU).

The activities carried out by the RPTU for management of spent radiation sources are also described in this paper.

2. Activities

For the management of spent radiation sources in the ways indicated before the following information it is necessary: type of source, identification number, radionuclide, activity and date. Also the source must be arranged in a suitable form for transportation. The main activities carried out by the RPTU to obtain this information and prepare transport are the following:

a) Characterisation of spent radioactive sources:
When the Activity Certificate is not available or the source is not marked with the isotope and activity dates or this mark is not visible, it is necessary to determine these dates. If the activity of the source is low enough; the source is removed from its shielding; then it is measured to determine the activity and the isotope using portable equipments. If activity is too high, theoretical models are applied to estimate the activity through external measurements.

b) Dismantling of equipments which contain sources:
In some cases ENRESA has to remove from the equipment the source together with its shielding or remove the source from the shielding to transport it in a suitable transport container (Figure 1). In general, only alpha sources are removed from their shielding using conventional methods.

Figure 1. Removal of an Am-Be source keeping inside a Cs-137 source of a density and moisture measurement equipment

c) Conditioning of sources:
Includes all operations needed to prepare the source for transport and storage (Figure 2). They may include cutting part of the shielding, putting an additional shielding, when the source is not in a safe position, extracting the source from the container, etc. In case of the transfer of sources of high activity to a transport container the task is carried out by contracting a supplier of sealed radiation sources to the international market. This contractor has all technical and personnel resources necessary for safe management of spent radiation sources.

Figure 2. Removal of the head of a teletherapy equipment with Co-60 source

3. Radiation protection and ALARA programme

The RPTU is a Unit which is authorised by the Spanish Regulatory Body (CSN) and is responsible for the fulfilment of Radiation Protection Regulations. The specialist in charge of RPTU holds a specific license from the CSN and has direct access to higher management levels. The RPTU include sufficient number of experts and technicians who are qualified in radiation protection.
The objectives of the radiation protection and ALARA programme are to reduce exposure to external radiation to the lowest possible level and prevent intake of radioactive materials in the body. All the methods established to meet these objects are applied in practice, taking into account that the characteristics of exposure may vary considerably according to the situation: type of installation, safety conditions of the source, user's knowledge about the source, etc. Also, the Programme takes into account that personnel do not work in fixed installations where it is possible to classify, to post working areas and to establish standard procedures. For this reason the Programme was based on a prior radiological evaluation of the activities and it is continuously being re-evaluated.

The main aspects of this Programme are the following:

a) Classification of areas:
All working areas are considered controlled areas because there is always risk of contamination spreading.

b) Work planning and procedures:
There are general written procedures for handling radiation sources. In some situations specific procedures are established after appropriate work evaluation and planning.

c) Monitoring and dose assessment:
It is one of the most important aspects of the Programme. In addition to standard TL-dosimeters, workers use direct reading dosimeters with alarms and extremity dosimeters. A programme for internal contamination control is also established.

d) Surveillance of working areas:
Before and during the job, radiation levels are continuously measured. Devices with acoustic alarms are also used when the activity of the source is very high.

e) Contamination control:
Workers are regularly checked for contamination on hands during the job. When the work has finished, a complete control is carried out in a low background area.

f) Protective clothing:
Workers usually wear conventional white cotton drill or nylon coats. When the process involves working with spread contamination or liquids workers wear one- use "TYVEK" overalls or aprons together with overshoes. Also, they use surgical or rubber gloves. When necessary they use respiratory protection devices and organ shields.

g) Information and training:
All workers involved in spent sources management are trained in radiation protection. Specific information and training is prepared when the activity of the source is relevant or when the operation is carried out for the first time.

The RPTU disposes of several types of detection equipment for their work. The most important ones are the following:

a) Radiation detectors: Hand-held Geiger-Müller detector, ionization chambers and neutron detectors.
b) Contamination detectors: Thin window proportional counter and scintillation detectors.
c) System of spectrometry: Portable spectrometers with NaI of 3"x3" and 1"x1".
d) Direct reading dosimeters: Acoustic alarm digital dosimeters.

4. Results

From 1989 the RPTU of ENRESA has reviewed more than five thousands and seven hundred of spent radiation sources most of which came from radioactive installations (Figure 3). During this time 24 teletherapy sources and 2 industrial irradiators have been transported for temporal storage or have been removed from their shielding in order to return them to a supplier.

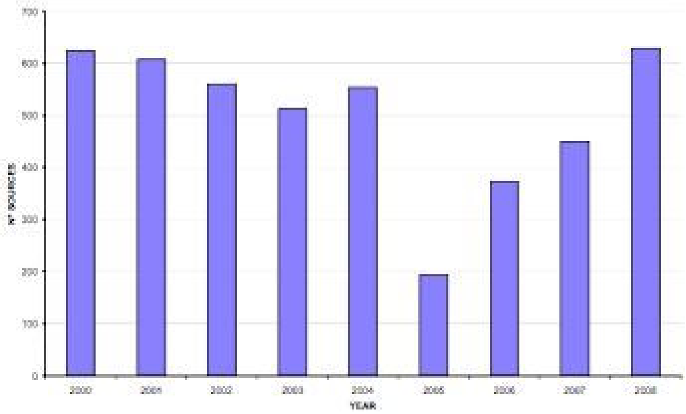

Figure 3. Radioactive sources yearly reviewed from year 2000

The results of the application of the Spanish protocol are 2327 pieces detected, between 1998 and 2008, 269 were radioactive sources. The majority were Ra-226 sources (64,3%) although only cover the 0,4% of the activity removed (Figure 4).

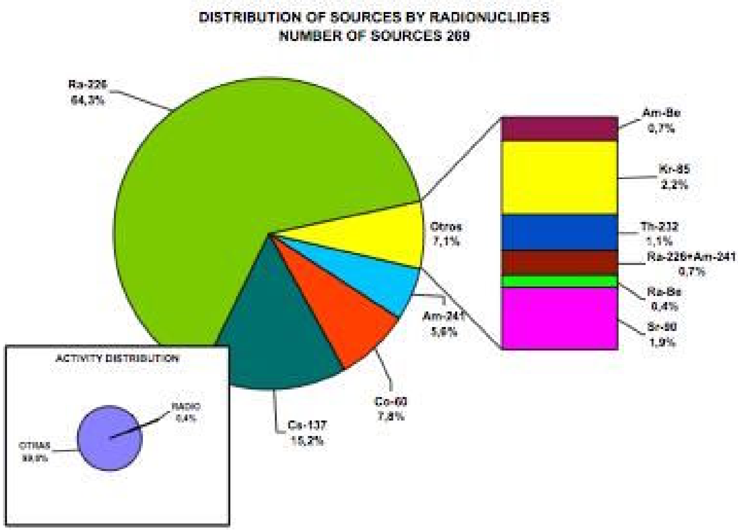

Figure 4. Sources detected in facilities of metallic industry (1998-2008)

During the campaign of orphan sources 251 sources has been characterized and removed with a total activity decayed to the removal date of 99 GBq.

The individual and collective dose to personnel is very low; it is far below the regulatory limit. The medium annual collective dose is below 1 mSv.p and the number of exposed workers is about 8. The applied Radiation Protection and ALARA Programme has proven to be adequate for these activities.

How to combine security and safety of radioactive sources and good patient service in public of large hospitals

J. Kopp (Klinikum Augsburg, Germany)

Abstract. A variety of radioactive sources in a wide range of activity are used in medical care. The spectrum runs from weak sources used as markers or in quality control of equipment to sources of high activity in radiotherapy or blood irradiators. It covers sealed sources as well as open sources that are mainly used in nuclear medicine.

Finding an appropriate balance between the security of the sources, the radiation safety of personnel, patient and public and the requirements of patient care is a challenge for the radiation protection officers, the stakeholder and the licensing authorities.

To highlight the problems the situation will be analyzed for diagnostic and therapy in Nuclear Medicine and for Radiotherapy devices with emphasis on Brachytherapy.
Possible improvements by combining tools used in radiation safety with security purposes will be worked out as well as existing limitations coming from the background of patient comfort, economic squeeze and existing technical conditions. This should possibly initiate a deeper discussion in one of the scheduled working groups.

Safety and security of sealed radiation sources for industrial NDT applications

B. Redmer, H-J. Malitte (BAM Berlin, Germany), B. Sölter (DGZfp Berlin, Germany), E. Reinhardt (Governmental District of Cologne, Germany), R. Hacker (Applus RTD Deutschland, Germany)

Abstract. The use of ionizing radiation for industrial NDT- applications requires the considerations of acts, ordinances, standards as well as a comprehensive education and training in handling of radiation sources. The European Council legislated directives for radiation protection, transportation and registration of radioactive sources, which were transferred into national legislation in Europe.

The use of sealed radiation sources includes the storage of the sources, transport to the test location and back, the actual application in the examination as well as the source documentation. The technical and organisational safety and security of sources is ensured at any time. Within the framework of quality management the user has to apply the principles of safety and security for handling of radioactive sources in his area of responsibility. The principles shall be specified within the instructions for radiographers. Thereby, the ALARA principle is applied for radiation protection in analogy.

The presentation gives an overview of the applicable acts and ordinances and their practical implementation on the example of on-site radiography with sealed radiation sources.

An industry perspective on an efficient safe and secure life cycle management of radioactive sources

W. Fasten
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Abstract. The International Source Suppliers and Produces Association, ISSPA, is an association made up of members from nine different countries. ISSPA is dedicated to the safe and secure use of radioactive sources during their entire life cycle.

The presentation commences with a brief overview of the life cycle model for sealed sources. The need for a robust safety and security culture is discussed and the challenges associated with the pre use and end of life management of sources are presented.

The challenges associated with the management of sources and controls throughout the whole life cycle are many.

For example, differences exist from state to state in the implementation of regulatory and foreign trade control infrastructure and transport security. Expenditures for safe and secure use and end of life management are often underestimated. There is a need for approved transport packages that can accommodate disused sources and devices. Disposal options are scarce and the costs are unknown. Furthermore, many obstacles to transport exist including denial of shipment and import/export controls. Transportation costs are significant.

Fortunately, sealed source and device manufacturers can provide experience in dealing with these challenges.

The presentation concludes with a discussion of the need for global harmonization and a robust safety and security culture. ISSPA member companies are committed to working with International Organisations and member states to develop policies, improve regulations and repatriate disused sources.

Session 3 - Planned exposure situations

Training programmes of workers dealing with security: national and regional aspects

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Abstract. The Greek Atomic Energy Commission (GAEC) is the competent authority for radiation protection and nuclear safety in Greece. Among other responsibilities - regulatory, inspective and monitoring – GAEC has also the responsibility to provide education and training to people involved in the national emergency response plan against nuclear and radiological threats. On the occasion of Athens 2004 Olympic Games organization, GAEC provided training on radiation protection, prevention, detection, emergency preparedness and response to more than 3,000 personnel belonging to the national authorities involved. GAEC continues to organize in regular basis seminars addressed to the personnel of these organizations, in order to establish the sustainability of national operational capability on preparedness and response.

GAEC's work related to education and training issues has been acknowledged internationally and has been recognised since 2003 as the European Regional Training Centre of the International Atomic Energy Agency (IAEA) in radiation protection and since 2005 as the IAEA's International Training Centre in nuclear security respectively. In this framework GAEC has organised, in collaboration with IAEA, several international specialised courses in Nuclear Security for Front Line Officers, Remote Monitoring and Mobile Expert Support Teams (MESTs) and in radiological emergencies for first responders.

Introduction

The Greek Atomic Energy Commission (GAEC) is the national competent authority for matters of radiation protection and nuclear safety. Among other responsibilities (regulatory, inspective and monitoring), it is responsible for the protection of nuclear and other radioactive materials and associated facilities and activities, as well as the prevention, detection and response in case of malicious acts involving nuclear and other radioactive materials out of regulatory control. In this framework, it shields the country from the danger of terrorist threat with radiological consequences and takes the suitable measures for the prompt and effective confrontation of incidents with entanglement of radioactive material.

A key element to fulfil its tasks is the provision of training courses related to the nuclear security, addressed to the personnel involved in the national response plan against nuclear and radiological threats such as the military forces, law enforcement, coast guards, fire brigade, Front Line Officers (FLOs), and Mobile Expert Support Teams (MESTs).

The aim of the present paper is the description of these training courses as well as, the GAEC's experience in providing training programmes addressed to workers, dealing with nuclear security, at the national, regional and international levels.

National training courses on Nuclear Security

On the occasion of the Athens Olympic Games in 2004, and in order to prevent radiological threats and emergencies, the physical protection systems of the crucial radiological installations in the country have been upgraded [1]. Among others, the physical protection of radiation sources used in medical and industrial applications has been enhanced. Also, radioactivity detectors have been installed or distributed at the country's external borders (airports, seaports, land entry points) and radioactivity detectors and portable spectrometers have been distributed to the police and fire brigade. The use of this type of radiation detection equipment and the detection response required technical knowledge and specialized training. Thus, adequate training, technical support, and follow-up had to be provided to the personnel authorized to use these systems. The mechanism developed during that period had to be maintained and improved through continuous training and knowledge dissemination on the new techniques and methodologies.

At that time, GAEC provided training on radiation protection, prevention, detection, emergency preparedness and response to approximately 3000 of persons working for several national organizations involved in the national emergency plan (military forces, police, coast guards, fire brigade, first line officers, etc.). GAEC still continues to organize frequently and on regular basis seminars addressed to the personnel of these organizations, in order to assure the sustainability of national operational capability on preparedness and response.

As far as the nuclear security is concerned, courses on illicit trafficking of radiation sources were organized in 2004 at the customs offices around Greece, which were attended by approximately 400 first line officers. Since that time, refresher training courses have been implemented in order to maintain and strengthen the skills and knowledge of the custom officers on detection equipment and relevant procedures.

Moreover, the GAEC participates in training courses on nuclear security and emergency response exercises organized periodically by the organizations involved in the national emergency plan. In 2007 an extensive training of 504 police officers was organized by the police concerning the detection response to Chemical, Biological, Radiological and Nuclear (CBRN) threats. GAEC also contributes in the yearly training on transportation of radioactive material by air organized by the airport fire brigade.

Regional and international training courses on Nuclear Security

GAEC since 2003, is the International Atomic Energy Agency's (IAEA) regional Training Centre for Europe for radiation protection and safety of radiation sources. In this concept, apart from different regional specialised courses in the field, GAEC hosts the 22 weeks Postgraduate Educational Course on Radiation Protection and the Safety of Radiation Sources in the English language, co-organized and co-funded by IAEA. The syllabus of this course contains elements of nuclear safety and security

In addition, since 2005, GAEC is the IAEA's International Training Center in nuclear security. In this framework, GAEC has organized, ten international specialized courses for Front Line Officers (FLOs) and Mobile Expert Support Teams (MESTs) on Nuclear Security advanced detection equipment and on data networking, remote monitoring and sustainability of border Radiation detection equipment in collaboration with IAEA, and funded by the European Union.

At the regional level, and in the framework of the project "Strengthening the Capacity of the Radiation Protection and Nuclear Safety Regulatory Authority of Cyprus" that was assigned to the GAEC by the radiation protection section of the department of labor inspection of Cyprus, three educational seminars were organized in Cyprus concerning the field of nuclear safety and security.

- Fighting illicit trafficking of radioactive material.
- Emergency response in case of radiological accident or other radiological event.
- Radioactivity dispersion codes use (Hysplit, Hotspot).

Structure of training programmes related to nuclear security

The training courses related to the nuclear security are addressed to the personnel of the military forces, police, law enforcement, coast guards, fire brigade, FLOs, and MESTs. The structure of these courses, takes into account that the main tasks of the workers dealing with security in case of a radiological/nuclear event are the:

- Detection of the presence of radiation using installed and/or portable detection instruments.
- Localisation of the radiation source using portable detection instruments (e.g. Personal Radiation Detector).
- Identification of the radiation source using the Radionuclide Identification Device (RID).
- Isolation of the radiation source.

The goal through this type of training courses is to strengthen Member States' capacities for prevention of, detection of and response to incidents involving Nuclear and other Radioactive Material. Therefore the main objectives of these courses are the following:

- Understand basic notions on health physics and radioprotection principles.
- Introduce the international nuclear security legal instruments and the IAEA nuclear security program.
- Raise awareness on illicit trafficking regional trends and patterns.
- Enhance coordination between first responders and second line of defence.
- Familiarize with relevant procedures.
- Develop in-depth competence on prevention, detection and monitoring technology and equipment to be used in the area of nuclear security.
- Extensive hands-on experience with instruments.
- Practical applications.

Concerning the outcome of these courses, it is expected that by completing the training course the participants are expected to:

- understand threats and risks of criminal and unauthorized uses of nuclear and radioactive materials,
- be familiar with the relevant international and regional institutional frameworks and legal instruments, the IAEA's role and responsibilities in the area of nuclear security,
- understand the basic principles of radiation, related health and safety principles and the legitimate uses of nuclear and radioactive material,
- be familiar with the equipment and instruments currently available to monitor, detect and identify nuclear and other radioactive material,
- be familiar with the initial steps of response to incidents involving nuclear and other radioactive material and be familiar with the role of to the integration of the local response into a national response plan and global efforts to combat illicit trafficking,
- be aware of basic needs for personnel training and other resources for effective detection and response and for the sustainable operation of equipment.

ALARA elements in the syllabus of the training programmes

These courses contain simple notions based on the ALARA principle since they are not addressed to people familiar with radiation.

In the case of a radiological/nuclear event, if the relevant procedures are not in place and followed, the dose received from a worker dealing with security (i.e. FLO), could be potentially high. It should be noticed that the security workers are not considered occupationally exposed workers and even more emergency workers, and therefore according to the international BSS, the dose limit of 1 mSv/y for the members of the public is applied. In addition and in the context of the optimisation principle, dose constraints at levels below public dose limits should be applied. Thus the application of the ALARA principle in the procedures to be followed, is of vital importance, and consequently due consideration has to be given during the training of these workers in the understanding this principle. The procedures for FLOs performing activities during a nuclear security event, include the assessment phase (confirmation of an alarm indicating presence of nuclear or other radioactive material) as well as the response phase (recovery, safe handling and returning the material back to regulatory control). For example, alarm levels to radiation detection instruments, distances from the isolated sources and dose rate levels in working areas, have to be set in such a way that the FLO performing a nuclear security activity, do not exceed the established annual dose constraint.

Conclusions

A key element to strengthen the country capacities for prevention of, detection of and response to incidents involving Nuclear and other Radioactive Material is the provision of training courses at national and international level, addressed to workers dealing with nuclear security. The structure of the courses must take into account the specific tasks of these workers in case of a radiological/nuclear event, and the relevant procedures to be followed. These procedures have to be based on the ALARA principle, given that these workers are considered to be members of the public. At the end these courses, the participants should be able to know how to deal with a situation involving radiation sources, and at the same time protect themselves from overexposure. The good knowledge of the procedures followed during an alarm (detection, localisation, identification), will help them to work efficiently and optimise the dose received. The knowledge of the three fundamental rules (time, distance, shielding) for self-protection and their practical application during the event is essential. In addition with the knowledge of the proper use and maintenance of the detection equipment, they will get the right measurements so as to evaluate properly the situation and take the appropriate actions according to the procedures.

References

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Aero-gamma measurements as an important tool after a nuclear accident

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Abstract. Gamma-ray spectrometric systems carried by helicopters prove to be indispensable for the surveillance of environmental radioactivity particularly after an accidental release of artificial radionuclides from a nuclear facility. The nuclear accident in Chernobyl has clearly shown that the efforts in performing radioactivity measurements in the environment had to be improved and intensified. As a result a network with more than 2000 measuring stations has been installed in Germany, which continuously measure the gamma dose rate in the environment.

Additionally to these stations four measuring systems equipped with high resolution gammaspectrometry systems are operated in Germany which allows to monitor environmental radioactivity of large areas in a relatively short time period. This offers an important tool especially for nuclear emergency management in case of accidental releases of radioactive material from a nuclear installation. Furthermore these systems can be used to search for lost radioactive sources, monitoring of areas with enhanced levels of natural radionuclides and for On-Site inspection activities in the frame of the CTBTO to clarify if any nuclear underground tests have been performed.

Some examples will be shown to demonstrate the potential of aero gammaspectrometry in the mentioned fields above.

Overview of ISIS (In-Situ Intercomparison Scenario) 2007 Workshop

F. Strebl, M. Schwaiger (Seibersdorf Laboratories, Austria)

No paper was provided. The PPT file of the presentation is available on the EAN Website (12th EAN Workshop section - www.eu-alara.net).

Experience of Georgian authorities in recovering orphan sources

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1. Introduction

Georgia had serious problems with s.c. orphan radioactive sources. There were found and recovered 293 of such sources. The number of people was overexposed. The lethal events are also fixed. Among the found orphan sources the most important are s.c. RTG. Each of them contains radionuclide $^{90}Sr/^{90}Y$ (initial activity of ^{90}Sr is 1 290 TBq). There were found and recovered six RTG-s. The sources were used to produce electric supply for antennas installed into the gorge of high mountain river Enguri. Due to braking radiation the sources are very hot, therefore using of thermocouples gives the possibility to receive enough electrical voltage to supply the antenna with energy. Usually the sources were installed into special device (Figure 1).

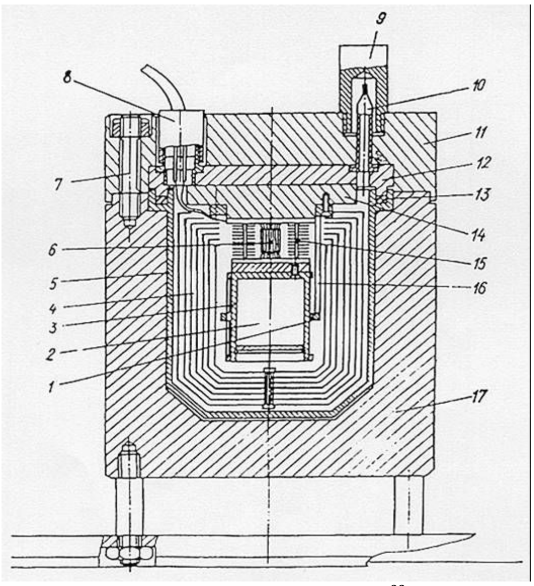

Figure 1. RTG device with ^{90}Sr source

Usually two sources were used to supply by electricity one antenna. Very often found orphan sources are military devices containing ^{137}Cs radionuclides (para. 4.1.2). As it was mentioned above there were fixed two types of devices (special containers): The first contains one source with activity ~ 3 Ci, the second two sources with activity ~ 10 mCi for each. Figure 2 demonstrates distribution of found and recovered orphan source on radionuclides.

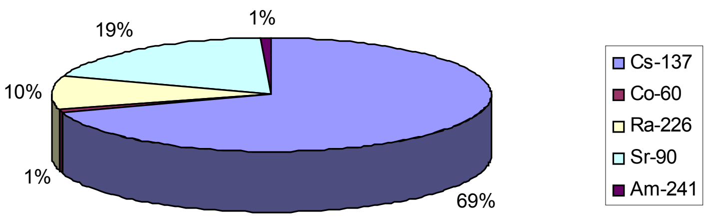

Figure 2. Found and recovered orphan radioactive sources (not considering RTGs)

Analyzing the situation with orphan radioactive sources in Georgia, it can be concluded that there were two ways for originating of orphan radioactive sources in Georgia: military and civil. Situation with orphan radioactive sources in Georgia is caused by complex of facts. At first it should be considered that as a part of former Soviet Union, Georgia was neighboured by NATO country. Therefore a huge amount of militaries were deployed on Georgian territory. The many of them use radioactive sources were not under civilian regulatory control. At the troops withdrawal from Georgia no strong regulatory control existed. There was period of time of soviet empire ruining, when old regulatory system was destroyed, but new one was not established still. At the same time weakening control within military deployments gave the possibility to sell or even abandon (to avoid fees for transportation and disposal) radioactive sources. Simultaneously many enterprises owned the sources due to economical difficulties stop their activities or changed the profile. As a result, in absence of regulatory control, number of sources becomes uncontrolled. To take into account main causes for loss of control over the sources (Figure 3), it is possible to conclude that the main aspect loss of control and originating of orphan sources was Financial Motive [1]. This motive was existed when some people found abandoned radioactive sources. They just tried to earn money and improve their wealth in difficult economical situation. Based on above-mentioned there is possible to identify three main causes for originating of orphan radioactive sources in Georgia:

- Temporary absence of regulatory control.
- Absence of radioactive waste management system.
- Difficult economical situation.

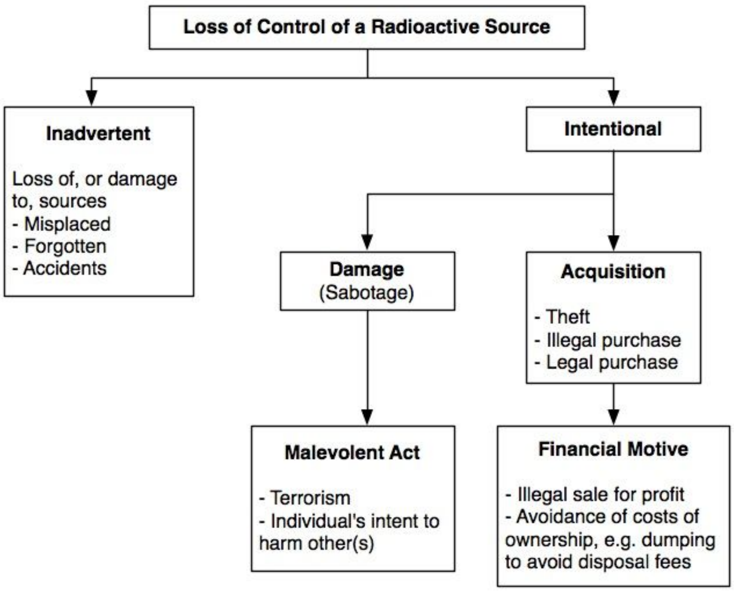

Figure 3. Causes loss of Control of a radioactive source

2. Accidents

Several radiological accidents have been developed in Georgia since 1997. The first great radiological accident took place at the military base in Lilo, when 11 soldiers were irradiated by ^{137}Cs (orphan ^{60}Co and ^{226}Ra sources also were found) [2].

In the scope of IAEA TC project GEO/9/004 "Radiological Emergency Assistance to Georgia" some analytical and monitoring equipment was provided to Georgian specialists to enable them to locate any additional sources left behind by the former Soviet Army on the territory of Georgia.

The next great accident was happened in Matkhoji in August 1998 were three powerful ^{137}Cs and one ^{60}Co were found. The same type sources are found in different regions of Georgia. The last orphan sources were found in Racha (two ^{137}Cs sources) region during the searching operation at summer 2005.
Especial attention also should be paid to illegal movement of radioactive sources through Georgian borders.

Notable cases refer to thermoelectric generators based on ^{90}Sr. Initial activity each of them was 1 295 TBq. There were found and safely stored six such sources. All these sources maybe used for terrorist purposes.

The last accidents occurred at 2009 when the orphan sources were found in western Georgia near village Ianeti (four ^{137}Cs sources with activity ~ 10 mCi each) and contaminated by ^{137}Cs details in Tbilisi.

3. Searching operations

Georgia took necessary steps to establish regulatory control on every type of nuclear and radiation activity: radioactive waste management system is under development (some important parts are already implemented - centralized storage is under operation); economical situation in the country increased greatly and continues become better. Simultaneously with this it is important to search and recover the sources which already became orphaned. Administrative searching can be considered as a first phase for whole searching operation, which should be followed by physical searching. There are three main possibilities to conduct physical searching operation: Airborne survey, car survey and pedestrian survey. All types of survey ware conducted in Georgia. Each type is characterized by its effectiveness and difficulties.

<u>Airborne survey:</u>
The most effective to quickly find and identify sources or land contamination.
Difficulties: Required expensive equipments. Not applicable for mountain regions.
This type survey was carried out in Georgia within the scope of IAEA TC project GEO/9/006 "Assistance for safe disposal of ^{90}Sr the thermogenerators" when 56 hours of airborne gamma survey of a large territory of the western part of Georgia and around Tbilisi was carried out at 2000 (Figure 4).

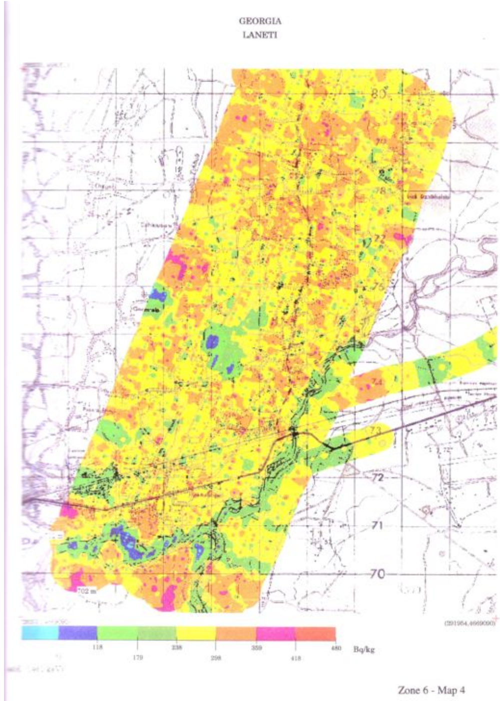

Figure 4. Result of Airborne survey for one area

<u>Car and pedestrian survey</u>
Effective to allocate the source. Applicable for mountain relief. (Not so expensive as airborne survey) (Figure 5)
Difficulties: Covering of large regions
Car survey can be effective if it is accompanied with pedestrian searching. These types of surveys were conducted in Georgia at 2002, 2003 and 2005. All these activities were actively supported by IAEA in close collaboration with USA, France, Indian and Turkish experts.

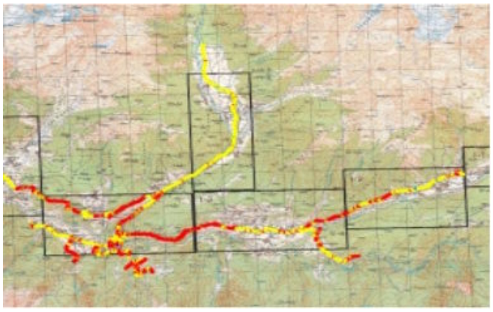

Figure 5. Results of car searching operation for one area

4. Recovery operations

All found orphan radioactive sources should be recovered. There is possible to distinguish to type recovery operations: recovery operation during searching activity and large-scale recovery operation. Large-scale recovery operation is required when powerful orphan radioactive source was found. Usually large-scale recovery operations usually contain three phases:

- Assessment.
- Actions planned.
- Implementation.

During the first phase the relevant information should be gathered and determined the nature and magnitude of the problem. During the second phase (Figure 6) evaluation of problem and remedial action should be carried out. The special recovery plan should be elaborated and taken all action for its implementation. It is also important to consider actions to prevent such accidents in future as on legislation, as on regulation level. The third phase is implementation of the recovery operation and assessment of its results.

Good examples for this activity are recovery operations for RTG and ^{137}Cs sources found near Ianeti.

The last accident connected to RTG was happened at the end 2001 - beginning of 2002 when two local woodgazers near village Lia (Tsalendjikha) district found two RTG sources. They naked them and tried to transport (Figure 7). As result two of them received serious damage for their health. (One of them was dead after long curing in Tbilisi and Paris). NRSS conducted on site measurement and collected all information for situation evaluation. Based on the basis of the special recovery plan was elaborated agreed among interested organizations. The special trainings were conducted to assess effectiveness of the elaborated plan. The recovery operation was carried out by specialists of Department of Civil Dependence and Emergency Situations leaded by NRSS experts. The same methodology was used for recovery operations sources found near village Ianety and contaminated details found in Tbilisi.

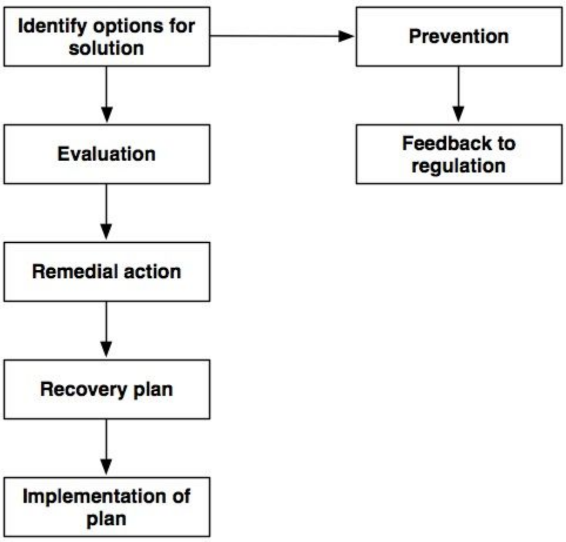

Figure 6. The second phase for large-scale recovery operation

Figure 7. RTG sources found near village Lia (Tsalendjkha)

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[2] The radiological accident in Lilo, IAEA, Vienna 2000.

Session 4 - Emergency situation management (especially due to malevolent acts)

Minimizing the radiation exposure risk of first responders during emergency situation management

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Abstract. This paper will set out the radiation protection strategy envisaged by the Federal Office for Radiation Protection in Germany in cases where the Federal Support Group for serious incidents involving radioactive materials is called upon to support regional police operations. A description of the central radiation protection role of the Federal Office for Radiation Protection within the infrastructure of the Federal Support Group, which enables the minimization of the radiation exposure of deployed forces, will be given, along with an overview of the training and exercise regimes which are considered an essential part of the operation. Lessons learned from the deployment of the Federal Support Group for serious incidents involving radioactive materials in the Polonium-210 case in Hamburg in 2006 show that the perceived harm caused by radioactive materials can be much greater than the actual harm caused. The paper will include examples of the lessons learned from the deployment in Hamburg in this respect.

1. Introduction

Radiation protection for first responders to incidents which comprise malevolent acts involving radioactive materials is of utmost importance. The integration of radiation protection into the response to such an incident is central to its success. In Germany, the defence against nuclear hazards is normally the responsibility of the state ("Bundesland") in which an incident occurs. Each German Bundesland has its own police force, criminal police office and radiation protection authority who are all equipped to deal with small to medium-scale incidents involving radioactive materials. However, if the incident is of a serious and/or criminal nature, for instance an emergency with nuclear material or an attack with a radiological weapon, the Bundesland can call on the federal government for additional forces from a unit known as the "Federal Support Group for serious incidents involving radioactive materials" (abbreviated to ZUB from the German). The ZUB includes specialists from the Federal Criminal Police Office (BKA), the Federal Office for Radiation Protection (BfS) and the Federal Police (BPol) [1].

When called upon, the ZUB is integrated into the local task force dealing with the threat. The control of the operation remains in the hands of the local Bundesland police administration. As every Bundesland has different ways of dealing with nuclear hazards, different regulations and specialists, it is crucial for the federal forces to remain flexible, whilst still allowing for the radiation protection to take a central role in the deployment. To ensure that this is the case, the organisational structure of the ZUB is designed such that the BfS plays a central role in its organisation, the details of which will be set out in Section 2 of this article.

The aim of this article is to demonstrate how the radiation exposure risk of first responders can be minimised during emergency situation management, by giving an overview of the strategy in place at the federal level in Germany (in Section 3). Training and exercises are an essential part of the defence against nuclear hazards and the German approach will be described in detail in Section 4. Another aim of the article is to show that communication is central to the success of a deployment of this nature and should be treated as a priority. Lessons learned from the deployment of the ZUB in the Polonium-210 case in Hamburg in 2006 show that the perceived harm caused by radioactive materials can be much greater than the actual harm caused. Section 5 includes examples of the lessons learned from the deployment in Hamburg in this respect.

2. Role of the Federal Office for Radiation Protection in the ZUB

Due to the high importance of radiation protection during ZUB deployments, the ZUB structure is designed such that the BfS takes a central role. During a deployment, the leader of the BfS unit will be in continuous contact with the leader of the ZUB (from the Federal Criminal Police Office (BKA)) and the leader of the operation in the local police force. The BfS unit and a core team from the BKA are always deployed with the ZUB; other forces from the Federal Police (BPol) and the BKA will join the deployment if necessary.

The leader of the BfS unit, a senior radiation protection expert, advises the operations leaders directly in all aspects of radioactivity and radiation protection. The topics could include, for instance, possible medical measures, protective measures for the deployed forces and the public, the transport of radioactive materials and informing the press and public. The BfS unit has measurement teams on the ground which can be deployed to detect radioactive material, make radionuclide determinations, estimate the activity levels and carry out contamination measurements. These teams can then remove radioactive sources or materials safely from the scene or deploy shielding if the radiation fields are affecting rescue operations. BfS experts either in the field, or in the operations centre, can carry out the evaluation of radioactive materials and estimate criticality risks. Similarly, these experts are on hand to estimate the radiological consequences following a detonation or dispersion of radioactive material and to make predictions for radioactive contaminations and radiation exposures.

Additionally, the BfS can undertake gamma-spectroscopy from the air for the determination of long-range contamination or for the search for sources. The lab-based capabilities of the BfS include incorporation measurements via body counters and the analysis of bodily waste, biological dosimetry and radiochemical analysis. The BfS can provide advice on transport (according to German law) and temporary and final storage of radioactive materials if required. The BfS has an on-call rota system, which ensures that sufficient forces (including leaders, experts and measurement teams) are available at all times to cover the initial phase of a deployment.

3. Radiation Protection Strategy

Although the exact deployment scenario is difficult to anticipate, the radiation protection strategy envisaged by the BfS in the case that the ZUB is called upon to support regional police operations follows the As Low As Reasonably Achievable (ALARA) principle. A team of radiation protection officers from the BfS act as first responders within the ZUB and are able to make on-site measurements, dose estimates and immediate radiation protection recommendations. The measurement results are then relayed to the leader of the BfS deployment, a senior radiation protection expert who is in direct continuous contact to the police deployment leaders. This expert, together with his team can then check that the radiation protection measures are appropriate and decide on the next steps for optimising the radiation protection (e.g., if more measurements are necessary or if additional equipment is required). The operational structure ensures that the radiation protection advice is timely, deployment-specific and central to the operations plan. The structure also ensures that the advice is communicated to all deployed forces through police channels and to the public via press conferences and statements.

Dose limits will be observed during a deployment of the ZUB. The dose limit for the public and for other first responders who do not routinely work with radioactive materials is 1 mSv per year. First responders within the ZUB who do routinely work with radioactive materials, i.e. the radiation protection officers and measurement teams from BfS, are allowed to receive a dose of up to 20 mSv per year due to routine operations. Their dose will be overseen and minimized as far as reasonably possible by a senior member of the radiation protection team at the scene, who has access to radiation measurement data and who can make informed and timely dose estimates. The radiation dose for deployed forces will be estimated by a senior radiation protection expert from the on-site radiation measurements and overseen by film and electronic dose meters. The goal is as low a radiation dose as reasonably attainable under deployment conditions

In order to save lives (or to prevent serious harm to people or catastrophic events developing), an exceptional radiation dose of up to 250 mSv (once only, or 100 mSv in a year) as a reference level has to be observed, depending on the informed consent of the first responder involved and the permission of the senior radiation protection officer in charge. This implies that training and education about the effects and nature of radiation for first responders before an incident is imperative, so that each first responder can make a more informed decision about the radiation dose he or she might receive. This training and education is treated as a central task within the Federal Support Group for serious incidents involving radioactive materials and is dealt with in more detail in the next Section.

One additional point that must be mentioned is that, in certain scenarios, for example if the contents of a Cs-137 source were to be distributed around a populated area [2], or the terrorist use of a "dirty bomb" [3] [4] were to be realised, then, by the time the ZUB is deployed, it might be the case that radiation doses over these limits have already been received by the public and/or first responders. In this situation, the BfS could make estimates of the doses received and would advise on appropriate measures for surveying incorporated radiation doses (e.g. urine samples or full body counter measurements), if appropriate, or medical measures in the case that deterministic effects are expected.

4. Training and exercise activities of the ZUB

It is clear that trust must exist between the police forces and the radiation protection forces, as they must rely on one another to protect the team from police dangers (for example booby traps and gunfire) and from radiation protection dangers (for example, open radioactivity at a crime scene). An effective way to build trust and good working relationships is training and exercises [5].

The ZUB has a training schedule that includes both training and exercises internally within the ZUB (between BPol, BKA and BfS) on two different levels. The first level is training and exercises within one of the partner institutions, organised by that institution for its employees alone. A good example of an internal training for a ZUB institution would be the senior radiation protection advisor meetings which occur on a regular basis at BfS. These meetings are for BfS experts only and include among other things scenario-based table-top exercises. Another example would be internal BfS measurement exercises, where teams of experts measure, identify and quantify radioactive samples using the same equipment as available in a deployment. The second level of training and exercises internally within the ZUB occurs between the subgroups of the different institutions. Examples of this kind of training are: lecture-based education on radiation protection for all non-BfS ZUB staff, organised by the BfS; crime scene work exercises between forensic experts and radiation protection specialists; training police in how to use specialised radiation protection equipment and training BfS staff on police procedures and equipment.

The first level of training and exercises within each partner institution maintains the skills base, forges stronger communication links and strengthens the feeling of commitment of the institution's members. The second level of training, between subgroups of different ZUB partner institutions, strengthens the communication link between the people in the subgroups, keeps skills updated and allows for the boundaries of the expertise of the other institution to be assessed. This is particularly useful for a deployment, as deployment leaders need to have a realistic idea of the capabilities of each institution within the ZUB.

Another type of exercise is that between the ZUB and one of the German Bundesländer. This kind of exercise is the largest and most costly of all the exercises and training undertaken by the ZUB and it is arguably the most important. The lessons learned from such an exercise have a profound effect on the future course of the ZUB and many changes are made following a review of an exercise.

Exercises and training are one of the main methods used for improving best practise in the field of the defence against nuclear hazards in Germany. If the different institutions within the ZUB are to work smoothly with each other, then communication channels have to be opened early and both sides have to be informed about their capabilities, methods and protective measures. Trust, training and education, built up before a deployment, will lead to it being far more likely that radiation protection advice is followed and the primary risks of radiation exposure minimized.

5. Lessons learned from Hamburg – actual versus perceived harm

In late 2006 the city of Hamburg in Northern Germany was faced with a potential dispersal of radioactive Po-210. The Russian citizen Dimitri Kovtun was investigated by Hamburg Police and found to have stayed in the city in late October 2006 before flying to London to meet with British citizen Alexander Litvenjenko at the beginning of November 2006. Litvenjenko was murdered in November 2006 in London by radiation poisoning from the incorporation of Po-210. The Hamburg Police considered it possible that Kovtun brought the illicitly-trafficked Po-210 from Moscow to London via Hamburg. At the time, the presence or scale of the dispersal was unknown, leading the city of Hamburg to call on the German Federal authorities for assistance in the form of the ZUB.

Although the deployment of the BfS as part of the ZUB and the deployment of the ZUB itself in Hamburg from 8th to 22nd December 2006 were successful and at no time were any members of the emergency services or the public at risk from the health effects of radiation [6] [7] [8] [9], the problems caused by poor communication during the deployment illustrate that the difference between the perceived harm caused by radioactive materials can be much greater than the actual harm caused. These differences in separating the perceived from the actual harm caused (or risks involved) with Po-210 were felt in three main areas of communication, namely: the internal communication between the different organisations; the external communication with the public and press and the discrepancies between the internal and external communication.

5.1. Internal communication challenges

A public example of the consequences of ineffective internal communication was given when the family members of the owner of one of the forensic sites were persuaded to take further medical tests after having already left the site for a hotel. The medical tests were planned as a precautionary measure and would give the family a chance to escape the media for a few days. There was no medical emergency and they had been living normally for several weeks at the site. There was no indication of radiation syndrome, nor were more than trace amounts of Po-210 found at the scene. One of the main reasons for recommending precautionary medical tests was to put to rest any doubts the family might have about their health. However, the fire brigade responsible for taking the family to the hospital arrived in full protective suits and with a kind of vehicle that is normally used to transport people under triage conditions, see Figure 1. These measures were inappropriate and resulted in the family experiencing a large amount of unnecessary anxiety. As a further result, the family lost trust in the emergency responders and this made obtaining their continued cooperation in the operation more difficult. In addition, as the photos were in the public domain, the effects had to be dealt with using further external communication efforts, as discussed in Section 5.2 below.

Figure 1. Photos taken from outside a hotel in Hamburg, demonstrating an inappropriate response by the emergency services.

5.2. External communication challenges

External communication was delivered formally in the form of police press conferences in Hamburg and informally in the form of pictures taken by journalists from the perimeter of the forensic sites. The press conferences were broadcast live on German television in the first week of the deployment and were used not only to confirm that traces of Po-210 had been found, but also to reassure the public that there was no risk to human health from the trace amounts found. These press conferences were partly undermined by a large proportion of the press coverage, which included pictures taken by journalists from the perimeter of the forensic sites (for example, those shown in Figure 1). After the publication of these pictures, breaking news reports on German news channels reported that the health consequences of the Po-210 contamination were in reality much more serious than previously admitted by the authorities. Journalists began to demand explanations from the deployment leaders at the scene, causing disruption to the deployment.

In the following example, taken from newspaper coverage [10], the BfS employees are wearing white forensic suits and carrying radiation contamination detectors, see Figure 2. The fact that the white forensic suits are normally used in all police forensic investigations is not at the forefront of the coverage, so the lasting impression on the readership is that there are measures being taken that are not purely precautionary, or that the scale of the operation is greater than the authorities have admitted. This impression, once established, undermines the trust the public has in the emergency responders and leads to a higher level of scepticism regarding the information presented formally in police press conferences. This headline appeared the day after the events described in Section 5.1 and the suspicious nature of the coverage is partly due to the unfavourable impression made on the journalists by the pictures shown in Figure 1. This example shows how important the internal communication is for ensuring effective and homogeneous external communication.

Sieht so Entwarnung aus?

Zeugen gesucht

Figure 2. Page 6 of the Bild Hamburg, 15th December 2006
"Sieht so Entwarnung aus?" (Does this look like the all clear?)

5.3. Discrepancies between internal and external sources of information

A communication challenge faced during the deployment in Hamburg that specifically related to the discrepancy between different internal and external sources of information was the fact that the police force involved in securing the forensic sites in the first hours of the deployment had little or no official information about the situation. The information they did receive was via telephone from friends and relations who had access to media sources. This led to information being passed around the police force that was in some cases misleading. The result was unnecessarily heightened anxiety in the police force and a reduction in the effectiveness of the deployment.

Another example of the discrepancy between the internal and external communication was the fact that several "worried well" from the police force and their families demanded health check-ups based on their impression of the situation from the media coverage. These police officers had not been inside the scenes involved in the deployment, so they were not under radiation protection surveillance. The check-ups were provided and resulted in an unnecessary strain on health physics resources.

5.4. Consequences of poor communication

The consequences of poor communication during a deployment are at the very least a loss of trust of the public and emergency responders, heightened anxiety and strains on health physics resources. In the worst case, poor communication of the radiation protection measures to be undertaken by the public and deployment forces could lead to deterministic radiation doses or to loss of life. This means that effective communication should be considered vital to ensure the ALARA principle is followed during a deployment. Based on the evaluation of the Hamburg deployment, a new ZUB communication strategy has been put in place that emphasises a customised, homogeneous and appropriate (made-to-measure) response [11]. The strategy includes information material for pre-deployment briefings and information cards for first responders and the public. An emphasis is put on routine education and training of ZUB first responders in radiation protection, as mentioned in Section 4.

6. Summary

Radiation doses during serious incidents involving radioactive materials should be minimized not only to reduce primary risks due to radiation exposure for first responders and the public, but also to help reduce the psychological trauma inflicted by the incident. In order to achieve this aim, radiation protection not only has to be ensured through the integration of radiation protection experts into the heart of the deployment infrastructure, but the radiation protection information must be effectively communicated. Communication should be treated as vital to the success of a deployment and considered within the emergency planning well in advance of a deployment [12].

Minimizing the radiation exposure risk during emergency situation management due to malevolent acts is a large task that involves a lot of preparation and planning. The radiation protection education of non-expert staff, joint training and exercises of emergency responders and the collection of pre-prepared information material for the deployed forces and the press is time consuming and costly. However; the benefits of the investment will be seen clearly if these efforts lead to the deployed forces and members of the public following the radiation protection advice given by the BfS, as this will contribute greatly to allowing the ALARA principle to be adhered to in a deployment situation.

Acknowledgements

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Training of emergency responders

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No paper was provided. The PPT file of the presentation is available on the EAN Website (12th EAN Workshop section - www.eu-alara.net).

The UK Health Protection Agency's response to polonium-210 incident in London 2006

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Abstract. On 23rd November 2006 Alexander Litvinenko died in London, allegedly from poisoning with ^{210}Po, an alpha emitting radionuclide. The potential for intakes of ^{210}Po arising from the spread of contamination to many locations in London posed a public health risk and generated considerable public concern.

The Health Protection Agency (HPA) had a leading role in co-ordinating and managing the public health response. In order to undertake this role effectively and to provide authoritative advice it was necessary to gather information on actual and potential exposures.
This involved:

- The development and implementation of an environmental monitoring strategy ensuring the protection of those carrying out the monitoring.
- Identification of monitoring objectives and setting of priorities.
- Specifying a 'reference level' of surface contamination above which remediation may be required.
- A risk assessment process to identify affected individuals, undertake individual dose assessment and interpret the results.

The presentation will provide an overview of HPA's response to the incident and consider the ALARA aspects of the environmental monitoring programme. A view will be provided of how the programmes of environmental and individual monitoring provided complementary information to direct the response and allocate resources where they were most appropriate.

1. Introduction

On the 23 November 2006, Alexander Litvinenko died in London, allegedly from poisoning by ^{210}Po, an alpha particle emitter. The spread of radioactive contamination, arising from the poisoning and the events leading up to it, involved many locations in London. The potential for intakes of ^{210}Po arising from the contamination posed a public health risk and generated considerable public concern. The scale of the event required a multi-agency response, including top level Government emergency response management arrangements. The Health Protection Agency (HPA) had a leading role in co-ordinating and managing the public health response.

To address the hazards associated with the incident, the Agency developed key objectives for the public health response: in brief:

- To prevent further exposure of the public:
  - identify sites and individuals that may be contaminated;
  - develop an environmental monitoring strategy to support this;
  - assess and advise on public access and remediation of contaminated sites.
- To assess risks to those potentially exposed:
  - develop and implement risk assessment criteria ;
  - offer, implement and report on personal monitoring through urine analysis.
- To provide advice and reassurance to those exposed and the public.

Polonium-210 contamination was found in tens of locations, including hospitals, hotels, offices, restaurants, bars and transportation. In some cases it was possible to carry out simple decontamination procedures at the time of monitoring and release the location as being safe for public access. However there were some locations where this was not possible and the levels of contamination were such that public access had to be prohibited until appropriate remediation or decontamination work had been undertaken. The acute phase of the response lasted into January 2007, with the recovery phase lasting into the summer of that year.

2. Initial response and assessment

The Radiation Protection Division of HPA maintains an Emergency Response Plan which has its origins in accidental releases from nuclear power plants but has been extended to also address 'newer' threats. The Division may also be expected to respond to 'lesser' incidents such as those associated with unshielded sources and contaminated laboratories.

This plan contains generic risk assessments and procedures for those involved in environmental monitoring in response to an incident including a reference level for surface contamination of 100 $Bqcm^{-2}$ supported by a dose constraint of 10 mSv. Monitoring teams would not be expected to remain in areas where contamination was above this level but it would be acceptable for relatively short periods with good standards of personal contamination control.
This approach was also consistent with the objectives of the monitoring to be undertaken in this incident namely:

- To identify and, where possible, remediate by simple cleaning any areas/items which were not significantly contaminated leaving them safe for continued use or return to normal usage.
- To identify those areas/items that were significantly contaminated and required additional remediation before they could be released for access.
- To record the results of the monitoring and cleaning activities so that others could easily identify where additional remediation was required and/or be reassured that previously contaminated areas/items were now safe; or had confirmation that no significant contamination was present.
- To report the results of the monitoring and recommendations for release/remediation to the owner/occupier, through the local authority.

The initial monitoring 'targets' were those places where Mr Litvinenko had been cared for since becoming ill and consisted of his home (which was monitored by the Police and their scientific advisers) and areas of two hospitals (which was undertaken by HPA).

Monitoring at the hospitals was completed within a few hours and levels of contamination, where detected, were generally low and fixed. It was therefore concluded that any further exposure associated with these areas would not be significant and that they could be released for normal use. Exposures already received by those working in the areas when contamination levels were higher could be assessed by individual urine analysis.

3. 10 $Bq.cm^{-2}$ reference level

It became clear at an early stage in the incident that guidance was needed on the likely relationship between contamination levels and health risk posed. This was required both by the monitoring teams and those involved in decisions on the remediation of contaminated areas and objects. Since contamination was being found in a wide range of places and on many different types of surfaces and objects, and also because future exposures depend partly on people's future behaviour, it was not possible to determine a simple relationship between contamination level and future health risk. Therefore, a two step approach was developed. The first step was to identify a level of contamination that would not lead to a future public health risk, regardless of people's behaviour in the future or the location of the contamination. Any locations with no contamination found above this level could then be declared safe for public access without further action. If contamination was found that exceeded this level, then the second step would be to undertake a more comprehensive survey/risk assessment in order both to determine whether a public health risk was posed, and to consider whether remediation activities were warranted.

In order to develop this first 'screening' contamination level, conservative but plausible assumptions were made concerning the time individuals would spend in the vicinity of the contamination, the amounts transferred from surfaces onto hands or into the air by the actions considered, and of the amounts of contamination taken into the body. These different calculations, taken together, indicated that if patchy (not widespread), but fixed, contamination up to 10 Bq cm^{-2} on hard surfaces was left in situ, it was very unlikely that any individual would receive a dose exceeding 1 mSv (i.e. the annual dose limit for members of the public).

4. Key thoughts and conclusions

- The use of simple personal protective equipment was sufficient to keep doses received by monitoring teams low in this incident.
- Relationship between environmental and individual monitoring:
  - Environmental monitoring identified places where people could have been exposed;
  - Risk assessment of those places identified those most at risk and who should be offered individual monitoring;
  - Individual monitoring provided reassurance of the environmental monitoring strategy and the reference level of 10 $Bq.cm^{-2}$.

Radiation protection measures during the investigation of polonium-210 traces in Hamburg in December 2006

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Abstract. In December 2006 the German Federal Office for Radiation Protection (BfS) was deployed, along with other federal forces, to assist an investigation by the Hamburg Police into the movements of Dimitri Kovtun in the German city of Hamburg. The investigation began after media reports linked Dimitri Kovtun to a meeting in London where the poisoning of Alexander Litvinenko with polonium-210 (Po-210) allegedly took place. The investigation focussed on Kovtun's movements during a visit to Hamburg in the week directly before the alleged poisoning. BfS was responsible for the measurement and confirmation of the presence of Po-210 at the sites visited by Kovtun, the radiological evaluation of the measurements, the radiation protection recommendations and for advising policy makers. Following a measurement for airborne contamination at the sites involved, both field and laboratory techniques (e.g., hand-held alpha detectors and grid ionisation chambers) were used to monitor the Po-210 contamination. Although the radiation protection workers are allowed to receive a yearly routine radiation dose of up to 20 mSv, the deployment followed a concept with a 1 mSv combined direct and incorporated maximum radiation dose for both the workers and the general public. This is in accordance with the ALARA principle of minimising the radiation exposure. However; the traces of Po-210 found by BfS were of little radiological consequence and in the vast majority of cases the radiation doses measured were much lower than 1 mSv.

Introduction

In late 2006, Alexander Litvinenko died as a result of a poisoning with a highly-radiotoxic alpha-emitter, polonium-210 (Po-210), which allegedly occurred at a meeting in London. Media reports at the time linked Dimitri Kovtun to this meeting and to the German city of Hamburg. An investigation was started by Hamburg Police into Kovtun's movements during a visit to Hamburg in the week directly before the alleged poisoning. As the presence or magnitude of the radiation hazard in Hamburg was unclear, the Hamburg Police called on the unit responsible for the defence against nuclear hazards at the Federal level in Germany, known from the German abbreviation as the ZUB. The ZUB is a collaboration between the Federal Office for Radiation Protection (BfS), the Federal Police (BPol) and the Federal Criminal Police Office (BKA) [1].

Figure 1. Map of Germany showing the 16 Bundesländer. The city of Hamburg (a Bundesland) is marked. North of Hamburg is the Bundesland of Schleswig-Holstein, where sites were also investigated

Radiation protection

The deployment followed a concept with a 1 mSv combined direct and incorporated maximum radiation dose for both the workers and the general public, even though the radiation protection workers at BfS are allowed to receive a yearly routine radiation dose of up to 20 mSv. This is in accordance with the ALARA principle of minimising the radiation exposure.

Measurements

BfS was responsible for the measurement of Po-210 at the sites visited by Kovtun, the radiological evaluation of the measurements and the radiation protection recommendations. Following a measurement for airborne contamination at the sites involved, both field and laboratory techniques were used to monitor the Po-210 contamination.

Figure 2. A BfS measurement expert at work at one of the sites investigated. Note that the clothing is appropriate for preserving traditional forensic evidence at the scene - there was no airborne contamination present

In addition to the type of measurements shown in Table 1, gamma spectroscopy was used in order to rule out a significant presence of Pb-210. This confirmed the Po-210 as coming from a **reactor-produced** source rather than a source separated from uranium-238 daughter products.

Table 1. Three examples of measurements taken at the scene using a hand-held alpha detector and then confirmed as Po-210 in the laboratory using a grid ionisation chamber and radiochemistry techniques.

Sample	Sample size (cm^2)	Po-210 (grid ionisation chamber, Bq/cm^2)	Po-210 (Radiochemistry, Bq/cm^2)	Hand-held α-detector (cps)
Sofa	180	0.23 ± 0.06	-	0.6
Car head-rest	130	3.1 ± 0.7	4.4 ± 1.1	9
Car neck-rest	200	1.5 ± 0.4	2.1 ± 0.7	0.78

As shown in Table 2, the highest radiation dose was received by the toddler. In all cases the BfS deemed that no further medical measures were necessary and that the people involved could be informed over the local authorities. Stochastic risks were discussed according to the dose.

Table 2. 59 urine samples were collected from 53 people.

Group tested	24h-activity (mBq/d)	Dose (mSv)
Toddler (urine from nappy)	106.0 / 156.0	0.84 / 1.25
Family of ex-wife	20.0 ± 4.8	0.03 ± 0.02
Special unit forces	4.4 ± 3.8	0.005 ± 0.004

Conclusion

The deployment of the ZUB in Hamburg from 8th to 22nd December 2006 was successful and at no time were any members of the emergency services or the public at risk from the health effects of radiation [2]. The traces of Po-210 found by BfS were of little radiological consequence and the radiation protection measures taken by BfS reflected this fact. However, neither the radiation protection measures taken by the emergency workers nor the reaction of the general public and press reflected the actual level of danger all of the time.

Summary and Outlook

The high scientific standards of the BfS were necessary in order to characterise and evaluate the low activities of Po-210 found during the deployment in Hamburg. The evaluation of the measurements enabled the BfS to offer effective radiation protection advice and to assist the police investigation. The majority of the Po-210 traces were found in places that had been in skin contact with Kovtun, leading to the conclusion that Kovtun had most probably incorporated Po-210 or become contaminated with Po-210 *before* his visit to Hamburg in October 2006. As yet, no formal charges have been brought by the German authorities against Kovtun and the costs of the operation remain under discussion.

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IAEA emergency preparedness and response programme

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On the use of an ALARA tool to countering nuclear or radiological terrorism

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Abstract. European national emergency response plans have long been focused on accidents at nuclear power plants. Recently, the possible threats by disaffected groups have shifted the focus to being prepared also for malevolent use of radiation that is aimed at creating disruption and panic in the society. The casualties will most likely be members of the public. According to scenario, the number of affected people can vary from a few to mass casualties. The radiation exposure can range from very low to substantial, possibly combined with conventional injuries. There is a need to develop practicable tools for the adequate response to such acts and more specifically to address European guidelines for triage, monitoring and treatment of exposed people.

In the framework of the European Commission specially targeted research project TMT Handbook a number scenarios of malicious uses of radiation have been analyzed. This paper elaborates on the use of an ALARA tool such as Visiplan as viable alternative to perform consequence assessment studies.

1. Introduction

European national emergency response plans have long been focused on accidents at nuclear power plants. This has resulted in well developed, reviewed and exercised plans taking place at these fixed facilities. The evolution of nuclear emergency planning has led to the refinement of response plans away from fixed nuclear sites, such as the accidents involving the transport of radioactive material. The magnitude of these events whilst generally smaller due to the smaller quantities of radioactive material involved pose there own problems due to the difficulties associated with prior planning for location specific factors, high density populations, etc. More recently, the possible threats by disaffected groups have shifted the focus to being prepared for malevolent use of radiation that are aimed at creating disruption and panic in the society.

Scenarios that fall into this malevolent category host a whole range of issues that require consideration. Historically, the terms accident and emergency have been used interchangeably. Unfortunately, the political landscape has changed to such an extent that in an emergency situation the question "mistake or malicious" has to be asked. Whilst this may not render the actual response at an individual or operational level any differently, there are aspects in the strategic and tactical response that may vary. A whole host of questions is raised and needs to be answered, in part to ensure the safety of the emergency responders.

In order to provide practical guidance for responders in the event of the malevolent use of radiation a program of work developed the Triage, Monitoring and Treatment Handbook (TMT Handbook) [1]. In a new application, this paper reports on – without entering into details – the usage of an ALARA tool, such as Visiplan [2]. Visiplan is a planning ALARA tool developed to estimate dose to workers and in this case, it has been used to estimate the possible consequences of an act of terrorism involving ionizing radiation, such a radiation exposure device, both in terms of received dose and number of affected people.

2. TMT Handbook

TMT Handbook was a special targeted research project of the 6th Euratom framework program that had as a primary objective the development of practical guidelines on the Triage, Monitoring and Treatment of the public exposed to the malevolent use of radiation.

Due to the focus on "accidental" releases much of the guidance is specifically focused towards these issues. The "malicious" event is one that is relatively new to our consciousness and therefore there is relatively little established guidance available specific to this situation. Whilst there are numerous overlaps with accidental situations in terms of the public protection a number of specific issues need to be considered,

- How do you ensure the effective triage of members of the public exposed to radiation or radioactive materials?
- What are the best means of monitoring members of the public, what strategies are adopted at a national level and what resources are available?
- Which treatments options are available and offer the most effective response?

This is of particularly significance in the malevolent event due to the potential for large numbers of people to be, or suspected to be, exposed. It is also apparent that whilst national plans have been developed to respond to these issues these have been, in the whole, developed in isolation. Any significant event could affect more than one country due to cross-border migration of contaminants, people, or transfer of goods.

Generic guidance on this topic has been published by national and international organizations. They are, however, not operational documents to be directly used in emergency situations. So, whilst depending on the scenario, the number of affected people can vary from a few victims to mass casualties; the radiation exposure can range from very low to substantial, possibly combined with conventional injuries. Therefore there was a need to develop practicable tools for the adequate response to such acts and more specifically to address European guidelines for triage, monitoring and treatment of exposed people. TMT Handbook developed consistent guidance on the response to the malevolent use of radiation that affects the public.

One of the first tasks in the development of the handbook was to analyze a number of potential scenarios which would result in a number of people being exposed to ionizing radiation. The analysis focused on the number of affected people and the dose distribution of this group. In most cases worst-case scenarios were adopted to give emergency authorities the opportunity to investigate whether present medical and first responders capacities were sufficient and adequate.

One of these scenarios was analyzed both qualitatively and quantitatively using the software package Visiplan. The novelty in the approach is that Visiplan is usually used for calculating occupational exposure of workers.

3. Radiation Exposure Device

In this scenario a hidden radioactive source is left in a public place with the purpose of irradiating as many people as possible. In this case, we have chosen a subway as a public place and the source is supposedly to be ^{60}Co. Here, ^{60}Co is a gamma emitter with a main energy of 1173 and 1332 keV.

We analyzed two cases: a) the source is left inside the car; b) the source is left on the platform at a given station, as shown in the figure below.

a) Hidden source left inside the subway car

b) A hidden source is left at the station platform

Information on time of the day (estimated number of people), car design parameters (materials composition, thickness), time spent at the station or on the train, etc., have been taken into consideration.

4. Results

The first case, a) would result in two forms of public exposure to radiation, namely those on board of the car and those standing at the platform once the train has arrived to the station. The dose expressed in mSv to people under those circumstances is shown in Figures a.1 and a.2, whereas the dose to people when the source is on the platform on the assumption that they will not wait for the train longer than 10 min is shown in Figures b.1 and b.2, respectively.

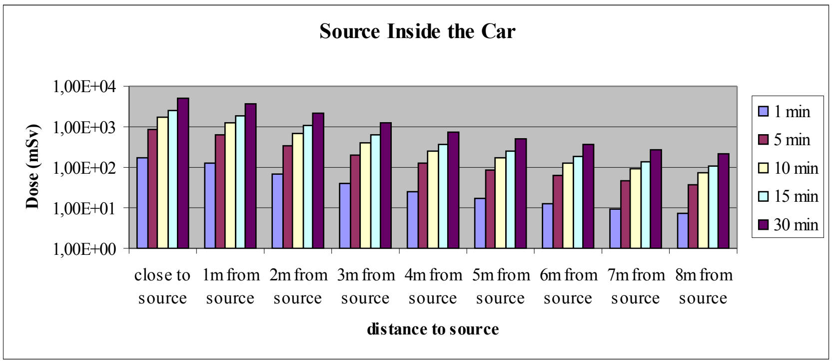

Figure a.1. Source assuming on the subway car as a function of the distance to the source and duration of the exposure

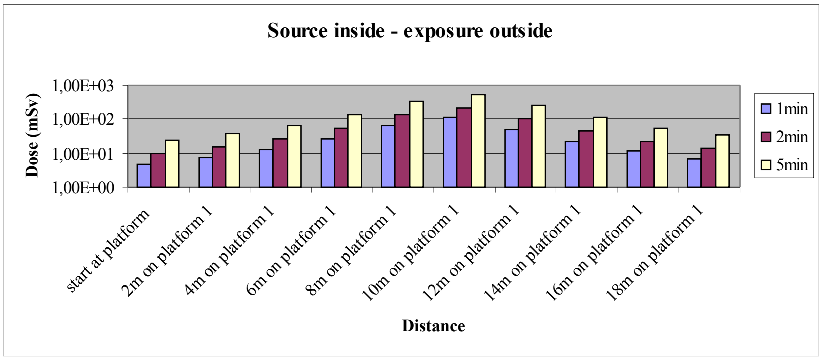

Figure a.2. Here it is assumed that the source is on board of the subway car and that people standing on the platform will be exposed for as long as the train has stopped and also as a function of distance to the source.

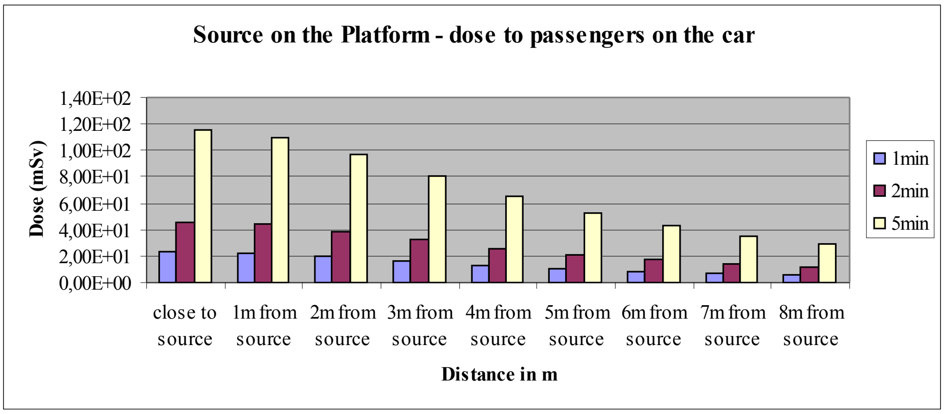

Figure b.1. The source is on the platform and it will irradiate people on the train as a function of distance and time spent at the station.

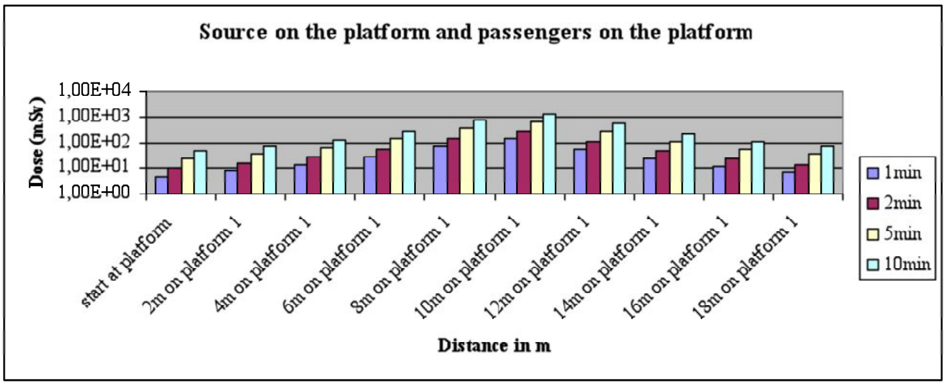

Figure b.2. Finally the source is hidden somewhere on the platform and the exposure of passengers is expressed as a function of the distance and time waiting for the train.

In order to perform a consequence assessment, the Table below shows the dose levels that would result in a medical emergency:

Dose (Sv)	Immediate	Delayed
0-0.1	None	Small risk of cancer or mutations offspring
0.1-0.5	Sometimes radiation disease	Early aging and risk cancer
0.5-1.5	Nausea, vomiting, spontaneous abortion, still-born	Reduction lymphocytes, damage offspring, cancers
1.5-2.5	Nausea, vomiting, diarrhoea, skin burns, dead embryo	Malfunctioning glands, possible death, healthy person may recover with probability to get cancer, etc.
2.5-6.0	List too long	< 60 days 50% mortality, survivors suffer from cancer, malfunctioning eyes, nerves
6.0-10		Death < 10 days
>10	Immediate death	None

Results of these VISIPLAN calculations were not only used for a consequence analysis of the RED scenario, but have also been used to establish a table-top exercise based on realistic assumptions and consequences, both with respect to the radiological and medical emergency response. This table-top exercise was given during the TMT Handbook course in February 2009 in order to train emergency response personnel in dealing with radiological emergencies due to malevolent acts.

5. Conclusions

Visiplan has proven to be a valuable and straightforward tool for estimating the possible consequences of a radiation exposure device in a scenario whereby the malevolent use of radiation will cause mass casualties and will also require trained personnel to treat and follow up the victims. The results of this research provided the TMT Handbook project with valuable information on the potential number of casualties exhibiting acute radiation syndrome, signs of overexposure to ionizing radiation and on the type of treatment they would require.

The same results of VISIPLAN provided a table-top exercise that adequately trains emergency response personnel in dealing with malevolent acts with radioactive material.

6. References

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7. Acknowledgements

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Session 5 - Justification and optimisation of doses in the use of security devices

Use of X-ray body scanner equipment in the UK and matters to consider to keep doses ALARA

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Abstract. X-rays have been used for many years to screen baggage and postal items for illicit materials. In the last 15 years, larger versions of this type of technology have been developed to screen vehicles. Within the last 10 years, X-ray transmission equipment to screen suspected smugglers arriving at airports has been introduced, as have limited trials involving backscatter devices to screen passengers prior to flying. At an airport, there are two categories of passengers who may be selected for X-ray examination:

A. Passengers about to fly and transiting through security who, through profiling, may pose a greater risk to the flight, and
B. Passengers who have landed and leaving the airport through customs control who, through intelligence or profiling, may be carrying illicit materials.

Examination of category A passengers is concerned with items that may be used for terrorist or criminal activity on the flight (fire arms, explosives, knives and similar) and many passenger may be selected to undergo such screening. This differs from Category B passengers since the examinations (carried out by custom officers) are concerned with narcotics and other illicit materials that may be brought into the country and involve fewer persons.

The use of transmission X-ray systems gives rise to greater dose (up to 5 µSv per examination) than backscatter X-ray systems (typically up to 100 nSv per examination). There is some medical justification for the screening of smugglers, since the item(s) swallowed may give rise to significant health effects if containment is breached, i.e. drugs overdose. This also enables customs officers to screen suspected smugglers at the airport instead of sending them to a hospital for X-raying.

In the UK, the use of this technology to screen passengers prior to a flight has not been explicitly justified. However, since backscatter X-ray screening systems were in use prior to May 2000, these systems may be used in the UK without the requirement of formal justification. Dose to screened passengers is much less than those screened by transmission systems but more people could be selected for screening.

Means of optimising doses include:

- improved selection criteria to reduce the numbers of persons scanned,
- improved image processing to provide an acceptable image but with a lower dose,
- selection of operating parameters for transmission systems to optimise image quality against dose received,
- development of image test tools to avoid the temptation of using security staff or engineers to test the equipment,
- development of other non-ionising techniques to scan passengers (as a replacement to backscatter screening).

Thus, the screening of passengers and others for illicit materials is likely to increase but technological advances (for image processing and use of non ionising techniques) and optimisation of doses by careful selection of the operating parameters (kV, mA, time) offer the possibility that doses can still be kept ALARA.

Introduction

X-rays have been used for many years to screen baggage and postal items for illicit materials. In the last 15 years larger versions of this type of technology have been developed to screen vehicles. However within the last 10 years, there has been the introduction in the UK of X-ray transmission and backscatter devices to screen people, in particular those travelling through airports.

There has been significant interest in this technology by security agencies for use in penal establishments, police raids on suspected drug suppliers, customs examination of suspected smugglers and to enhance airport pre-flight security.

In parallel to this there has been much interest by the press in the use of this technology. On balance the privacy issue of "strip searching" a passenger, thereby exposing matters of a personal nature, appears to be of more public concern than the radiological hazard.

Use of X-Ray Body Scanners at Airports

Exposed Persons

At an airport, there are two categories of passengers who may be selected for X-ray examination:

A Passengers about to fly and transiting through security who, through profiling, may pose a greater risk (to the flight), and

B Passengers who have landed and leaving the airport through customs control who, through intelligence or profiling, may be carrying illicit materials (narcotics, gemstones or similar) concealed on them, i.e. smugglers.

Examination of category A passengers is concerned with items that may be used for terrorist or criminal activity on the flight (fire arms, explosives, knives and similar) and many passengers may be requested to undergo such screening using backscattered X-rays. This differs from Category B passengers since the examinations, using transmission X-ray systems, (carried out by custom officers) are concerned with narcotics and other illicit materials that may be brought into the country and involve fewer persons than the previous category.
The use of transmission X-ray systems gives rise to greater dose (up to 5 µSv/examination) than backscatter X-ray systems (typically up to 100 nSv/complete examination). There is some further justification for the screening of suspected smugglers, since the item(s) swallowed might give rise to significant health effects in the event containment is breached, e.g. drugs overdose.

Regulations and Standards

The European Union Council Directive 96/29/Euratom (known as the Basic Safety Standards Directive) laid down the basic safety standards for the protection of the health of workers and the public against the risks arising from ionising radiation. The justification of practices utilising sources of ionising radiations was included within this Directive and implemented within the UK by the Justification of Practices Involving Ionising Radiation Regulations 2004 [1]. The guidance to these regulations lists a number of existing practices prior to 13 May 2000 which do not explicitly require to be justified. X-ray backscatter security equipment was in use prior to May 2000 and hence accepted as an existing practice. Dose to screened passengers is much less than those screened by transmission systems but more people could be selected for this type of screening.

The first radiological review of an x-ray backscatter device by HPA's Radiation Protection Division (then the National Radiological Protection Board [NRPB]) was made in 1999. Further assessments have since been made of similar equipment. The principal legislation covering the use of this equipment is the Ionising Radiations Regulations 1999 [2]. This covers occupational exposure in the workplace but does not provide much guidance for public exposure. Consideration of dose constraints for comforters and carers is raised in the regulations as is the NRPB recommendation on a public dose constraint from a single practice (see next paragraph) but there is no guidance covering the deliberate exposure of the public for non-medical purposes.

NRPB [3], in its response to ICRP publication 60, made the recommendation that there should be a public dose constraint of 0.3 mSv/y from a controlled source, with advice on further optimisation below this figure if this was readily achievable. It was felt appropriate to use this figure to determine if foreseeable annual doses were optimised from backscatter x-ray equipment, i.e. up to 5000 examinations per year would be required to give rise to 0.3 mSv. Even frequent flyers were unlikely to be scanned this often. However it was also noted that passengers were unlikely to be examined two hundred times a year hence the annual effective dose would be less than 20 µSv, the value below which further optimisation may not be appropriate.

Based on the low dose received from the examination (comprising of three scans), no recommendations were made to restrict passengers who may be scanned, e.g. children, pregnant women etc. A dose of 100 nSv per examination was comparable to the background dose rate of 30 - 60 nSv/h for the area and significantly less than the 5000 nSv/h exposure during the flight.

Since 1999 when HPA first reviewed the radiological safety of x-ray backscatter equipment, a relevant USA standard (ANSI N43.17 [4]) was published in 2002 and a draft IEC standard has been produced for comment (draft IEC 62463 [5]) concerned with the specification of x-ray systems for the screening of persons for security. In recent years, a number of organisations have indicated a desire to use transmission x-ray systems for scanning persons entering airport, prison or other secure facilities, extending the use beyond the examination of suspected smugglers on entry to the country. Since this is considered a new practice, anyone wishing to introduce this practice in the UK would need to submit a justification[1] case through the relevant authority. The dose per scan from transmission x-rays is higher than backscatter equipment. If used frequently then this could give rise to exposures greater than 0.3 mSv (approximately 60 scans), the constraint used up to this point.

Restriction of Exposure

Restriction of exposure from this practice focuses on three areas

1 Optimisation of operating parameters to provide an acceptable image with minimum dose,
2 Criteria to select those scanned, and
3 The use of other non-ionising technologies to avoid ionising radiation exposures.

1 Optimisation of operating parameters

Improvements in imaging technology and a reduction in the kV and particularly mA can have a significant impact on dose reduction. The security criteria will determine what image quality is acceptable but the radiation protection professional can still seek optimisation of the operating parameters so that the minimum dose is received for an acceptable image to be produced.

One point worth taking into account is the setting up of these systems. Without an adequate test tool, there is a risk that the engineer will use himself/herself to test the system. Suppliers of this type of equipment should provide a suitable test tool to avoid this temptation!

2 Criteria for selection of persons to be scanned

Profiling of persons who may be selected to be scanned would hopefully minimise the numbers selected for this examination. However profiling is still likely to encompass large groups, e.g. prisoners entering a prison, passengers flying on high risk flights, persons arrested during police narcotics raids (to check for hidden needles) and so on. As a note on the potential wide scale use of this technology, one police force offered the use of an x-ray backscatter unit to a school which had had problems with its pupils carrying knives.

3 Use of non-ionising radiation to scan persons

There have been recent developments in the use of non-ionising technologies to replace backscatter x-ray systems and their use may be promulgated providing the relevant authorities are satisfied with their performance. However it is unlikely that transmission systems could be so easily replaced.

Whilst the radiation protection professional may have some influence over (1), the decision on who to scan and with what technology ultimately rests with the security professionals.

References

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[3] Statement by the National Radiological Protection Board: 1990 Recommendations of the International Commission on Radiological Protection. Documents of the NRPB, Volume 4, No 1 1993 ISBN 0-85951-360-2

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[5] Draft IEC 62463 Radiation protection instrumentation – X-ray systems for the screening of persons for security and the carrying of illicit items

Radiation protection control area around passenger baggage X-ray units

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Abstract. Checking passengers and their hand baggage for explosives and illegal or dangerous items and protecting transit systems from acts of terror presents unique security challenges. The number of new x-ray inspection systems installed on the airports raised the question about the radiation protection of security workers and passengers. Radiation exposure from baggage control x-ray units is to be recognized as a private or group hazard of each person alone. We have utilized an active electronic dosemeter (AED) to be used for real time measurements of security workers "possible" occupational dose. We measured the area dose around the baggage control x-ray unit in order to establish the control areas or areas of concern if any. Measurement were performed for a period of more than one year taking into account the passenger number, the number of items scanned and the x-ray radiation quality. The result is that the working area near the x-ray baggage control units used for hand baggage security scanning on airports is not to be regarded as radiation protection control area nor area of concern if the workers are obeying the security procedure rules. If properly installed, used and maintained X-ray control units used for security purposes do not represent any radiation exposure risk to the passengers.

Type testing of basic-protection devices in Germany

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Abstract. The German X-ray ordinance lays down the basic requirements for type approvals of X-ray device. Type approvals in Germany are issued by BfS. The type testing of X-ray devices is carried out by PTB, the German institute for metrology, providing various scientific and technical services.

In autumn 2009, a new X-ray ordinance shall come into force in Germany. With this ordinance, a new category of type approved X-ray devices, called "basic-protection devices", will be introduced. In general, type approvals shall ensure high safety standards in radiation protection. Especially, the exposures of the operators due to ionizing radiation shall be kept "as low as reasonably achievable" ("ALARA-principle").

In this presentation, the technical requirements for basic-protection devices as well as the type-test procedures for this new category of X-ray devices will be described.

Summary and Recommendations of the 12th EAN Workshop

P. Shaw (HPA), P. Croüail (CEPN)

Workshop background, objectives and programme

Radiation protection has always included security-related provisions (for example to prevent the unauthorised use of sources), which have contributed to the overall system of radiation safety. In recent years, however, interest in security issues has dramatically increased and the challenge is to ensure that safety and security measures are designed and implemented in an integrated manner so that security measures do not compromise safety and *vice versa*.

The aim of the workshop was to consider how the implementation of ALARA, in terms of planned and emergency exposure situations, involving worker and public doses, is affected by the introduction of security-related measures. In the case of new equipment and procedures, there is also the question of whether exposures arising from security screening devices can be justified and optimised. In addressing these issues, the workshop tried to consider how an optimum balance between protection, safety and security can be achieved.

As with previous workshops, half the programme time was devoted to presentations, and half to Working Group discussions and their findings. Participants had the opportunity to consider the findings of each group, contribute to discussions, and formulate the final conclusions and recommendations of the Workshop. There were 56 participants from 16 different countries, and a total of 24 oral presentations and 2 posters, arranged under the following sessions:

- Introduction and scene-setting
- Security and safety measures
- Planned exposure situations
- Emergency situation management (especially due to malevolent acts)
- Justification and optimisation of doses in the use of security devices.

Two afternoon sessions were set aside for Working Group discussions, based on the following topic areas:

- Implementation of the Code of Conduct and HASS – ensuring ALARA
- Balancing security and safety – how to achieve an optimum solution
- Management of emergency exposure situations from an ALARA perspective
- Justification and optimisation in the use of security devices

On the final day, the reports from the groups were presented and discussed, and form the workshop conclusions and recommendations described later. Individual presentations (papers and slides) and the working group reports are available to download from the EAN website (http://www.eu-alara.net/).

Themes and issues arising

The introductory session focused on international developments, in particular from the European Commission (e.g. HASS), IAEA (e.g. the Code of Conduct on the Safety and Security of Radioactive Sources) and from ICRP recommendations (Publications 103, 109, and 111). The first two of these have largely been implemented successfully. It was noted that many security-related documents were originally issued as stand-alone documents, but the trend now was to integrate safety and security requirements, either into the same document, or at least into comparable document structures. Further integration is envisaged through the eventual harmonisation of HASS thresholds and IAEA D-values.

The new ICRP system of exposure situations was presented, for which dose constraints (for planned exposure situations) and dose reference levels (for emergency and existing exposure situations) should be set as an upper bound on the optimisation process. The message from the workshop is that there is still much work to do in terms of implementing these recommendations in practice. For example, there are questions about when the different exposure situations apply, what the actual values of dose constraints and reference levels should be, and how to apply optimisation below these values. There is now the opportunity to provide feedback to international bodies on many of these issues, and it was suggested that EAN should help by collating comments from its members.

The 2nd session raised a number of interesting issues on the balancing of safety and security measures. Although both can be said to share a common goal – protecting people from harm – there is a difference in approach. Safety mostly focuses on the control of the source, whereas security is concerned with controlling the actions of (certain) people. These differences have
practical implications; for example safety relies on sharing information and mutual trust, whereas security may require the opposite. The workshop contained a number of presentations on the security measures being applied to different practices. Most of these described source-related controls (e.g. physical security measures), for which there would seem to be a good synergy between safety and security, even though the approach does have to be tailored to different sectors.

In contrast, people-related controls (e.g. security checks and surveillance) were not discussed in any detail, and this may well be an area where there is more potential for conflicting requirements.

The session on planned exposure situations encompassed both normal operations (i.e. in which measures are taken to counter security threats) and the recovery of orphan sources. Examples were given of training programmes for staff involved in both these activities. Such programmes can involve large numbers of persons and require much greater resources than have traditionally been devoted to radiation safety training – perhaps a reflection of the societal importance assigned to security issues.

Dose constraints for security-related staff were mentioned several times; with the consensus being that 1 mSv per year was appropriate in most cases. There was less information on dose constraints for recovery staff; further developments and exchanges of information in this area would be useful.

The same issues – staff training and dose reference levels – were raised in the 4th session in relation to emergency situation management. In this context, training is important not only for radiation protection purposes but also to ensure that the emergency response is proportionate, and that the level of risk (especially to the public) is communicated in a consistent manner. More generally, as recommended in ICRP publication 109, the national authorities should prepare plans for all type of emergency exposure situations, and relevant stakeholders should be consulted during this process. Dose reference levels for emergency responders are beginning to emerge – these are within the range of values recommended by ICRP, although there are significant differences in the values being proposed in different countries. There is also an operational need for derived reference levels, in terms of dose rate and contamination levels, to help guide the optimisation process on the ground. Again, further developments and information exchange in these areas would be useful.

The final oral session considered radiation sources used for security purposes, which continue to increase in type and number. In many cases, these new practices can be managed through the normal requirements for planned exposure situations, although there are some reservations in relation to the safe use of certain types of portable equipment. Special attention was given to the introduction of x-ray security screening devices (“body scanners”) at airports and other locations. The consensus was that such devices must still be subject to controls, even if the dose per scan is extremely low (e.g. as is the case with backscatter scanners). Furthermore, each type of use/location should be subject to the justification principle, to prevent widespread and indiscriminate scanning of the public.

Workshop conclusions and recommendations

As mentioned above, the working group reports, containing details of the discussions, conclusions and recommendations, are available at http://www.eu-alara.net/. A brief summary of these is given below.

Implementation of the Code of Conduct and HASS – ensuring ALARA

- EAN should assist in compiling feedback for the EC on the practical implementation of the HASS directive.
- Better cooperation and information exchange between EU regulatory authorities on the movement of sources between Member States is necessary.

- EC Regulation 1493/93 should be reviewed to ensure that it is consistent with IAEA guidance on import/export of radioactive sources.

Balancing security and safety – how to achieve an optimum solution

- The justification of a practice is a safety judgement, but security should be considered as an integral part of the licensing and inspection process.
- Safety and security can be integrated and made to work in practice, and both should be proportionate based on realistic assessments of the credible risks, both due to accidents and malevolent acts.
- As experience is gained, more could be done to establish harmonised international security levels and controls for different categories of sources.

Management of emergency exposure situations from an ALARA perspective

- The potential radiation exposures to different persons (responders, public, etc.) from different emergency scenarios should be assessed in order that a proportionate response, including practical protection and communication strategies, can be planned.
- Plans must be flexible. In the event of an emergency it is important for the actual radiological conditions to be assessed as soon as possible, to help direct the response and facilitate information exchange between the agencies involved.
- Training of responders is essential and, where possible, should be harmonized so as to develop a "common language" of protection.

Justification and optimisation in the use of security devices

- The use of ionizing radiation for security purpose should not be trivialized. Thus, even when individual doses are low, the use of security screening devices should still be subject to regulatory control, with different types of use subject to specific justification.
- Public doses should be below the 0.3 mSv/y dose constraint, with a requirement for further optimisation below this dose. In practical terms this requires much lower reference doses for individual scans, with further optimisation applied through the correct setting up, operation and quality assurance of scanning systems. To this end, draft IEC standard 62463 should be agreed and adopted.
- Where possible, persons should be informed prior to being scanned, and an alternative to x-ray scanning should be available upon request.

The next EAN Workshop, on "ALARA in the Medical Sector", is planned for 7-10 of June 2011, in Norway. Details will be announced on the EAN website.

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